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Extreme Events, Global Warming, and Insurance-Linked Securities: How to Trigger the "Tipping Point"

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Large-scale disasters have occurred at an accelerated rhythm in the past 5 years. Further, the continuous increase of exposed values in high-risk areas and the potential impact of global warming on the intensity of weather-related events shall accelerate the number and increase the scale of mega-catastrophes in the near future. That is a new era for catastrophe risk management that calls for the development of new solutions, in complement to the traditional insurance and reinsurance. The authors discuss some of the main drivers of the radical shift that happened in the insurance-linked securities (ILS) market after the 2005 hurricane season in the Atlantic basin, which has rapidly become one of the world peak zones in terms of exposure. They explain why, despite this very encouraging evolution, the market has not expanded more (contrary to credit derivatives for instance). They propose three complementary ways to increase interest in these instruments that could effectively trigger the tipping point toward a much more significant volume of capital entering the ILS market: (1) increasing investors' interest through tranching, (2) addressing the basis risk challenge through index-based derivatives, and (3) innovating through the development of new products; the authors introduce the concept of derivative solutions based on equity volatility dispersion.
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Setting the stage: when Wall Street meets climate change

Consensus has emerged that anthropogenic climate change is occurring. A few years ago, this might have been just a theoretical view, but the recent debate on global warming has reached new dimensions, with a clear call for concrete mitigating actions, including in the United States. Discussions and proposals to address potential consequences of global warming have not only emerged stronger in more countries, but have also emerged in sectors that had not traditionally paid a lot of attention to it. Indeed, the debate on climate change had mainly been driven by NGOs, government and international bodies, and research institutions until just a few years ago. Now that the business case for sustainable development is more widely considered, the private sector in general, and the financial institutions in particular, are increasingly involved, when not true drivers of changes to come.

For instance, in April 2004, a group of 13 public pension funds managing over $800 billion in assets wrote a letter to then U.S. Securities and Exchange Commission (SEC) Chairman William Donaldson asking him to clarify that climate change is indeed a material risk requiring disclosure on SEC filings and to strengthen current disclosure requirements, for example, by providing interpretive guidance on the materiality of climate change risks. More recently, in June 2006 this now-enlarged group of investors – 50 members of the Investor Network on Climate Risk, representing nearly $3 trillion in assets – reiterated this demand to the new SEC chairman.[1]

Wall Street is becoming a major player in enhancing the global warming debate by watching more closely investments in sources of energy that produce large quantity of greenhouse gases. The impact on the insurance and finance industry may have been very well summarized by John Coomber, former CEO of Swiss Re, the world reinsurance leader, who stated in a 2006 interview that "climate change is the number one risk in the world ahead of terrorism, demographic change and other global risk scenarios".[2]

The series of seven severe hurricanes that made the U.S. landfall in 2004 and 2005, along with several flood episodes in Europe (including several catastrophic floods in England and Germany), and major heatwaves/droughts, have certainly contributed to put the climate change issue on the agenda of many top decision-makers in a much more salient way than ever before. Even though it is extremely difficult to estimate how much of the damage caused by these hurricanes was due to a change in climate versus random patterns (e.g., hurricane cycles),[3] these episodes have radically modified the general perception about our vulnerability to extreme weather-related events. These catastrophes also highlighted the possible impact of a change in climate on the recurrence and intensity of such events in the near future. Is the worst still to come? To better understand this shift, both among the general public and within the financial world, several facts are worth reminding here.

On the climate side

One of the expected effects of global warming will be an increase in hurricane intensity. This has been predicted by theory and modeling and substantiated by empirical data. Higher ocean temperatures lead to an exponentially higher evaporation rate in the atmosphere, which increases the intensity of cyclones and precipitation. In 2005, the temperature of the water in the Gulf of Mexico was 1°F higher than the long-term

[1] Ceres (2006).

[2] Swiss Re (2006).

[3] The increasing degree of urbanization and increased value–at-risk in high-risk areas remains the most important driver of the recent evolution in economic and insured losses. For example, the population of Florida has increased by nearly 500 percent since 1950, and more than $2 trillion insured exposure is located directly on the coasts. Without robust mitigation measures in place, it is just common sense that the next series of major hurricanes that make landfall there will have tremendous economic consequences. This state has become one of the world peak zones today (see Wharton Risk Center (2007)).

average, and 2005 also tied the 1933 record for the most hurricanes (21 in total). (Record-keeping began in 1851.)

While there is scientific evidence that the total number of hurricanes in the Atlantic basin region has remained about the same in the past 50 years (except for a few years including 2004 and 2005), there have been more Category 4 and 5 hurricanes in recent years (the most intense hurricanes on the Saffir-Simpson scale). In fact, there have been as many as four times more Category 4 and 5 hurricanes during the period 1996–2005 than during the period 1900–1925.

It is not to say, however, that there is a great level of confidence regarding the attribution. For instance, the 2007 International Panel on Climate Change report concludes that it is "more likely than not that anthropogenic influence has contributed to increases in the frequency of the most intense tropical cyclones." The question of whether the recent increase in hurricane intensity in the Atlantic Ocean is mainly explained by the return of a high hurricane cycle that would end around 2015/2020, or due to climate change, has been an important focus of debate in the scientific community for the past few years.[4] The third alternative – a possible combination of the two, high cycle and change in climate patterns – would lead to a somewhat perilous situation in world peak zones affected by these changes in hurricane/flood activities.

On the economic/insured loss side

As a matter of fact, 2004 inflicted about $113 billion in economic losses, the second most devastating year of this 44-year period.[5] And 2005 alone inflicted twice as much loss. In fact, 99.7 percent of all catastrophic losses worldwide in 2005 were due to weather-related events. In 2005, insured losses from Hurricanes Katrina, Rita, and Wilma alone are estimated at over $85 billion (including the $23 billion for flood claims paid by the government-run and -funded National Flood Insurance Program). The U.S. federal government provided over $120 billion in federal relief – another historical record.

Another figure explains quite well the radical risk perception shift that has operated in the United States: if one considers the 20 most costly insured catastrophes that occurred in the world over the past 36 years (1970–2006), half of them (10 events) have occurred since 2001, nine of those in the United States. Thus, it does not come as a surprise that the Gulf of Mexico has become a world peak zone for the insurability challenge.

Extreme weather-related events (such as hurricanes, floods, and ice storms) are certainly important elements of the "insurance and finance meeting with climate change" phenomenon. We will mainly focus on that aspect in this paper. Nevertheless,

[4] For example, Emanuel (2005); Webster *et al*. (2005); Landsea *et al*. (2006). See, for instance, the exchange between Roger Pielke, Jr., Christopher W. Landsea, and Kerry Emanuel in Nature 438, Nos. 22 and 29 (2005). See also Webster *et al*. (2006) and Chan (2006). Another issue lies in the lesser quality and completeness of the data collected several decades ago and whether that allows for good comparison over time, see Kossin *et al*. (2007).

[5] Munich Re (2005).

