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NATURAL DISASTERS DIALOGUE
FIRST MEETING

MANAGING ECONOMIC EXPOSURES OF NATURAL DISASTERS: EXPLORING ALTERNATIVE FINANCIAL RISK MANAGEMENT OPPORTUNITIES AND INSTRUMENTS

W O R K I N G   P A P E R

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I. INTRODUCTION

Natural disasters can cause immediate damages to people, productive assets and the economic infrastructure of entire regions, which in turn may have longer term adverse effects on economic activity. Economic disasters occur when the natural catastrophic events strike densely populated areas with high concentrations of economic assets. The pattern is recognizable across the world, but the economic effects are less pronounced in developed countries, due to better risk mitigation and insurance coverage, while the human and social devastation has been extensive in developing countries[1,2]. Several factors have accentuated a concern for human and economic exposures 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., and economic assets are more often than not being built in exposed regions (Kleindorfer & Kunreuther, 1999). This combination of higher event frequency and extended exposure of economic assets increases the potential damage from natural catastrophes and poses a real challenge to sustainable economic development. In this scenario, the poorest population groups are more exposed to natural catastrophes (Charveriat, 2000). Not only do the low-income groups suffer the majority of casualties, due to poor housing and construction quality, but economic rehabilitation is further strained by inadequate emergency shelter, health care facilities, etc.

Despite the growing concern for environmental risk exposures, less than one fourth of all losses emanating from natural disasters around the world are insured. Obviously, one cannot expect full insurance coverage, e.g. public assets in large economies are covered at a federal or governmental level. However, most insurance for economic effects of natural catastrophes covers private assets in developed countries, while developing countries are left largely without committed financial coverage (Sigma 2/2000; Guy Carpenter, 2000). Although global insurance companies are expanding their activities to emerging markets, developing countries remain highly exposed to natural catastrophes, which leave them at the mercy of the international community's philanthropic capacity when disaster strikes. This situation appears less than optimal from economic, social and political perspectives, and inspires the search for alternative ways to obtain financial coverage for major catastrophe risks. Hence, the introduction of new risk management techniques may provide an important impetus to the ongoing poverty reduction efforts in Latin America and the Caribbean (LAC).

Background
The changing environmental reality has increased economic damages from catastrophic events in the LAC region significantly in recent years, and there is no reason to believe that this trend will reverse without some form of intervention in the exposed areas. It appears essential to facilitate risk mitigation efforts that help reduce the potential effects from natural catastrophes and make it easier to retrofit the economic infrastructure and productive assets after a disaster. Whereas development efforts often attempt to satisfy immediate economic needs, it is sensible to support initiatives, e.g. urban development, public procurement, financial, legal and regulatory infrastructure, etc., that will reduce the economic vulnerability from future natural catastrophes. In this context, it is also opportune to consider the possibilities offered by

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[1] The official reporting of catastrophic events in developing countries in many cases do not provide estimates of the economic losses caused by the events. Hence, the statistical information on global catastrophe losses tends to under represent the true economic impact in developing countries.

[2] Natural disaster occur without any human interference and as such represent "Acts of God", but economic disasters can also arise from man made activities, including terrorist attacks, etc. These types of manmade disasters are not considered in this paper.

new international risk-transfer instruments that may allow the region to better cope with the adverse economic and social effects from natural disasters.

The report makes a general assessment of the need for catastrophe risk transfer in Latin America and the Caribbean. It analyzes different ways in which risk transfer can take place in the form of conventional reinsurance contracts as well as newer derivative instruments and risk-linked securities. The report 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 in the region. It is not evident that the primary insurance capacity in the emerging markets is able to satisfy the market need for catastrophe risk coverage in the foreseeable future, despite the expanded activity level of global insurance companies in the region (Sigma 4/2000). This points to fundamental weaknesses in the region's insurance environment, where e.g. lack of formal building codes and urban planning impedes the viability of property insurance contracts. This in turn means that basic and economical property insurance policies are unavailable to the mass market, which is a prerequisite to achieve higher insurance coverage in the region. The attractive high growth market segments relate to life insurance products that provide relatively wealthy high net worth individuals with guarantees for their future retirement income, whereas the acquisition of non-life insurance premiums expands at more modest rates[3]. The reality is, that most catastrophe risk exposures in Latin America and the Caribbean for various reasons have not obtained financial coverage. Given the current status, it may be worth considering a more proactive role to promote the use of alternative catastrophe risk transfer mechanisms.

Considering the increasing economic exposures from natural catastrophes in Latin America and the Caribbean, the aim of this report is to outline financial risk management alternatives, e.g. reinsurance, financial derivatives and hybrid capital market instruments, and assess the relevance of alternative risk management approaches in the LAC region.

The report is organized in a number of sections that address the following issues:
- Current trends in global catastrophe losses and insurance claims.
- The emergence of new markets for the financial transfer of catastrophe risks.
- The viability of alternative catastrophe risk transfer instruments.
- Applications of new risk transfer solutions in the region.

II. NATURAL DISASTERS AND CATASTROPHE 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 thus seriously affects the social and economic activity of that sub-region. Hence, a natural catastrophe can be defined as a natural disaster that causes many casualties and large economic losses that, in case insurance coverage has been sought, may threaten the solvency of individual insurance companies (Cutler & Zeckhauser, 1999). Risk exposures associated with natural catastrophes are generally characterized by low frequencies, high levels of uncertainty and significant economic impacts. Natural hazards are often categorized as windstorms, flooding, earthquakes, drought and wildfires, cold waves and frost, and other events such as hail, avalanches, etc. Official registration of natural catastrophes requires a cut-off point determined either by a

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[3] Life insurance premiums in Latin American countries typically range between .60-.90% of GDP and grow by 10-25% p.a. In contrast, non-life insurance premiums typically range between .60-1.30% of GDP and grow by 3-7% p.a. This compares to indemnity insurance premiums in the U.S. of around 3-3.5% of GDP.

minimum number of casualties[4] or a minimum aggregate economic loss[5] associated with catastrophic events[6]. This enables comparable trend analysis of the statistical recordings over time, even if the data at times 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 a total loss of USD 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). However, the insurance community quickly 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 both two and three times higher. This realization had a sobering effect on the market for catastrophe risk insurance, and did among other things inspire the search for alternative ways to transfer catastrophe risk. This potential increase in claims on catastrophe insurance contracts does not appear coincidental as eight out of the ten most costly insurance losses from natural catastrophes, measured in constant 1999 dollars, have taken place within the last 10 years [Table 1].

Table 1. The 10 Most Costly Insurance Losses During 1970-1999
[USD millions in 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

While the frequency of certain catastrophic events appears to be on the rise, the loss severity of the natural disasters is also increasing. A major reason for this is that more and more people have established themselves and built economic assets in areas that generally are more exposed to these types of hazards. This combination of increased population density and higher insured values in the exposed areas extends the loss severity when disasters strike. This is not just a phenomenon characterizing loss exposures in the developed economies, but also captures the major trajectories in developing countries where new urban developments and infrastructure investments are similarly exposed to the effects of natural catastrophes.
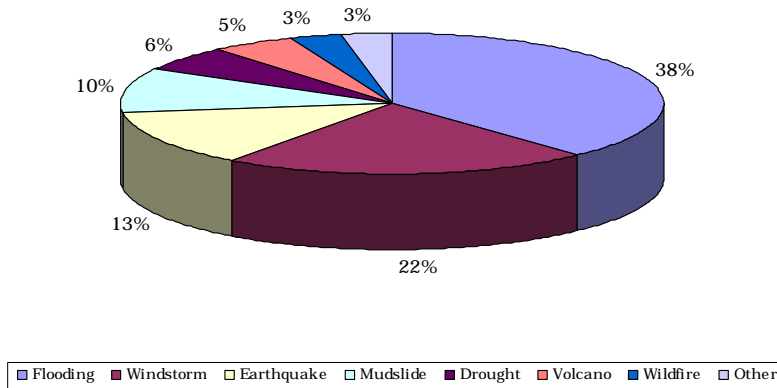
Types of natural disasters
Around 70% of the natural disasters in Latin America and the Caribbean that caused catastrophic events during the period 1970-1999 had a meteorological origin, such as rainfall and hurricanes, whereas the remainder arose from geological phenomena, e.g. earthquake, vulcanic eruption, etc. [Figure 1].

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[4] Casualties usually refer 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 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 USD 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.

[6] This definition ignores smaller disaster events that in the aggregate may seriously affect community welfare over time.

Figure 1. The Most Common Natural Disasters During 1970-1999
[Latin America and the Caribbean]

Flooding ■ Windstorm □ Earthquake □ Mudslide ■ Drought ■ Volcano ■ Wildfire □ Other

Source: C. Charveriat, Natural Disaster Risk in Latin America and the Caribbean, *IDB*, 2000.

The most costly catastrophic events in the region so far have been the Mexico City earthquake in 1985 with estimated losses of around USD 6 billion in 1999 prices, and the El Niño related flooding in Argentina, Peru, and Ecuador during 1998 causing comparable damages of around USD 6.6 billion. However, a number of hurricane events have also caused severe damages, e.g. hurricane George causing USD 2 billion damages in the Dominican Republic and hurricane Mitch casing damages of USD 2.4 billion in Honduras and Nicaragua.

The vulnerability to catastrophic events has increased in Latin America and the Caribbean due to demographic moves, and the associated increases in population density in exposed areas, e.g. along coast lines. Urban areas are more vulnerable to natural disasters because people and economic assets are agglomerated in the large cities. The vulnerability is further exacerbated by poor housing, weak building codes, lack of urban planning, and insufficient infrastructure. Hence, countries with high poverty levels are more exposed to the disruptive social effects of natural catastrophes, and tend to experience more fatalities and more severe economic damages on a per capita basis when disaster strikes.

Global distribution of losses
The total estimated economic losses from all natural catastrophes around the globe were close to USD 100 billion during 1999. However, the insured losses from these catastrophic events only amounted to around USD 24.4 billion. This significant under coverage in the insurance market is partly ascribed to public infrastructure investments in large economies being self-insured at the state or federal level. However, the under insurance is also explained by the fact that there is very little insurance coverage in developing countries although many of the natural disasters occur in these regions. When the distribution of insured losses across global regions is analyzed, it is telling that the entire LAC region accounted for approximately 1.5% of all insured damages that arose during 1999 [Figure 2]. Only the African region could muster a lower insurance coverage of losses from natural disasters displaying a percentage of 0.

Figure 2. Distribution of Insured Damages per Region During 1999
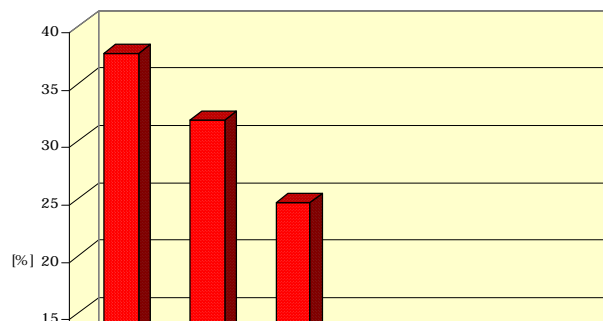
Approximately eight out of ten of the most costly insurance losses from natural catastrophes during 1999 occurred in developed countries. At the same time, the severity of the catastrophes, as indicated by the number of fatalities, was considerably lower in the developed countries compared to catastrophes occurring in emerging market regions [Table 2].

