

## **Convergence of Insurance and Financial Markets: Hybrid and Securitized Risk Transfer Solutions**

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### **Abstract**

One of the most significant economic developments of the past decade has been the convergence of the financial services industry, particularly the capital markets and (re)insurance sectors. Convergence has been driven by the increase in the frequency and severity of catastrophic risk, market inefficiencies created by (re)insurance underwriting cycles, advances in computing and communications technologies, the emergence of enterprise risk management, and other factors. These developments have led to the development of hybrid insurance/financial instruments that blend elements of financial contract with traditional reinsurance as well as new financial instruments patterned on asset backed securities, futures, and options that provide direct access to capital markets. This paper provides a survey and overview of the hybrid and pure financial markets instruments and provides new information on the pricing and returns on contracts such as industry loss warranties and CAT bonds.

# **Convergence of Insurance and Financial Markets: Hybrid and Securitized Risk Transfer Solutions**

## **1. Introduction**

One of the most significant economic developments of the past quarter century has been the convergence of the previously separate segments of the financial services industry. Convergence has coincided with the increasing globalization of the financial services sector, and has been facilitated by the deregulation of financial markets in Europe, the United States, and Asia. The development of dynamic financial markets for derivatives and other innovative securities as well as advances in computer, modeling, and telecommunications technologies have accelerated convergence. An important factor driving convergence is the increasing focus on shareholder value maximization by corporations worldwide. The resulting shift in focus from traditional risk management “silos” to enterprise-wide risk management has created a growing demand for new risk management products by non-financial corporations and financial institutions alike. Convergence has also occurred in retail markets with bancassurance gaining significant market share in many industrialized countries and insurers competing for the consumer savings dollar by introducing new products and services.

Convergence has been somewhat slower to develop in the market for risk transfer within the property-liability (re)insurance industry, a market traditionally dominated by reinsurance. Although reinsurance was one of the first truly global markets, having been deregulated in Europe, for example, twenty to thirty years before the rest of the European insurance industry, intra-insurance markets have been somewhat slower than other financial markets to adopt modern risk transfer techniques. In part, this has been due to the informational opacity of insurance markets, where underwriting information is carefully guarded and market participants earn rents by exploiting private information. Insurance markets are also unusually susceptible to

informational asymmetries between buyers and insurers and between insurers and reinsurers, raising transactions costs and inhibiting financial innovations that require higher levels of transparency. The inherent conservatism of insurance markets and the resulting market inertia also play a role in impeding convergence.

In spite of the best efforts of some in the industry to resist change, a number of powerful economic forces have combined in the past several years to force the acceleration of convergence between the property-casualty risk transfer market and financial markets. The first and perhaps most important driver of convergence is the growth in property values in geographical areas prone to catastrophic risk. Trillions of dollars of business and residential property exposure exist in disaster prone areas in the U.S., Europe, and Japan, and exposures in Asia are growing rapidly as economies such as China and India develop rapidly. The result has been an unprecedented increase in insured property and insured losses from property catastrophes. In 1992, Hurricane Andrew shook the industry to its core by causing an unprecedented \$24 billion of losses (in 2007 dollars). However, this event was dwarfed by the losses in 2005, when Hurricanes Katrina, Rita, and Wilma and other events combined to cause insured losses of \$114 billion (Swiss Re 2008). Losses of this magnitude are substantially larger than the total equity capital of global professional reinsurers (Guy Carpenter 2008) but represent less than ½ of 1% of the value of U.S. stock and bond markets. The recognition that it is more efficient to finance this type of risk in securities markets rather than in insurance markets has led to the development of innovative financial instruments such as catastrophic risk (CAT) bonds and options.

The second major driver of convergence is the reinsurance underwriting cycle. It is well known that reinsurance markets undergo alternating periods of *soft markets*, when prices are relatively low and coverage is readily available, and *hard markets*, when prices are high and

coverage supply is restricted. The existence of hard markets increases the difficulties faced by insurers in predicting costs and managing risks. As shown in Figure 1, the cycle is worldwide and has shown no signs of moderating over time. Because underwriting cycles tend to have low correlations with securities market returns, convergence has the potential to moderate the effects of the reinsurance underwriting cycle and thereby create value for insurers and insurance buyers.

A third major driver of convergence concerns advances in computing and communications technologies. These developments have facilitated the collection and analysis of exposure, loss, and other underwriting data and have enabled the development of catastrophe modeling firms such as Applied Insurance Research, Risk Management Solutions, and Equecat. These firms have developed powerful and sophisticated models of insurer exposures and events that can cause insured losses, facilitating risk management and enhancing market transparency. The fourth major driver of convergence has been the development of “holistic” or enterprise-wide risk management, whereby traditionally separate functions such as the management of insurable risks, commodity risks, currency risks, interest rate risks, and other corporate financial risks have begun to be merged under a single risk management umbrella. Holistic risk management has increased the familiarity of corporate managers with financial instruments and enhanced their receptiveness to innovative solutions.

A fifth major driver of financial convergence, which primarily reflect market imperfections, are various regulatory, accounting, tax, and rating agency factors (RATs). RATs serve in some cases as market facilitators, enabling (re)insurers to comply with various regulations and control regulatory and tax costs; but in other cases RATs serve as impediments to the development of the market (Cummins 2005). A sixth driver of convergence is modern financial theory, which has enabled market participants to acquire a much deeper understanding

of risk management transactions and facilitated the development of innovative new products.

The objective of this paper is to provide an overview and analysis of the innovative products that have been developed to broaden and deepen the market for property-liability risk transfer. Two major types of product innovations are considered – *hybrid products* that combine features of financial instruments and traditional (re)insurance but do not necessarily access capital markets directly and *financial instruments*, which closely resemble traded securities but go beyond (re)insurance industry capacity to directly access capital markets. The latter instruments are part of a class of securities known as *event-linked securities* or more commonly in this context as *industry-linked securities (ILS)*, the terminology adopted in this paper. Particular attention is devoted to CAT bonds, the ILS product that has been quantitatively the most successful of the convergence-oriented products. In addition to providing a comprehensive review of the market, we innovate by providing the first discussion and analysis of the new catastrophe options products introduced in 2007, the first discussion of the pricing of industry loss warranties, and the first analysis of price and return characteristics of the newly introduced Swiss Re catastrophe bond indices and the CAT bond mutual funds first introduced in 2001.

The remainder of the paper is organized as follows: Section 2 reviews the literature on property-liability risk securitization, focusing on the most important scholarly contributions. Section 3 discusses hybrid financial products that combine elements of reinsurance and securitization. Section 4 analyzes financial products, including pricing and returns on CAT bonds, and section 5 concludes.

## **2. Selective Literature Review**

This section reviews the literature on alternative risk transfer in insurance. The discussion focuses on the literature that the authors consider to have the most significant scholarly research

content, i.e., papers that either develop theories and hypotheses or provide rigorous empirical tests. We also focus on the evolution and development of risk transfer markets, institutions, and instruments. Although there is also a growing literature on mathematical/financial pricing models for insurance derivatives, we do not cover it here because it is outside the scope of the present paper (e.g., Aase 2001, Bakshi and Madan 2002, Grundl and Schmeiser 2002, Lee and Yu 2002, 2007, and Egami and Young 2008). Numerous professional journal and industry-oriented publications are not specifically reviewed here but are cited throughout the text.

## **2.1 . Market Inception Period**

Although researchers have analyzed reinsurance and reinsurance markets for decades, scholarly analysis on hybrid reinsurance-financial products and insurance derivatives and securitization is a relatively recent phenomenon. This literature was triggered by the events surrounding Hurricane Andrew in 1992 and the subsequent introduction of insurance futures and options by the Chicago Board of Trade (1992).

Because insurance derivatives were a new phenomenon in the early 1990s, the literature that developed at that time focused on explaining and analyzing insurance derivatives, comparing derivatives to conventional reinsurance, and discussing hedging strategies for insurers. D'Arcy and France (1992) analyze empirically the effectiveness of insurance futures based on catastrophe loss indices and conclude that such contracts could significantly reduce the volatility of insurer profits. However, they also cite a number of concerns among insurers about the use of the contracts including lack of insurer expertise, concerns about counterparty credit risk, and uncertainties surrounding the regulatory treatment of the contracts. They conclude presciently that, “concerns of insurers about insurance futures . . . may cause the demise of this contract.” In fact, the CBOT offerings eventually were withdrawn in 2000.

Cox and Schwebach (1992) also analyze the advantages and disadvantages of insurance derivatives for hedging catastrophe risk. They point out that derivatives provide a potentially valuable tool for hedging risk, allow investors to participate in the insurance markets without being a licensed insurer, and may have lower transactions costs than traditional reinsurance. However, they also outline some serious barriers to the success of insurance futures. Niehaus and Mann (1992) evaluate the advantages of insurance futures and develop a theoretical model of insurance futures markets too. They conclude that futures have the potential to reduce counterparty credit risk and enhance liquidity in the market for underwriting risk. However, the theoretical model shows that the success of insurance futures will depend upon the magnitude of the risk premium that investors require in order to bear underwriting risk.

Interestingly, the earliest literature on insurance derivatives identified (but did not resolve) most of the issues that continue to be discussed. These include the tradeoff between moral hazard, which is highest when indemnity-style contract payoffs are used, and basis risk, which is associated with index-linked products. Other important issues relating to the success of financial innovation include insurer acceptance of the new contracts, counterparty credit risk, and the magnitude of risk premia.

## **2.2. Market Evolutionary Period**

The period of time when the market was experimenting with different capital market instruments can be termed the *evolutionary period*, which approximately spans the years 1992 through 2004. Several different types of financial instruments were tried during this period, many of them unsuccessful. As indicated above, CBOT insurance futures were introduced in December of 1992. When the contracts failed to generate much interest among insurers, they were replaced in 1995 by CBOT options contracts based on insured catastrophe loss indices

compiled by Property Claims Services (PCS). (These options are discussed in more detail below.) However, due to limited trading, the PCS options were delisted in 2000 (United States GAO, 2002). Another early attempt at securitization involved contingent notes issued to investors known as “Act of God” bonds. The funds from the bond issues were held in trust, and the trust agreement permitted the insurer to borrow against the trust in the event of a catastrophic loss. Act of God bonds also failed to catch on, primarily because financing catastrophe losses through the bonds created the obligation for the insurer to repay the trust over time. A more successful securitization is the catastrophe (CAT) bond, described in more detail below, which releases funds to insurers following catastrophes without creating the obligation to repay. The first successful CAT bond was issued by Hannover Re in 1994 (Swiss Re 2001).

During the evolutionary period, scholarly researchers were generally enthusiastic about the prospects for capital market instruments. Papers were published explaining why it is difficult for conventional insurance and reinsurance markets to finance the risk of large catastrophes. E.g., Jaffee and Russell (1997) identify a number of insurance and capital market imperfections that impede the ability of insurance markets to finance large, infrequent losses. They conclude that capital market instruments may contribute to solving this financing problem, but that continued government involvement may be needed.

Harrington, Mann, and Niehaus (1995) examine whether insurance futures and options are likely to lower insurers’ costs of bearing correlated risks such as risks posed by natural catastrophes. The analysis evaluates futures and options relative to other techniques such as holding additional equity capital, purchasing reinsurance, and sharing risk with policyholders. They conclude that the success of futures and options will depend upon the relative costs of ensuring performance in the futures markets relative to the costs of other alternatives. Their

empirical analysis shows that index options provide significant risk reduction only for certain types of property insurance.

Doherty (1997, 2000) argues that capital market innovations such as catastrophe bonds and options are driven by the quest to reduce transactions costs such as moral hazard and credit risk. In particular, he argues that the success of capital market instruments will hinge on a tradeoff between moral hazard and basis risk. Because reinsurance contracts tend to be indemnity based, i.e., to pay off based on the losses of the company reinsured, the optimal mix of reinsurance and index-linked financial contracts depends upon the relative costs generated by moral hazard, which primarily affects indemnity-based contracts, and basis risk, which characterizes indexed contracts. Doherty and Richter (2002) argue that the optimal contract may involve a combination of index-linked financial instruments and indemnity-based reinsurance contracts to cover the basis risk “gap.”

The two most important empirical studies of the degree of basis risk for insurer hedging using catastrophe index-linked insurance derivatives are Harrington and Niehaus (1999) and Cummins, Lalonde, and Phillips (CLP) (2004). Harrington and Niehaus (1999) study basis risk by correlating insurer loss ratios with loss ratios based on state specific PCS catastrophe losses and also analyze correlations of individual insurer loss ratios and industry loss ratios in various geographical areas. Their results indicate that state-specific PCS catastrophe derivatives would provide effective hedges for many insurers, especially in homeowners insurance, and that basis risk with state-specific derivatives is not likely to be a significant problem.

CLP form hedges for nearly all insurers writing windstorm insurance in Florida using detailed exposure data and simulated hurricane losses provided by Applied Insurance Research. They find that hedging using statewide contracts is effective only for the largest insurers.

However, smaller insurers in the two largest size quartiles can hedge almost as effectively using four interstate regional indices.<sup>1</sup> These empirical analyses suggest that the basis risk of index-linked insurance derivatives is not a trivial problem, especially for relatively small primary insurance companies. Thus, hedging based on index-linked financial contracts is likely to be most effective for large primary insurers and reinsurers with broad-based geographical exposure.

Although the insurance-linked options market has not yet been successful, the volume of CAT bonds has grown steadily since the introduction of the bonds in 1994. However, during the evolutionary period, researchers noticed that the prices of CAT bonds, defined as the bond premium divided by the expected loss, were higher than expected. The expectations were based on capital market theory, which predicts that securities with near-zero market betas should have prices close to the risk-free rate of interest (Cantor, Cole, and Sandor 1996; Litzenberger, Beaglehole, and Reynolds 1996). However, Cummins, Lalonde, and Phillips (2004) found that CAT bond premia averaged nearly 7 times expected losses for bonds issued in 1997-2000.

The rationale for the high evolutionary-period CAT bond spreads has been investigated by several researchers. Bantwal and Kunreuther (2000) use behavioral economics to explain the reluctance of investment managers to invest in cat bonds. In particular, they suggest that ambiguity aversion, loss aversion, and uncertainty avoidance may account for the reluctance of investment managers to invest in these products.

A financial theoretic approach to explaining CAT bond spreads is provided by Froot (2001). Although risk management theory predicts that reinsurance protection against the largest CAT events should be most valuable, Froot provides evidence that insurers purchase relatively

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<sup>1</sup> This finding is consistent with Major (1996), who finds that contracts based on zip-code level loss indices provide better hedges than those based on statewide data, based on a simulation analysis. Harrington, Mann, and Niehaus (1995), using insurer loss ratios by line, find that line-specific indices provide effective hedges in the short-tail lines, while a national catastrophe index provides significant risk reduction only for homeowners/farmowners insurance.

little CAT reinsurance against large events and that reinsurance premiums are high relative to expected losses. He also provides evidence that the ratio of reinsurance prices to expected losses is comparable to spreads on CAT bonds during significant periods of time (e.g., 1993-1997).<sup>2</sup> To understand why theory fails, he examines eight potential explanations for the high spreads on reinsurance and CAT bonds, including insufficient capital for reinsurance due to capital market and insurance market imperfections, adverse selection, and moral hazard. He concludes that the most compelling explanations for the high spreads are supply restrictions associated with capital market imperfections and market power exerted by traditional reinsurers.

### **2.3. Market “Takeoff” Period**

Although the market for insurance-linked futures and options remains in the experimental stage, the market for CAT bonds has continued to expand, particularly following the large losses from Hurricanes Katrina, Rita, and Wilma (KRW) in 2005. Industry analysts now observe that, “the ILS market is now an established part of the reinsurance and retrocessional scene to be used by insurers and reinsurers alike” (Lane and Beckwith 2008) and that “the market [has gone] mainstream” (GC Securities 2008). Moreover, the insurance-linked securities market has expanded from coverage of catastrophes to other perils such as extreme mortality risk, automobile insurance, and liability insurance, as well as securitizations of life insurance embedded values (Cowley and Cummins 2005, Rooney and Brennan 2006, Swiss Re 2006).