Table 1 Four main insurance/finance areas affected by climate change

Weather-related extreme events (Underwriting/ Insurability challenge)	Liability risks (The next asbestos/tobacco?)
New risk and business opportunities (New technologies, emission control policies and trading systems)	New financial solutions (Alternative risk transfer instruments)

we also recognize that these are not the only consequences of climate change that several industry sectors (including insurance and finance) will worry about – or celebrate as new business opportunities associated with global warming. Others include asset management, liability risks, as well as new product development associated with the emergence of green technologies and carbon trading systems (Table 1). In Kunreuther and Michel-Kerjan[6] we provide a more detailed analysis of these issues.

In that context, we would like to look at the appetite of the financial world for risks associated with such extreme events. More specifically, we will discuss the recent evolution in the securitization markets for catastrophes – the so-called insurance-linked securities (ILS). What have been some of the recent innovations in this market (e.g., sidecars)? How has the market for other alternative risk transfer instruments, such as industry loss warranties and catastrophe bonds (cat bonds), evolved as a result of the unprecedented 2004 and 2005 hurricane seasons? What has been the impact of the absence of any major hurricane-making landfall in the U.S. in 2006 despite forecast of a very intense hurricane season?

Since their inception more than a decade ago, catastrophe-linked securities have often been presented as a very promising solution to address the capital need of companies exposed to potential catastrophe risk (if not the definitive answer since they open to the very large capacity of the financial markets). It is fair to say that in a relative sense, the 2005–2007 period has been a wake-up call for new investment opportunities.[7] We have witnessed historical records in cat bond issuance and the development of a multi-billion dollar market for other innovative instruments. In absolute terms, however, this market remains a tiny niche. A liquid market has not been able to develop, as of yet.

The recent evolution is promising, though. Would the last 2 years be considered as the tipping point of this market? In other words, have we reached a critical mass in issuances to trigger enough interest from investors and potential risk hedgers (all types of companies, including – but not limited to – insurers and reinsurers)? If not, how could one find the way to ensure the necessary conditions so that the insurance-linked securities will experience that tipping effect and become a much larger market on its own? This paper suggests ways to address some of the current limitations, and also innovative approaches to expand this market further.

[6] Kunreuther and Michel-Kerjan (2007).
[7] Lewis (2007).

Financial capacity provided by ILS: past and present

In this section, we discuss three types of ILS[8] instruments provided by the capital markets: industry loss warranties (ILWs), catastrophe bonds, and sidecars. The first two are similar to excess-of-loss reinsurance, while sidecars are more often quota-share-like coverage and hence are similar to proportional reinsurance.

Industry loss warranties

The first ILWs were issued in the 1980s to cover airline industry losses and they were developed in the property and casualty insurance industry in the aftermath of major natural disasters that occurred in the past 15 years. As the name indicates, an ILW (also known as original loss warranty) is a financial instrument designed to protect insurers and reinsurers from severe losses due to extreme events such as natural disasters. The ILW market today focuses almost exclusively on catastrophic risks, and has increased significantly after Hurricanes Katrina, Wilma, and Rita in the Gulf of Mexico.

ILWs operate as follows: The buyer who wants to hedge his risk pays the seller a premium at the inception of the contract. In return, the buyer can make a claim in the event of a major industry loss – hence the name. The payout of an ILW can be structured in a simplified way such that the buyer can make a claim equal to the limit of the ILW if a pre-defined industry loss index (IL) exceeds a threshold known as the trigger (T) for a particular state/region, regardless of the buyer's actual amount of incurred loss.[9]

$$Claims = L \text{ if } IL T$$
$$Claims = 0 \text{ if } IL < T$$

For example, the buyer of a *$200 million limit U.S. Wind ILW in Florida in 2008 attaching at $20 billion* will pay a premium to a protection writer (generally a reinsurer) and in return will receive $200 million if total losses to the insurance industry from a single U.S. hurricane in Florida in 2008 exceeds $20 billion.

In this sense, ILWs are similar to excess-of-loss reinsurance but where the insurer now has some *basis risk*: the covered loss of the insured's book of business does not necessarily correlate perfectly with the amount of claim collectable from the index-based contracts.[10] ILWs might thus be more attractive for single state insurers/reinsurers or companies with a higher concentration of business in a limited number of

[8] For a comprehensive discussion of alternative risk transfers markets at the beginning of the 2000s, see Lane (2002) and Dischel (2002).

[9] We give here the example of a derivative swap, which is the most commonly used ILW contract. But it does not have to be. There could be a first indemnity-trigger (loss encounter by the buyers) and then a second trigger based on industry loss. There could also be several thresholds T to which are associated different payments L.

[10] Zeng (2000).

locations, thus enabling them to take on larger books of business in their primary area of operation.

The estimation of the industry losses is then critical. In the U.S., the Insurance Services Office's property claims services (PCS) index is often used as the reference for estimating these losses. In Europe, however, there is no centralized structure that estimates industry losses. Recently, there have been calls to create such a European organization in order to provide both hedgers and investors with more clarity, and then foster this market.

Note here that as an ILW is very similar to a non-indemnity cat bond, it presents the same basis risk issues (see below). To date, most of ILW buyers have been large companies who see these instruments as another way to spread their exposure. For those that write a large portion of market share, the basis risk might be reduced as well, because their losses are likely to be representative of the industry losses in the aftermath of a major natural disaster.

One of the main advantages of ILWs is that they involve relatively low transaction costs for both the buyers (insurers or reinsurers) and sellers (e.g., hedge funds). The sellers do not have to evaluate the expected loss to the (re)-insured portfolio of a specific company from the trigger event, only the exceedance probability curve of the entire industry (that typically reduces the uncertainty, thus the cost associated with a higher level of volatility).

In April 2006, Lane Financial published an analysis of the evolution of ILW premiums between 2005 (pre-Katrina), January 1, 2006, and April 1, 2006, and that for different trigger levels (from $5 billion up to $50 billion insurance industry losses) and different types of risk (wind in Florida, wind nationwide, earthquake in California). The study is based on information contained from specialist dealers over the last 5 years. Although this information is not exhaustive, we feel Table 2 provides a reasonably accurate picture of the nature of those changes.[11]

As the table indicates, for a $5 billion trigger, estimated prices increased by 54 percent, and for a $50 billion trigger, by 113 percent due to a major hurricane in Florida, compared with prices prior to Katrina. Despite this increase, the market has grown significantly in the aftermath of Katrina, which indicates a strong appetite from insurers and reinsurers for access to other sources of capital than traditional reinsurance or retrocession. It is estimated that nearly $4 billion in ILWs were issued between September 2005 and September 2006.[12] As most of these transactions were done from company to company, though, it is difficult to precisely know the aggregate volume and prices.

Catastrophe bonds (''Cat Bonds'')

Catastrophe bonds, in a similar manner to ILWs, enable an insurer or reinsurer to access funds if a severe disaster produces large-scale damage. Cat bonds typically cover narrowly defined risks on an excess-of-loss basis. They are issued in the form of debt with high coupons.

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[11] Lane (2006).
[12] State Board of Administration (SBA) of Florida (2006).