Table 2.   The 15 Largest Insured Catastrophe Losses During 1999

Country		Event	Insured loss	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

During 1999 more than 95 percent of the human death toll derived from natural disasters in developing countries despite the fact that these countries only constitute a marginal count of the total insured losses. These somewhat obscure statistics highlight that emerging markets have high exposures to the social and economic effects from natural catastrophes, while economic assets remain extremely under-insured [Table 3].

**Table 3.   The 15 Worst Catastrophes During 1999**

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

Trends

The frequency of catastrophic events appears to have been increasing significantly over the past fifteen to twenty years [Figure 3]. Even though the selection criteria used to identify natural catastrophes are adjusted for inflationary price effects, more natural catastrophes have been registered in recent years than has been the case in prior 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 disaster events. A certain part of the increase in the reported natural catastrophes may also relate to the fact that a number of natural disaster events previously went unreported, because they had limited economic and social impacts.

Figure 3.   Frequency of Catastrophic Events During 1970-1999
[Number of events]
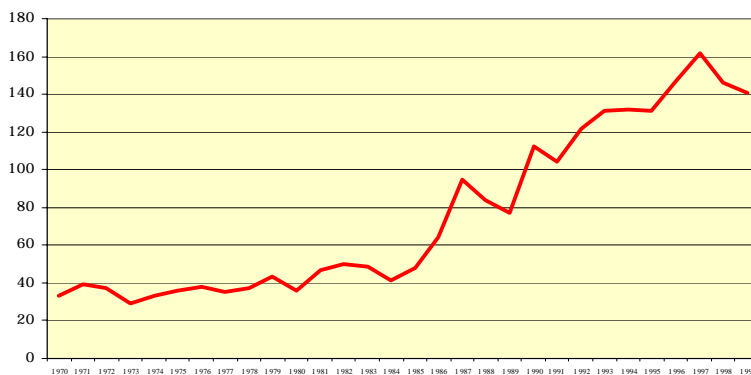
Source: Swiss Re, Natural catastrophes and man-made disasters in 1999, *Sigma* 2/2000.

As population density increases, what may previously have gone unnoticed is now registered as a catastrophic event. For example, there is no evidence from objective measures that the annual frequency of earthquakes is increasing. However, we have witnessed changing climatic conditions in recent years that have caused a number of major windstorm events around the globe, e.g. hurricanes, typhoons, winter storms, flooding and landslides. In other words, there is some evidence of increased exposures from windstorm effects. Although the precise patterns and paths of hurricanes remain uncertain, their seasonality makes them easier to predict. Intense rainfall and flooding events are associated with El Niño effects caused by changes in sea temperatures across the Pacific Ocean (Swiss Re, 1998). It appears evident that the combination of population growth, increased urbanization and an expanded economic asset base has lead to a significant increase in the size of insured losses. What is more, the annual variation in natural catastrophe losses has increased considerably, thereby increasing the uncertainty element of catastrophe risk exposures [Figure 4].

Figure 4.   Insured Catastrophe Losses During 1970-1999
[USD millions in 1999 prices]
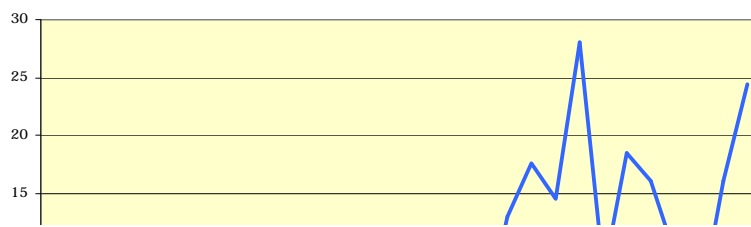
Use of computerized catastrophe modeling techniques that simulate the effects of a large number of weather scenarios makes it possible to better estimate the potential economic impacts of natural events in different regions with reasonable accuracy. Whereas our understanding of the complex relationships that influence the global climatic patterns remains incomplete, it is often possible to determine the potential catastrophe losses within appropriate statistical confidence intervals. It is symptomatic of this trend throughout the past decades, that close to 70% of all insured losses from natural catastrophes during 1999 emanated from windstorms, including hurricanes, typhoons, winter storms, etc. [Table 4].

Table 4.   Insured Catastrophe Losses During 1999[7]

[USD millions]	Insured loss	Pct.
Windstorms	17,036.5	69.7
Earthquakes	3,100.0	12.7
Floodings	1,298.1	5.3
Drought, 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 & Company, The world catastrophe reinsurance market 2000.

III. THE MARKETS FOR CATASTROPHE RISK TRANSFER

Until the mid-1990s, the reinsurance market was the only source to transfer risk exposures associated with natural catastrophes. Primary insurance companies would insure homeowners' properties, industrial facilities, agricultural crops, automobiles, etc. These insurance policies typically combine exposures to a variety of hazards within comprehensive contracts. However, the policies can also cover damages associated with specific natural events and may exclude other events. The basic idea underlying primary insurance is that the insurers assume aggregate risk exposures from policies where risk events are independent of each other and therefore can be diversified. The insurance companies act as financial intermediaries that aggregate the risk of the

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[7] According to information assembled by *Swiss Re*, the reported economic losses and insured losses between countries in emerging markets and developed markets were distributed in the following way during 1999:

[*USD millions*]	Economic losses	Insured losses	Pct. insured
Emerging markets	58,400	3,700	6.3%
Developed markets	39,800	20,700	52.0%
Total	98,200	24,400	24.8%

Hence, approximately half the catastrophe risk exposures in the developed countries were covered by insurance contracts, whereas around 6% of the catastrophe risks, or in reality considerably less than that, were covered in the developing countries.

population and thereby diversify their risk exposures across large portfolios of individual insurance customers.

Primary insurance companies may feel they have accumulated too large risk exposures in particular insurance policies and within certain geographical regions. In this case they can sell part of the insurance policies to other primary insurers and in return 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 diversify their risk exposures further across types of insurance policies and geographical regions. Just like private individuals and corporations use the primary insurance market to reduce their risk exposures to acceptable levels, the insurance companies can sell part of their policies to other insurance companies to reduce their exposures. This constitutes a basic reinsurance principle that has been refined in the global reinsurance market. Several large insurance companies engage solely in this kind of reinsurance business on a global scale.

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 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.
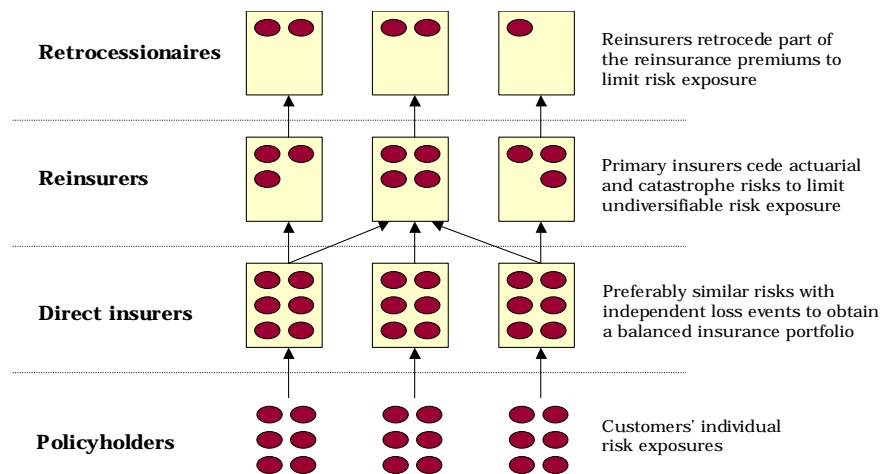

Adapted from Swiss Re, *An Introduction to Reinsurance*, Zurich, 1996.

An insurance portfolio is balanced when it consists of many policies that cover similar events the occurrence of which are independent of each other. In a balanced portfolio the loss ratio is reasonably predictable, as Bernoulli's 'law of large numbers' tends to prevail, although there can be wide discrepancies between expected and realized losses. Hence, the risk exposures of most insurance companies are managed by ceding part of the insurance policies into the reinsurance market. In the case of catastrophe exposures, the individual event risks are not independent of each other because all policy holders are hit when a natural disaster happens. So, when disaster strikes e.g. property exposures cluster within certain regions and aggregate losses tend to be very large. The aggregation 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 to reinsurance companies. 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 extreme agglomeration of loss events. When catastrophe events severely strain the stability of the entire insurance industry, they are referred to as *cataclysms* (Cutler & Zeckhauser, 1999). In reality, these risks cannot obtain insurance coverage and constitute so-called *uninsurable risks*, because reinsurance companies are unwilling 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 non-proportional treaties. Facultative insurance treaties provide cover for individual risk factors, such as windstorm, earthquake, etc. Obligatory and facultative reinsurance treaties can be either proportional or non-proportional (Swiss Re, 2000). In proportional reinsurance treaties, the direct insurer and the re-insurer divide all premiums and losses between them in accordance with a contractually determined ratio. In non-proportional reinsurance there is no predetermined division of premiums and losses. A non-proportional treaty typically defines a deductible, 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.
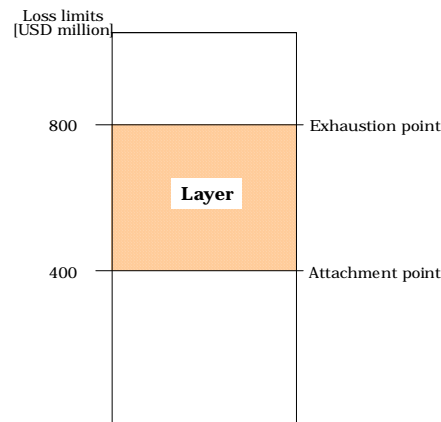
Catastrophe risk exposures are usually covered in non-proportional excess-of-loss insurance treaties (contracts), where the cedant obtains insurance cover from the re-insurance companies in case a catastrophic event leads to a loss in excess of the deductible, *attachment point*, and up to a maximum amount, *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, i.e. different percentages of the individual layers can be ceded in accordance with the insurance company's overall capacity for different risk exposures.
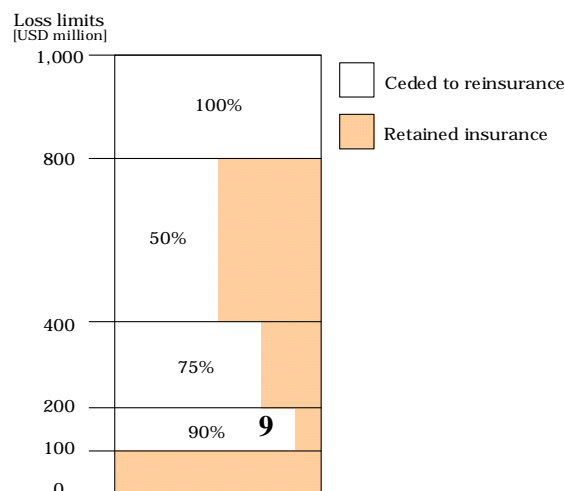
As long as the insured exposures remain within reasonable monetary boundaries the reinsurance market works fine. However, exposures related to natural disasters occur relatively infrequently and within short time intervals. This is depicted statistically as event spikes, rather than events that are evenly distributed over time. Individual policy risks from natural disasters are highly correlated within geographical areas, which make them difficult to diversify through portfolio aggregation. Determining where, when and how disasters will strike is highly uncertain, even though events may be subject to seasonal patterns, e.g. hurricane season, heat waves, winter storms, cold spells, etc. The loss severity of events can vary dramatically from one season to the next, and may hit insurance companies in unexpected ways. However, 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 re-insurer would feel reasonably confident that excessive losses incurred on an unfavorable catastrophe insurance contract in one period would be compensated by the business partners in subsequent periods by engagement in new more favorable contracts. In this way the insurance industry has been able to cope reasonably well with the uncertainties of natural disasters. The reinsurance market continues to function based on trust and long-standing business relationships. 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 exposures increase, this practice may change.