Curiously, even as the CAT bond market has grown, so has the literature which tries to explain why insurance-linked securities have “not succeeded.” This perhaps reflects the lag between academic thinking and real-world market developments. For example, Gibson, Habib,

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<sup>2</sup> High spreads on catastrophe reinsurance are also documented and analyzed in Froot and O’Connell (2008). Froot and Posner (2003) provide a theoretical analysis suggesting that parameter uncertainty does not appear to be a satisfactory explanation for high event-risk returns.

and Ziegler (2007) entitle their paper, “Why Have Exchange Traded Catastrophe Instruments Failed To Replace Reinsurance?” They develop a theoretical model showing that differences in information gathering incentives between financial markets and reinsurance companies can explain why, over a decade after the introduction of insurance-linked securities, “financial markets have not displaced reinsurance despite the latter's alleged inefficiencies as the primary risk-sharing vehicle for natural catastrophe risk (p. 3).” Although the model is interesting, the paper is fundamentally off-target in three major respects: (1) The volume that has developed in the CAT bond market is primarily in over-the-counter rather than exchange-traded contracts. (2) Given the volume and widening participation in the CAT bond market, it is difficult to argue that the market has “failed.” And (3) other authors have observed that it is not expected that financial instruments would ever fully *replace* reinsurance, but rather that CAT securities can be valuable in dealing with specific market imperfections by plugging gaps in supply, particularly for high layers of coverage (e.g., Cummins 2008).<sup>3</sup> It is possible that their model could be used to explore more realistically-posed questions about the market, but the authors do not do so.

Another paper based on the incorrect premise that the CAT-linked securities market has failed is Barrieu and Louberge (2007). They argue that the volume of cat bond issues would increase if intermediaries issued hybrid cat bonds, i.e., structured financial instruments combining a simple cat bond and put option protection against a simultaneous drop in stock market prices. They utilize a game-theoretic model and attempt to demonstrate that “introducing hybrid cat bonds would increase the volume of capital flowing into the cat bond market, in

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<sup>3</sup>Plantin (2006) develops a theoretical model which explains the existence of reinsurers. He develops a model of equilibrium in reinsurance and capital markets in which professional reinsurers arise endogenously with the role of credibly monitoring primary insurers, so that the insurers can raise capital more easily. A similar rationale has been proposed to explain the role of other financial intermediaries such as banks (e.g., Diamond 1984).

particular when investors are strongly risk averse, compared to issuers of cat bonds.” This paper is off-target in two major ways, i.e., failure to recognize that there is significant investor and issuer interest in CAT bonds and that one of the most attractive features of CAT bonds is their lack of coordination with stock prices. Although the authors are correct that hedging against a joint event is cheaper than hedging against the events independently, it is not clear that hedging against drops in equity prices is a major priority for (re)insurers, especially given the rapid inflow of new equity capital into the reinsurance market following KRW (Cummins 2007).

A theoretical paper that helps to explain the co-existence of reinsurance and CAT bonds is Lakdawalla and Zanjani (2006). They point out that fully-collateralized CAT bonds initially seem a paradoxical departure from the “time-tested concept of diversification that allows insurers to protect insured value far in excess of the actual assets held as collateral.” In a world with free contracting, where frictional costs are similar for reinsurance and CAT bonds, CAT bonds are “at best redundant, and at worst welfare-reducing.” However, in a world with contracting costs and default risk, they demonstrate that CAT bonds can be welfare-improving by, “mitigating differences in default exposure attributable to contractual incompleteness and heterogeneity among insureds.”

Another theoretical paper with implications for the co-existence of reinsurance and CAT bonds is Brandts and Laux (2007). They argue that private information about insurers’ risk affects competition in the reinsurance market. Non-incumbent reinsurers are posited to be subject to adverse selection because only high-risk insurers may find it optimal to change reinsurers. This results in high reinsurance premiums and cross-subsidization of high-risk insurers by low-risk insurers. Because information-insensitive cat bonds with parametric triggers are not subject to adverse selection, the availability of cat bonds with sufficiently low basis risk reduces cross-

subsidization as well as the incumbent reinsurer's rents. However, absent specific benefits of CAT bonds, insurers will continue to choose reinsurance contracts with indemnity triggers. Both Lakdawalla and Zanjani (2006) and Brandts and Laux (2007) reinforce the conclusion that CAT bonds have a role to play but are not expected to totally displace traditional reinsurance.

### **3. Hybrid Reinsurance-Financial Risk Transfer Products**

As the risk transfer market has evolved over time, products have been developed that have characteristics of both traditional reinsurance and capital markets approaches to risk transfer. This section discusses and analyzes the principal products that fall into this category. To provide context for this discussion and a baseline for interpreting how such products differ from conventional risk transfer approaches, we begin with a brief discussion of reinsurance.

#### **3.1. Risk Transfer Through Conventional Reinsurance**

Traditionally, the primary (only) method of risk transfer for insurers was to purchase reinsurance from other insurers or from professional reinsurers. The principal types of reinsurance are discussed in numerous industry and academic sources (e.g., Swiss Re 1997b, 2002) and, therefore, the treatment here will be brief. Because most of the hybrid and financial risk transfer products developed in recent years have been motivated by the need to deal with "mega" risks such as risks posed by natural catastrophes, the discussion emphasizes reinsurance products for covering this type of risk.

Traditional reinsurance products can be categorized into a four-element matrix where the columns represent the mathematical sharing of risk under the contract and the rows represent the nature of the primary insurer's obligation to cede risks to the reinsurer. The two types of arrangements to cede risks are treaty (or obligatory) and facultative. Under treaty reinsurance, the primary insurer agrees to cede all risks of a given type (defined by line of business and/or

geographical area) to the reinsurer, whereas facultative reinsurance involves more ad hoc arrangements to cede specific risks or types of risks. From an economic perspective, treaty reinsurance has the advantage of reducing adverse selection, i.e., reinsurers are often wary of facultative reinsurance because ceding insurers may choose to reinsure “bad” risks and retain “good” risks. Adverse selection is less of a problem under treaty reinsurance because the reinsurer shares in all risks falling under the purview of the treaty. Thus, in facultative reinsurance, underwriting tends to be more expensive per policy reinsured. Nevertheless, both types of reinsurance play important roles in the risk transfer market.

The two categories of reinsurance contract structure are proportional and non-proportional. In proportional reinsurance, the ceding insurer and reinsurer share premiums and losses in a proportion fixed in the reinsurance contract. E.g., the ceding insurer may pay 60% of losses with the reinsurer paying 40%. Proportional reinsurance is of two primary types – quota share and surplus share. In quota share, all policies reinsured have their premiums and losses split in the same proportion. In surplus share, the proportionate split varies by policy and depends upon the policy coverage limit. Policies below a given amount (the “line limit”) are not subject to quota-sharing, while the proportionate split on policies above the limit depends upon how far the policy exceeds the line limit. Proportional reinsurance is used primarily by smaller insurers to increase their underwriting capacity and provide capital relief caused by the drain on surplus from prepaid underwriting expenses incurred when writing new policies.

The reinsurance contract structure that is used to transfer most “mega-risks” is non-proportional. In non-proportional reinsurance, the reinsurer does not participate in the claim unless it exceeds a specified threshold, and once the claim has breached the threshold, the reinsurer has a specified maximum payment above the threshold. Non-proportional reinsurance

has the same mathematical structure as a *call option spread*, familiar from financial markets.

The payoff under a non-proportional contract can be expressed as follows:

$$L_R = \alpha \{ \text{Max}[L_T - M, 0] - \text{Max}[L_T - (M + R), 0] \} \quad (1)$$

where  $L_R$  = the loss paid by the reinsurer,

$L_T$  = the total loss,

$M$  = the retention (lower strike price),

$R$  = the reinsurer's maximum payment under the contract, and

$\alpha$  = the proportion of loss paid by the reinsurer ( $0 < \alpha \leq 1$ ).

Non-proportional reinsurance is often called *excess of loss (XOL)* reinsurance and the contract payout is often expressed as “R XS of M,” i.e., the reinsurer is obligated to pay the amount R in excess of the retention M. For example, the contract might pay \$100 XS of \$200 or \$100 million excess of a threshold of \$200 million. A loss sharing proportion less than 1 (e.g.,  $\alpha = 0.9$ ) is usually present to control moral hazard, i.e., to give the ceding insurer the incentive for careful underwriting and claims settlement under the contract.

The losses that trigger payoffs under non-proportional contracts can be defined in various ways, such as per risk, per event (catastrophe), or per calendar period (“stop loss”). The non-proportional contracts used to cover catastrophes are usually per event.

The other important parameters of conventional reinsurance that are useful in understanding the role of hybrid and capital market contracts are the time period covered by the contract and the perils covered under the contract. Conventional reinsurance contracts are typically negotiated and priced annually and are single-peril contracts, e.g., a contract might be issued to cover Florida windstorm exposure. There are some disadvantages of single year-single peril contracts, such as pricing exposure to the underwriting cycle, that have led to both

insurance market and capital market innovations.

### **3.2. Alternative Risk Transfer: An Overview**

An overview of alternative risk transfer (ART) approaches that are used in the insurance and reinsurance industries is shown in Figure 2, which illustrates how the various institutions and instruments fit into the alternative risk transfer marketplace. As discussed above, this paper focuses on hybrid reinsurance-financial products and financial instruments. However, ART risk pools and insurers are also important and are included in the figure for completeness.

The alternative risk transfer market has developed steadily over the past forty to fifty years. The development of the ART market has been motivated by various inefficiencies in the markets for insurance and reinsurance that have led both insurance and non-insurance corporations to seek lower cost solutions that mitigate inefficiencies. E.g., non-insurance corporations were motivated to develop self-insurance programs because of the high transactions costs of dealing with the insurance industry. The transactions costs arise due to inefficiencies such as adverse selection and moral hazard, which require insurers to engage in underwriting and monitoring in order to control claim costs and align claim experience with expected loss estimates included in the premiums. Corporations with natural internal risk pools, such as fleets of vehicles or buildings in multiple locations, were motivated to self insure to reduce transactions costs. E.g., due to informational asymmetries, firms with favorable loss experience often were not given full credit for their loss experience by insurers and hence were required to subsidize firms with less successful risk management and loss control programs. The natural response to these informational asymmetries was the formation of self insurance programs.

Beginning in the 1960s, corporations began to recognize that further cost reductions might be possible by formalizing their self insurance programs in subsidiary corporations that

became known as *captive insurance companies* or *captives*. Although a detailed analysis of the advantages of captives is beyond the scope of this paper, captives formalize the primary cost advantages of self insurance, i.e., reducing administrative costs, reducing transactions costs of moral hazard and adverse selection, and giving the corporate parent investment control of the premiums paid to the captive. In addition, unlike most self insurance plans, captives have direct access to reinsurance markets and thus are likely to receive more favorable terms on the transfer of upper layers of risk. If properly structured, captives also have tax advantages over self-insurance programs, because the parent can deduct premium payments to captives whereas self insurance plans can deduct only the paid losses. Hence, captives provide a valuable tax deferral mechanism.<sup>4</sup> The growth of the captive market has been remarkable – by 2006 there were 4,652 captives in existence world-wide (Cummins 2008b).

The original captives were *single-parent captives*, i.e., subsidiaries that insured only the risks of the parent corporation. However, the market soon evolved to include *profit-center captives*, i.e., captives that insure the parent and also assume risks from unrelated third-party corporations. *Group and association captives* were also formed to insure the risks of several primary corporations which may be from the same industry (e.g., the energy industry) or members of an association. Such firms can achieve better risk diversification than through a single-parent captive, and being a member of a group or association captive also can help to ensure that premium payments are tax deductible. Major insurance brokers and others also offer *rent-a-captives* to insure the risks of smaller corporations, for whom the formation of a single-parent captive is not cost effective. The most recent form of the rent-a-captive is the *segregated*

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<sup>4</sup> The rules governing the deductibility of premiums paid by a parent corporation to a captive are complex and have been the subject of considerable litigation. However, premiums now appear to be deductible for captives with a “sufficient” amount of business covering firms other than the parent, captives that cover “siblings,” i.e., other captives owned by the same parent, and group captives that are jointly owned by several parents. For further discussion of captives, see Wohrmann and Burer (2002) and Swiss Re (2003).

*cell captive*, which provides stronger legal protection from the claims experience of unrelated participants for corporations in a multiple-parent captive.

Although global data are not readily available, an indication of the relative importance of the various types of captives can be obtained from their premium volume in Bermuda, the world's leading captive domiciliary jurisdiction. Of total Bermuda captive premium volume in 2005, 26% came from single parent captives, 34% from group and association captives, 26% from profit-center captives, 10.5% from rent-a-captives, and the balance from miscellaneous categories such as health-care captives (Cummins 2008b).

Another ART-type institution available for liability insurance risks in the United States is the *risk-retention group (RRG)*. Risk-retention groups are mutual organizations authorized by Congress in response to the liability insurance crisis of the 1980s to provide additional liability insurance capacity to businesses. Although RRGs account for only a small proportion of the U.S. liability market, they are important in some states and in providing liability coverage for professionals (doctors and lawyers) and the healthcare industry.

The main innovations in insurance markets and products until the 1990s focused on lowering transaction costs and dealing with moral hazard and adverse selection, primarily in markets for high frequency, low severity losses. Favorable tax treatment of premiums and obtaining access to the wider reinsurance market were important as well. We will see that transaction costs, moral hazard, and adverse selection continue to be important factors in the development of products linked to capital markets. However, hybrid and purely financial instruments are more likely to focus on low frequency, high severity risk transfer.

### **3.3. Hybrid Reinsurance-Financial Products**

The types of risk transfer mechanisms of primary interest in this paper are hybrid

reinsurance-financial products and financial instruments. Hybrid products tend to incorporate characteristics of both financial instruments and conventional reinsurance, while the financial instruments more closely resemble pure financial products traded in capital markets. We now turn to a discussion of these alternative risk transfer devices.

**3.3.1 Finite Risk Reinsurance.** Finite risk reinsurance is an ART product, often used to provide income smoothing for primary insurers with limited assumption of risk by the reinsurer. Finite reinsurance, which combines a multi-year banking transaction with limited reinsurance coverage, has five distinguishing features: (1) Risk transfer and risk financing are combined in a single contract. (2) The amount of underwriting risk transferred to the reinsurer is less significant than under conventional reinsurance contracts.<sup>5</sup> (3) Finite risk contracts almost always cover a multi-year period rather than being annually renewable. (4) Investment income on the premiums paid by the primary insurer (cedent) is explicitly included when determining the price, placing an emphasis on the time value of money not found in conventional reinsurance. (5) There is usually risk-sharing of the ultimate results (positive or negative balance at the end of the contract) between the reinsurer and the buyer.

Finite reinsurance represents convergence in that the reinsurer absorbs more credit risk than under an annually renewable contract, because of the possibility that the cedent will default on its agreed-upon premium payments, and also exposes the reinsurer to interest rate risk because the investment income feature usually involves some sort of interest guarantee. The

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<sup>5</sup>Actually, the term “finite” reinsurance is somewhat misleading in that conventional reinsurance is also finite, i.e., subject to policy limits, deductibles, etc. Nevertheless, the term does express the idea that the intent of the contract is to provide more limited risk transfer than under conventional policies. In several jurisdictions internationally, finite risk reinsurance must transfer significant underwriting risk in order to receive regulatory, tax, and/or accounting treatment as reinsurance. In the U.S., the relevant GAAP accounting rule is SFAS 113 (Financial Accounting Standards Board 1992). For further discussion, see Swiss Re (1997a, 2003).

premium or claim payments under the policy may also be denominated in a currency other than the reinsurer's home country currency, exposing the reinsurer to foreign exchange risk.

*Finite quota share* reinsurance is a type of finite reinsurance that involves the proportionate sharing of the premiums and losses of a block of business. An example of a quota share reinsurance transaction would be the transfer of part of the cedent's unearned premium reserve to the reinsurer in return for a *ceding commission*. This is often motivated by accounting rules that require the insurer to set up an unearned premium reserve based on total premiums received even though most of the acquisition and underwriting costs are paid at policy issue. Thus, issuing new business leads to an artificial increase in the insurer's leverage ratio, which is mitigated through the ceding commission of quota share reinsurance; the commission enables the cedent to recapture its prepaid expenses. The "finite" aspect of the transaction is often imposed by linking the commission to the loss experience on the business transferred and/or placing an overall limit on the reinsurer's liabilities for losses under the loss sharing agreement. Finite quota share reinsurance thus serves a financing function, enabling insurers to grow more rapidly.

A *spread loss treaty* is a type of finite risk reinsurance designed to reduce the volatility of the ceding insurer's reported underwriting profit. To achieve this goal, the cedent enters into an agreement to pay a fixed annual premium to the reinsurer. Under the contract provisions, the primary company borrows money from the reinsurer when its underwriting results are adverse due to unexpectedly high insurance losses and repays the "loan" when losses are relatively low. The premium is deposited into an "experience account" each year, the account is credited with interest, and losses are deducted. Because the experience account is usually carried "off balance sheet," the arrangement smoothes the ceding insurer's reported income.<sup>6</sup>

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<sup>6</sup>The off-balance sheet feature of these contracts runs afoul of U.S. GAAP accounting rules. Under FASB

The arrangement is distinguished from being merely a “savings account with a credit line” because the reinsurer typically bears significant underwriting risk. That is, if the balance is negative at the end of the multi-year contract term, the reinsurer is liable for part of the balance, usually defined as  $\text{Min}[\text{Max}(-\alpha B, 0), D]$ , where  $\alpha$  = a proportion between zero and 1,  $B$  = the experience account balance, and  $D$  = a cap on the reinsurer’s obligation. There is also often a limit on the amount the reinsurer would have to lend in any given year due to unexpectedly high losses. In addition to smoothing underwriting results, these contracts provide the cedent with protection against the reinsurance underwriting cycle. Because the annual premium is usually set for the entire period of the contract, the cedent is not vulnerable to renewing the contract on unfavorable terms if the cycle enters a hard market phase.