Table 2 Evolution of ILW premiums compared to pre-Katrina 2005 (2005–2006)

	Florida wind (%)		*U.S. all natural perils (%)*		*California earthquake (%)*	
ILW strike	*1/1/06*	*4/1/06*	*1/1/06*	*4/1/06*	*1/1/06*	*4/1/06*
\$5.0	19	54	33	NA	9	43
\$10.0	27	83	26	85	13	75
\$12.5	33	87	23	105	18	76
\$15.0	38	92	24	111	25	81
\$20.0	32	132	0	133	23	100
\$25.0	39	164	−4	124	22	89
\$30.0	42	176	−15	130	28	49
\$40.0	56	178	0	157	29	44
\$50.0	38	113	0	160	25	42
Average	36	120	10	126	21	66

Source: Data from Lane Financial (2006).

How does this work? Consider an insurer or reinsurer, *SafeCompany*, that would like to cover part of its exposure against catastrophic losses. In order to do so, it creates a new company, *BigCat,* whose only purpose is to cover *SafeCompany* and not any other company. In that sense, *BigCat* is a single purpose reinsurer (also called "special purpose vehicle, SPV"). When the reinsurance contract is signed, the sponsor (*SafeCompany*) pays premiums to *BigCat*. On the other side, investors place their funds with the SPV *BigCat*; these funds constitute the initial principal for the bond to be issued by *BigCat*. Reinsurance premiums collected from *SafeCompany* will be used to provide the investors with a high enough interest rate to compensate for a possible loss should a disaster occur.

What happens next? If the losses exceed a pre-specified trigger, then the interest on the bond, the principal, or both, are forgiven depending on the specifications of the issued catastrophe bond. These funds are then provided to *SafeCompany* to help cover its claims from the event. In addition to the interest rate on the cat bond, there are at least four other components for the investor to consider: the protection of the principal, the nature of the trigger, the size of the bond, and the maturity of the bond. We explain each of them now.

Protection of the principal: The principal of a catastrophe bond often consists of different tranches, some of which might or might not be protected. A *protected tranche* guarantees that the investor will receive the principal from this tranche when the bond matures. For this tranche, if a covered event occurs, the SPV stops paying interest and can extend the maturity of the loan for several years. An *unprotected tranche* has both principal and interest at risk should a covered event occur.[13]

Trigger: the nature of the trigger varies from one bond to another. The trigger can be *indemnity-based*, meaning that the transaction is based on the actual losses of the

[13] For a theoretical treatment of optimal climate risk hedging through weather bond, see Barrieu and El Karoui (2002).

Table 3 Maturity of cat bonds issued between 1997 and 2006

Maturity	*1 year*	*2 years*	*3 years*	*4 years*	*5 years*	*10 years*
1997	2	1	1	0	0	1
1998	7	0	0	0	1	0
1999	5	0	3	0	2	0
2000	3	1	4	0	1	0
2001	2	1	3	1	0	0
2002	0	1	4	2	0	0
2003	0	1	3	1	2	0
2004	1	2	1	1	2	0
2005	1	2	7	0	1	0
2006	2	4	12	1	1	0
Total (91)	23	13	38	6	10	1

Source: Data from Guy Carpenter.

sponsor. This eliminates the basis risk for the sponsor, but also reduces the transparency of the transaction for the investors. The trigger can also be based on industry losses using a predetermined *industry index of losses* (e.g., the index is calculated by the PCS in the United States). The trigger can also be determined by a *parametric index,* such as an earthquake of magnitude 7 or greater on the Richter scale occurring in the San Francisco Bay area or a Category 4 hurricane in Florida. A parametric trigger provides transparency for the investors, but sponsors may have significant basis risk (see the discussion on basis risk above for ILWs).

Size of the bond: The size of the issued bonds has increased over time. For example, of the five bonds that were issued in 1997, only one had capitalization higher than $200 million; in 2000 there were two such bonds; and in 2005 there were four (out of a total of 10). Likewise, there were two bonds with capital lower than $50 million in 1997 (out of a total of five), but none of the 43 new bonds issued between 2003 and 2006 had a capital lower than $50 million.[14] The transaction costs associated with the complex execution of these instruments (compared to traditional reinsurance) contributes to this trend toward larger bonds.

Maturity of the bond, or how to stabilize insurance and reinsurance prices: The maturity of a bond is the period during which the SPV will cover *SafeCompany*. One advantage of cat bonds over traditional 1-year reinsurance contracts is that they can typically offer longer term coverage: 1–5 years. Over time, the proportion of cat bonds with longer maturity has increased, an indication that these instruments are gaining trust within the reinsurance/finance community. Table 3 describes the maturity of cat bonds that were issued between 1997 and 2006. The average maturity is about 3 years, with some cat bonds having only a one-year maturity and others having 5 years or

[14] Guy Carpenter (2007). Note that before the 2004–2005 hurricane season, the largest bond issued ever was the $470 million Zenkyoren's Phoenix in 2003 to cover earthquakes in Japan. Since then we have witnessed the issuance of much larger cat bonds, as the $1.2 billion bond issued by State Farm in 2007 (see below).

more. In a context of highly volatile reinsurance prices that often occurred after large catastrophes, cat bonds offer an important element of stability for insurers by guaranteeing a pre-defined price over several years as far as the entire capital of the bond is not triggered (in which case a new bond has to be issued under price conditions that are likely to differ). We believe that this price-stability aspect has been largely undervalued so far.

With many firms complaining about catastrophe insurance price increase in the aftermath of the 2005 hurricane season, and with pressure from rating agencies for better catastrophe exposure management, the price stability offered by cat bonds with multi-year maturity might be a critical element for insurance companies and other issuers as well. Indeed, the sponsor of a cat bond does not have to be an insurer. For instance, Vivendi Universal (Universal Studios) issued in 2002 a $175 million bond, Studio Re, to cover its production studios against an earthquake in Southern California. Walt Disney also issued a bond to cover its large park in Japan. The first European corporate bond was issued in 2003 by EDF, the French electrical company; this $230 million bond, Pylon, covers the company against windstorm in France. In 2006, another corporate sponsor went with coverage by cat bond: Dominion Resources, an energy producer, obtained protection for oil-drilling assets located off the coasts of Louisiana and Texas by issuing a $50 million bond, Drewcat.

Bonds do not have to cover only natural disasters, nor are they issued only to protect a commercial enterprise. For example, the first bond that insured against terrorism was issued in Europe in August 2003. The world governing body of football (soccer), the International Federation of Association Football, which organized the 2006 World Cup in Germany, developed a $262 million bond to protect its investment. Under very specific conditions, the catastrophic bond covered losses resulting from both natural and terrorist extreme events that would have resulted in the cancellation of the World Cup final game without the possibility of it being re-scheduled to 2007.[15] Moreover, the government of Mexico, which through its FONDEN facility sponsored the $160 million CAT-Mex transaction in May 2006, was the first government to issue a cat bond. Whether more companies, trade associations and state and federal governments, working in collaboration with experts in the field, will diversify their coverage through ILS shall be a key factor of development for these instruments.