The world population has continued to grow in size, economies have continued to prosper and accumulated more valuable real assets, all the while there has been a demographic trend of people moving towards regions that are more prone to natural catastrophes. The advent of hurricane Andrew in 1992, caused the largest single event damages so far, and affected practices in the entire insurance industry. These effects were further accentuated by the fact that insured losses could have been substantially higher, if the hurricane had taken a slightly different path. The event tightened conditions in the insurance industry (Sigma 7/1997; Froot et al., 1998; Froot, 1999), as many contract renewals were abandoned and premiums on continuing and new insurance contracts increased significantly.

Capacity and price development
The cost of reinsurance coverage is typically indicated by the rate-on-line (ROL) derived as the premium divided by the covered insurance limit (Froot, 1999; Guy Carpenter, 2000).   **ROL = Premium/Cover limit**
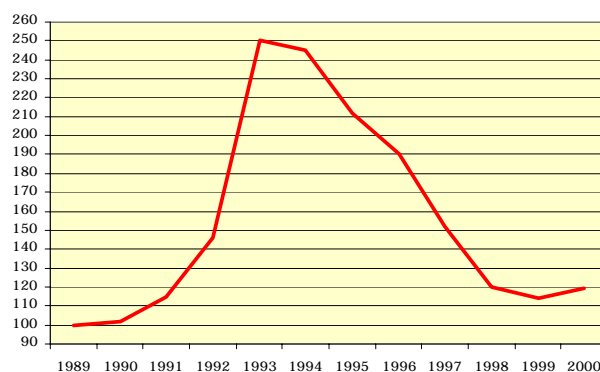
Prices for catastrophe reinsurance have followed a cyclical development pattern (Figure 5). Reinsurance premiums rose dramatically in the aftermath of hurricane Andrews in 1992, which imposed the highest insured loss ever from a single natural catastrophe. In subsequent years, 1995-1999, the market eased considerably, to the extent that some re-insurers undercut the market and charged negative prices. Then again, with severe windstorm losses claimed during 1999, prices are firming again[8] (S&P, 2000; Guy Carpenter, 2000; Sigma 2/2000).

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

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

Sources: Guy Carpenter & Company, The world catastrophe reinsurance market 2000.

The cyclical nature of reinsurance prices indicates that the implied uncertainty may be influenced by the immediate loss experiences from significant catastrophic events. When severe catastrophe losses occur, the solvency of marginal reinsurance companies is threatened, and the accumulated reserves of well-capitalized reinsurance companies are significantly drained. Conversely, during longer periods with relatively low loss frequencies, the reinsurance companies accumulate large reserve positions that allow them to pursue a more aggressive price behavior. The size of accumulated reserves, and hence the general industry capacity, 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 may be alleviated by the introduction of more accurate climatic models and meteorological forecasting techniques. A higher degree of transparency in catastrophe insurance contracts, and use of standardizing catastrophe risk measurement approaches may help reduce the implied uncertainty further, and thereby increase pricing efficiency in the market for catastrophe reinsurance.

Financial risk management alternatives
As conditions for reinsurance of catastrophe risk exposures continued to tighten during the mid-1990s, the market situation induced 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 the current capacity in the global catastrophe reinsurance market. The market consists of conventional reinsurance contracts, but also mutual agreements among primary insurers that are difficult to quantify, it is scattered across many countries, and represented by different types of reinsurance contracts, e.g. proportional property treaty, property per risk, and facultative treaties (Guy Carpenter, 2000). Hence, the global property catastrophe reinsurance market may be estimated at a current size roughly around USD 75 billion[9]. As potential one-time losses could reach this amount, e.g. hurricane Andrew, there appears to be a real need for alternative sources of risk transfer particularly for higher risk layers. The capital market constitutes one such alternative. The catastrophe reinsurance market is dwarfed in comparison to the size of the global capital market, which has been estimated to around USD 30 trillion, with the U.S. market accounting

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[9] The estimate indicates the limit from 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 United States, Canada, Japan, Australia, United Kingdom, Germany, Switzerland and France.

for more than a third of the global market[10]. The 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 USD 125 billion[11]. So, investors in the capital market are familiar with sizeable shifts in fortune and should be able to absorb large potential losses associated with natural catastrophes. Losses associated with catastrophe risks are largely uncorrelated with the return on securities (Sigma 5, 1996; Goldman Sachs, 2000), which should make risk-linked financial assets attractive for diversified institutional investors because it improves the risk-return profile of their invested portfolio.

The first capital market instrument linked to catastrophe risk was placed in 1994 when Kover, a captive of Hannover Re, issued a USD 85 million catastrophe bond, linked to worldwide property catastrophe losses[12]. Since this inaugural transaction many other risk-linked securities transactions have followed raising a total insurance coverage of around USD 6 billion. A number of exchange-traded derivatives linked to catastrophe risk were introduced to the market during this period. The Bermuda Commodity Exchange started trading in catastrophe risk options based on the Guy Carpenter Index on catastrophe property losses. The Chicago Board of Trade introduced futures and options contracts based on the PCS catastrophe property loss indexes. Finally, the Catastrophe Risk Exchange (CATEX) was formed to trade individualized insurance contracts on an electronic bourse.

A portfolio of financial assets with less than perfectly correlated return characteristics will display a lower variance in the return 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, i.e. 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.

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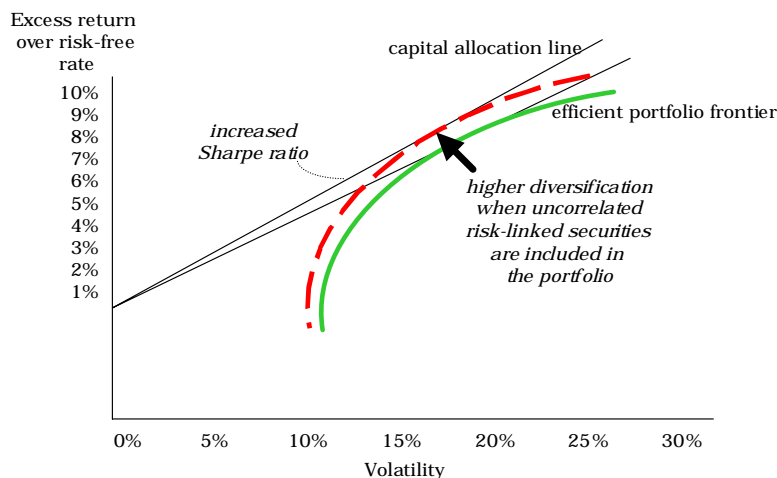
[10] These numbers were indicated in a study by the U.S. General Accounting Office, which ascribed the U.S. share of the global market for traded stocks and bonds at around USD 13 trillion. By comparison the market capitalization of all equities quoted on the New York Stock Exchange amounted to USD 12 trillion in 1999.

[11] The historical volatility of the stock market corresponds to a daily change in market value of approximately 1%, whereas the daily fluctuation in bond returns is closer to .7%. Hence, the expected daily change in the market value of all liquid U.S. securities has had a magnitude of around USD 125 billion.

[12] The transaction excluded coverage in the U.S. and Japan. Insurance coverage was triggered by actual loss indemnity.

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)[13]. 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)[14]. The exchange also offered a catastrophe call spread option contract (Cummins & Geman, 1995). Like other financial futures these contracts were traded with quarterly settlement dates in March, June, September, and December. During 1996 CBOT introduced new futures and options contracts based on the catastrophe index established by Property Claims Service (PCS)[15]. The introduction of financial futures and options contracts based on different loss indexes offered primary insurance and reinsurance companies, as well as large corporations new alternative and relatively flexible ways to hedge their catastrophe risk exposures.

A call spread option entails the simultaneous purchase of a call option at a lower strike price and 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 a 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.

Catastrophe Call Spread (*Bull Call Spread*)
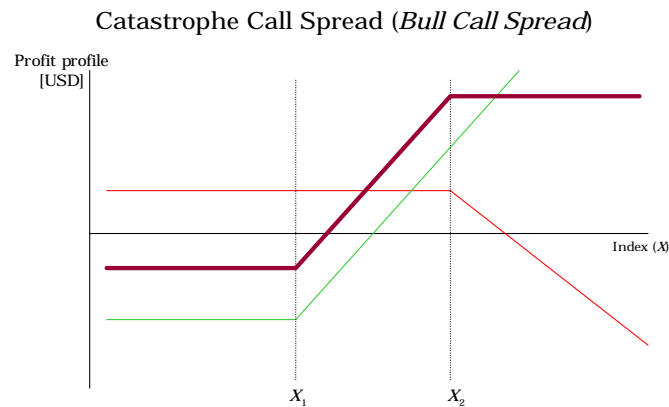
Adapted from T. J. Andersen, *Currency and Interest Rate Hedging*, Simon & Schuster, 1993

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, and by selling the equivalent amount of futures contracts just before maturity to reverse the open futures

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[13] The index measures the insured property losses in different US regions (Midwest, Northeast, Southeast, Florida, Gulf) caused by hurricanes, winter storms, thunderstorms, tornadoes and other "atmospheric perils". The GCCI is reported for two semiannual periods, 1/1-6/30 and 7/1-12/31, and calculates both current and aggregate event losses for the two sub-periods. The index indicates the ratio of losses over insured values.

[14] 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). The settlement value = loss ratio x USD 25,000; the loss ratio = losses/premiums (the ratio capped at 2).

[15] The PCS Index contracts cover 9 geographical indexes for catastrophe losses in the Northeast, Southeast, East Coast, Midwest, West, California, Florida, Texas and national. PCS Index = PCS loss estimate/100 million rounded off to one decimal point, e.g. USD 8,537,846,000/100,000,000 = 85.4.

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 had 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 very liquid, so investors are able to adjust invested positions instantaneously when market outlooks change.

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 indexes that underpin the futures and options contracts co-varies with the catastrophe exposure the hedger is attempting to cover. This might not be the case if, e.g. the loss index covers property damages in the Southeast and the property portfolio to be hedged is scattered across different geographical 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).