Although finite reinsurance can serve legitimate business purposes, there is also a “dark side” to this type of product.<sup>7</sup> Because properly structured finite reinsurance can be used to manage the capital structure of an insurer by increasing or decreasing its liabilities and because the degree of risk exposure of the reinsurer is often very limited, there is a temptation for managers to misuse finite reinsurance to manage their balance sheets in ways that are misleading to investors. E.g., in March 2005, “Hank” Greenberg, the long-time CEO of American International Group (AIG), was forced to resign amid allegations that AIG had misused finite reinsurance to fictitiously bolster its loss reserves. The allegations eventually led to the conviction of five prominent executives of AIG and General Reinsurance Company, the counterparty to the AIG transactions, for conspiracy and securities fraud (Roberts 2008). Other firms also have been accused of misusing finite reinsurance. Thus, finite reinsurance seems to be

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113 and EITF 93-6, U.S. insurers must show positive account balances as assets and negative balances as liabilities unless there is no contractual obligation to repay negative balances. This mitigates the smoothing aspects of the contract for U.S. firms.

<sup>7</sup> Regulatory aspects of finite reinsurance are discussed in VonDahlen (2007).

especially susceptible to unethical conduct, and market participants should proceed with caution.

**3.3.2. Retrospective Excess of Loss Covers.** *Retrospective excess of loss covers (RXLs)* (also called adverse development covers) are a finite risk product that protects the cedent against adverse loss reserve development in lines such as commercial liability insurance, where claims settlement covers a considerable period of time. RXLs provide retrospective reinsurance protection because they apply to coverage that has already been provided rather than coverage to be provided in the future, as under prospective reinsurance contracts.<sup>8</sup> RXLs provide partial coverage for the primary insurer if reserves exceed a level specified in the contract and thus can be conceptualized as a call option spread written by the reinsurer and purchased by the cedent. If developed losses incurred exceed the retention (striking price) specified in the contract, the cedent receives payment from the reinsurer to partly defray the costs of the adverse development. The price is based on the discounted value of the reinsurer's expected costs, and the reinsurer may assume some liability in the event that one or more of the cedent's other reinsurers defaults on its obligations. Thus, the reinsurer assumes underwriting risk, timing risk (the risk that the claims will be settled faster than recognized in the discounting process), interest rate risk, and credit risk, extending coverage significantly beyond conventional reinsurance.

Besides transferring risk, RXLs have the less obvious advantage of mitigating a significant source of asymmetrical information between the cedent and the capital market. An insurer's managers inevitably know much more about the firm's reserve adequacy and probable future reserve development than the capital market. This creates a "lemons" problem in which

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<sup>8</sup> RXLs are most important under occurrence based liability policies, where coverage is provided during a specified period (the *accident year*) and claim settlement covers a lengthy period of time following the end of the coverage period. At the end of the accident year, the majority of claim payments has not been made but can only be estimated, leading to the creation of the *loss reserve*. The process through which the reserved claims become payments is called *loss reserve development*, and RXL contracts protect against adverse loss reserve development by transferring some of this risk to the reinsurer.

the insurer may have difficulties in raising capital or participating in the corporate restructuring market due to uncertainty regarding its reserves. However, one of the core competencies of a reinsurer is the ability to evaluate the adequacy of insurance prices and loss reserves. The reinsurer can leverage this knowledge to create value for its owners by writing RXL reinsurance. Thus, such contracts provide a signal to capital markets that a knowledgeable third party has evaluated the cedent's reserves and is willing to risk its own capital by participating in the risk.

**3.3.3. Loss Portfolio Transfers.** With RXL contracts, insurers transfer reserve development risk to the reinsurer, but retain the subject loss reserves on its own balance sheet. A finite risk cover that restructures the cedent's balance sheet is the *loss portfolio transfer (LPT)*. In a LPT, a block of loss reserves is transferred to the reinsurer in exchange for a premium representing the present value of the reinsurer's expected claim payments on the policies included in the reserve transfer. Because loss reserves are usually carried at undiscounted values on the cedent's balance sheet, the value of the reserves transferred exceeds the premium payment. This has the effect of decreasing the cedent's leverage (e.g., its liabilities to equity ratio). A LPT accomplishes a number of objectives including reducing the cedent's cost of capital, making it more attractive as a merger partner, permitting it to avoid costly runoff operations, and enabling the cedent to focus on new opportunities. Although the transferred reserves are usually carried on the reinsurer's balance sheet, there is no reason why they could not be securitized, provided that regulatory issues could be resolved.

**3.3.4. Blended and Multi-Year, Multi-Line Products.** Reinsurers also issue *blended covers*, which combine elements of both conventional and finite risk reinsurance. Although motivated to some extent by regulation, which often disallows finite risk solutions as legitimate reinsurance transactions unless they involve a significant shifting of underwriting risk, the

principal objective of blended covers is to combine the non-traditional risk-management features of finite risk reinsurance with the more significant underwriting risk transfer of conventional reinsurance. Thus, blended covers may cover multiple years, insulating the cedent from the reinsurance cycle, and usually involve the recognition of the time value of money. Such contracts also may involve the transfer of foreign exchange rate risk and timing risk. Multiple-year treaties are less common than annual contracts and tend to be more available during the “soft” phase of the reinsurance cycle.

The ultimate evolution of reinsurance away from conventional yearly renewable contracts that primarily transfer underwriting risk towards contracts that protect the cedent against a wider variety of risks is represented by various types of *integrated* or *structured multi-year/multi-line products (MMPs)*. MMPs modify conventional reinsurance in four primary ways: (1) By incorporating multiple lines of insurance in the same policy, (2) by providing coverage at a pre-determined premium for multiple years, (3) by including hedges for financial risks as well as underwriting risks, and (4) by sometimes covering risks not traditionally considered insurable such as political risks and business risks (Swiss Re 1999). MMPs not only provide very broad risk protection for the cedent but also lower transactions costs by reducing the number of negotiations that must be completed to execute the cedent’s risk management program.

The prices of MMPs also may appear favorable relative to separate reinsurance agreements with multiple reinsurers, because the issuer of the MMP can explicitly allow for the diversification benefits of covering several lines of business whose losses are not perfectly positively correlated. MMPs can be conceptualized as “cross-selling” at the wholesale financial services level. As in the case of retail financial services, however, it is not necessarily the case that “cross-selling” dominates “cross-buying,” i.e., the practice of buying from the best producer

of each product purchased. In addition, because such contracts incorporate several elements usually covered separately, there is a lack of transparency that may impede market development. Thus, the ultimate success of MMPs in the risk transfer market remains uncertain.

**3.3.5. Multiple Trigger Products.** Going even further beyond conventional reinsurance policies are *multiple-trigger products (MTPs)*. MTPs reflect the principles of “states of the world” theory from financial economics, which holds that payments in some states of the world will trade at higher (lower) prices depending upon the overall market outcome. MTP reinsurance recognizes that payments to the cedent by the reinsurer are more important in states of the world where the cedent has suffered other business reversals in comparison with states when the cedent’s net income is relatively high. Thus, the payment under the MTP contract depends upon an insurance event trigger and a business event trigger, both of which must be activated before the cedent receives payment. For example, an MTP contract might cover the cedent for catastrophic hurricane losses in Florida that occur simultaneously with an increase in market-wide interest rates. The cedent would thus be protected against having to liquidate bonds at unfavorable prices to pay insurance claims resulting from the catastrophe, but would not have to pay for protection covering circumstances in which a catastrophe occurs when securities market conditions are more favorable.

In effect, MTPs combine conventional reinsurance protection and financial derivatives in a single, integrated contract. In the Florida hurricane example, the MTP product combines reinsurance protection with an embedded interest rate derivative. Because the probability of the simultaneous occurrence of an interest rate spike and a property catastrophe is low, the MTP product is likely to be priced considerably below a catastrophe reinsurance policy, thus enabling the cedent to direct its hedging expenditures to cover events for which the payoff of the hedges

has the highest economic value.

**3.3.6. Industry Loss Warranties.** A type of multiple-trigger contract that has become particularly successful during the past few years is the *industry loss warranty (ILW)*. ILWs are dual trigger contracts designed to pay off on the occurrence of a joint event where a specified industry-wide loss index exceeds a particular threshold at the same time that the issuing insurer's losses from the event equal or exceed a specified amount. The former trigger is called the *index trigger* or *warranty*, and the latter is the *indemnity trigger*. The insurer purchasing an ILW thus is covered in states of the world when its own losses are high and the reinsurance market is likely to enter a hard-market phase. Because one of the triggers is the insurer's own losses, ILWs generally overcome regulatory objections to non-indemnity bonds and hence permit the contracts to qualify for reinsurance accounting treatment.<sup>9</sup> The indemnity trigger is usually set very low such that the insurer is almost certain to recover if industry losses satisfy the index trigger.

There are several important contractual provisions that must be defined in an ILW. ILWs are purchased to cover specified perils such as windstorm or earthquake, or they may cover all perils with the exclusion of specified events such as earthquake or terrorism. The contract also specifies the warranty, i.e., the magnitude of the index that triggers payment, and the size of the indemnity trigger (e.g., \$10,000). In addition, the contract must specify the index that triggers the contract, such one of the Property Claims Services (PCS) indices.

Index triggers are of two primary types: (1) *binary triggers* (the primary trigger type), whereby the contract pays 100% of value once losses breach the warranty, or (2) *pro rata triggers*, where the writer of the contract pays proportionately based on how much the index exceeds the warranty. The ILW also specifies the length of the contract (often one year) and the

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<sup>9</sup> Insurance regulators sometimes object to index-linked products on the grounds that they expose insurers to excessive basis risk and potentially can be used for speculation rather than hedging.

region covered by the contract (e.g., a single U.S. state, the Southeastern U.S., Japan, or continental Europe). The contract also specifies the maximum limit of coverage such as \$10 million. Finally, the contract usually includes a reinstatement provision, whereby the buyer can reinstate the limit for the balance of the contract term in the event of contract payoff by paying an additional premium. The price of the contract, or *rate on line*, is generally expressed as a percentage of the maximum coverage limit. Most of these provision parallel excess of loss (XOL) reinsurance, except that XOL reinsurance generally has only an indemnity trigger.

In addition to the advantages of a dual trigger, ILWs also are attractive because no underwriting information is usually required due to the fact that the seller is mainly underwriting the industry loss index rather than the buyer's losses, because the indemnity trigger is low. ILWs also are attractive to buyers due to the low indemnity retention and the ability to plug gaps in conventional reinsurance programs. Because ILW payoffs are primarily driven by the index trigger, they have the disadvantage of exposing the buyer to basis risk. In addition, traditionally ILWs did not directly access capital markets and thus expose buyers to the reinsurance cycle. However, more recently, sellers and intermediaries have begun to securitize ILWs, thus reducing this potential limitation. In recent periods, the seller side of the market has expanded beyond traditional reinsurers to include hedge funds, sidecars, and banks because of the very low barriers to entry in this market (Benfield 2008). The market has also expanded to encompass multi-year ILWs and ILWs incorporating multiple index triggers. Critics of ILWs cite high frictional costs, low liquidity, and lack of transparency in the secondary market as disadvantages of the contracts, but these problems may be mitigated in the future by securitization. About \$6 billion in risk capital was provided by ILWs in 2007 (GC Securities 2008).

Although minimal volume data on ILWs are available, pricing statistics have recently

become available. The ILW prices for the U.S. from April 2002 through July 2008 are shown in Figure 3. Rates on line are shown for contracts attaching at industry losses of \$20, \$30, and \$50 billion. As expected, the prices are highest for the lowest attachment point (\$20 billion) and decline for higher attachment points, which have lower probabilities of exceedance. The results show that the cyclicity in reinsurance prices carries over to the ILW market. Prices increased dramatically as a result of Hurricanes Katrina, Rita, and Wilma (KRW) and remained at post-KRW levels until January 2007, when prices began to decline in response to the relatively low catastrophe losses in 2006. However, by 2008, prices had still not returned to pre-KRW levels, indicating the continuation of a relatively hard market for high coverage layers.

**3.3.7. Sidecars.** An innovative financing vehicle that has similarities to conventional reinsurance but accesses capital markets directly through private debt and equity investment is the *sidecar*. Sidecars date back to at least 2002 but became much more prominent following the 2005 hurricane season (A.M. Best Company 2006). Approximately \$7 billion in equity and debt capital was raised through sidecars from 2005-2007 (Guy Carpenter 2008a). Nearly all sidecars to date have been established in Bermuda, because of Bermuda's favorable regulatory and tax systems (Ramella and Madeiros 2007).

The sidecar structure is diagrammed in Figure 4. Sidecars are *special purpose vehicles* sponsored by reinsurers to provide additional capacity to write reinsurance, usually for property catastrophes and marine risks. The sidecar is formed by a ceding reinsurer, and all of its risk-bearing activities are typically confined to this specific reinsurer. The capital raised by the sidecar is held in a collateral trust for the benefit of the ceding reinsurer. The cedent then enters into a reinsurance contract with the sidecar, which often represents a quota share agreement. The sidecar receives premiums for the reinsurance underwritten and is liable to pay claims under the

terms of the reinsurance contracts. Sidecars generally have limited lifetimes to capitalize on high prices in hard markets and quickly withdraw capacity in soft markets.

The ceding reinsurer can earn profits on transactions with the sidecar through ceding commissions and sometime also profit commissions. Thus, it can replace risk-based underwriting profit income with fee income, transferring the risk to the sidecar. In comparison with issuing debt or equity securities, the sidecar is usually formed off-balance-sheet and hence does not affect the issuing reinsurer's capital structure. Thus sidecars may reduce regulatory costs and enhance the issuer's financial rating. Sidecars can also be formed quickly and with minimal documentation and administrative costs.<sup>10</sup> Sidecars are attractive to reinsurers in comparison with reinsurance retrocessions because they do not require the sharing of underwriting information with competitors but are inherently transparent to the (private) investors. Sidecars and CAT bonds can work together as complementary instruments in much the same way as quota share and excess of loss complement each other in a traditional reinsurance program.

The sidecar is usually owned by a holding company, and the holding company raises capital for the sidecar by issuing equity and debt, although often sidecars are exclusively equity financed. If debt securities are issued, a tiered structure can be used, similar to that of an asset-backed security, to appeal to lenders with differing appetites for risk. Private equity, hedge funds, insurers, and reinsurers provide the capital for the typical sidecar. In fact, the growth of the sidecar market has been significantly driven by hedge funds seeking attractive non-traditional sources of investment yield. In effect, the investors obtain access to the uncorrelated risk of retrocession while the sponsoring reinsurer handles all underwriting responsibilities, alleviating

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<sup>10</sup> For further discussion, see Cummins (2007) and Lane (2007).

the hedge fund's need to create its own reinsurance infrastructure.

**3.3.8. ART Products: Conclusions.** Hybrid ART instruments clearly extend traditional reinsurance and provide examples of the convergence of insurance and financial markets. The contracts have evolved over time from those which primarily extend existing reinsurance products to arrangements such as sidecars that access broader capital markets, providing targeted and time-limited infusions of risk-bearing capacity. Although continued financial innovation can be expected in the future, a few caveats should be kept in mind when considering ART:

(1) Many of the contracts implicitly exploit the existence of market imperfections and unexploited arbitrage opportunities. In a complete markets setting with more or less perfect information, most of these contracts would not be viable. For example, financial quota share reinsurance seems to be motivated primarily by regulatory accounting rules. Similarly, spread loss reinsurance would not be attractive if external capital were not more costly than internal capital. If priced in efficient financial markets, a loss portfolio transfer should not change the stock market equity valuation of either the insurer or the reinsurer. That is, market imperfections and imperfect information create the “gains from trade” in many of these transactions.

(2) Insurance/financial markets may evolve away from rather than towards highly structured, relatively opaque products such as MMPs. Among other potential limitations, these contracts typically access the capital of a single reinsurer. Even though the reinsurer can lay off some of the risk in a retrocession, MMPs as presently structured do not bring new risk bearing capital into the market. The fact that MMPs are complex, dealing with multiple lines and a variety of financial risks, would seem to make them more difficult to securitize than more transparent products, limiting their growth potential.