The maturity of cat bonds leads to an important distinction between *issued* bonds and *outstanding* bonds. Consider the following example: if a $200 million bond is issued on January 1, 2007, for 1 year, then the 2007 risk capital issuance is $200 million and the capital outstanding is also $200 million. Imagine now that this bond is issued for 5 years: the maturity of the bond is thus December 31, 2011. For 2007, the capital issued is $200 million, but for the next 4 years, the capital issued is $0. As the bond is outstanding for 5 years, each year between 2007 and 2011 the amount of capital *outstanding* is $200 million (if the bond has not been triggered in the meantime). In

[15] Kunreuther and Michel-Kerjan (2004). More and more cat bonds cover against multiple events. In fact, in 2005 and 2006, over half of the capital at risk through cat bonds was for multi-event rather than single-event bonds.

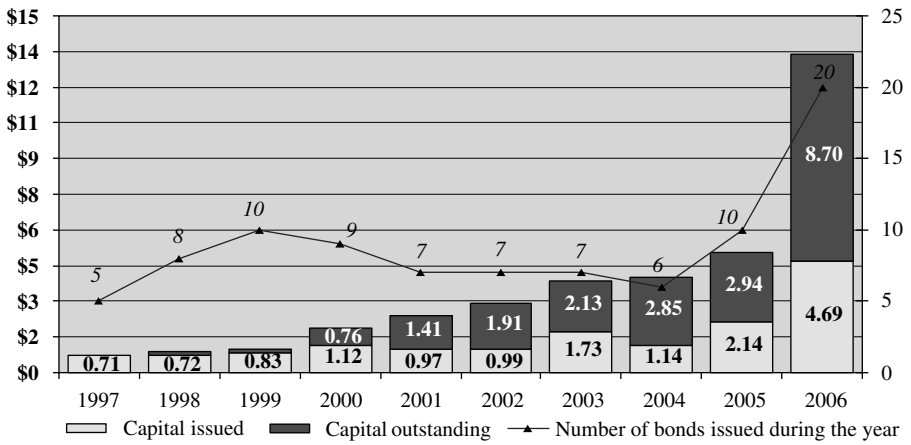

Figure 1. Catastrophe bonds: Capital risk issued and outstanding 1997–2006 (in $ billion).
Sources: Data from Swiss Re capital markets, Goldman Sachs and Guy Carpenter.

other words, issuance tells us about new deals, while outstanding capital tells us about present and past issuances.

Cat bonds have been in the market for about 10 years now, which enables one to make some comparisons as to the evolution of issuances and capital outstanding. At the end of 2004, there was nearly $4 billion in cat bond principal outstanding (including $1.14 billion of new issuances that year). At the end of 2005, outstanding risk capital grew to nearly $5 billion with nearly $2.1 billion of that issued. At the end of 2006, outstanding risk capital continued to significantly grow to $8.5 billion with nearly $4.7 billion of that being issued.

Figure 1 illustrates the evolution of risk capital issued and outstanding, and the number of bonds issued between 1997 and December 2006.[16] The market recorded a total issuance of over $4.7 billion in 2006 (20 new issuances, two times more than in 2005), a 125 percent increase over the $2.1 billion in 2005. This is a new record high, a 75 percent increase over the $1.14 billion issued in 2004, and a 20 percent increase over the $1.73 billion issuance in 2003 (the previous record). In that sense, 2005 and 2006 were a real trigger: the risk capital issued over these 2 years was equal to what had been issued over the preceding 5 years. Bonds outstanding increased significantly as well, which reflects the issuance of multi-year bonds in previous years.[17]

As this article is being written, the U.S. company State Farm has issued a "jumbo" cat bond: a $1.2 billion risk capital bond which is the largest cat bond ever issued. The bond is innovative in that it is cumulative: the company covers its portfolio in the case of cumulative losses due to a series of pre-defined events (hurricanes in the U.S., earthquake in Japan, among others) over the 3-year maturity of the bond.

[16] The figure combines bonds for natural disasters in the U.S. and abroad, as well as the first liability cat bond (Avalon Re) issued by Oil Casualty Company in 2005 for $405 million.

[17] As of October 2007, capital issued is already over $6 billion and outstanding capital is nearly $14 billion.

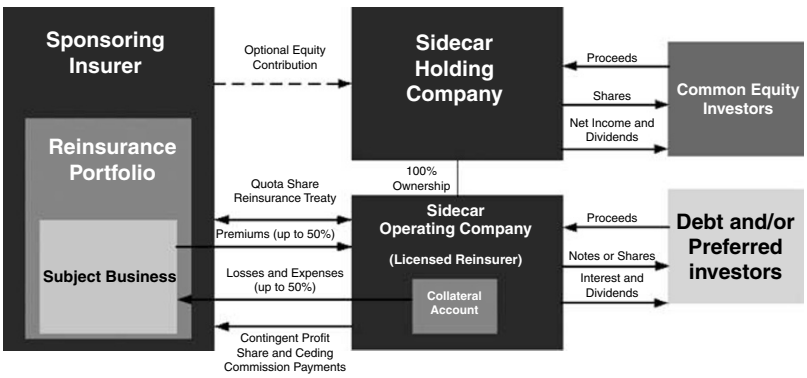

Figure 2. Operation of a sidecar.
Source: Goldman Sachs.

Sidecars

A phenomenon of the post-Katrina market environment has been the development of the so-called "sidecars." A sidecar is a special purpose company that provides reinsurance coverage exclusively to its sponsor (a reinsurer or a large insurer) by issuing securities to investors. The company that offers the sidecar has to be licensed as a reinsurer. Unlike ILWs or cat bonds that generally provide excess-of-loss reinsurance, sidecars are often based on quota-share reinsurance. The sidecar company shares the risks of certain insurance/reinsurance policies with the underwriter in exchange for a portion of the premiums (generally up to 50 percent) and dividends in shares. Figure 2 shows a simplified diagram to illustrate the stakeholders that are involved in a sidecar.

Like cat bonds, sidecars are complex financial transactions. They typically require a larger investment (in the $200–300 million range, although there have been several sidecars with investment lower than $100 million) than cat bonds and are of a shorter duration. A sidecar company is designed to last 2 years or less, and then self-liquidates or renews, depending on market conditions. As we discussed above, cat bonds would typically cover a longer period of time. Another difference is that cat bonds are typically designed to hedge low probability/high severity events whereas sidecars (see below) allow investors to take a slice of the whole business of a reinsurance program in quota-share, which might translate into higher expected loss but also higher returns over a shorter period of time in case of a sidecar. Between November 2005 and July 2006, over $3 billion of hedge fund money has been invested into sidecars that cover natural disasters in North America. Figure 3, compiled by Goldman Sachs, indicates the name, capital and sponsor of each of the 10 sidecar companies that were created over that period of time (four in 2005, six in the first two 2006 quarters).