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. The electronic trading system is based on integrative XML technology that allows all member institutions to link up to a global exchange posting board. Insurance and reinsurance companies as well as large corporations use the exchange as a B2B market place for various catastrophe risk transactions. 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 cede catastrophe risk exposures and reinsurance companies to post their retrocession needs.

In recent years, financial institutions, energy traders, and energy companies have developed an active dealer-market in a number of over-the-counter weather derivatives based on Heating Degree Days (HDD) and Cooling Degree Days (CDD) temperature indexes[16]. The derivatives typically construed as call and put options[17], and swap agreements[18]. In response to the surge in the over-the-counter market for weather

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[16] A heating degree day (HDD) is derived from the average daily temperature corresponding to the level of energy consumption used to heat buildings. The HDD index increases by one point for every degree by which the daily temperature is below 65^0 F. A cooling degree day (CDD) is derived from the average daily temperature corresponding the level of energy consumption used to cool buildings. The CDD index increases by one point for every degree by which the daily temperature is above 65^0 F. Hence, the indexes replicate a thermostat that turns the heater off in the winter when the temperature exceeds 65°, and turns the cooler off in the summer when the temperature drops below 65°. The accumulated values of the HDD and CDD indexes are good approximations of the energy consumption during winter and summer periods respectively.

[17] The holder of a *call* option is compensated when the index value exceeds the agreed strike price, and the writer of the option has to honor the payout. The holder of a *put* option receives compensation when the index value falls below the agreed strike price, and the writer of the option must honor the payout.

[18] The buyer of a *swap* receives compensation when the index is above the strike price, and makes a payout when the index is below the strike price. The seller of a swap receives compensation when the index is below the strike price, and makes a payout when the

derivatives, the Chicago Mercantile Exchange (CME) has introduced traded futures and options contracts based on the Heating Degree Days (HDD) and Cooling Degree Days (CDD) indexes[19]. These contracts allow energy producers and users to hedge against the so-called *volumetric* risk effects associated with changes in weather conditions, and as such they compete with the contracts offered in the over-the-counter market. However, the exchange-traded contracts are also widely used by the book runners of the over-the-counter products to manage the risk of their derivatives portfolios. In general the parameters of the over-the-counter products are very flexible, as size, maturity and strike prices can be tailored to the needs of individual counterparts. In contrast, the exchange-traded derivatives are standardized contracts and therefore less flexible. On the other hand, the standardized contracts have a unit price, are actively traded and hence have more liquidity, and do not entail counter-party risk as is the case in the over-the-counter market.

A plethora of derivatives has emerged as the markets for different financial derivatives expanded throughout the 1990s. Some of derivatives are related to catastrophe risks. These derivatives 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, e.g. Henry Hub, electricity, e.g. Palo Verde, California/Oregon border, etc., credit risk, e.g. credit spread options, default swaps, etc. Energy price developments are somehow correlated with different exogenous meteorological and economic events, e.g. temperature swings, rain fall, and disruptions in economic activity. Economic risk indicators such as credit spreads may also bear some relationship to catastrophic events, particularly when credit spreads reflect particularly exposed industries, e.g. agriculture, utilities, etc. Similarly, the performance of specialized loan portfolios, e.g. business sectors or geographical regions, should have some relationship to catastrophe-induced changes in economic activity. In other words, there appears to be a large number of seemingly un-scrutinized price and index relationships that could be used to manage economic portfolios exposed to catastrophe risk. This might represent new hedging opportunities for shrewd investors. However, it is beyond the scope of this analysis to delve into a detailed analysis of these potential relationships. One caveat for further exploratory research in this specific area is that it can possibly identify short-term arbitrage opportunities, but may fail to establish viable long-term market mechanisms for risk transfer.

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 an indigenous financial asset portfolio to support the issuance of securities that often are of higher credit quality than the originator of the financial assets (e.g. Blum & DiAngelo, 1998; Fabozzi, 1998). The improved credit rating provides this financing alternative with lower cost of funding and offers the issuer an opportunity to obtain favorable off-balance sheet financing. For many financial institutions, e.g. commercial banks, stringently enforced capital requirements has effectively restricted the ability to put new loans on the books. Hence, for banks with high loan origination capacities, 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 US 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.

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index is above the strike price. Hence, the swap buyers and sellers are counterparts that effectively lock-in their energy prices throughout the length of the swap agreement.

[19] The contracts are standardized so the HDD and the CDD indexes reflect the accumulated daily HDDs and CDDs over a calendar month, where each index degree has a value of USD 100 at settlement.

The development of the market for mortgage backed securities has become more sophisticated with the introduction of new derivative mortgage instruments, such as collateralized mortgage obligations (CMO) with different tranches, e.g. 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 U.S. was enhanced by a favorable regulatory and federal tax regime. With the Tax Reform Act in 1986, the special purpose vehicle referred to as a real estate mortgage investment conduit (REMIC) avoided double taxation of interest income as the residual holders of the mortgage payments became liable to pay income tax, whereas the REMIC was held without any tax obligations as an entity (Roever, 1998). Without this favorable tax ruling, the market for mortgage-backed securities probably would not have been as successful.

As the reinsurance market for catastrophe risks tightened significantly in the aftermath of hurricane Andrew in 1992, the asset securitization technique was transposed to the reinsurance market (Litzenberger et al., 1996; Froot et al., 1998). However, the purpose in this instance 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 would be able to obtain coverage for particular exposures, e.g. property damage, auto liability, etc., in case of predefined catastrophic events, such as windstorm, hurricane, earthquake, etc. 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 & Poor's, 2000). However, the risk securitization approach has also been applied directly by corporate entities, e.g. Oriental Land Co. (Tokyo DisneySea®, Disney hotels and the Disney Resort Line), that otherwise would seek cover through large insurance companies.

A cat-bond is typically structured around a special purpose vehicle established in a tax favorable jurisdiction[20] (ISO, 1999; Standard & Poor's, 2000; Goldman Sachs, 2000). The SPV issues the cat-bonds and receives the up-front payment from the investors buying the securities. The SPV engages into an insurance contract with the ceding entity, that in turn pays an insurance premium for the entire insurance period, or on a periodic basis, e.g. monthly or quarterly, as a percentage of the insured amount. The insurance contract typically provides the cedant with insurance coverage on an excess-of-loss basis (EOL), which corresponds to common practice in the catastrophe reinsurance market. Hence, the ceded risk exposure may cover losses associated with a particular insurance layer between the deductible (attachment point) and maximum limit (exhaustion point). The reinsurance price obtained through the risk securitization process should bear some relationship to the expected actuarial loss on the embedded catastrophe risk exposure[21].

The securitization of financial assets usually entails the creation of a new company. The financial assets are placed in an independent legal entity, a special purpose vehicle (*SPV*), that will apply all the incoming cash flows from the financial assets to service payment obligations of securities issued by the SPV. Before the advent of asset securitization, the banks kept all the mortgage loans on their own balance sheets, which limited their ability to arrange new loans. As the three

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[20] There currently are a number of tax issues related to the establishment of SPVs to furnish catastrophe risk transfer in the US. Most SPVs have been established in Bermuda, Cayman Island or Ireland that allow reinsurance companies to establish the SPVs as separate cells 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 cells in the US market.

[21] 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 that reinsurance contracts, partly because the methodology is relatively new and the SPV structures rather comprehensive and costly.

government supported agencies, Federal National Mortgage Association (*Fannie Mae*), Federal Home Loan Mortgage Corporation (*Freddie Mac*) and Government National Mortgage Association (*Ginnie Mac*), started to buy the mortgage loans from banks and issue mortgage backed securities (*MBS*), the market has become more efficient through specialization. This development has 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 the investor markets.

The securitization techniques is also used to structure cat-bonds. Here, the SPV uses the up front proceeds from the bond issue, less expenses accrued in connection with the arrangement, 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 & Della Sala, 1998). The SPV is rated by a credit agency, e.g. Standard & Poor's, Moody's Investor Services or Duff & Phelps Credit Rating. The presence of a low risk collateralized trust account usually provides the SPV with a relatively high credit rating[22]. The SPV often engages into 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 only will receive the principal back at maturity if the cedant avoids to incur aggregate losses of a certain amount associated with the defined catastrophic events. Hence, the major risk consideration for potential investors in the cat-bonds should be the catastrophe risk exposure inherent in the securities. There has been a significant number of risk-linked securities transactions over the past five years providing total risk coverage of around USD 6 billion[23].
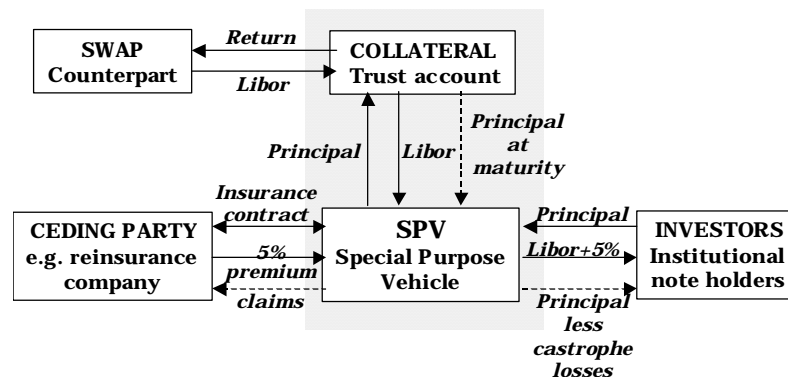
The roles of the trustee[24] and the rating agency are important in all asset-backed securities transactions, but in risk-linked securities the assessment of the inherent catastrophe risks plays a crucial role informing the investors about the risk-return profile of the cat-bonds.

A critical element of the credit evaluation process is an assessment of the validity and integrity of the supporting catastrophe risk analysis. The analysis is usually performed by a specialized consulting firm that uses advanced simulation models to estimate the probability that catastrophic events of certain magnitudes may occur and what the resulting insured losses will be. A number of consultancies have specialized in these analyses, and include Applied Insurance Research (AIR) in Boston, Massachusetts, EQE

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[22] 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 is 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% of the principal is at risk at maturity. The 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, whereas the more risky class A-2 bonds would receive 575 basis points over Libor.

[23] This number should be compared to the total risk capacity in the catastrophe reinsurance market estimated to be around USD 75 billion.

[24] 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.

International, Inc. in San Francisco, California, Risk Management Solutions (RMS) in Menlo Park, California, Tillinghast, Weatogue, Connecticut, and Weather 2000 located in New York City.

The implied uncertainty, and conversely the stability of loss expectations influence reinsurance prices. Computerized risk modeling can help assess the stability of expected future catastrophe 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 event 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. The model simulations describe the probabilistic catastrophic loss characteristics of individual reinsurance layers. The simulation output normally comprises three essential pieces of information to characterize the catastrophe risk exposure.