(3) In principle, many contracts that incorporate both insurance and financial risks could

be replicated by separately trading insurance derivatives and financial derivatives. In this case, the value added from constructing the hedge could be uncoupled from the need for a residual claimant such as a reinsurer. Therefore, contracts that payoff based on joint underwriting and financial triggers may not be viable on an ongoing basis, but “pure play” instruments such as sidecars that allow investors to gain exposure to underwriting risk are likely to remain important.

#### **4. Financial Market Instruments**

Whereas the preceding section considered hybrid products, the present section focuses on instruments that access the capital markets directly. Capital market instruments are important because of their ability to absorb the risk of large catastrophes and their potential to add liquidity and transparency to the risk transfer market.

##### **4.1. Financial Market Instruments and Securitization: Introduction**

Securitization involves the repackaging and trading of cash flows that traditionally would have been held on-balance-sheet. Securitizations generally involve the agreement between two parties to trade cash flow streams to manage and diversify risk or take advantage of arbitrage opportunities. The cash flow streams to be traded often involve contingent payments as well as more predictable components that may be subject to credit and other types of counterparty risk. Securitization transactions facilitate risk management and add to the liquidity of (re)insurance markets by creating new tradable financial instruments that access broader pools of capital.

Securitizations in general fall into two primary categories: (1) Asset-backed securities such as mortgage-backed securities and securities backed by portfolios of bonds, loans, including automobile loans, student loans, home equity loans, and credit card receivables, and other types of assets traditionally held on-balance-sheet, and (2) non-asset backed products such as futures and options. ABS are typically collateralized, i.e., backed by underlying assets, whereas non-

asset backed products are guaranteed by the transaction counterparty and/or by an exchange. Both ABS and non-ABS can be issued and traded on organized exchanges or over-the-counter. Further analysis of ABS versus non-ABS securities is provided in Cummins (2005). Most of the insurance securitizations to-date have been patterned after existing ABS and non-ABS securities design structures familiar from other financial markets.

#### **4.2. Contingent Capital**

A type of securitization transaction that can be used to financial insurance-linked risk is *contingent capital*. A contingent capital agreement is similar to a put option, allowing an insurer to issue capital (e.g., common stock, hybrid capital, or debt) at a predetermined strike price following the occurrence of a defined catastrophic event. For example, if the insurer's stock price falls below the strike price following a hurricane of specified magnitude, the insurer would have the option of issuing shares at the agreed upon strike to replenish its capital. Contingent capital agreements can be fully funded similarly to CAT bonds but are usually in the form of options.<sup>11</sup> The benefits of contingent capital include a low up-front option fee, balance sheet protection when it is most needed – after a major catastrophic event – and access to financing with neither a corresponding increase in leverage nor a dilution of shareholders' equity. A disadvantage of contingent capital is that issuing shares has a dilution effect not present with CAT bonds or options, and issuing contingent debt adversely affects the insurer's capital structure. Until recently, the presence of both catastrophe risk and credit risk impeded the development of the contingent capital market. However, the development of the ILS market has enhanced the attractiveness of catastrophe risk exposure to capital market participants, and the participation of large banks has bolstered issuer confidence regarding counterparty credit risk.

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<sup>11</sup> An early contingent capital transaction, issued over-the-counter by Aon Corporation, was called a "CAT-E-Put," an abbreviation for "catastrophic equity put option." For further discussion of contingent capital see Culp (2002).

Approximately \$1.2 billion in contingent capital was issued in 2007, the majority involving debt or hybrid debt (Benfield 2008). An example of a contingent debt transaction is the \$500 million Farmers Insurance Group transaction in 2007, which gives the insurer the option to issue loan notes at a fixed price to a group of banks, triggered by a Texas, Arkansas, Oklahoma or Louisiana windstorm loss of at least \$1.5 billion. The deal represented the first time a commercial bank had cooperated with a reinsurer to provide regulatory capital for an insurer and in doing so assumed the subordinated credit risk of the insurer and catastrophe risk.

### **4.3. Catastrophe Futures and Options**

Hurricane Andrew in 1992 revealed that the insurance industry had drastically underestimated the potential for catastrophic losses and raised questions about the capacity of the insurance and reinsurance industries to respond to large catastrophic events. As a result, market participants began to explore alternative measures for hedging catastrophic risk. The first such effort was the introduction of catastrophe futures and options by the Chicago Board of Trade (CBOT) in 1992. The contracts paid off on catastrophe loss indices and were patterned on the futures and options contracts widely traded on financial exchanges for commodities, interest rates, etc. When the options failed to attract much interest among hedgers and speculators, they were replaced in 1995 with redesigned options based on catastrophe indices compiled by Property Claims Services (PCS), an insurance industry statistical agent. The CBOT-PCS contracts were generally traded as call and put option spreads. The indices were based on PCS estimates of catastrophic property losses in specified geographical areas of the U.S. during quarterly or annual exposure periods. Contracts on nine indices were offered – a national index, five regional indices, and three state indices (for California, Florida, and Texas).

Although the CBOT-PCS options generated moderate trading volume, they were delisted

in 2000 due to lack of investor interest. Various reasons have been proposed to explain the failure of the CBOT contracts, including insurer perceptions that the contracts had excessive basis risk, lack of insurer expertise in options trading, low liquidity, investor fears about counterparty credit risk, and uncertainty about regulatory accounting treatment of the options (American Academy of Actuaries 1999). Other efforts to launch catastrophe options, e.g., by the Bermuda Commodities Exchange, also ended in failure. These failures are particularly regrettable given that options in theory provide a more efficient mechanism for hedging catastrophe risks than more highly structured and fully collateralized mechanisms such as CAT bonds.

Because options seem to make sense from an economic and financial perspective and because insurers and reinsurers have become much more comfortable in dealing with financial instruments as alternatives to reinsurance, there have been several recent efforts to re-launch options with payoffs triggered by catastrophic property losses. In March 2007, futures and options contracts were introduced by two exchanges – the New York Mercantile Exchange (NYMEX) and the Chicago Mercantile Exchange (CME). Contracts were also introduced by the Insurance Futures Exchange (IFEX), whose contracts trade on the Chicago Climate Exchange (CCX), which was launched in 2003 to trade futures and options on greenhouse gases such as carbon dioxide. Deutsche Bank and Swiss Re have joined the IFEX effort as market makers. To date, there has been minimal trading in the NYMEX and CME futures and options, but the IFEX contracts have generated some trading volume, e.g., open interest in June 2008 exceeded 3,000 contracts, equivalent to about \$30 million in policy limits (IFEX 2008). Although this is very small compared to ILWs and CAT bonds, the market has potential for future growth.

The principal characteristics of the futures and options contracts launched in 2007 are shown in Table 1. Comparable information is shown in the table on the CBOT-PCS options for

purposes of comparison. Interestingly, there are some significant differences in design features among the four types of contracts shown in the table.

The IFEX-Event Loss Futures (ELF) contracts are unique among insurance derivative contracts offered to date because they are designed to mimic ILWs. This makes sense because market participants have become familiar with ILWs and because the IFEX contracts can be used to hedge ILW risk. The contracts are designed to pay off on PCS insured catastrophe loss indices, specifically for U.S. tropical windstorm losses in a broadly defined geographical region including the 50 U.S. states, the District of Columbia, Puerto Rico, and the Virgin Islands. The contracts currently available are “1<sup>st</sup> event” and “2<sup>nd</sup> event” contracts, with triggers of \$10, \$20, \$30, \$40, and \$50 billion. For example, suppose an insurer buys a 1<sup>st</sup> event contract with a trigger of \$10 billion. The contracts are *binary*, paralleling the most common type of ILW contract, meaning that the contract would pay \$10,000 for the 1<sup>st</sup> event that breached the \$10 billion limit as measured by PCS insured losses. Because of the binary feature, the payoff does not depend on the magnitude of the losses above the limit, i.e., indices of \$10.1 billion and \$30 billion would lead to the same contract payoff of \$10,000. Because of the “1<sup>st</sup> event-binary” feature, the contract would not pay off if two catastrophes occurred, one causing damage of \$5 billion and the next causing damage of \$6 billion. If the 1<sup>st</sup> event contract is triggered, the insurer could obtain additional protection by purchasing 2<sup>nd</sup> event contracts. The contract coverage period is the calendar year. Because of the binary feature and the broad geographical area covered by the contracts, the IFEX futures are subject to substantial basis risk except for the largest insurers and reinsurers.

The NYMEX and CME contracts differ from the IFEX contracts in that they are not binary and that regional contracts are available. I.e., instead of paying \$10,000 for any loss that

breaches the trigger, these products are valued at \$X times the value of the triggering index. NYMEX offers contracts covering U.S. losses nationally, U.S. losses for Texas through Maine (excluding Florida), and losses for Florida. The CME offers six U.S. regional contracts. The NYMEX and CME contracts differ in terms of the triggering index, with NYMEX using PCS insured property losses divided by \$10 million and CME using a parametric index developed by Carvill Corporation, which determines loss severity using a mathematical model that is a function of storm wind speed and radius. The NYMEX contracts cover U.S. insured property losses from any cause except earthquake and terrorism, while the CME contracts cover U.S. hurricane losses. The contracts also differ in that the NYMEX losses cover accumulations of losses from any covered cause, whereas CME contracts are available that cover numbered events (e.g., 1<sup>st</sup> event, 2<sup>nd</sup> event), seasonal accumulations, and accumulations from seasonal maximum events. The NYMEX contracts have an annual coverage period, while the CME contracts cover the hurricane season (June 1 through November 30). NYMEX and CME contracts potentially have less basis risk than the IFEX contracts because regional contracts are available. However, the CME adds a source of basis risk by using a parametric index.

It is instructive to compare the insurance futures and options contracts introduced in 2007 with the earlier CBOT-PCS options. The CBOT options were similar to the IFEX and NYMEX options in using PCS index triggers, and they were similar to the NYMEX and CME contracts in offering regional as well as national contracts. The CBOT contracts differed from the 2007-issued contracts in that they primarily covered losses in calendar quarters rather than annually or during the hurricane season and they included losses from all sources, including earthquake.

Except for the fact that IFEX contracts parallel ILWs and the current contracts exclude terrorism and earthquake, there seem few design features in the current contracts that predict that

they will succeed relative to the CBOT-PCS contracts. The hope for success seems to hinge on the market's being more sophisticated at present than it was during the 1990s and on the existence of a much larger volume of CAT bonds and ILWs that could be hedged using futures and options. The futures/options market seems to be affected by an unfortunate "Catch 22," i.e., potential hedgers are unwilling to trade until liquidity develops but no liquidity will develop until sufficient numbers of hedgers are willing to trade. Uncertainties regarding the accounting, regulatory, and rating agency treatment of the contracts also may impede market development. Of course, such problems have been overcome in the past with respect to futures and options on other underlyings (such as non-catastrophe weather risk), and it seems clear that some sort of catastrophe derivatives market will succeed eventually.

#### **4.4. Catastrophe Swaps**

Another type of insurance-linked derivative is the *catastrophe swap*. In a catastrophe swap transaction, the insurer (cedent) agrees to pay a series of fixed premium payments to a counterparty in exchange for floating or variable payments triggered by the occurrence of a specified insured event. The swap can be negotiated directly with the counterparty (e.g., a reinsurer) or placed through another financial intermediary. Although it is not necessary for the swap counterparty to have insurance risk exposure, it is possible for two insurers or reinsurers to swap risks. Swaps also can be executed that fund multiple risks simultaneously such as swapping North Atlantic hurricane risk for Japanese typhoon risk in the same contract as an earthquake swap.

Swaps have advantages over CAT bonds in being simpler to execute, having lower fixed costs, and not tying up funds in a single purpose reinsurer. The disadvantage of swaps relative to CAT bonds is that they are not fully collateralized and therefore expose the buyer to counterparty credit risk. The illiquidity of swaps is also a disadvantage relative to tradable securities such as

bonds and (potentially) options.

Information on the volume of catastrophe swaps is almost entirely anecdotal. For example, in 2007 the newly formed Caribbean Catastrophe Reinsurance Facility (CCRF), which is jointly sponsored by sixteen Caribbean countries to provide immediate liquidity to their governments in the event of a hurricane or earthquake, arranged a \$30 million swap to transfer part of their risk to capital markets (Cummins and Mahul 2008). Another example is the 2003 agreement between Mitsui Sumitomo Insurance and Swiss Re to swap \$12 billion of Japanese typhoon risk against \$50 million each of North Atlantic hurricane and European windstorm risk. In this type of contract, the objective is to calibrate the contract such that no money changes hands until the occurrence of a triggering event.<sup>12</sup>

#### **4.5. CAT Bonds**

Insurance-linked bonds are by far the most successful non-traditional instrument used to hedge both catastrophic and non-catastrophic risks. This section reviews the size and growth of the CAT bond market, discusses the characteristics of CAT bonds, and analyzes CAT bond pricing. The discussion presents significant new information on the returns on CAT bonds and their correlation with other market investment alternatives. CAT bonds are emphasized because they have generated much larger volume than other event-linked securities.

**4.5.1. The CAT Bond Market Size and Growth.** Although the CAT bond market got off to a slow start during the 1990s, the market has matured and has become a steady source of capacity for both insurers and reinsurers. The market set new records for bond issuance volume in 2005, 2006, and 2007. CAT bonds make sound economic sense as a mechanism for funding mega-catastrophes. Catastrophes such as Hurricane Katrina and the fabled and yet to be realized

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<sup>12</sup> For further discussion of risk swaps see Takeda (2002).

\$100 billion-plus “Big One” in California, Tokyo, or Florida are large relative to the resources of the insurance and reinsurance industries but are small relative to the size of capital markets. Securities markets also are more efficient than insurance markets in reducing information asymmetries and facilitating price-discovery. Thus, it makes sense to predict that the CAT bond market will continue to grow and that CAT bonds will eventually be issued in the public securities markets, rather than being confined primarily to private placements as at present.

The new issue volume in the CAT bond market from 1997 through 2007 is shown in Figure 5. The data in the figure apply only to non-life CAT bonds. Recently, event-linked bonds have also been issued to cover third party commercial liability, automobile quota share, and indemnity-based trade credit reinsurance. There is also a growing market in life insurance securitizations of various types. Figure 5 shows that the market has grown from less than \$1 billion per year in 1997 to \$2 billion in 2005, \$4.7 billion in 2006, and \$7 billion in 2007. The number of transactions also has been increasing, to 27 during 2007, many of which had multiple tranches and included “shelf registrations.”<sup>13</sup> A substantial number of the issuers in 2005-2007 were first-time sponsors of CAT bonds, although established players such as Swiss Re continue to play a major role (GC Securities 2008). The amount of risk capital outstanding in CAT bond markets has also grown steadily. Almost \$14 billion of risk capital was outstanding in the CAT bond market by the end of 2007 (GC Securities 2008).

Putting these numbers in perspective, CAT bonds accounted for 8% of global property reinsurance policy limits in 2007 and 12% of U.S. only property limits, compared to 88% and 82%, respectively, for traditional reinsurance and 4% and 6%, respectively for ILWs (GC Securities 2008). Because CAT bonds and ILWs tend to be used for higher layers of coverage,

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<sup>13</sup> Shelf registration allows for additional issuances in future months.

they represented much larger proportions of total limits for high-layer property reinsurance. Hence, the CAT bond market is maturing, and the bonds are becoming part of the strategic arsenal of risk-hedging tools regularly used by insurers and reinsurers.

**4.5.2. CAT Bond Structure.** A typical CAT bond structure is diagrammed in Figure 6. The transaction begins with the formation of a single purpose reinsurer (SPR). The SPR issues bonds to investors and invests the proceeds in safe, short-term securities such as government bonds or AAA corporates, which are held in a trust account. Embedded in the CAT bonds is a call option that is triggered by a defined catastrophic event. On the occurrence of the event, proceeds are released from the SPR to help the insurer pay claims arising from the event. The release of funds is typically proportional to event size rather than binary. In most CAT bonds, the principal is fully at risk, i.e., if the contingent event is sufficiently large, the investors could lose the entire principal in the SPR. In return for the option, the insurer pays a premium to the investors. The fixed returns on the securities held in the trust are usually swapped for floating returns based on LIBOR or some other widely accepted index. The reason for the swap is to immunize the insurer and the investors from interest rate (mark-to-market) risk and also default risk. Thus, the investors receive LIBOR plus the risk premium in return for providing capital to the trust. If no contingent event occurs during the term of the bonds, the principal is returned to the investors upon the expiration of the bonds.

Some CAT bond issues have included *principal protected tranches*, where the return of principal is guaranteed. In this tranche, the triggering event would affect the interest and spread payments and the timing of the repayment of principal. E.g., a two-year CAT bond subject to the payment of interest and a spread premium might convert into a ten-year zero coupon bond that would

return only the principal. Principal protected tranches have become relatively rare, primarily because they do not provide as much risk capital to the sponsor as a principal-at-risk bond.