While all these sidecars were sponsored by reinsurance companies, in August of this year, Lexington Insurance Company, a member of AIG, set up its own sidecar, Concord Re, to reinsure business on a quota share basis. This is the first-ever sidecar structured for a primary insurance company. Concord Re is capitalized with $730 million from equity securities issued by Concord Re's parent holding company,

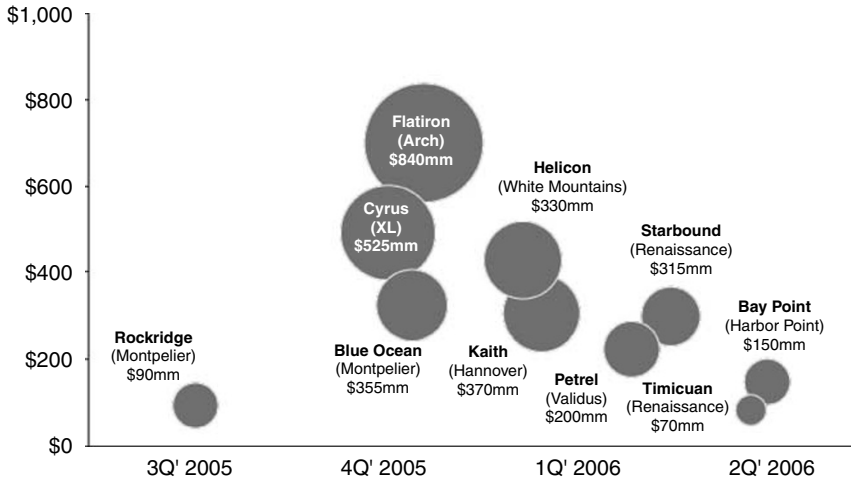

Figure 3. Reinsurer sidecars to cover against natural disasters in North America ($ million) – Reaction to 2005 Hurricane season: November 2005 and July 2006.
Source: Goldman Sachs.

Concord Re Holdings. Looking back at the year 2006 as a whole, a total of 14 sidecar transactions were completed, providing $3.55 billion of capacity.[18]

To sum sup, the 2005 hurricane season has led insurers and reinsurers, along with some other issuers, to use alternative risk transfer instruments at an unprecedented level. How does the future of these markets look like? If reinsurance premiums stay high, many of the sidecars will likely renew. If the market becomes softer due to lower than average catastrophic losses, or if industry losses are so extreme that they trigger payments from sidecars and cat bonds, investors' interest in these ILWs instruments might slacken.

Capital market solutions, such as sidecar reinsurance structures do provide value, but they do not necessarily provide a cheaper alternative compared to traditional reinsurance. Sidecars are similar to cat bonds, but have key differences. Purchasers of cat bonds usually must take the product "as is" without any creative or discretionary insight into the product's formation. Further, cat bonds are typically pegged to a specific catastrophic event. Unlike cat bonds, sidecar investors can leverage their position and negotiate the product. Certain portions of the reinsurer's book of business will be targeted to maximize potential profits. Sidecars attract opportunistic capital, and usually exist for 2–3 years. Investors have flexibility to exit the market if prices decline. Despite sidecars' ability to attract private capital and increase reinsurance capacity, they fail to suppress rates because the price of risk remains high. The cost of risk will be passed down to consumers.

As we summarize this section, one important element we shall highlight here is that Hurricane Katrina swamped KampRe, a $190 million catastrophe bond arranged by

[18] Lane (2007).

Swiss Re for Zurich. It was the first cat bond issued to totally call in investor funds.[19] The 2005 hurricane season also wiped out a $650 million sidecar, Olympus Re, arranged in 2001 by White Mountain Insurance.[20] These two events might actually have had a good impact on the market. First, these losses did not stop investments in those new instruments. Investors who bet against the odds of another devastating Atlantic hurricane season now stand to cash in on them, as, contrary to expert predictions, the season turned out to be the mildest in years. Second, these were the first ILS to pay something back to their sponsors, which might make these instruments more "real" from a financial protection perspective. Indeed, companies might be tempted to seriously limit, or even cancel, their insurance coverage if they have been paying a policy for 5 or 7 years without getting anything back from their insurance company because none of their losses exceed her deductible. Likewise, the fact that cat bonds had never paid anything 9 years after their inception might have been a limiting factor to their development.

Despite recent very encouraging movements and increased traded volume, one shall consider how to increase this market more radically. Over the past 10 years, ILS market activities have been mainly a response to one element: the occurrence of major catastrophes followed by significant increases in reinsurance price, creating the need to gain access to less expensive financial protection and diversification. If this continues to be the case, we shall witness a regular but moderate expansion; that expansion will only be driven by future catastrophes. As we discussed in the first section, we think these will occur at an accelerated rhythm in the coming 5–10 years. It is very unlikely, however, that such development will be sufficient to generate a large and liquid market if it is only based on a reaction to catastrophes that just occurred. In order to think creatively as to how to enhance the ILS markets for extreme events, the comparison with the great development of other financial products over the same past 10 years is worth making. We now turn to two of them: credit and weather derivatives.

An element for benchmark: the market for credit and weather derivatives

Credit derivatives

Credit derivatives are certainly one of the most successful stories in recent capital market developments. With more than $20 trillion of outstanding credit derivatives in 2007 (Figure 4), this market allows investors to trade the risk of default on a certain security (in general, a debt or a loan) separately from the other risks. To put this figure into perspective, the credit derivatives market was "only" $40 billion of outstanding notional value in 1996 and $180 billion in 1997, according to the British Bankers Association.[21] The rise of credit derivatives has helped banks to dramatically reduce their capital exposed to their lending activity, and investors to reach a new asset class and additional liquidity on traditional illiquid assets.

[19] Although not all the relevant insurance claims affecting this issue have been processed, the bonds are trading as though complete loss is expected.
[20] Moyer (2006).
[21] British Bankers Association (2006).

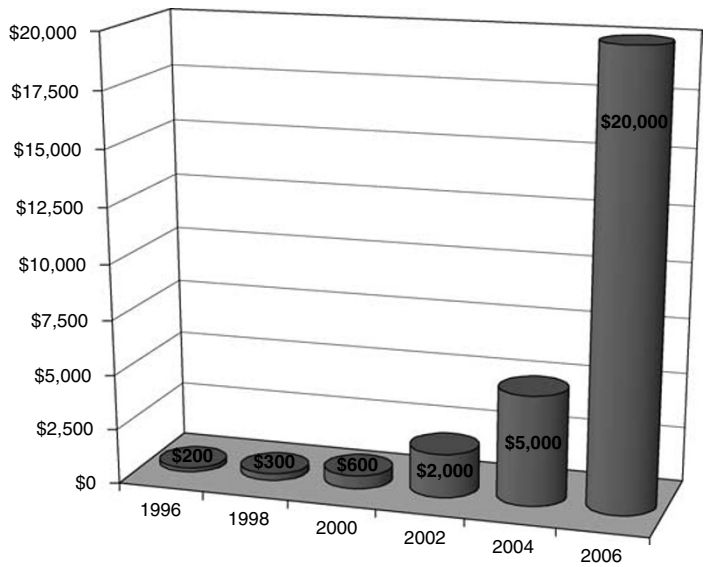

Figure 4. Global credit derivatives market, 1996–2006 (in $ billion).
Note: Global *credit* derivatives market in 2006 was $20 trillion.