LEP (loss exceedance probability)

$$LEP = \ P(x)\mathrm{d}x$$

the loss exceedance curve

P (probability of loss)

the probability density function

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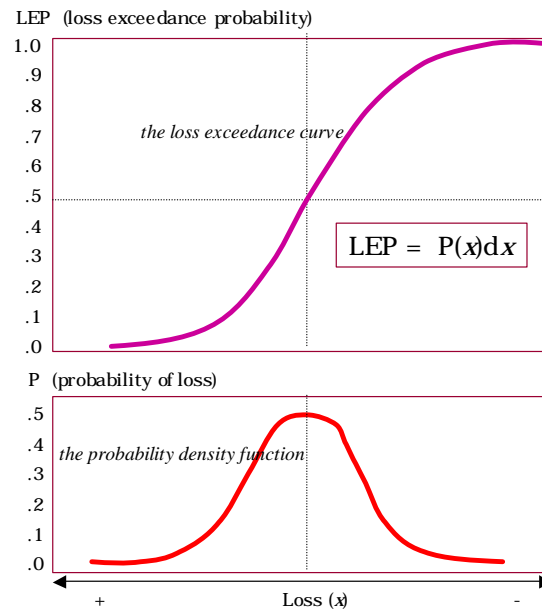
Frequency of loss: the likelihood that losses from the ceded insurance exposure will exceed the deductible (attachment point).
Expected loss: the average product of the frequency and total losses along the loss exceedance curve between the deductible (attachment point) and the upper limit of the reinsured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

(Layered Reinsurance Program – Example)

LEP (loss exeedance probability)

the loss exceedance curve

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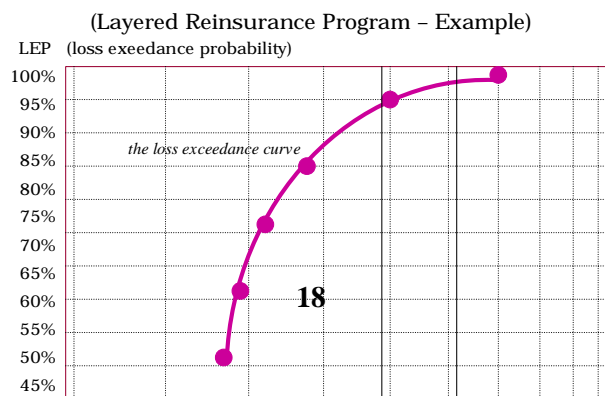
The actuarial probabilities calculated in the simulation models are based on statistical data series that allow some quantification of the expected loss profile.

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 ceding party. For the cedant, this solution provides close to perfect coverage of losses. However, for the cat-bond investors the solution is wrought with the issues of *moral hazard*[25] and *adverse selection*[26], because there is no guarantee that the cedant will try to mitigate losses once the cat-bonds are placed, and as an insider, the cedant may actually 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*, e.g. the Guy Carpenter Catastrophe Index, the PCS Index, etc. 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 cedant to a potentially high *basis risk*[27], if the actual losses differ materially from developments in the underlying index. The triggers could build on *physical indicators* measuring the event magnitude in different ways, e.g. wind speed, wave height, rainfall, etc. These measures are considered objective and can be more closely associated with potential catastrophe losses, and therefore may better accommodate the needs of both cedant and investors. A final methodology is to adopt a *parametric formula* as a trigger. This hybrid approach can develop triggers that are closely associated with the cedants exposure[28], but at the same time are well defined, objectively measurable, and analyzable[29].

Catastrophe risk swaps
The risk transfer characteristics of the cat-bond structure can be replicated through the establishment of catastrophe risk swaps. In the risk swap the cedant makes fixed payments equal to the premiums paid in the 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, e.g.

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

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

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

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

[29] 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 US. The company would also like to establish a robust indicator or trigger that would enable the issuance of a long term contract, i.e. 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% coverage, whereas this registration in the outer grid would not lead to any cover, i.e. loss recovery is related to the intensity of the asset structure in the two grids. An interesting aspect of this approach is that the grid structure permits some standardization, as different trigger structures are based on the same magnitude measure.

indemnity losses, loss indexes, 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[30]*, presumably on an insurance company or possibly a bank[31], i.e. 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. However, engagements in swap agreements will 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. Furthermore, the risk-linked securities are placed among many institutional investors, which diversifies the risk exposure and provides access to an entirely new source of catastrophe risk transfer.

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.
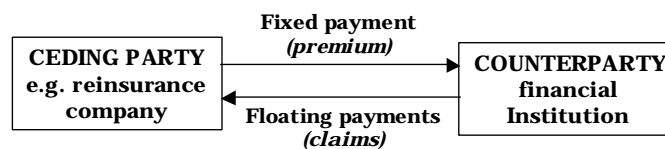
Other instruments provide capital replenishment rather that risk transfer solutions, and therefore can establish financial contingencies in the capital market to fund the recuperation of future catastrophe losses. These instruments provide committed capital in case of catastrophic events through the issuance of common equity, preferred equity, or senior debt instruments[32] (Colarossi, 1999, 2000). Contingent surplus notes have been issued by a number of insurance companies in a total amount of around USD 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. For regulatory purposes, an insurance company may treat the notes as statutory surplus as it enables the insurance company to finance catastrophic losses. Once issued, the notes must be repaid in accordance with a predetermined redemption schedule. Alternative funding arrangement could be structured as contingent equity, sometime referred to as cat-equity puts, that could allow the holder to issue different types of liable capital, e.g. common stock, redeemable preference shares, subordinated capital, etc., if specific cat-related events occur. The holder of a contingent capital instrument will pay an annual premium as compensation for the put option embedded in the instrument[33].

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[30] *Counter party credit risk* occurs when there is a chance that the other party to an insurance transaction or derivative may fail its obligations due to bankruptcy.

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

[32] 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.

[33] A relatively new type of insurance has been introduced recently by the Commonwealth Disaster Management Agency (CDMA) and Liberty Syndicate (Liberty Mutual Group), which against a premium of 1% p.a. based on the insured amount will provide small states that are members of the Commonwealth insurance cover that allows them to continue servicing their external debts for a period of 36 months after their economies have been severely hit by a natural catastrophe such as earthquake, flooding, mudslide, hurricane, typhoon, tropical storm or volcanic eruption.

## IV. THE EFFECTIVENESS AND VIABILITY OF ALTERNATIVE INSTRUMENTS

The eventual choice of risk transfer mechanisms will be influenced by the characteristics of the specific financial instruments and their implications for moral hazard, adverse selection, basis risk, and credit risk exposures. A major concern relates to the issue of *moral hazard*. This may arise when a hedger has obtained cover for a particular risk based on realized losses, because the insured party no longer has a strong incentive to mitigate the size of future losses and hence the insurance provider can be adversely affected in case of a catastrophic event (Grossman & Hart, 1983; Doherty, 1985). Use of hedging instruments that are based on objectively determined indexes will generally be less exposed to moral hazards.

The issue of *adverse selection* constitutes a comparable concern, bounded in the fact that the information by the insured party and the insurance provider is asymmetric, e.g. the party that wants to acquire insurance coverage often knows more about the risk exposure than the insurance company that is going to cover the risk (Rothschild & Stiglitz, 1976; Hillier, 1997). Hence, the party receiving the insurance coverage may try to gain an advantage at the expense of the insurance provider. Conversely, the insurer may charge a premium price to compensate for the uncertainty associated with the adverse selection issue. In either case, the consequence is an inefficient transfer of risk exposures. The inverse situation may also arise, whereby the insurer knows more about the risk exposure than the hedger that is seeking coverage. This can lead to "cherry picking", where the insurance company only provides insurance cover 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 will normally circumvent the problem of adverse selection.

Basis risk arises from discrepancies between the risk indicators used in the financial instruments and the positions the instruments are used to hedge. For example, if the value of the index that underpins the hedging instrument differs significantly from the value of the risk exposure it is intended to cover, the hedge will be exposed to a high basis risk. Instruments that use standardized indexes will often have high basis risk, because it is difficult to apply a general index to an individualized risk portfolio.

Finally, there is a concern for the level of *counter-party credit risk* associated with the hedging instrument, i.e. the hedge depends on the solvency of the insurer. For example, catastrophe risk coverage from insurance companies with a low credit standing jeopardizes future coverage, because a natural catastrophe puts added pressure on the solvency of the weakest insurance companies. Using exchange traded derivatives or issuing risk-linked securities in the capital market will circumvent the counter-party credit risk issue.

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 clearing house will normally guarantee the delivery of the traded contracts, so there is no need to monitor individual counter-party risks. 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*, where the risk cover is based on actual losses and 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, e.g. 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.
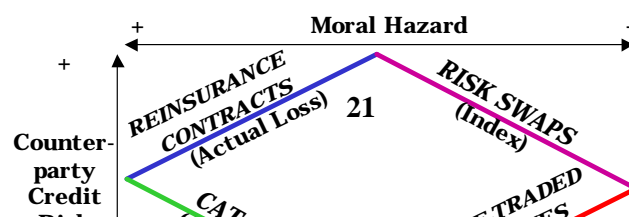
From a counter-party credit risk perspective, the issuance of risk-linked securities is advantageous. However, the trade-off between instruments is also influenced by other factors like speed, flexibility and fee structures. When applying different triggers in the hedging instruments, the relationship 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 indexes 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 achieve 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, i.e. 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.

Cat-bonds have low counter-party credit risk.
Using a parametric trigger can can reduce both moral hazard and basis risk
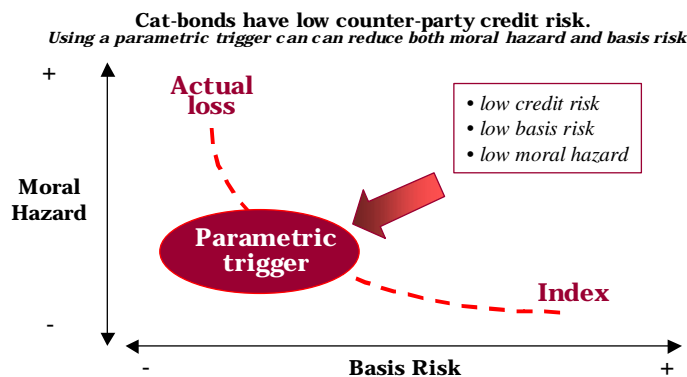
The choice of financial instruments and the structures adopted to transfer catastrophe risk exposures should be based on an evaluation of the inherent risk elements of moral hazard, adverse selection, basis risk, and credit risk. The level of moral hazard and adverse selection bias is a function of the 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 overall market exposures.

The moral hazard and adverse selection issues are mitigated by the same underlying triggers across the different risk transfer instruments. 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 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. In contrast to the risk issue associated with different triggers, the

choice of financial instrument determines the level of counter-party credit risk, as individualized reinsurance contracts and OTC 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 choice of insurance trigger influences the levels of moral hazard, adverse selection and basis risk across instruments, where credit risk depends on the type of instrument.
Market reception refers to the risk transfer structures that are considered to have the most favorable exposure to the inherent risk elements.

instrument \ risk element	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	~	~	~	+	-

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 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 indexes or parametric formulas as triggers because this reduces the issues of moral hazard and adverse selection.