Insurers prefer to use a SPR to capture the tax and accounting benefits associated with traditional reinsurance.<sup>14</sup> Investors prefer SPRs to isolate the risk of their investment from the general business and insolvency risks of the insurer, thus creating an investment that is a “pure play” in catastrophic risk. In addition, the bonds are fully collateralized, with the collateral held in trust, insulating the investors from credit risk. As a result, the issuer of the securitization can realize lower financing costs through segregation. The transaction also is more transparent than a debt issue by the insurer, because the funds are held in trust and are released according to carefully defined criteria.

**4.5.3. CAT Bond Characteristics.** The characteristics of CAT bonds continue to evolve, but the overall trend is toward a higher degree of standardization. CAT bonds differ in several respects, including types of triggering events, perils and regions covered, bond tenor (time period covered by the bonds), and sponsoring organization.

CAT securities have been structured to pay-off on four types of triggers – insurer-specific catastrophe losses (*indemnity triggers*), insurance-industry catastrophe loss indices (*industry-index triggers*), *modeled loss triggers*, and *parametric triggers*, based on the magnitude of the event. In bonds with indemnity triggers, the bond payoff is determined by the event losses of the issuing insurer; whereas in industry-index triggers, the bond payoff is triggered by the value of an industry loss index such as one of the PCS indices. A pure parametric trigger pays off if the covered event exceeds a specified physical severity level, such as a Richter scale reading for

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<sup>14</sup>Harrington and Niehaus (2003) argue that one important advantage of CAT bonds as a financing mechanism is that corporate tax costs are lower than for financing through equity and that the bond poses less risk in terms of potential future degradations of insurer financial ratings and capital structure than financing through subordinated debt.

an earthquake. In modeled loss triggers, the payoff is determined by simulated losses generated by inputting specific event parameters (Richer scale for earthquakes or wind speed, landfall, and other characteristics for hurricanes) into the catastrophe model maintained by one of the catastrophe modeling firms.

The choice of a trigger for a CAT bond involves a tradeoff between moral hazard and basis risk (Doherty 2000). Pure indemnity triggers are subject to the highest degree of moral hazard because the sponsoring insurer may have lower incentives to underwrite or settle claims carefully once the bond is in place. The lowest degree of moral hazard and highest basis risk are provided by pure parametric triggers, where insurer exposures and losses are completely irrelevant. An intermediate case is provided by modeled triggers, which use as inputs insurer exposure maps and coverage characteristics but do not depend upon actual reported insurer losses. Indices have also been developed that are hybrids of the four basic types or that incorporate more complicated functional forms than standard parametric indices.

Although it might seem that considerations of moral hazard might lead to minimal use of indemnity contracts, the choice of trigger really does seem to involve a tradeoff between the costs of moral hazard, on the one hand, and the costs of basis risk on the other. As a result, no single trigger type predominates in the market. For example, of total CAT bond volume for the period 1997-2007, the percentages of volume by trigger were 30.0% indemnity, 25.9% parametric, 21.5% industry index, 8.5% modeled, and 14.0% hybrid. For 1997, the percentage of indemnity triggers was even higher, 39%. In part, this may reflect incentive provisions included in most CAT bonds, whereby the issuing insurer and bondholders share the risk in a specified proportion above the trigger.

In terms of perils and regions, the U.S. predominates as providing the primary exposure

base for CAT bonds with 29.6% of total volume from 1997-2007 representing U.S. earthquake risk and 31.8% representing U.S. hurricane risks. Other important perils-regions include European windstorm (15.2% of volume), Japan earthquake (11.0%), and Japan typhoon (8.5%). Multiple peril bonds have also grown in popularity over time, accounting for 44.6% of total issue volume from 1997-2007 and 52.3% in 2007. The market has gravitated towards multiple-year bonds, reflecting the desire for issuers to avoid the reinsurance underwriting cycle and spread the fixed costs of bond issuance over time. In terms of number of issues, 77.5% of CAT bonds since 1997 have been for more than one year, and 62.5% have had tenors of three years or more. The most common bond tenor is three years, accounting for 41.7% of the number of bonds issued.

In terms of issuer type, the vast majority of bond volume is sponsored by primary insurers and reinsurers, with a slight increase over time in the importance of primary insurers. For 1997-2007, primary insurers initiated 49.0% of bond volume and reinsurers initiated 46.6%, with the balance mostly consisting of non-insurance sector corporate issues. For 2007, insurers initiated 51.5% of issue volume, and reinsurers accounted for 44.8%. As the market has matured, there has been a major shift over time in the buyers of CAT bonds. In 1999, 55% of CAT bonds by volume were purchased by insurers and reinsurers; but by 2007, only 7% were purchased by insurers and reinsurers and the majority purchaser (55% of volume) consisted of dedicated CAT bond mutual funds. Hence, the market has truly “gone mainstream” during the past few years.

**4.5.4. CAT Bond Prices.** CAT bonds are priced at spreads over LIBOR, meaning that investors receive floating interest plus a spread or premium over the floating rate. In the past, CAT bonds have been notorious for having high spreads, and much has been written trying to explain the magnitude of the spreads (e.g., Froot 2001). However, there are now significant indications that the spreads are not unusually high relative to the cost of reinsurance, such that CAT bonds are now

competitive with conventional reinsurance.

Although CAT bonds are not publicly traded, there is an active non-public secondary market that provides some guidance on yields. The secondary market yields on CAT bonds are shown quarterly from the third quarter of 2001 through the first quarter of 2008 in Figure 7. Figure 7 shows the expected loss, the premium over LIBOR, and the bond spread (ratio of premium to expected loss), based on averages of secondary market transactions.<sup>15</sup>

There are two primary conclusions to be drawn from Figure 7: (1) CAT bond spreads have declined significantly as the market has matured. In 2001, the ratio of premium to expected loss was around 6, consistent with the findings of Cummins, Lalonde, and Phillips (2004) for the period prior to 2001. However, the spreads declined steadily until the time of Hurricane Katrina, standing at slightly over 2.0 in the first quarter of 2001. Hence, the “high” bond prices explored by earlier researchers did not exist by early 2005. (2) The market is not immune to the underwriting cycle, i.e., bond premia and spreads increased significantly as the market tightened following KRW in 2005 and 2006. However, spreads returned to lower levels, trading in the range of 2.5 to 3 during 2007 and early 2008. Analyses of spreads in reinsurance markets indicate that ratios of premiums to expected loss in the range of 3 to 5 are to be expected for the higher layers of coverage targeted by most CAT bonds (Froot and O’Connell 2008, Cummins and Mahul 2008). Thus, it is no longer the case that CAT bonds are significantly more expensive than reinsurance, as the market has matured and become “mainstream.” However, CAT bond prices are affected by underwriting cycles.

It is also relevant to compare CAT bond yields to yields on comparably rated corporate bonds. This comparison is shown in Figure 8, which compares the returns on BB CAT bonds with returns on the Merrill Lynch BB corporate bond index from January 1998 through February 2008.

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<sup>15</sup> The data are from Lane and Beckwith (2005, 2006, 2007b, and 2008).

The results show that BB CAT bond yields were comparable to yields on BB corporate bond yields from 2001 up until the time of Hurricane Katrina in 2005. However, around the time of Katrina, CAT bond returns increased relative to corporates and became much more volatile, although the return gap had been reduced considerably by the end of the period. Thus, even though yields on CAT bonds are now lower and comparable to reinsurance in terms of price, the market remains relatively thin and vulnerable to the effects of mega-catastrophes.

**4.5.5. Correlation With Other Investments.** Proponents of CAT bonds and other ILS have long argued that these securities provide a valuable new source of diversification for investors. In addition to having no credit risk, ILS are often said to be “zero beta” investments in the sense of being uncorrelated with market security returns (Litzenberger, et al., 1996). In the past, little systematic empirical evidence has been presented to support the claim that CAT bonds are valuable for diversification. However, beginning in 2001, several CAT bond mutual funds were established which provide price data through Bloomberg.com and other sources. In addition, to provide more transparency to participants in the CAT bond market, Swiss Re began compiling CAT bond investment performance indices in 2007, based on secondary market trading. The CAT bond mutual funds and Swiss Re CAT bond index data are analyzed in this paper to provide evidence on the attractiveness of CAT bonds as investments.

Summary statistics on the CAT bond mutual funds listed on Bloomberg are provided in Table 2. The table shows that the funds are relatively small, ranging in size from \$35 million to \$366 million. However, CAT bond funds have substantially more up periods than down periods and none of the funds has a negative average return, unusual for a period characterized by significant market turbulence (i.e., none of the funds existed prior to 2001 and hence the returns do not incorporate the stock market boom years of the 1990s). Four of the thirteen mutual CAT

Bond funds reported in the table are restricted to institutional investors. These funds have high initial minimum investments such as \$1 million, whereas the other (low price) funds reported in the table have much lower initial minimum investment requirements. The average prices for the institutional investor restricted (high price) funds are in the range of \$10<sup>4</sup>, while the price of the other CAT Bond mutual funds reported are in the range of \$10<sup>2</sup>.

Swiss Re maintains four total return insurance-linked securities (ILS) indices – an overall ILS index, a BB-rated index, a California earthquake index, and a U.S. windstorm index.<sup>16</sup> As a first look at the correlations between returns on ILS and other assets, the bivariate correlation matrix of the Swiss Re BB-rated ILS index with four other investment indices is shown in Table 3. The correlations are for total returns on the indices shown in the table, i.e., the returns include both coupon and price returns for bonds and dividends and price returns for stocks. The results indicate that insurance-linked securities have very low correlations with the other investment classes shown in the table. The correlation with the Standard & Poor's 500 stock index is 0.03, insignificantly different from zero. Hence, CAT bonds appear to be zero beta securities, as proponents have long maintained. The correlations with debt securities are also very low. E.g., the correlation of the Swiss Re index with the 3-month Libor yield is 0.11, and the correlation with the Lehman Brothers BB corporate bond index is 0.22. The correlations with the debt indices are expected because part of the return on CAT bonds comes from the coupon return, i.e., the bond holders receive LIBOR plus the premium. Overall, however, it is clear that CAT bonds have low correlations with other asset classes.<sup>17</sup>

To provide additional information on the relationship between CAT bond returns and

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<sup>16</sup> The indices are based on secondary market prices, and the data series begin on January 6, 2005.

<sup>17</sup> Empirical evidence that catastrophes are uncorrelated with the stock market in Japan is provided in Yang, Wang, and Chen (2008). They conduct an event study that there is no significant catastrophe effect for the Japanese stock market as a whole, although catastrophes have a negative effect on insurance stocks and a positive effect on construction industry stocks.

returns on other assets, we conducted regression analysis. Specifically, the following regression equation was estimated for each of the Swiss Re total return indices:

$$\log(I_{ILS,t} / I_{ILS,t-1}) = \alpha + \beta_1 \log(I_{BI,t} / I_{BI,t-1}) + \beta_2 \log(I_{SP,t} / I_{SP,t-1}) + \beta_3 \log(R_{Baa,t}) + \varepsilon_t \quad (2)$$

where  $I_{ILS,t}$  = Swiss Re total return index in period t,

$I_{BI,t}$  = Merrill Lynch U.S. BBB bond index in period t,

$I_{BY,t}$  = Moody's U.S. Baa corporate bond yield in period t, and

$\varepsilon_t$  = a random error term for period t.

Regressions were run including each independent variable separately, including all two-variable combinations of the three regressors, and including all three regressors. The sample consists of weekly return data from 1/6/2005 to 1/30/2008.

Analogous regressions were estimated for each of the mutual funds reported on Bloomberg.com for which sufficient data were available; that is  $\log(P_{i,t}/P_{i,t-1})$  was substituted as the dependent variable in equation (2), where  $P_{i,t}$  is the price of mutual fund i in period t. In addition, for the mutual funds, a pooled regression was estimated, specified as follows:

$$\log(P_{i,t} / P_{i,t-1}) = \alpha + \beta_1 \log(I_{BI,t} / I_{BI,t-1}) + \beta_2 \log(I_{SP,t} / I_{SP,t-1}) + \beta_3 \log(R_{Baa,t}) + \omega_i + \varepsilon_t \quad (3)$$

where  $\omega_i$  = a unit (fixed-effect) coefficient for mutual fund i.

The reason for running the pooled regression was to expand the number of degrees of freedom to explore relationships that might be obscured in individual fund regressions due to the small number of time series observations per fund.<sup>18</sup> Because the funds restricted to institutional investors are aimed at different audiences and hence may have different stochastic properties, they were analyzed in a separate panel regression. That is, equation (3) was estimated with

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<sup>18</sup> We did not run a pooled regression for the Swiss Re indices because the California earthquake and U.S. windstorm indices are subsets of the overall and BB bond indices, and the BB bond index is a subset of the overall index.

returns for the institutional investor restricted funds and once more for the funds with no institutional investor restriction.

Similarly to equation (2) all panel regressions were run using one, combinations of two, and all three regressors. The dependent variables in equation (3) were converted into USD before running the regression, and the sample consisted of monthly returns from fund inception to 6/27/2008.<sup>19</sup>

The results of the Swiss Re index total return regression analysis is shown in Table 4. The degree of explanatory power of the regressions is very low. The maximum adjusted  $R^2$  in all of the regressions is 0.02, indicating that CAT bond returns are generally not correlated with returns on stocks and bonds. The variable that is statistically significant most frequently is the Moody's Baa corporate bond yield, as expected, because part of the return on a CAT bond consists of the coupon payment. The Standard & Poor's 500 stock index return is significant for the U.S. windstorm CAT bond total return, but the betas are very low (maximum of 0.03). This provides further evidence that CAT bonds are close to being zero-beta securities and hence valuable to investors for diversification.

Because the individual mutual fund regression table is lengthy and the results are consistent with those of the pooled regressions, only the pooled regression results are shown in the paper.<sup>20</sup> The results for the low-price mutual funds are shown in Table 5, and the results for the high price mutual funds are shown in Table 6.

The results for the low price mutual funds, shown in Table 5 reveal significant positive relationships between CAT bond mutual fund returns and the Moody's Baa corporate bond yield, reflecting the interest part of the bond premium received by investors. The return on the Merrill-

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<sup>19</sup> For some funds, the sample period was shorter, such for ELNCTBD.

<sup>20</sup> The individual mutual fund regression results are available from the authors.

Lynch total return index is also statistically significant in the fixed effect regressions but not in the regressions that exclude fixed effects. The fixed effects regressions are likely to be more reliable, given that statistical tests revealed that fixed effects are present in the data. Therefore, it is interesting to conclude that CAT bond total returns are correlated with total returns on BBB corporates, as suggested by Figure 8, even though the betas are low, in the range of 0.1 to 0.13. In the more fully specified models, the CAT bond returns are also significantly related to the S&P 500 index, although again the betas are quite low, in the range of 0.055. These results suggest that even if CAT bonds are not truly “zero-beta,” they are very close.

The results for the high price mutual funds, shown in Table 6, show fewer significant coefficients, probably because of the smaller number of observations. Here only the Merrill Lynch BBB bond returns are statistically significant in the fixed effects regressions. However, the betas are considerably higher than for the low price mutual funds, in the range of 0.26 to 0.33. This may be because the high price funds have adopted more aggressive return objectives, doing more trading in non-ILS assets, whereas the low price funds are purer ILS funds.<sup>21</sup> Overall, however, the R<sup>2</sup> statistics in these regressions confirm that ILS are not highly correlated with other asset classes and therefore are valuable as portfolio diversifiers.

**4.5.6. CAT Bonds: Conclusions.** The CAT bond market is maturing and seems to have become a permanent and mainstream component of the risk transfer landscape. The market is broader and deeper than ever, and bond securitizations have expanded to encompass new types of risks such as automobile, liability, and agricultural losses as well as sovereign risks, as exemplified by the 2006 Mexican CAT bond issue, designed to provide funds to the Mexican

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<sup>21</sup> None of the funds included in the study has an objective of investing 100% in ILS. Most of the funds say they will invest at least 75% in this type of asset, and some of the funds just indicate that they will invest a high percentage of assets in bonds.

government to aid in earthquake disaster relief (e.g., Vedenov, et al. 2006, Cardenas 2006, Cummins and Mahul 2008). Bond prices have declined and the market has become more liquid, with the investment base expanding to include institutional investors, hedge funds, and dedicated CAT bond mutual funds, among others. Nevertheless, the market remains small relative to other asset backed securities markets and is susceptible to price volatility from catastrophic events and reinsurance cycles. In the future, continued growth of the market can be expected, which should help to moderate the effects of underwriting cycles, increase liquidity, and further improve the efficiency of risk transfer markets.