Credit derivatives can be structured in multiple ways, but the two dominant types of products are the Credit Default Swap (CDS) and the Collateralized Debt Obligation (CDO). The CDS is a contract that transfers, for a premium, the risk of default on a type of debt underlying, and which pays off if a registered case of default occurs. The cases of defaults have been progressively standardized, thanks to the work of the International Swaps and Derivatives Association. The CDO is a new type of security (or securities, as there are many tranches for a single issue) that is structured by pooling credit risks and taking credit from the diversification of the risk profile of the basket to issue lower risk tranches (typically rated AAA) due to subordination of losses. The first loss is concentrated in equity tranche, usually retained by the issuer or hedged through the CDS market.

The comparison between credit derivatives and ILS is relevant as both share common features, such as relative illiquidity of underlying risks, asymmetry of information between issuer and investor, and asymmetry of risk profile with a high loss potential but limited gain (as distributions of losses are heavily skewed).[22]

Weather derivatives

The first weather derivative contract was developed in 1996, about the same time that the first cat bonds were created.[23] The weather derivatives market developed more

[22] As this paper is written, it is not clear how the credit derivative market will be corrected by the 2007 subprime crisis.

[23] The first deal was made in July 1996 when Aquila Energy structured a dual-commodity hedge for Consolidated Edison Co. The transaction involved ConEd's purchase of electric power from Aquila for

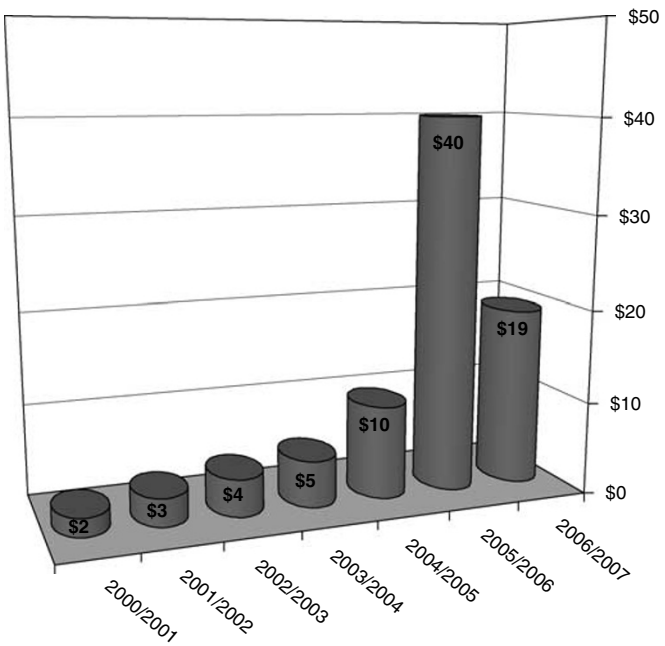

Figure 5. Global weather derivatives market, 2000–2006 (in $ billion).
Note: Global weather derivatives market was $19.2 billion in 2006.

strongly in 1997. As the market for these products grew, the Chicago Mercantile Exchange (CME) introduced the first exchange-traded weather futures contracts (and corresponding options), in 1999.

But the recent years have seen a tremendous development of this market. According to a survey jointly released in June 2006 by the Weather Risk Management Association (WRMA) and PricewaterhouseCoopers, the total weather derivatives market had grown more than 10-fold over where it stood 2 years before, to more than $45 billion notional in size (Figure 5).

The WRMA's 2007 industry survey shows that the total number of contracts traded worldwide – both over-the-counter and on the CME – was 730,087 for the period April 2006 to March 2007. This is a decline from 2006's total of just over 1 million contracts, but substantially higher than earlier years. Likewise, the value of contracts traded during 2007 was $19.2 billion, thus substantially higher than other years (if one sees 2005/2006 as an exception due to very peculiar market conditions post 2005

the month of August. The price of the power was agreed to, but a weather clause was imbedded into the contract. This clause stipulated that Aquila would pay ConEd a rebate if August turned out to be cooler than expected. The measurement of this was referenced to Cooling Degree Days (CDDs) measured at New York City's Central Park weather station. If total CDDs were from 0 to 10 percent below the pre-defined expected level, the company received no discount to the power price, but if total CDDs were 11–20 percent below normal, ConEd would receive a $16,000 discount.

hurricane season in the U.S.): in 2004 and 2005, the total value of contracts was $4.6 billion and $8.4 billion, respectively.[24]

We shall note here that temperature-related contracts on both CME futures and the OTC market accounted for the vast majority of deals, with a notional value of $18.9 billion. Notional values for rain- and wind-linked contracts were steady at $142 million and $36 million only, respectively.

Most of the activity in weather derivatives has occurred in U.S. markets so far. That might change, however, with Euronext launching in 2007 a joint venture with Meteo France to develop customized weather index helping corporations to understand and design weather hedges. We shall see how this new index will impact the development of this market.

Enhancing capital market solutions: the need to address stakeholders' concerns

Capital market solutions, despite the recent movements, remain marginal in the global risk transfer market. But this macro picture can be misleading. Here we discuss some factors that have so far impeded a more significant growth. Should these be addressed, we are confident that ILS would play an even more important role to cover the economic consequences of weather-related events and other extreme disasters.[25]

Issuers' concerns

Issuers typically turn to ILS because they are increasingly aware of their catastrophe exposure due to recent disasters, the resulting increased pressure from rating agencies to better manage their exposure, and regulatory changes.

Rating agencies' influence in the insurance market has soared tremendously. Rating agencies, and among them Standard and Poor's, Moody's, Fitch or A.M. Best, have increasingly upgraded their models and quantitative/qualitative assessment of insurers. Sustained growth of premium and financial optimization has topped the agenda of the largest insurance companies as the so-called hybrid debt became more popular. Funding acquisition, funding a business strain, optimizing the cost of capital or the coverage of solvency margin have been the factors behind a significant growth of debt issuances, with ever increasing sophistication of products (Tier 1 or Basket D for Moody's, which ranks the hybrid debt between A and E, depending on their equity content[26]).

Until recently, the regulatory pressure was mostly visible in the U.S. But the situation is changing in Europe as well. With the new series of regulations under

[24] Weather Risk Management Association (2007).

[25] For a discussion of the recent developments in ILS markets published recently in this journal, see Butt (2007); De Mey (2007); Wu and Soanes (2007); Ramella and Madeiros (2007); Csiszar (2007).

[26] To reach a high level of equity content, hybrid debt must be perpetual, without ability from the issuer to call the paper. Deferral of interest, or even cancellation of coupons in case of solvency event, allows to reach higher level of equity content. Tier 1 treatment is still prospective as CEIOPS has not fixed the actual requirement of such eligibility yet. As of QIS 3, Tier 1 debt will be the highest quality debt with regard solvency treatment.

Solvency II, the landscape is considerably evolving. For example, under Solvency II insurance companies will now be obliged to sustain a 1 in 200 years' event as *pillar I* target capital will be required on a 99.5 percent VaR for a 1-year time horizon. Interestingly enough, as the Committee of European Insurance and Occupational Pensions Supervisors' (CEIOPS) target is to align solvency capital to risk-based economic capital, capital relief will be reachable through risk transfer instruments, either reinsurance or securitization.[27] It is foreseeable that reinsurance programs and allocation of capital to P&C lines of business will be affected by Solvency II, as it has been by rating agencies Capital Adequacy models change. These elements shall have a positive effect on the insurance-linked security market.