The application of parametric triggers appears to be the most favorable approach for investors and hedgers alike, because it can be construed to match underlying exposures to reduce basis risk while relying on statistically well documented and objective measures of natural events. The past experience with exchange traded catastrophe risk derivatives in the form of standardized index-based futures and options contracts has so far been negative. The catastrophe risk contracts have not been economically viable and the exchanges are closing trading in these contracts.
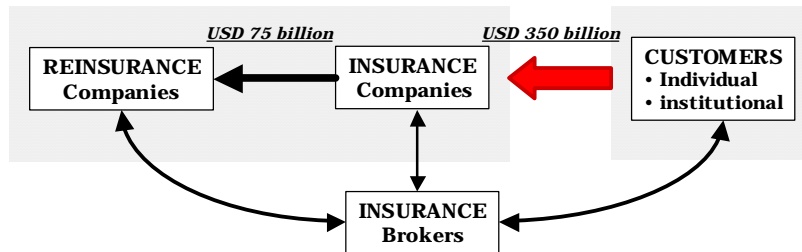
Reinsurance
The total amount of catastrophe exposures covered in the global excess-of-loss (EOL) reinsurance market is estimated around USD 75 billion (Figure 6). Although proportional reinsurance treaties for comprehensive property insurance and mutual reinsurance arrangements among primary insurers provide some additional coverage for catastrophe related risks, the all inclusive market capacity for catastrophe reinsurance coverage is of a limited size and cannot be considered high compared to the potential risk exposures that can arise from single hurricane and earthquake events. In

some cases these catastrophic events are expected to cause aggregate damages well in excess of USD 75 billion in insured property losses (Sigma 7/1997, Guy Carpenter, 2000). In other words, there appears to be a general consensus that the reinsurance industry lacks sufficient coverage for the higher layers of infrequent high impact mega-catastrophes or cataclysms. As catastrophe insurance exposures continue to expand due to population and economic growth, demographic relocation toward exposed areas and changing weather patterns, the underinsurance issue is exacerbated further. This phenomenon, often referred to as *uninsurable risk*, relates to the impending factors of moral hazard, adverse selection, the potential mega-size of losses and the extreme uncertainty surrounding event probabilities.

Figure 6.   The Conventional Insurance Market

The global market consists of about 135 reinsurance companies and 2000 direct insurers most of which also engage in some reinsurance activities.

In view of the limited size of the current reinsurance market and the recurrence of large windstorm damages during 1998 and 1999, the catastrophe reinsurance market is now becoming tighter and prices firmer (Standard & Poor's, 2000; Guy Carpenter, 2000). Whereas the reinsurance industry traditionally has worked on the basis of stable long-term business relationships, this may change as market conditions are tightened. It is symptomatic for this trend that multiyear contracts, which have been the market norm, are gradually being converted into annual contracts in the current market environment. On the other hand, insurance practices are also changing so objective probabilistic computer modeling is becoming the accepted way to analyze risk exposures[34]. These risk assessment techniques may eventually reduce some of the underlying uncertainties that face the reinsurance market.

The availability of catastrophe reinsurance is influenced by the cyclical nature of the market capacity and pricing, which in turn are highly dependent on the recent loss experiences in the industry. Whereas one could ascribe this phenomenon solely to the myophic behavior of reinsurance companies, there may also be a number of regulatory constraints that enforce the behavior (Jaffee & Russell, 1997). For example, current accounting rules prohibit insurance companies from assigning the accumulated surplus into irreversible reserves dedicated to cover specific future catastrophe losses[35]. Hence, the current accounting practice, imposed by the FASB, prevents prudent insurance companies from the ability to effectively smooth the cash flows of premiums and claims over longer time periods. In addition, all the retained earnings are considered taxable, and the U.S. Internal Revenue Service (IRS) appears to be rather inflexible about it, even when the retained earnings are earmarked as 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 catastrophe risks in the aftermath of major catastrophic events, governments have regularly intervened to ensure availability of

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[34] The insurance industry has traditionally determined the probable maximum loss (PML) associated with a particular catastrophic risk factor based on projections of the worst historical events.

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

coverage. In the U.S., the Florida Hurricane Catastrophe Fund (FHCF) and the California Earthquake Authority (CEA) are prime examples of this. These funds were established through the instigation of state authorities that by law require homeowner insurers operating in the state to purchase coverage from the funds. The funds in turn cover the risk exposure by funding or ceding different risk layers on a stop-loss basis. It is worth noting that the IRS has allowed capital accumulation in these funds on a tax-free basis. Obviously, the IRS could grant the same tax relief directly to private insurers at a comparable cost.

Several other developed countries have solved the issue of uninsurable risk through the establishment of government sponsored funds. In France, flooding and earthquake damages are covered through a special program (Catastrophe Naturelle - Cat Nat for short), which is reinsured with the 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 instituted a reinsurance pool (Norsk Naturskadepool), compulsory in all property insurance policies to cover residential and commercial property damages from natural catastrophes. The Japanese Earthquake Reinsurance Company (JER) provides mandatory reinsurance that cover damages to residential property from earthquake and volcanic activities.

There seems to be a general consensus that governments must play a central role in an economy's ability to furnish coverage for uninsurable risk. However, there is no agreement as to what the exact role of the government should be. It is argued that government imposed catastrophe reinsurance arrangements are required, because the uninsurable catastrophe risks are mounting as reflected in the excessive loss potentials. As governments generally are assumed to have zero default risk, government supported insurance schemes have easier access to risk capital than reinsurance companies that are subject to insolvency risk. However, there are potential downsides to government guarantees, because they may induce the less solvent insurers to excessive expansion, i.e. write more insurance contracts and grow premiums to obtain cheaper up front funding (Bohn & Hall, 1999). This may obviously have a destabilizing effect on the insurance industry as a whole.

There have been other proposals for government intervention to cover the higher layers of catastrophe losses that otherwise would remain uninsured risk exposures. For example, it has been suggested that the government could issue hurricane and earthquake catastrophe call options to the insurance industry in cover of losses in excess of say USD 25-30 billion (Cummins et al., 1999). The government would receive a call option premium from the insurance companies from the sale as compensation for potential future payouts under the option contracts. This arrangement would expand capacity in the catastrophe reinsurance market and limit government involvement in case of natural disasters. In the U.S., the federal government already provides direct catastrophe insurance coverage through disaster relief programs like FEMA, small business loans and various congressional appropriations. However, these arrangements are less effective risk management approaches.

Despite the limitations of the catastrophe reinsurance market there should be additional capacity for new diversifiable risk exposures. Reinsurance companies are interested in alternative catastrophe risks, e.g. exposures in new catastrophic events in different developing countries. As long as the catastrophe risks are uncorrelated with existing economic and environmental exposures in the developed economies there will be a natural demand, because new exposures can be diversified into the reinsurance companies' existing risk portfolios. Even if the reinsurance market appears to represent a somewhat finite supply, there are good opportunities for insurance contracts with 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 (CBOT), the other futures exchange to offer catastrophe derivatives, has experienced dwindling interest in their contracts, and is about to close trading of its contracts. Trading in standardized exchange contracts is being terminated because general interest and the resulting trading volume have been unsatisfactory. Despite the fact that derivative instruments have been widely praised and touted as promising alternatives for insurance companies to hedge their catastrophe risk exposures (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. First of all, using the contracts to hedge catastrophe exposures is associated with substantial basis risk, which has provided a significant practical barrier to their use. Some studies indicate that standardized derivative contracts cover somewhere between 60% and 80% of the underlying risk exposures (Major, 1999), which for many hedgers is unsatisfactory.

In contrast, trading in the weather derivatives offered by the Chicago Mercantile Exchange (*CME*) continues to show high market interest. However, in this case we are dealing with contracts that involve a vast number of natural counterparts, e.g. energy producers and energy consumers. Whereas, the weather derivatives have some correlation to different catastrophe indexes that are influenced by changing weather conditions, these derivatives do not represent an immediate refuge for hedgers that are looking for alternative ways to cover their exposures. The activity on exchange traded weather contracts are also used actively by the energy traders and financial institutions that engage in the over-the-counter market for weather derivatives, which tends to spur trading activity further.

In recent years, catastrophe risk swap agreements in the over-the-counter market have emerged as a flexible and relatively simple way to obtain coverage for indigenous 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 as the hedger depends on the other party to honor the swap in case of loss.

Risk-linked securities
Given the size of the global capital market, which dwarfs the international reinsurance market, there should be a good potential for the issuance of risk-linked securities such as cat-bonds, contingent securities and cat-put equity instruments. As the return from catastrophe risk exposures are fundamentally unrelated to the return 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 provide a new efficient way of diversifying cataclysmic risk exposures than currently seems possible in the reinsurance market[36]. Around USD 6 billion worth of risk-linked securities have been issued so far (Figure 7). A major challenge at this stage of the market development is to make investors familiar with the new investment vehicles and

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[36] Goldman, Sachs has simulated the return on the portfolio of outstanding risk-linked securities based on the 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% p.a. 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.

convince them of their effects on the risk-return profile of invested portfolios. To the extent that new risk-linked securities cover different types of catastrophe risks than are already represented in the market, say exposures to risks in Latin America and the Caribbean, they can enhance portfolio diversification and stimulate additional demand among institutional investors.

Figure 7.   Overview of the Market for Catastrophe Risk Transfer
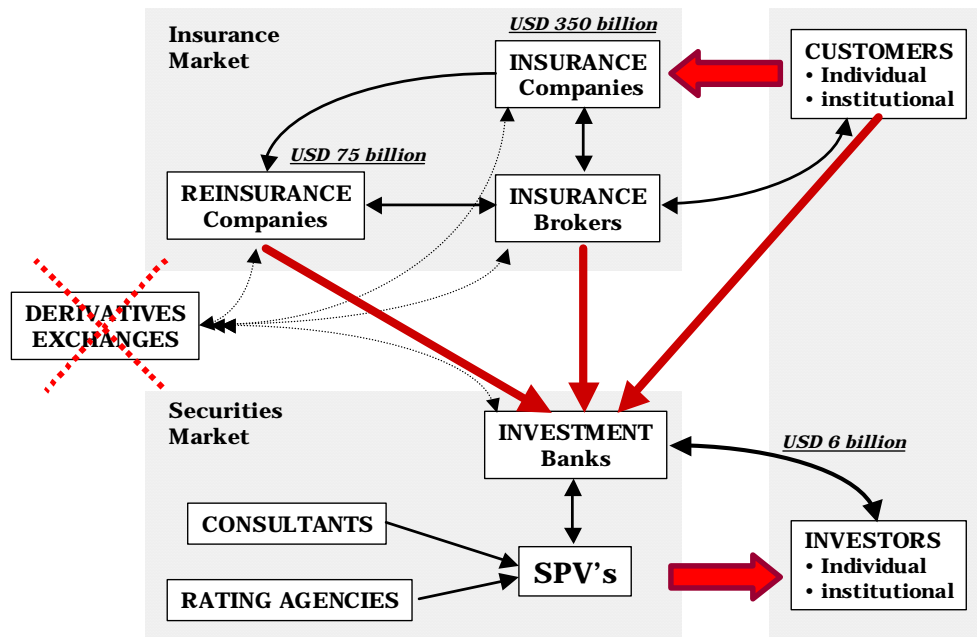
The transaction costs ascribed to these transactions have been quite high, because everything has been tailored to the specific circumstances of the issuers. However, it appears evident that major cost savings can be achieved over time from scale economies as issuance practices become increasingly standardized and transparent. Standardization of deal structures and the emergence of generalizable triggers will help reduce the cost associated with the investors' transaction analysis and increase their confidence in this new risk class. The ability to use the same analytical models to assess the investment profile of the risk-linked securities will help reduce investors' operating cost and increase the speed of investment decisions. A major challenge in the further development of the market is to structure robust triggers that can be used across a larger number of transactions as generally accepted benchmarks. To make the issuance of risk-linked securities economical, the retention by the cedant should arguably be substantial. This provides a higher comfort level for the investors, because a higher participation by the cedant reduces the issues of moral hazard and adverse selection (Froot et al., 1998). The securitization technique appears better suited to cover the higher layers of catastrophe risk. However, the layers should not be too high, because the likelihood of mega-catastrophic events might become too small to justify the larger interest rate spread required to make risk-linked securities attractive for the investors. Similarly, small transaction sizes do not justify the relatively high transaction costs. Finally, the triggers adopted in the insurance contract should be transparent and beyond the control of the cedant to avoid problems related to moral hazard and adverse selection.