## **5. Conclusions**

Although reinsurance was one of the first truly global financial markets, the inherent conservatism and inertia in the insurance and reinsurance industries as well as technological and informational problems long impeded the convergence of (re)insurance and financial markets. However, a number of forces have emerged during the past two decades which have accelerated convergence. Perhaps the most important driver of convergence is the growth in property values in geographical areas prone to catastrophic risk. For example, Hurricanes Katrina, Rita, and Wilma and other events combined to cause insured losses of \$114 billion in 2005 (Swiss Re 2008), placing renewed stress on the capacity of the (re)insurance industry. Thus, insurers and reinsurers are virtually compelled to seek capital market solutions to their risk-bearing capacity problems. A second major driver of convergence is the reinsurance underwriting cycle, which forces insurers to periodically experience high prices and coverage restrictions which inhibit risk management and create market inefficiencies. Other factors that are driving convergence include the growth of enterprise risk management, advances in computing and communications technologies, modern financial theory, and regulatory, accounting, and tax factors.

The quest for convergence has led to a significant amount of experimentation and financial innovation over the past quarter century. The two principal types of convergence-oriented financial products are reinsurance-financial hybrid instruments that combine features of reinsurance with financial market concepts and insurance-linked swaps, futures, options, and bonds, which parallel the product design-features of financial products and access securities markets directly rather than relying on the capacity of insurance and reinsurance markets.

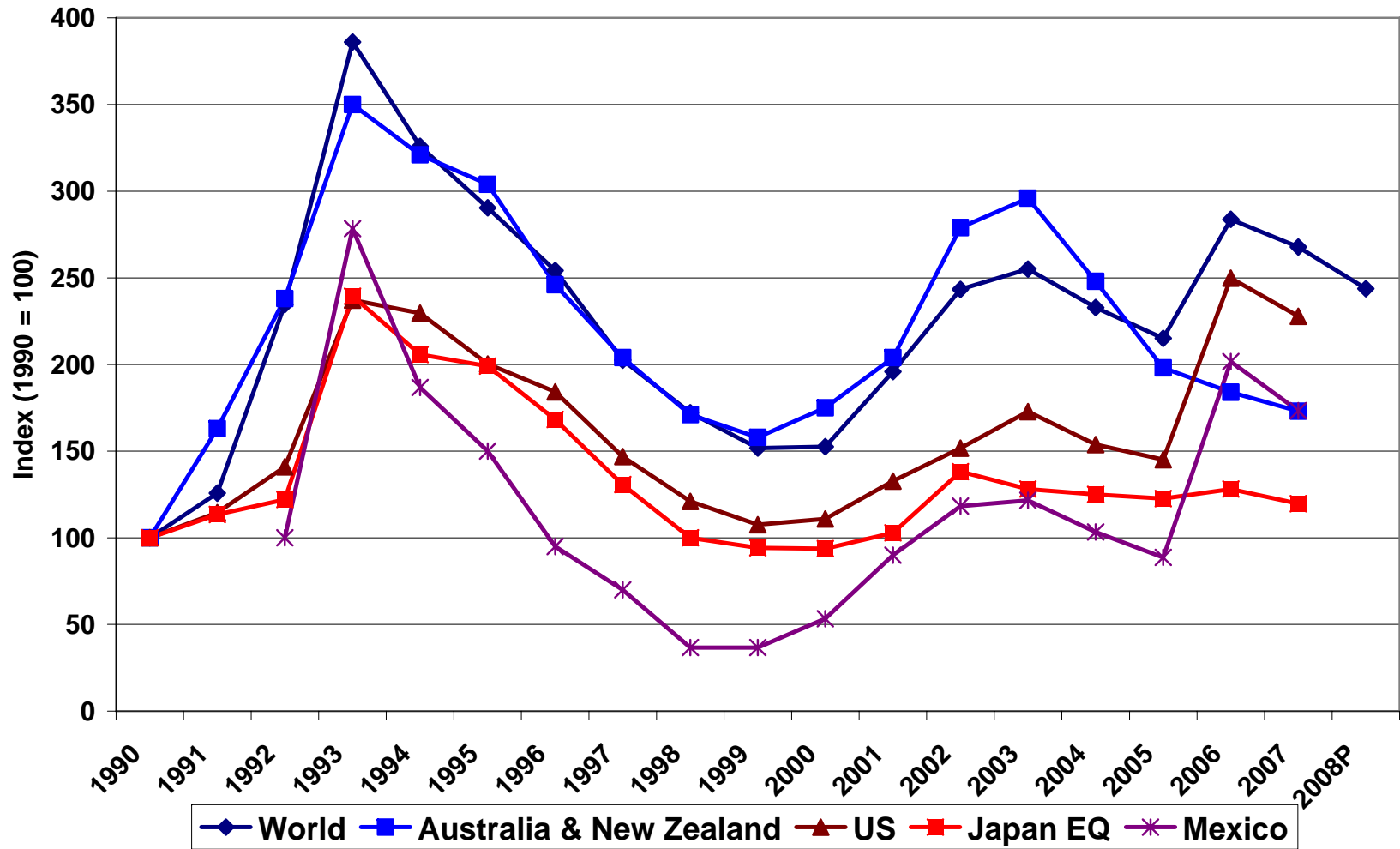
A variety of hybrid products have been developed. Products that are closer to reinsurance than to financial products include finite reinsurance, multi-year and multi-trigger products. However, more evolutionary products also have been developed including industry loss warranties (ILWs) and sidecars. It appears that ILWs are the most successful of the hybrid products and that sidecars have an important role to play in expanding capacity during hard markets and hence mitigating somewhat the effects of underwriting cycles. The case to be made for more opaque products such as multi-year, multi-trigger reinsurance is weaker and the continued success of these contracts remains in doubt.

Although there continues to be some activity in the contingent capital and insurance swaps market, the securitized insurance products that have been most successful are insurance-linked bonds, especially CAT bonds. The CAT bond market is thriving and seems to have reached “critical mass,” achieving record bond issuance in 2005, 2006, and 2007. Bond premia have declined significantly since 2001, and the bonds are now priced competitively with catastrophe reinsurance. CAT bonds and ILWs now account for a significant share of the property catastrophe reinsurance market, especially for high coverage layers.

Overall, the future looks bright for the insurance-linked securities market. CAT bonds, swaps, sidecars, industry loss warranties, and other innovative products will play an increasingly

important role in providing risk financing for large catastrophic events. Event-linked bonds are also being used increasingly by primary insurers for lower layers of coverage and non-catastrophe coverages such as automobile, agricultural, commercial liability, and sovereign disaster relief financing insurance. However, it remains to be seen whether CAT futures and options will play an important role in catastrophe risk management in the years to come. Basis risk and counterparty credit risk, as well as the need to educate insurance industry participants, are the primary impediments to the success of these contracts.

**Figure 1**  
**Catastrophe Reinsurance: World Rate on Line Index**



Source: Guy Carpenter (2008).

**Figure 2: Alternative Risk Transfer**

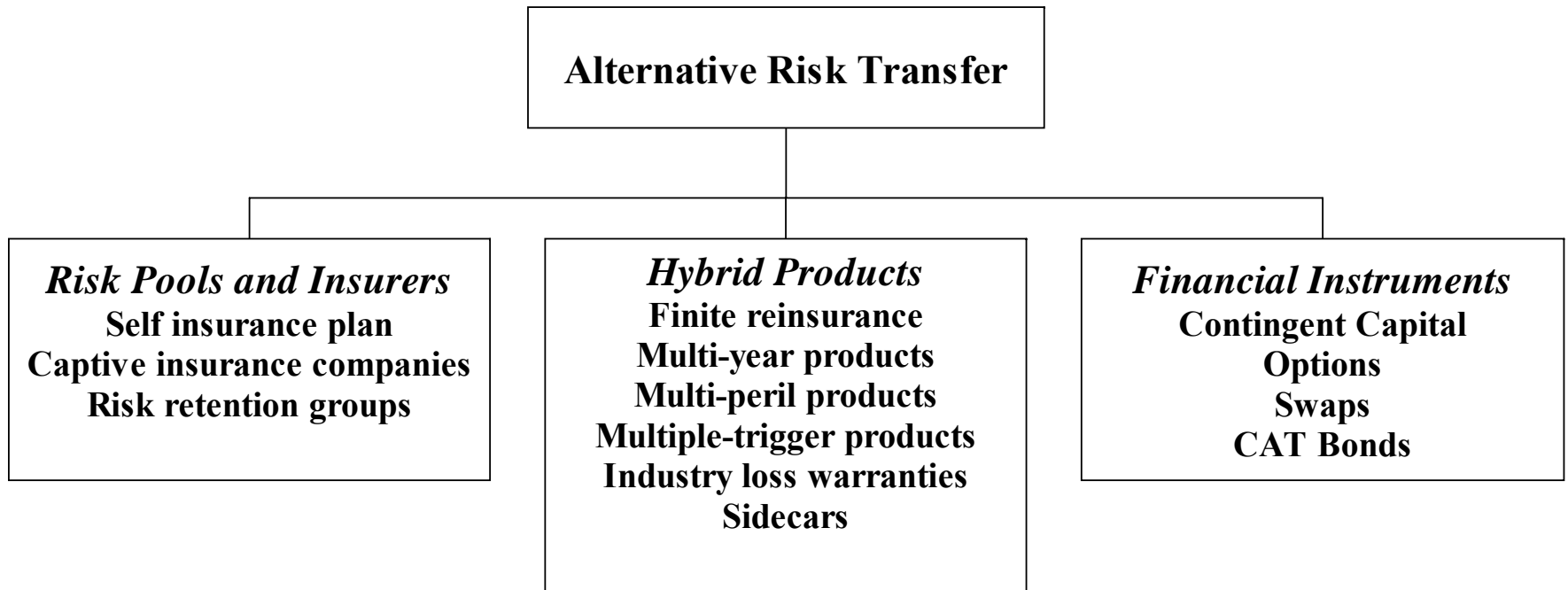
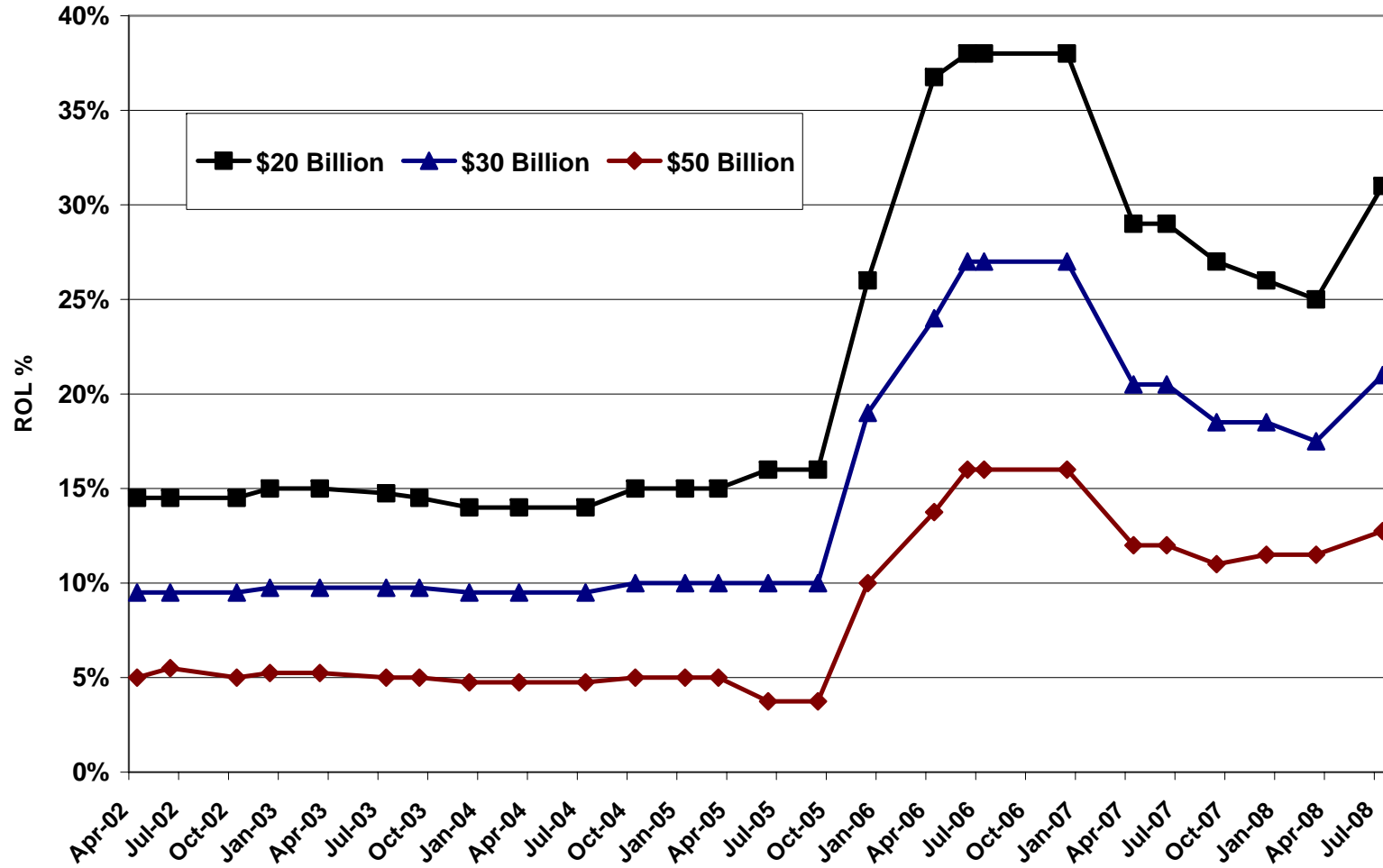


Figure 3: ILW Pricing: U.S. All Perils



Source: Access Re.