Another concern of the potential issuers lies more directly in the design of the ILS. The definition of the trigger is central because it determines both the profile of risk transfer to capital markets and the impact on target ratio for the issuer (e.g., how solvency margin, economic capital or rating capital are affected, along with the distribution of expected P&L). Issuers favor indemnity triggers not only because they cover their exposure, but also because of their simplicity of analysis and lack of basis risk that arises in parametric or index-based solutions. On the other hand, investors favor these latter solutions because they provide a much clearer view of their potential exposure since they typically rely on a third party to measure the trigger (modeling firms, U.S. Property Claim Service for losses, etc.).

Not surprisingly, the pricing of ILS remains a challenge. We typically hear complaints about the high cost of ILS. That is both true and unfair. "True" because ILS have, until recently, been uncompetitive with traditional providers of reinsurance from a single "Rate on Line" perspective, except for very specific risks like higher tranches of retrocession or peak exposures in risk-prone areas (Gulf of Mexico, Florida, earthquake in California).[28] They typically remain highly structured and customized products. "Unfair" because, as we discussed above, ILS present important attractive features, even though they might be harder to quantify and price. As collateralized (largely or fully) and multi-year programs, ILS address the issue of credit risk and price volatility. They also allow issuers to draw from an alternative source of capital and to leverage their bargaining power with traditional risk-financing providers (insurance and reinsurance).

Investors' concerns

What is the demand for insurance-linked securities? Over the past few years, the investor base has not only dramatically surged in volume, it has also changed its structure. Once an alternative wrap for reinsurance and insurance companies familiar with the risks and eager to diversify their exposure, ILS have also become another family of investment products for "alternative investors" such as hedge funds, cat funds and private equity funds. These investors are very specialized and sophisticated

[27] The European directive for reinsurance will make securitization of risks easier for the insurance market with the recognition of the Special Purpose Reinsurance Vehicle. The directive is due to be translated into national law by 2008 in the European Union.

[28] In both cases, a limit in capacity available was also a strong force driving the issue of ILS.

and are drawn by the strong features of the ILS (i.e., high Sharpe ratio[29] and low correlation with traditional capital market assets). Mutual funds and money managers are also becoming more active in the market, eager to benefit from the high yielding instruments in a context of flat interest rate and historically low yield on government and corporate bonds.

In order to enhance investors' appetite, several issues need to be addressed. First, it is important to make the risk/reward profile more explicit, a key element for investors who are faced with innumerous opportunities of investments (equity, bonds, ABS, credit, commodities, etc.). In this environment, insurance risks exhibit strong features, but the further development of these products will lean on high standard quantitative expertise and models, and the confidence in these products and the reliability on the models. Second, the new investors in this market are very yield sensitive (hedge funds or cat funds have minimum threshold for their investments, and leverage is often necessary to reach adequate rates of returns). As a result, investors were until recently interested only in high yielding tranches, which translated in bonds attaching around 1–2 percent of annualized probability of first loss. These levels of attachment made the ILS unsuited for traditional investors, concerned about a loss in their principal. In parallel, the high level of due diligence needed limited the penetration of these products among money managers. Recently, ILS were issued with a broader range of yielding tranches.

Moreover, while rating agencies formerly did not often rate investment grade cat bond tranches for single-event triggers, S&P decided in early 2007 to rate single event cat bonds up to BBB+ if first loss is sufficiently remote (below 20bps). For investors compelled by their status to hold only investment grade paper, that is a critical move. As the products become more standardized and the range of issuers and programs increases, traditional investors will have more flexibility. We also believe they benefit from a more convenient regulatory environment. For example, the French financial markets regulator AMF approved the possible inclusion of catastrophe bonds in mutual funds' portfolio only in early 2007. Pioneer, the asset manager, also launched in July 2007 a fixed income fund in which significant amounts of cat bonds are added to enhance yield. The firm also plans to launch later in 2007 a dedicated cat bond fund targeted to retail investors.[30]

An additional point under scrutiny by investors was liquidity of investment. (Re)insurance risks can be underwritten under multiple wrappers, from retrocession contracts to ILW, from cat bonds and cat swaps to shares of sidecars. Some hedge funds and private equity funds, given their expertise in illiquid and buy and hold strategy, would be keen on taking stakes in sidecars, high yielding but totally illiquid before dissolution of the sidecar. At the other end, mutual funds and cat funds, which must mark their investment to market on a regular basis, focus on cat bonds that can be traded in the secondary market.

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[29] The Sharpe ratio is a measure of the excess return on a risk-adjusted target of return, divided by volatility of the product. It is a key indicator for investors as it helps discriminate between investments with the same level of risks measured by volatility of expected return.

[30] The Economist (2007).

Looking ahead: solutions and innovations for reaching the tipping point

The ILS market is still in its infancy and without doubt it will be quite different 5 years from now, thanks to new innovation bursts and a progressive lift of the limiting factors we have underlined. We would like to conclude this paper by providing four axes of development that will help structure the market in the near future.

Increasing investors' interest in insurance linked products through tranching

To develop further, the ILS market must definitely draw more investors beyond the hedge funds and private equity firms. The increasing popularity of the securitization among issuers will help increase the range of risks available in the market, but other solutions have to be found as well. "Tranching" is likely to help: several distinct risks are pooled together and the resulting portfolio is divided into multiple tranches with different expected return. The tranching technology allows structuring firms to transform low rated bonds into investment grade securities by concentrating the risks in lower quality tranches stemming from subordination and overcollateralization. These higher risk tranches, called junior or equity, are usually bought by alternative investors attracted by the potential waterfall they would receive if no triggering event occurs. Some groundbreaking deals have reached the market, with notable recent transactions by ABN Amro and Guy Carpenter (Bay Haven Re in 2006, Fremantle Re in June 2007).

So far, investors were able to pick up the risks they were offered when issuers went to the market. It was the book running process. In the future, investors could approach insurers and define the risks they are looking for; structuring firms or risk transfer hubs would emerge to find these risks or create them through tranching.

Addressing the basis risk challenge through index-based derivatives

As parametric or index-linked securities will always retain basis risk, solutions to address this point (other than indemnity triggered) will be found in other corners. Standardized products such as Deutsche Bank–sponsored Event Loss Swaps and index-based derivatives present attractive features for investors. The first attempt more than 10 years ago to launch index-based products failed to attract attention and liquidity (Cat index on the Chicago Board of Trade (CBOT) in 1995). But it might have been too early in a sense. Capital markets have dramatically evolved since and the investor base is deeper today. A very encouraging frontier was crossed recently with the New York Mercantile Exchange (NYMEX) and the Chicago Mercantile Exchange (CME) both adding natural catastrophe-related futures and options for trading.[31] Derivatives will be written on these indexes and the year to come will further illustrate the attraction of insurance risks to capital market investors.

[31] This new initiative is very encouraging, almost 10 years after the CBOT stopped trading such options. The NYMEX product is based on the final aggregate annual ISO's PCS loss estimate for the contract year (3 years available to trade). The CME product is settled on a parametric index, for individual storms making landfall in the U.S. (there are contracts for three subsequent hurricane landfalls in five U.S. regions available to trade).