The Bond Market Association, which counts all the major securities traders as members, formed a market committee in the spring of 2000 to focus specifically on the promotion of risk-linked securities[37]. The committee works actively to increase investor

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

knowledge about risk-linked securities, and improve market transparency, integrity and liquidity by providing standards for disclosure, risk analysis, and secondary market trading. In many ways the market for risk-linked securities can be compared to the mortgage backed securities market, which took off in during the 1980s partially induced by a favorable tax regime and adherence to a market standard.

The price of risk-transfer in the cat-bond market has been somewhat higher than for conventional reinsurance contracts (Goldman Sachs, 2000), although new diversifiable risks can be associated with favorable pricing conditions. Risk-linked securities have typically provided a premium of 1-5% above the return offered by corporate bonds with the same credit rating[38]. Transactions have so far been quite individualized, but this trait should be amended as standardization and transparency increase. Investors unfamiliar with the instruments often require a slight premium to accept this new risk class. On the other hand, issuers have been willing to assume the higher cost to establish an alternative risk transfer mechanism with a promising market potential. By establishing a presence in the market for risk-linked securities, the transaction costs of future issues are expected to become significantly lower, as documentation, transaction structures and practices are being reused.

V. APPLICATIONS OF NEW RISK TRANSFER INSTRUMENTS

The existing insurance coverage for catastrophe risk exposures in Latin America and the Caribbean is miniscule. Catastrophe reinsurance treaties predominantly cover assets in developed economies, whereas only a small fraction applies to assets in developing countries. Some catastrophe insurance policies are sold throughout the region, and some argue that insurance coverage is a demand issue. However, things are slightly more complex than that, and insurance coverage remains low for a number of reasons. Insurance premiums are expensive for most people, and in the absence of formal requirements and economic incentives, there is no 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. Risk mitigation is minimal so property damages can be considerably higher than expected. In other cases insurance companies have little way of knowing the true risk exposures, and therefore withdraw their insurance business altogether.

The economic impact of natural catastrophes is influenced by the frequency of the events and the associated loss severity. Therefore, social and economic vulnerability to natural catastrophes can be reduced significantly through risk mitigation that dampen the potential impact of disasters, such as urban and environmental planning, resistant building structures, effective building codes, etc. (Kunreuther, 1999, 2000; IDB, 2000). The economic vulnerability to natural disasters is exacerbated in Latin America and the Caribbean by the general underdevelopment of insurance markets that provide little cover for catastrophe risks. Property insurance is limited to a very small and secluded segment of commercial and public sector entities and high net worth individuals[39]. The risk mitigation and coverage issues are obviously related. For example, it is not possible to establish a meaningful insurance industry without the stringency of enforced building codes and urban planning. So, effective catastrophe mitigation is a necessary condition for the development of viable local insurance markets.

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[38] 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 return 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.

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

Regional needs

A variety of natural disaster exposures are prevalent across Latin America and the Caribbean. Mexico, Central America and the Caribbean Isles are primarily exposed to Pacific and Atlantic hurricanes and windstorms. Mexico and the Central American countries have additional exposures in earthquake prone sub-regions. Countries on the Pacific side of South America in particular, but also other countries across Latin America, are exposed to storms, flooding and landslides deriving from El Niño effects. In terms of frequency, three types of natural catastrophe risk stand out in the region: flooding, windstorm and earthquake. The economic losses associated with the natural disasters are generally highest in connection with earthquake events and lowest in the case of flooding incidents. Therefore, the three natural phenomena have had almost equal effect measured by their overall economic impact in the region over the past 30 years (Figure 8).

Figure 8.   Economic Losses Caused by Natural Disasters, 1970-1999
[Latin America and the Caribbean]
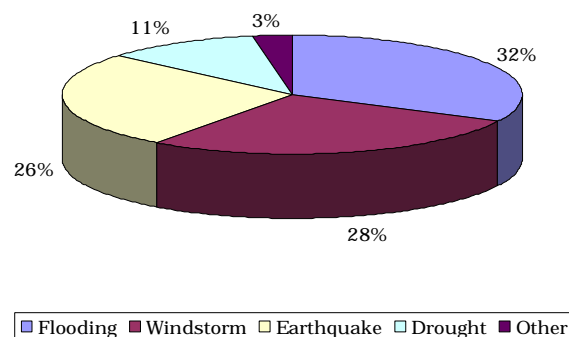
Source: C. Charveriat, Natural Disaster Risk in Latin America and the Caribbean, *IDB*, 2000.

The aggregate losses caused by natural disasters in Latin America and the Caribbean during the past 30 years are estimated at around USD 100 billion measured in current dollars (Charveriat, 2000). However, the occurrence of natural disasters in the LAC region has increased in recent years. For example, losses from major natural disasters amounted to around USD 12 billion during 1998 primarily caused by flooding and hurricane events, and was around USD 5 billion in 1999 relating to the Columbia earthquake and the Venezuela flooding incidents. 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 exposures. Furthermore, meteorological observations of hurricane and related windstorm events are reasonably well covered, which should make it possible to develop quite reliable estimates of the catastrophe risk probabilities. Hence, for the purpose of risk transfer instrument development, it may be worthwhile to intensify the initially focus on hurricane and windstorm exposures prevalent in the region. However, the significant flooding events resulting from El Niño effects constitute another category of catastrophe risk that clearly needs attention. The El Niño phenomenon is now relatively well understood and the phenomenon can be forecasted within reasonable margins. However, it remains an area that needs further development to improve regional forecastability and reach more precise loss estimations. Similarly, the earthquake risk exposures in the region are substantial and consequently warrant further scrutiny. The earthquake prone sub-regions are fairly well identified and mapped, but more research is needed to assess the likelihood of different earthquake scenarios. It is equally important to determine the potential regional damages that may emanate from these earthquake events.

Risk transfer mechanisms

International reinsurance contracts and capital market transactions, such as cat-bonds and contingent capital, are viable precautionary measures that may help countries in the region manage their catastrophe risk exposures more actively. A less ambitious approach is to extend insurance coverage gradually through continued development of local insurance markets, and postpone any considerations about new risk transfer opportunities in the international financial markets until local insurance coverage is sufficiently saturated. The latter approach has a long time horizon, so countries in the region would be unable to take advantage of the emerging risk transfer opportunities. However, the two approaches are not mutually exclusive. For example, proposals at the World Bank has outlined insurance schemes that build on the creation of government supported insurance pools combined with government issuance of cat-bonds in local and international capital markets (Pollner, 1999; World Bank, 2000). These ideas remain on the drawing board in Latin America and the Caribbean where the World Bank group now seems to retain a more conventional focus on local insurance market development (Lester, 2000). However, the underlying idea is being applied in the Turkish Catastrophe Insurance Pool (TCIP) being implemented in the wake of the earthquake incidents around Istanbul (Gurenko, 2000).

The insurance coverage for earthquake exposures has historically been very low in Turkey[40]. For one thing, the local insurance industry is relatively underdeveloped with 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 the exposure to earthquake events. Prospects of expanding the insurance coverage for earthquake risks has been further hampered, because replacement of dwellings by law has effectively been funded almost free of charge by government sources and therefore has provided little incentive to engage in insurance contracts. The recent earthquake events exposed these inherent market weaknesses and urged the establishment of a government backed insurance pool to cover these otherwise uninsurable catastrophe risk exposures. The establishment of TCIP builds on new laws that make specific earthquake insurance policies compulsory to all households, and requires passage of laws that enforce risk mitigation and eliminate government subsidized interest-rate free loans to homeowners. The earthquake insurance policies are to be sold by local insurance companies and brokers, but will be covered directly through the TCIP.

The aggregate exposure of the insurance pool will be managed by a pool management company (*Milli Re*), that has been established specifically for that purpose. The TCIP is scheduled to provide coverage for total earthquake losses up to an aggregate amount of USD 600 million. If claims exceed the financial reserves of the fund, which will be determined by the premiums received from the insurance takers, the World Bank will fund the next risk layer. A large part of the next higher risk layer should be ceded in the international reinsurance market, whereas the highest risk layer, up to a certain exceedance limit is funded by the World Bank. Hence, the World Bank assumes a more formal exposure to the earthquake risk in and around Istanbul, where the exposure otherwise would take the form of post hoc emergency loans for disaster relief. The exposure is now considered and evaluated up front, which has a number of potential advantages. The local insurance companies become directly involved in the efforts to extend insurance coverage in the market, a substantial part of the risk exposure will be covered by reserves accruing from compulsory insurance premiums and commitments by pool members, and the World Bank will be less exposed to situations where it has to inadvertently reallocate financial resources to deal with unexpected earthquake events. In turn, the World Bank has the opportunity to cover part of its residual risk exposure by engaging in various risk transfer arrangements in its own name.

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[40] The penetration of earthquake insurance is estimated to around 2% outside Istanbul and 15% within Istanbul. However, most of the insurance coverage applies to affluent residential customers and almost no coverage is obtained by, or provided to households in the low-income and middle-class segments of the population.

Figure 9.   Sketching the Turkish Catastrophe Insurance Pool (TCIP)
(Example)
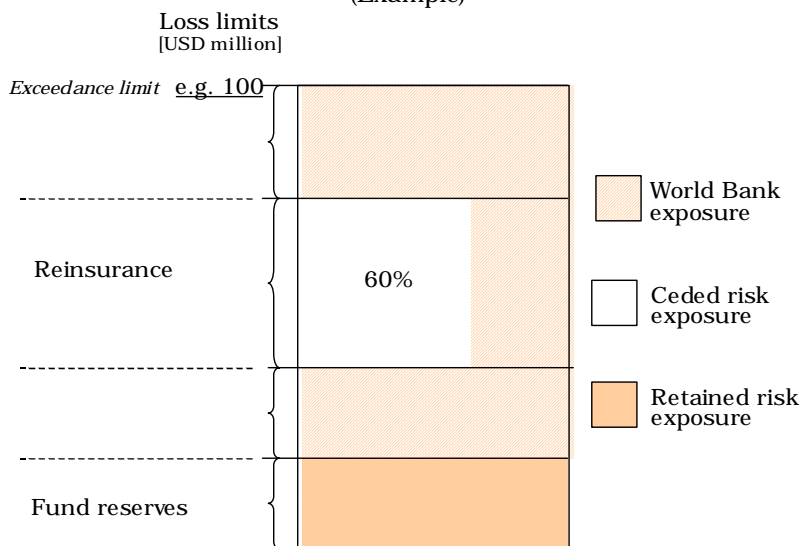
The imposition of public funds has been considered as a possible way to mitigate the economic effects of natural catastrophes by making funds available when disaster strikes. However, such lending inevitably crowds out other loan facilities approved to support long term development projects. Hence, adhering to emergency catastrophe funding policies may inadvertently cause inconsistencies in economic development programs and weaken commitments to long-term project lending and development activities. Social investment funds may also provide valuable funding to the reconstruction of public and private infrastructure in the wake of disasters, but the financial support is again obtained through reallocation of investment resources rather than from new available funding or risk transfer capital. The establishment of mitigation and vulnerability reduction funds can serve a useful purpose by promoting and funding important investments in e.g. structural improvements in buildings and infrastructure that clearly will help reduce the potential risk exposure. Facilities for innovation in disaster prevention would serve a similar purpose. Whereas the mitigation efforts are useful means to reduce the overall exposures, they cannot completely eliminate the risks, i.e. there will always be significant residual catastrophe risk exposures that need to be managed.