**Figure 4**  
**The Structure of a Typical Side-Car**

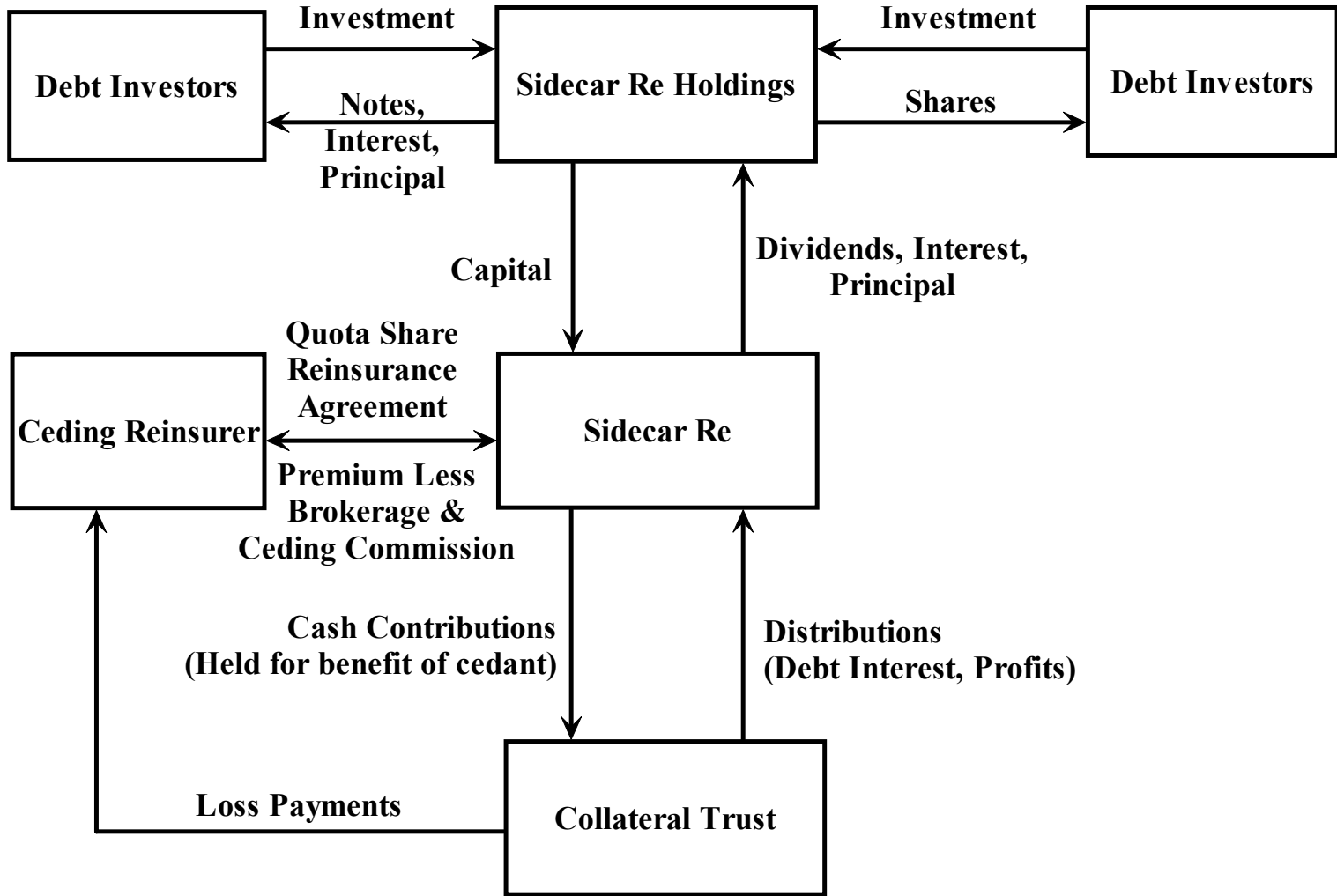
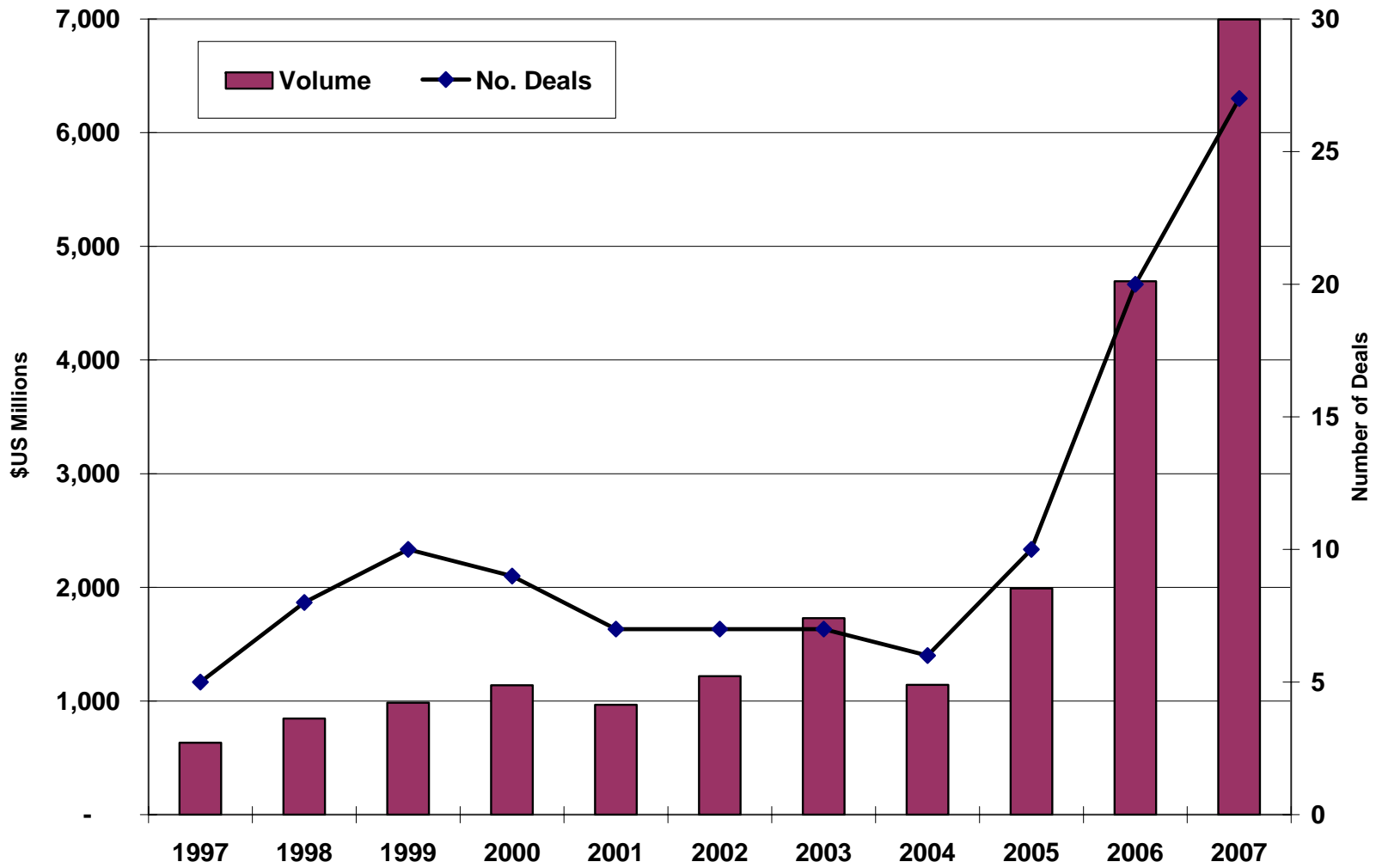


Figure 5 : CAT Bond New Issue Volume



Source: GC Securities (2008).

**Figure 6**  
**CAT Bond With Single Purpose Reinsurer**

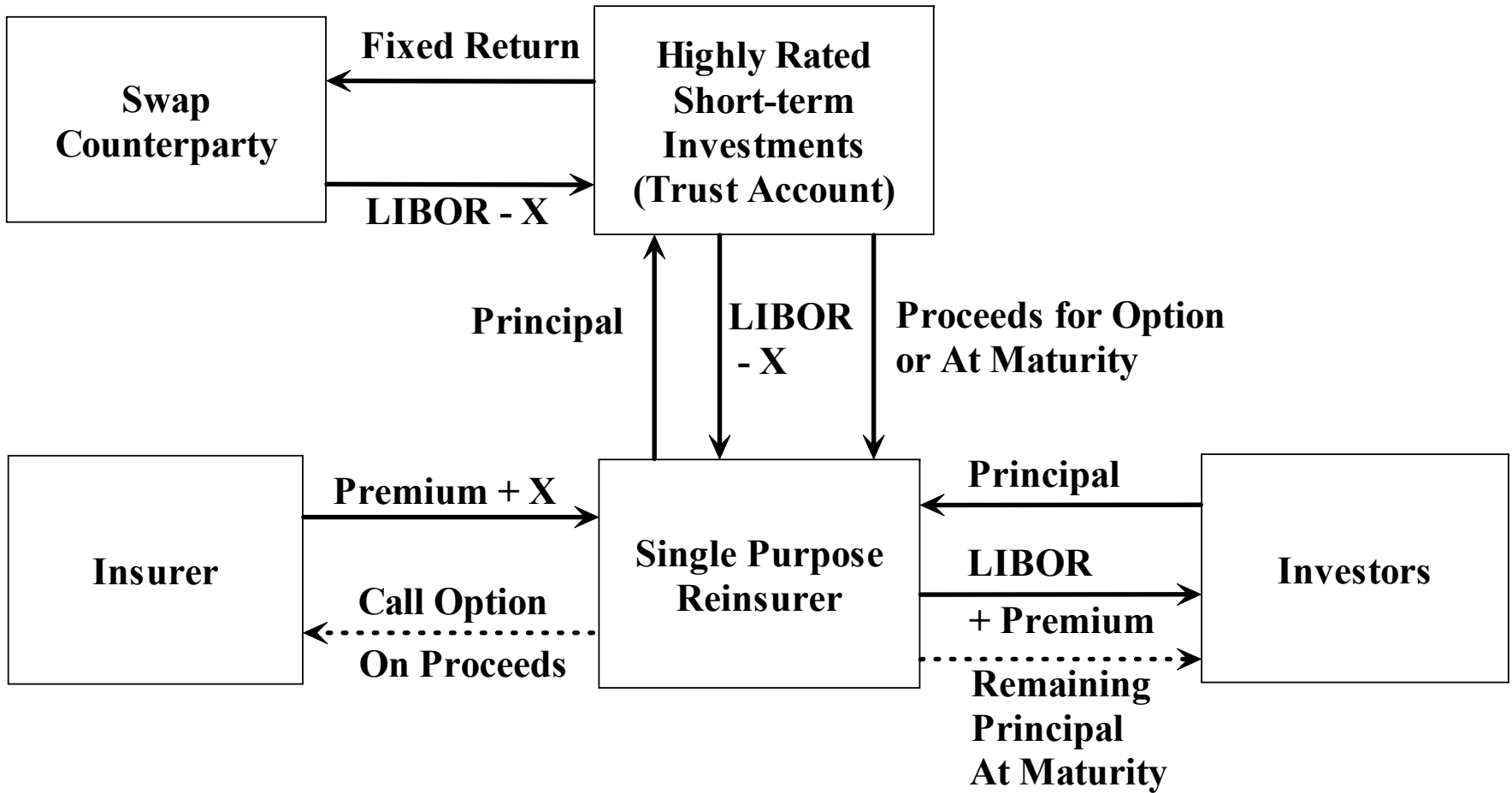
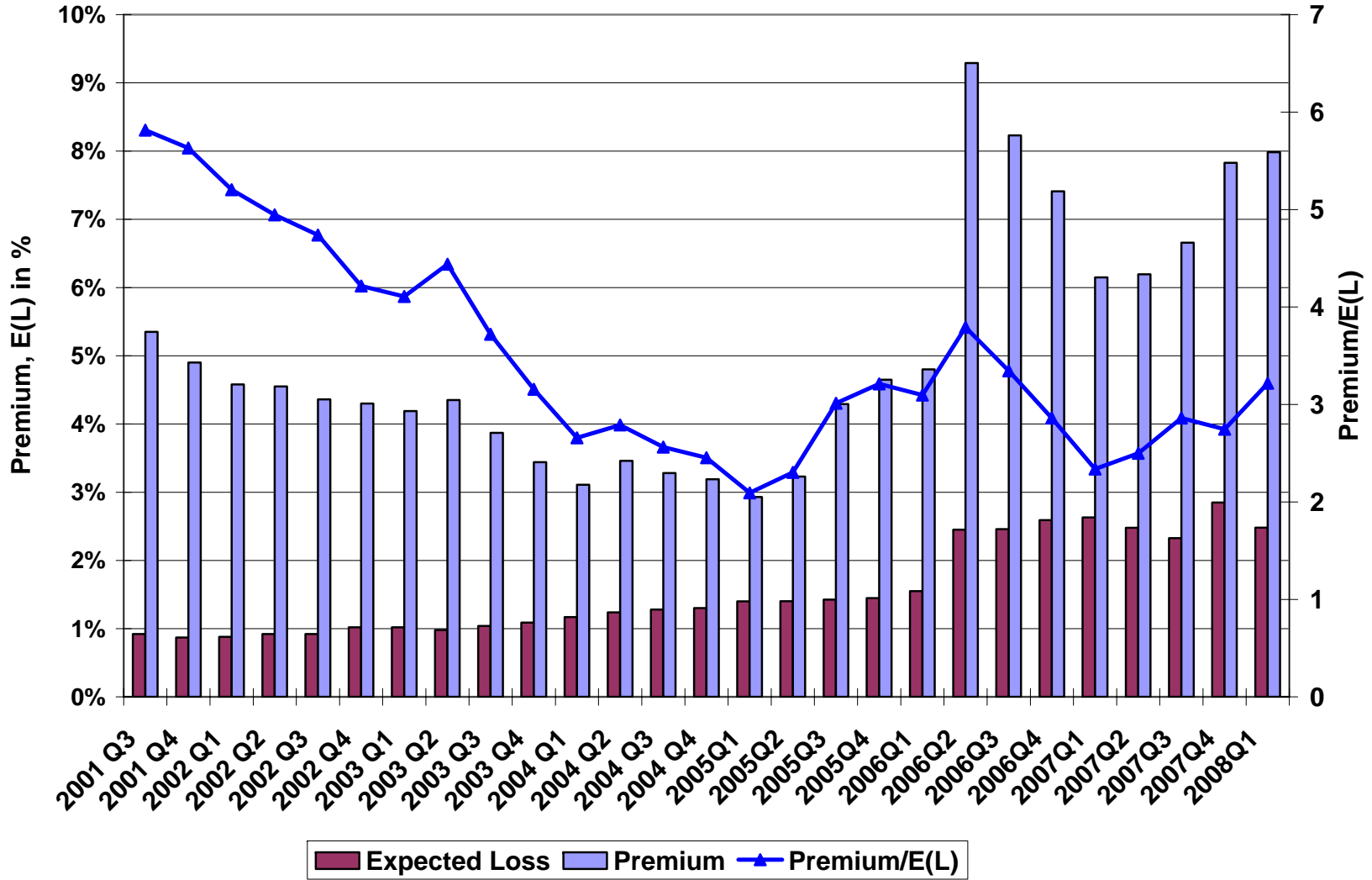
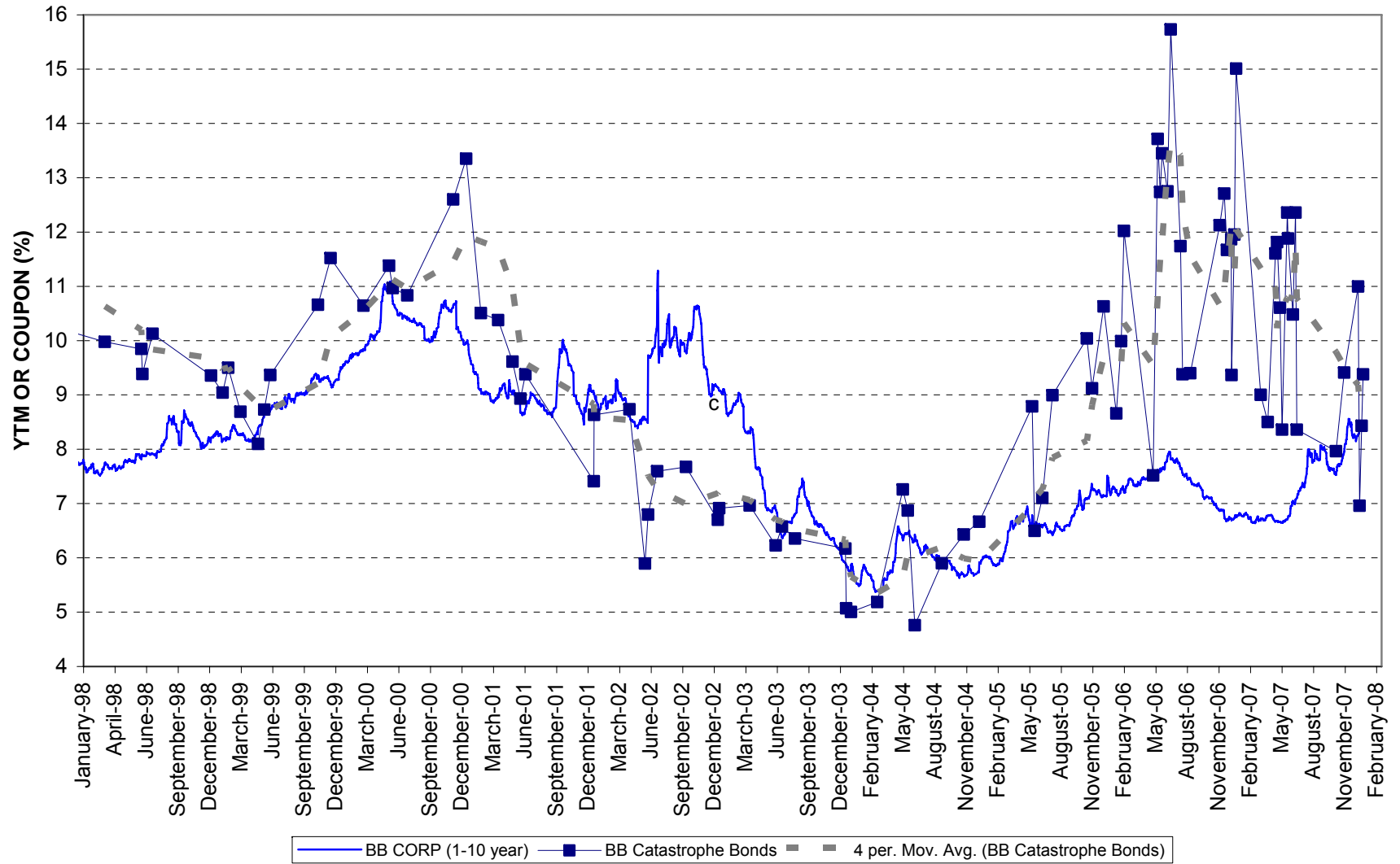


Figure 7: CAT Bond Pricing



**FIGURE 8 : CATASTROPHE BONDS VS. COMPARABLE CORPORATE BONDS 1997 - 2007**



**Table 1: Principal Characteristics of Catastrophe Futures and Options**

<b>Exchange</b>	<b>IFEX</b>	<b>NYMEX</b>	<b>CME</b>	<b>CBOT PCS</b>
Type of Contract	Futures	Futures and options	Futures and options	Options
Loss Index	PCS	PCS/Gallagher Re	Carvill Hurricane Index (parametric) (CHI)	PCS
Index Definition	PCS loss	PCS loss/10 M	Index is function of storm wind speed/radius	PCS Loss/100M
Event	U.S. tropical wind	U.S. insured property losses ex terrorism & earthquake	U.S. hurricane	U.S. insured property losses
Geographical Region	50 U.S. states, DC, Puerto Rico, Virgin Isl	National Texas-Maine (ex Florida) Florida	Six U.S. regions	National, 5 regions, 3 states
Trigger	Annual aggregate losses from (1) 1 <sup>st</sup> event, or (2) 2 <sup>nd</sup> event	Annual aggregate loss	Aggregate loss	Aggregate loss in geographical area
Trigger Products	\$10, \$20, \$30, \$40, and \$50 billion losses	Not applicable	(1) Numbered event, (2) seasonal, (3) seasonal maximum event	Strikes in multiples of 5 points
Trigger Type	Binary	Aggregate/European	Aggregate/American	
Contract Payoff	$\$10,000 \text{Max}[I-T,0]/I$	$\$10 * \text{Index}$	$\$1,000 * \text{CHI}$	\$200 per index point
Maximum Payout	\$10,000 per option	No maximum	No maximum	No maximum
Contract Period	Annual	Annual	(1) landfall + 2 days (2) 6/1 to 11/30 + 2 days (3) 6/1 to 2 days after 11/30	Calendar quarter
Contract Expiration	18 months after end of contract period	3 months after close of year	(1) 2 days after landfall (2) 11/30 + 2 days (3) 11/30 + 2 days	6 or 12 month development period
Launch date	9/21/2007	3/5/ 2007	3/12/2007	9/1995

Note: IFEX = Insurance Futures Exchange, NYMEX = New York Mercantile Exchange, CME = Chicago Mercantile Exchange, CBOT = Chicago Board of Trade, PCS = Property Claims Services.