Innovating through the development of new products

Up to 2005, the range of ILS has been limited to a few solutions, among them cat bonds and ILW. In 2005 and 2006, sidecars were developed. Other innovations shall be developed to better tail issuers' needs and investors' appetites, and also help lower the price of financial protection. A second generation of contingent capital products and "just in time capital" were developed recently and have been successfully marketed. For example, Goldman Sachs launched for XL the Stoneheath sidecar in November 2006, which also embeds contingent issues of capital in case of pre-defined events. Other solutions of convertible securities are in the pipeline.

Thinking differently? Derivative solutions based on equity volatility dispersion

Our last axis of development illustrates that alternative solutions will also expand beyond the debt or equity forms, and even beyond the tradable securities form. Today, the capital market offers an incredible range of tools and products, especially in the derivative universe. Relevant strategies have been successfully marketed in early 2007 and met strong interest from insurance companies.

We believe that developing investment strategies based on equity volatility dispersion should provide another promising solution and we are currently working on its market deployment. The idea is to reduce the volatility of a given portfolio by buying a product that pays off if the volatility of a given industry portfolio fluctuates more than the one of a given index (e.g., S&P 500) over a pre-defined period of time. By *equity volatility dispersion* we mean the difference between the volatility of that portfolio (or basket) minus volatility of the underlying index (e.g., S&P 500 or other predefined indices). Companies typically want to reduce their volatility, and if one can create solutions to cover excess volatility there is certainly great interest in that. While not specific to insurance, equity volatility dispersion would actually help in the face of catastrophic risks.

Insurance companies which conducted an in-depth analysis of their peak risk exposure (natural hazards, pandemics, mega-terrorism risks) realized that the probability of these peak risks is often difficult to quantify with certainty.[32] The problem with such large-scale risks though is that they could affect both underwriting results (huge claims) and equity investments (stock markets of insurance companies typically go down in the days following a major catastrophe and then go up again to reflect expected future gains from increased premiums). When structured adequately and based on a portfolio of stocks potentially highly impacted by such extreme events (e.g., a portfolio representing the insurance and reinsurance companies operating in an exposed zone of the world), the derivative solutions have proven highly efficient by providing a broader financial protection.

How does it work? The company buys a special product (e.g., a swap) that pays off if the volatility of the insurance industry portfolio is more than X points higher than

[32] For instance, what is the probability of a "dirty bomb" exploding in Europe this year? What would be the direct and indirect impacts of such a terrorist attack? (Michel-Kerjan and Pedell (2006)).

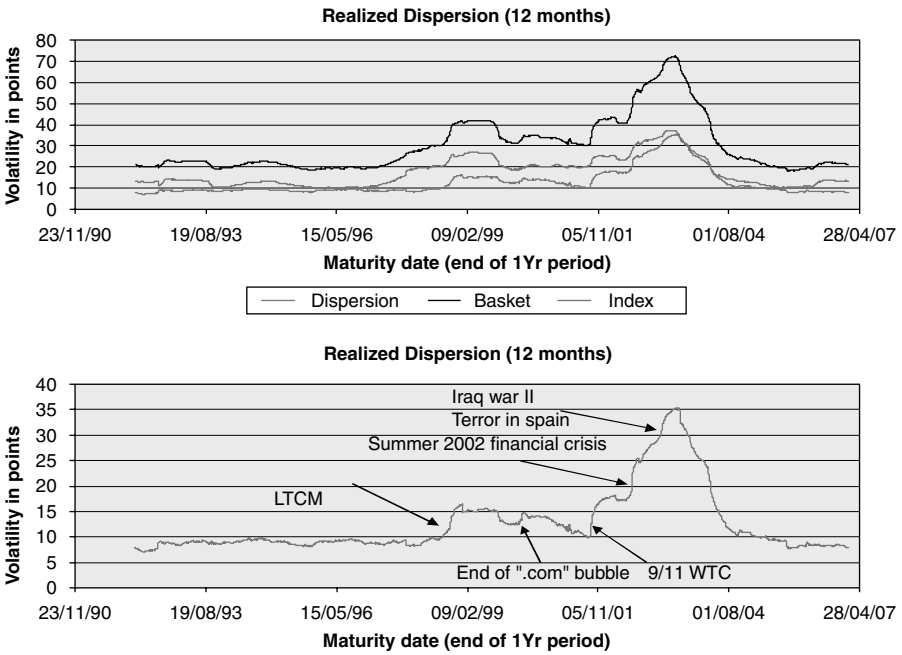

Figure 6. Dispersion solution graph. Simulated payoff ranging from less than 10 points to more than 30 points (each point gets a payoff of several million dollars).

the volatility of a given index. For instance, company A will receive $10 million for each point difference between the volatility of its portfolio and the volatility of the index; if at the maturity of the product (let us say 1 year), the realized dispersion (difference between the two volatilities) is 5, then the company will receive $50 million. One of the main advantages for the investors to have an industry portfolio (instead of the portfolio of a specific company) lies in a much higher transparency for the investors, but sponsors may have significant basis risk.

In Figure 6 we illustrate in a simplified way the payoff of such a strategy, designed to hedge a pandemic outbreak. In case of a pandemic event or financial crash, the investment whose back test is illustrated would over-perform, allowing the investors to recover their claim or asset losses with financial gains on the instrument. Indeed, we see in the first Figure 6 that the volatility of the basket is much higher (higher curve) than the volatility of the index (second curve). The dispersion curve (lowest curve on the graph) is the difference between the two. The strategy can be wrapped as a swap or as a fund or security (e.g., European Medium Term Note). Zooming in, the second Figure 6 depicts several major events that occurred over the past few years and the simulated payoff in points. We can see that in the left part of the figure the dispersion has remained relatively stable in the 1990s (in the range of 10–15), but has increased significantly and durably after 9/11 and due to the uncertainty about the war in Iraq. It regains its 1990 level only in 2004.

Fortunately, no pandemic event was captured in the back test – but the payoff of the strategy illustrates that both insurance events and financial market events are ''covered'' thanks to the instrument. This last example of a ''capital market solution'' clearly illustrates the emergence of a new approach in the risk transfer industry[33] that goes beyond the pure traditional ''underwriting management'' or pure ''asset management'' approach. Innovative and simple ways are thus possible, leveraging new asset classes based on second order risks, such as equity volatility dispersion that we introduced here. The potential of this new approach to hedge the risk of truly catastrophe risks remains mainly unexploited as of yet.

In conclusion, the past 3 years have seen a significant increase in ILS use and the development of several new innovative products, and more deals are in the pipeline as this paper goes to press. With over $25 billion of outstanding capital today (including sidecars, ILWs, etc), the annual rate of growth we have witnessed in the recent years and the increasing search for innovation and market opportunities, the threshold of $50–75 billion outstanding capital might very well be reached in less than 5 years from now. Another major series of catastrophes in highly insured zones of the globe shall accelerate the process even more.

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[33] For a discussion on other multi-function instruments, see Barrieu and Loubergé (2007).

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