Government financed calamity funds, e.g. "Fonden" in Mexico, have been touted as potentially effective ways to smooth volatilities in the level of economic activity caused by natural disasters (World Bank, 2000). These funds are based on the principle that governments as self-insurers should reserve the funds needed to cope with disasters up-front, although in many cases, the funds remain undercapitalized. A potentially negative effect of public funds established to cover damages from catastrophes is that it may reduce the incentives to engage in commercial insurance contracts, because the government is expected to cover the brunt of the potential losses. Therefore, government subsidized support to catastrophe risk exposures probably should engage households and businesses in compulsory insurance schemes. On the other hand, it is widely recognized that commercial insurers often have limited appetite to cover the upper layers of catastrophe risk exposures, and many government induced insurance pools have been established to cover these otherwise uninsurable risks (Guy Carpenter, 2000).

Standardization

To make risk transfer opportunities based on reinsurance contracts and risk-linked securities more efficient, transaction practices should become more standardized and transparent (Bond Market Association, 2000). This may be achieved by introducing a number of key environmental measures to characterize the major catastrophe risk exposures in the region, such as Caribbean hurricanes, El Niño related rainfall patterns in Latin America, Central American earthquake events, etc. Basic risk measures could be used and reused across different risk-financing transactions that cover comparable catastrophe exposures, and would thereby exploit potential scale economies in specific types of catastrophe risk-financing transactions.

Risk management approaches
Four basic risk management approaches can be outlined as relevant for consideration in the LAC region. It should be noted that the approaches are not mutually exclusive.

- Cover the catastrophe risk exposures prevalent in regional investment projects
- Facilitate country risk management plans and establish cover for higher catastrophe risk layers
- Introduce local insurance pools and stop-loss facilities to cover otherwise uninsurable catastrophe risk exposures
- Monitor and manage regional risk exposures on an aggregate basis

An obvious way to reduce immediate catastrophe risk exposures in the region is to perform rigorous catastrophe risk analyses on all project finance facilities considered for the region, and limit the identified risk exposures by enforcing stringent risk mitigation requirements. Residual exposures in the loan facilities that exceed predetermined risk limits could be covered by tailored reinsurance contracts and risk swap agreements. The project led approach to catastrophe risk management is geared to reduce specific project exposures, but does not necessarily lead to better risk management practices across the region.

Another approach would be to encourage governments in the region to analyze their catastrophe risk exposures and develop country risk management plans. These efforts would help the countries to arrange insurance coverage for the identified catastrophe exposures. The lower risk layers, that represent more immediate catastrophe needs, could be supported by tax financed calamity funds that provide the financial means for short-term rehabilitation and disaster relief. To cover exposures in higher risk layers, the governments may engage directly in risk transfer on the international financial markets, e.g. in the form of contingent capital, cat-bonds, risk swaps, etc. A catastrophe risk management plan may help structure and arrange the risk capital needed to support various post-disaster reconstruction programs. However, adopting financial solutions merely establishes funding arrangements that allow the government to cope with potential disaster events by providing the liquidity required to support rehabilitation and reconstruction needs. Therefore, the country risk management plans should also address issues of risk mitigation and post-disaster rehabilitation preparedness, which obviously are important considerations.

Another approach may introduce mandatory insurance contracts managed by a national insurance pool that extends catastrophe property insurance widely to all segments of the population and thereby provides cover for otherwise uninsurable catastrophe risks. Local insurance companies could be required by law to engage as national sales agents of the mandatory insurance contracts, and could also be held liable to reinsure the lowest risk layer on a mutual basis to reduce moral hazard issues associated with their role as insurance agents. The setup would require that the governments take some stringent risk mitigation initiatives, such as enforcing effective property registration and building codes. Alternatively, the insurance pool could engage local insurance companies on a voluntary basis.

The insurance pool could reinsure parts of the higher risk layers of the catastrophe property exposures in the international financial markets. In order to reduce the insurance companies' direct commitment a part of the next lowest risk layer, e.g. 50 per cent, could be ceded to international reinsurance companies. The higher risk layers could be covered through issuance of risk-linked securities and contingent surplus notes. The risk-linked securities would maintain a relatively high credit standing due to their collateralized structure, whereas the contingent capital instruments could carry a credit enhancement in the form of a guarantee from a multilateral institution. Issuance of risk-linked securities may be most appropriate for the lower end of the higher risk layers, because a higher likelihood of risk event would justify the higher interest rate premium required to place the instruments among investors in the global capital market (Froot et al, 1998). Conversely, contingent capital instruments may be most appropriate to cover the upper end of the higher risk layers, because the option premiums ascribed to the implicit put contracts are lower when the options are well out-of-the-money at the time of issuance. Committed risk financing could possibly be obtained against a government counter-guarantee, for the highest risk level to the extent this is deemed essential to the successful implementation of the insurance pool. To limit the formal exposure covered by the insurance pool, the arrangement could incorporate a maximum exceedance level, e.g. USD 100 million, above which no cover is formally arranged for (Figure 10).

Figure 10.   Insurance Pool with Layered Risk Transfer Program – Example
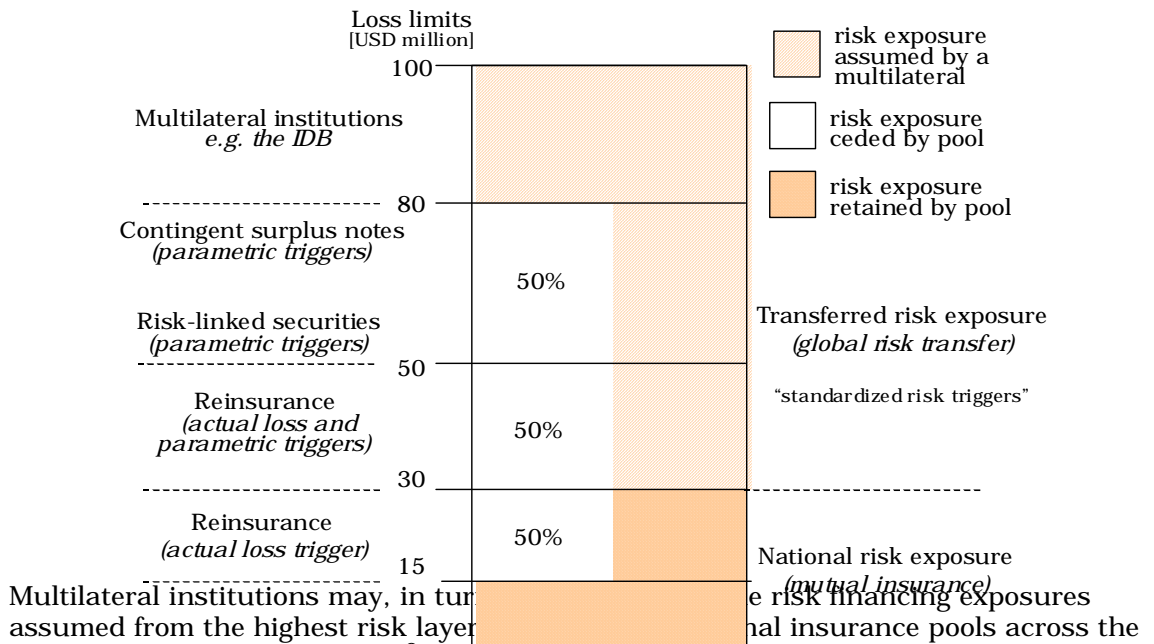
Multilateral institutions may, in turn, ... e risk financing exposures assumed from the highest risk layer ... al insurance pools across the region through catastrophe risk transactions in the global capital market. This may be accomplished in the form of facultative risk treaties, where the assumed catastrophe exposures are aggregated in contracts exposed to the same regional catastrophe risks, e.g. hurricane risk across the Caribbean Isles. It may also be possible to aggregate the risk exposures across several countries in the region, and handle the agglomerated exposures within a joint regional risk management company. Integrative arrangements of this type would have the benefit of pooling the catastrophe risk exposures locally and thereby provide a natural first line of risk diversification that engage local primary insurance companies in the insurance market development. The national governments and multilateral institutions on their part could facilitate the exposure management of higher risk layers across the region and thereby possibly create better diversification and economic efficiencies in the risk management process.

The overall exposure to natural catastrophes could also be analyzed on a regional basis to assess the aggregate potential need for risk transfer arrangements. It may be an advantage to identify and map the catastrophe risks that generally expose the countries throughout the region and think about how potential funding needs associated with catastrophic events may be obtained more favorably in the wholesale market. It should be possible to arrange partial cover for the major catastrophe risk exposures in the international financial markets in a way that may enable countries in the region to use their financial resources more effectively and better enhance sustainable economic development.

VI. CONCLUSIONS

The frequency and severity of economic losses from hurricanes, earthquakes, and El Niño related flooding appear to be on the rise across the LAC region. The social and economic vulnerability is hampered by low insurance coverage for catastrophe risks, particularly among the poorest segments of the population, and insufficient insurance markets across the region. These circumstances call for new responses to manage catastrophe risk exposures. A first important initiative is to encourage mitigation efforts aimed at reducing the economic vulnerability to natural events. Such efforts may include urban planning, enforced building codes, emergency contingency plans, etc. However, mitigation can only accomplish so much, and more is needed to cope with the inevitable residual economic impacts of natural catastrophes. To this end new opportunities are available to establish risk transfer and contingent funding arrangements in the global financial markets to manage the inherent catastrophe exposures. These instruments comprise layered reinsurance contracts, risk-linked securities, catastrophe risk swaps and contingent surplus notes. The reinsurance and capital market instruments do not represent either-or alternatives, but constitute complementary instruments that can be integrated in an overall catastrophe risk management strategy. The international reinsurance market has additional capacity for contracts associated with new diversifiable catastrophe risk exposures. Since disaster events in the LAC region are largely uncorrelated with events in the developed economies, there should be incremental market capacity to assume Latin American and Caribbean catastrophe risk exposures.

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