**Table 2**  
**CAT Mutual Fund Key Statistics**

**Panel A: No Institutional Investor Restrictions**

Ticker Symbol	ACATCHA	ACATEUA	ACATUSA	LPC2USD	LPC2CHF	LPC2EUR	LEUPCBC	LEUPCBE	LEUPCBU
Maximum Return (monthly %)	1.21	1.32	1.46	1.59	1.10	1.22	1.49	1.23	1.33
Minimum Return (monthly %)	-2.20	-1.93	-2.19	-2.51	-1.90	-1.77	-1.07	-1.35	-2.33
Average Return (monthly %)	0.41	0.66	0.38	0.36	0.46	0.33	0.93	1.10	0.38
Sharpe Ratio	1.21	0.99	2.04	2.23	2.61	1.68	1.95	1.59	2.16
Volatility	1.69	2.02	2.19	2.84	2.13	3.31	1.63	2.06	2.28
% Periods up	77.27	84.09	90.91	90.57	88.68	90.57	86.90	88.10	90.48
% Periods down	22.73	15.91	9.09	9.43	11.32	9.43	13.10	11.90	9.52
Skewness	1.49	1.65	1.79	1.53	1.69	2.43	1.73	1.58	1.73
Assets (USD mil)	225.932	333.651	235.92	34.87	103.731	54.705	305.12	281.881	161.75
Inception Date	10/11/2004	10/11/2004	10/11/2004	6/30/2003	6/30/2003	6/30/2003	1/1/2001	1/1/2001	1/1/2001

**Panel B: Institutional Investors only**

	ACATCHI	ACATEUI	ACATUSI	ELNCTBD
Maximum Return (monthly %)	1.25	1.35	1.50	0.67
Minimum Return (monthly %)	-1.86	-2.27	-2.28	0.15
Average Return (monthly %)	0.44	1.00	0.47	1.57
Sharpe Ratio	1.51	1.11	2.17	2.96
Volatility	1.75	2.15	2.3	0.41
% Periods up	77.27	84.09	90.63	100.00
% Periods down	22.73	15.91	9.37	0.00
Skewness	1.74	1.57	1.75	-0.48
Assets (USD mil)	225.932	366.651	235.918	138.898
Inception Date	10/11/2004	4/29/2005	4/29/2005	12/22/2006

Note: All fund returns are monthly measures. Maximum Return, Minimum Return, Volatility, and Skewness are measured in percentages. Assets valued as of 5/30/2008 except for LPC2CHF, LPC2EUR, and LPC2USD which are valued as of 11/30/2007

Note: Funds included are AIG Diversified CAT Bond Fund - Asfr (ticker ACATCHA); Aig Diversified CAT Bond Fund - Euro A (ticker ACATEUA); AIG Diversified CAT Bond Fund (ticker ACATUSA); Clariden Leu CAT Bond Fund CHF-Class (ticker LEUPCBC); Clariden Leu CAT Bond Fund Eur-Class (ticker LEUPCBE); Clariden Leu CAT Bond Fund USD-Class (ticker LEUPCBU); and Clariden Leu CAT Bond Fund II USD-Class (ticker: LPC2USD); AIG Diversified CAT Bond Fund - Isfr (ticker ACATCHI); AIG Diversified CAT Bond Fund - Euro I (ticker ACATEUI); AIG Diversified CAT Bond Fund - USD I (ticker ACATUSI); and Elan CAT Bonds (ticker ELNCTBD). All funds are registered in Switzerland, except for ELNCTBD which is registered in France. Average annual returns are computed over the period 12/31/2004 to 6/27/2008 for ACATCHA, ACATEUI, ACATEUA, and ACATUSA. Average annual returns are computed over the period 6/30/2005 to 6/27/2008 for ACATEUI and from 12/31/2005 to 6/27/2008 for ACATUSI, respectively. Average annual returns are computed from 2/28/2007 for ELNCTCBD and from 1/31/2002 to 5/30/2007 for LEUPCBC and 2/27/2008 to 11/30/2007 for LPC2CHF, respectively. Average annual returns are computed from 9/30/2003 to 11/30/2007 for LPC2EUR and from 8/29/2003 to 11/30/2007 for LPC2USD, respectively. Minimum and Maximum returns and percents of periods up and down computed over the same periods as for average returns.

**Table 3**  
**Correlation Matrix of Returns on Insurance-Linked Securities (ILS) and Other Asset Classes**  
**January 2002 to September 2007**

	<b>Libor 3 Month</b>	<b>Swiss Re BB ILS</b>	<b>LB Government Bond</b>	<b>LB BBB Corporate Bond</b>	<b>S&amp;P 500</b>
<b>Libor 3 Month</b>	1.00	0.26	0.01	-0.10	0.07
<b>Swiss Re BB ILS</b>	0.11	1.00	0.22	0.22	0.03
<b>LB Government Bond</b>	0.01	0.22	1.00	0.77	-0.39
<b>LB Corp BBB</b>	-0.10	0.22	0.77	1.00	0.03
<b>S&amp;P 500</b>	0.07	0.03	-0.39	0.03	1.00

Source: GC Securities Ltd.

Note: Libor 3 Month = 3 month London interbank offer rate, Swiss Re BB ILS = Swiss Re BB insurance-linked securities index, LB = Lehman Brothers, S&P 500 = Standard & Poor's 500 stock index.

**Table 4**  
**Regressions of Changes in Swiss Re CAT Bond Indexes**  
**Weekly data from 1/6/2005 to 5/30/2008**

Swiss Re Cat Bond Index	$\Delta$ (Merril Lynch U.S. BBB Bond Index)		$\Delta$ (S&P Weekly Average Index)		Moody's Seasoned Baa Corp. Bond Yld		Intercept		N	Adjusted R2
	Coeff.	t-stat	Coeff.	t-stat	Coeff.	t-stat	Coeff.	t-stat		
<b>SRCATTRR: Swiss Re CAT Bond Total Return Index</b>										
Model 1	-0.00317	-0.16					0.00205	13.72 ***	180	-0.01
Model 2			0.01191	1.30			0.00214	13.18 ***	162	0.00
Model 3					0.00088	2.26 **	-0.00361	-1.44	180	0.01
Model 4	-0.00025	-0.01	0.01190	1.29			0.00214	13.21 ***	162	0.00
Model 5	0.00017	0.01			0.00088	2.27 **	-0.00361	-1.45	180	0.01
Model 6			0.01244	1.36	0.00077	1.67 *	-0.00281	-0.94	162	0.01
Model 7	0.00374	0.18	0.01260	1.37	0.00077	1.68 *	-0.00284	-0.95	162	0.00
<b>SRBBTRR: Swiss Re BB Rated CAT Bond Total Return</b>										
Model 1	-0.01060	-0.53					0.00162	10.28 ***	180	0.00
Model 2			0.01463	1.55			0.00172	10.87 ***	162	0.01
Model 3					0.00072	1.46	-0.00301	-0.93	180	0.01
Model 4	-0.01247	-0.58	0.01410	1.47			0.00173	10.89 ***	162	0.00
Model 5	-0.00790	-0.38			0.00071	1.43	-0.00296	-0.90	180	0.00
Model 6			0.01488	1.58	0.00036	0.70	-0.00062	-0.18	162	0.00
Model 7	-0.01068	-0.49	0.01441	1.50	0.00035	0.66	-0.00051	-0.15	162	0.00
<b>SREQTRR: Swiss Re California Earthquake CAT Bond Total Return Index</b>										
Model 1	0.00411	0.30					0.00176	16.49 ***	180	-0.01
Model 2			-0.00050	-0.12			0.00189	19.01 ***	162	-0.01
Model 3					0.00064	2.20 **	-0.00236	-1.30	180	0.02
Model 4	0.00600	0.45	-0.00024	-0.06			0.00189	18.75 ***	162	-0.01
Model 5	0.00656	0.47			0.00065	2.23 **	-0.00240	-1.33	180	0.01
Model 6			-0.00005	-0.01	0.00065	2.48 **	-0.00232	-1.39	162	0.01
Model 7	0.00945	0.65	0.00037	0.09	0.00067	2.52 **	-0.00241	-1.44	162	0.01
<b>SRUSWTRR: Swiss Re US Wind CAT Bond Total Return Index</b>										
Model 1	0.02551	0.79					0.00232	9.64 ***	180	0.00
Model 2			0.02821	2.05 **			0.00252	10.67 ***	162	0.02
Model 3					0.00114	1.76 *	-0.00497	-1.20	180	0.01
Model 4	0.03710	1.22	0.02981	2.12 **			0.00250	10.58 ***	162	0.01
Model 5	0.02993	0.91			0.00117	1.81 *	-0.00518	-1.25	180	0.00
Model 6			0.02868	2.07 **	0.00068	1.00	-0.00184	-0.42	162	0.01
Model 7	0.04091	1.35	0.03048	2.16 **	0.00074	1.08	-0.00225	-0.51	162	0.01

Note: \* significant at 10%, \*\* significant at 5%, and \*\*\* significant at 1%. All t-statistics calculated with robust standard errors. All index values have values equal to 100 as of 1/6/2005. The symbol  $\Delta$  signifies the variable is defined as  $\ln(X_t) - \ln(X_{t-1})$ .

Note: SRCATTRR Index tracks the total rate of return for all outstanding USD denominated cat bonds. SRBBTRR Index tracks tracks the total return for all outstanding USD denominated 'BB' cat bonds, rated by S&P at the inception of the cat bond. SREQTRR Index tracks the total return for all single peril California earthquake cat bonds. SRUSWTRR Index tracks the total return for all single peril US wind cat bonds. All indexes are based on Swiss re pricing indications only.

**Table 5**  
**Panel Data Regressions of Change in CAT Bond Mutual Fund Prices**  
**Monthly Data from Fund Inception to 5/30/2008**  
**Low Price-Low Initial Investment**

	$\Delta$ (Merril Lynch U.S. BBB Bond Index)		$\Delta$ (S&P Weekly Average Index)		Moody's Seasoned Baa Corp. Bond Yld		Intercept		N	Adjusted R2
	Coeff.	t-stat	Coeff.	t-stat	Coeff.	t-stat	Coeff.	t-stat		
<b>No Fixed Effects</b>										
Model 1	0.10688	1.21					0.00603	7.46 ***	512	0.00
Model 2			0.01155	0.42			0.00641	7.77 ***	515	0.00
Model 3					0.00770	4.69 ***	-0.04388	-4.08 ***	512	0.04
Model 4	0.10517	1.20	0.01320	0.47			0.00599	7.23 ***	512	0.00
Model 5			0.05564	2.07 **	0.00871	5.34 ***	-0.05070	-4.75 ***	512	0.04
Model 6	0.13355	1.65 *			0.00799	4.92 ***	-0.04625	-4.35 ***	512	0.04
Model 7	0.12980	1.59	0.05403	2.06 **	0.00896	5.61 ***	-0.05281	-5.07 ***	512	0.05
<b>Fixed Effects</b>										
Model 1	0.10208	2.55 **					0.00605	42.09 ***	512	0.00
Model 2			0.01214	0.51			0.00641	75.09 ***	515	0.00
Model 3					0.00790	2.74 ***	-0.04518	-2.40 **	512	0.04
Model 4	0.10010	2.42 **	0.01488	0.62			0.00600	40.70 ***	512	0.00
Model 5			0.05566	2.15 **	0.00895	2.86 ***	-0.05227	-2.55 **	512	0.04
Model 6	0.13401	2.89 ***			0.00827	2.74 ***	-0.04811	-2.42 **	512	0.04
Model 7	0.13070	2.79 ***	0.05424	2.13 **	0.00929	2.86 ***	-0.05495	-2.57 **	512	0.05

Note: \* significant at 10%, \*\* significant at 5%, and \*\*\* significant at 1%. All t-statistics calculated with robust standard errors. All prices stated in USD.

The symbol  $\Delta$  signifies variable defined as  $\ln(X_t) - \ln(X_{t-1})$ .

Note: Funds included are AIG Diversified CAT Bond Fund - Asfr (ticker ACATCHA); AIG Diversified CAT Bond Fund - Euro A (ticker ACATEUA); AIG Diversified CAT Bond Fund (ticker ACATUSA); Clariden Leu CAT Bond Fund CHF-Class (ticker LEUPCBC); Clariden Leu CAT Bond Fund Eur-Class (ticker LEUPCBE); Clariden Leu CAT Bond Fund USD-Class (ticker LEUPCBU); and Clariden Leu CAT Bond Fund II USD-Class (ticker: LPC2USD). All funds are registered in Switzerland.

**Table 6**  
**Panel Data Regressions of Change in CAT Bond Mutual Fund Prices**  
**Monthly Data from Fund Inception to 5/30/2008**  
**High Price-High Initial Investment**

	$\Delta(\text{Merril Lynch U.S. BBB Bond Index})$		$\Delta(\text{S\&P Weekly Average Index})$		Moody's Seasoned Baa Corp. Bond Yld		Intercept		N	Adjusted R2
	Coeff.	t-stat	Coeff.	t-stat	Coeff.	t-stat	Coeff.	t-stat		
<b>No Fixed Effects</b>										
Model 1	0.25453	0.89					0.00667	3.65 ***	124	0.01
Model 2			-0.05954	-1.26			0.00761	4.56 ***	128	0.00
Model 3					0.00762	1.11	-0.04213	-0.95	124	0.01
Model 4	0.25236	0.89	-0.05706	-0.86			0.00687	3.59 ***	124	0.00
Model 5			-0.04069	-0.64	0.00673	1.00	-0.03620	-0.83	124	0.00
Model 6	0.33654	1.28			0.01025	1.53	-0.06024	-1.39	124	0.02
Model 7	0.32926	1.23	-0.03204	-0.48	0.00949	1.44	-0.05518	-1.29	124	0.01
<b>Fixed Effects</b>										
Model 1	0.25796	1.59					0.00666	14.39 ***	124	0.01
Model 2			-0.05066	-1.40			0.00760	408.15 ***	128	0.00
Model 3					0.00548	0.65	-0.02824	-0.51	124	0.00
Model 4	0.25608	1.65 *	-0.04903	-1.13			0.00683	11.65 ***	124	0.00
Model 5			-0.03889	-1.75 *	0.00462	0.55	-0.02252	-0.41	124	-0.01
Model 6	0.32534	2.36 **			0.00828	1.14	-0.04736	-1.01	124	0.01
Model 7	0.31823	2.29 **	-0.03031	-0.90	0.00755	1.09	-0.04248	-0.95	124	0.01

Note: \* significant at 10%, \*\* significant at 5%, and \*\*\* significant at 1%. All t-statistics calculated with robust standard errors. All prices stated in USD. The symbol  $\Delta$  signifies variable defined as  $\ln(X_t) - \ln(X_{t-1})$ .

Note: Funds included are AIG Diversified CAT Bond Fund - Isfr (ticker ACATCHI); AIG Diversified CAT Bond Fund - Euro I (ticker ACATEUI); AIG Diversified CAT Bond Fund - USD I (ticker ACATUSI); and Elan CAT Bonds (ticker ELNCTBD). All funds are registered in Switzerland, except ELNCTBD, which is registered in France.

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