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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 contracts 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 article 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.

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

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maximization by corporations worldwide. Convergence has also occurred in retail markets with bancassurance gaining significant market share in many countries.

Convergence has been somewhat slower to develop in the market for risk transfer within the property-liability insurance industry, a market traditionally dominated by reinsurance. In part, this is attributable 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 especially susceptible to informational asymmetries between buyers and insurers and between insurers and reinsurers, raising transactions costs and inhibiting financial innovations that require transparency. The inherent conservatism of insurance companies and the resulting market inertia also play a role in impeding convergence.

Powerful economic forces have combined in recent years to accelerate convergence between the property-liability insurance 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 property exposure exist in disaster prone areas in the United States, Europe, and Asia, resulting in sharp increases in insured losses from property catastrophes. In 1992, Hurricane Andrew caused unprecedented losses of $24 billion (2007 dollars). This event was dwarfed by the losses in 2005, when Hurricanes Katrina, Rita, and Wilma (KRW) and other events combined to cause insured losses of $114 billion (Swiss Re, 2008). Such losses are very large relative to the total equity capital of global reinsurers (Guy Carpenter, 2008) but represent less than half of 1 percent 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 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. 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 consists of advances in computing and communications technologies. These technologies have facilitated the collection and analysis of underwriting exposure and loss data as well as the development of catastrophe modeling firms. These firms have developed sophisticated models of insurer exposures and loss events, facilitating risk management and enhancing market transparency. The fourth major driver of convergence has been the development of holistic or enterprise-wide risk management (ERM), whereby traditionally separate functions such as the management of insurable risks, commodity risks, currency risks, interest rate risks, and other risks have begun to be merged under a single risk-management umbrella. ERM 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 reflects market imperfections, is the various regulatory, accounting, tax, and rating agency factors (RATs).

RATs serve in some cases as market facilitators, enabling (re)insurers to develop products to control regulatory and tax costs, but they also can serve as impediments to market development (Cummins, 2005; World Economic Forum, 2008). A sixth driver of convergence is modern financial theory that has enabled market participants to acquire a much deeper understanding of risk management and facilitated financial innovation.

The objective of this article is to provide an overview and analysis of financial innovations in the market for property-liability risk transfer. Two major types of innovations are considered—*hybrid products*, which combine features of financial instruments and traditional (re)insurance but do not necessarily access capital markets directly, and *financial instruments*, which go beyond (re)insurance industry capacity to access capital markets directly. The latter instruments are part of a class of securities known as *event-linked securities* or in this context as *insurance-linked securities* (ILS), the terminology adopted in this article. Particular attention is devoted to Cat bonds, the most successful of the convergence-oriented products. In addition to providing a comprehensive review of the market, we provide the first comparative analysis of the new catastrophe options products introduced in 2007, a discussion of the prices of industry loss warranties, and the first analysis of price and return characteristics of the recently introduced Swiss Re catastrophe bond indices and Cat bond mutual funds.

The remainder of the article is organized as follows: The second section reviews the literature on property-liability risk securitization, focusing on the most important scholarly contributions. The third section discusses hybrid financial products, and the fourth section analyzes financial products. The fifth section analyzes correlations between Cat bonds and other assets, and the sixth section concludes.

SELECTIVE LITERATURE REVIEW

This section reviews the literature on alternative risk transfer (ART). The discussion focuses on the literature that the authors consider to have the most significant scholarly content, that is, papers that either develop theories or provide rigorous empirical tests. We also focus on the evolution and development of risk-transfer markets, institutions, and instruments.[1] Industry-oriented publications are not specifically reviewed here but are cited throughout the article.[2]

Market Inception Period

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

[1]Although there is also a growing literature on mathematical/financial pricing models for insurance derivatives, this literature is outside the scope of the present article. For example, see Aase (2001), Bakshi and Madan (2002), Grundl and Schmeiser (2002), Lee and Yu (2007), Egami and Young (2008), and Muermann (2008).

[2]A practitioner perspective on ILS is provided in Albertini and Barrieu (2009).

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 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. 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 early literature on insurance derivatives identified (but did not resolve) most of the issues that continue to be discussed. These include the trade-off between moral hazard, which is highest when indemnity-style contract payoffs are used, and basis risk, which is associated with indexed products. Other issues include insurer acceptance of the new contracts, counterparty credit risk, and the magnitude of risk premia.

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 1994 through 2004. Several different types of financial instruments were tried during this period, many of them unsuccessful. As mentioned above, CBOT insurance futures were introduced in December 1992. When the contracts failed to generate much interest among insurers, they were replaced in 1995 by CBOT options contracts based on catastrophe loss indices compiled by Property Claims Services (PCS). However, due to limited trading, the PCS options were delisted in 2000 (U.S. Government Accounting Office [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. A more successful securitization is the 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. For example, 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 and Niehaus (2003) argue that tax costs of equity capital have a substantial effect on the cost to U.S. insurers of supplying catastrophe reinsurance for high layers of coverage. They suggest that the development of Cat bonds was motivated as a means "by which insurers can reduce tax costs associated with equity financing and simultaneously avoid the financial distress costs of subordinated debt financing" (p. 367). However, they caution that frictional and regulatory costs may impede the development of the Cat bond market.

Harrington, Mann, and Niehaus (1995) examine whether insurance futures and options can lower insurers' costs of bearing correlated risks such as risks posed by natural catastrophes. The analysis evaluates futures/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 futures markets relative to other alternatives. Analyzing insurer loss ratios, they 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.

The evolutionary period literature also analyzed the trade-off between moral hazard and basis risk resulting from the choice of payoff triggers in ILS. 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 securities 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. A pure parametric trigger pays off if the covered event exceeds a specified physical severity level, such as a Richter scale reading for an earthquake. In modeled loss triggers, the payoff is determined by simulated losses generated by inputting specific event parameters into the catastrophe model maintained by one of the catastrophe modeling firms.

The choice of a trigger for ILS involves a trade-off between moral hazard and basis risk (Doherty, 2000). Pure indemnity triggers are subject to the highest degree of moral hazard. The lowest degree of moral hazard and highest basis risk are provided by pure parametric triggers, where insurer exposures and losses are irrelevant. An intermediate case is provided by modeled triggers, which use as inputs insurer exposure maps and coverage characteristics but not 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.

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 trade-off between moral hazard and basis risk. Because reinsurance contracts tend to be indemnity based, that is, to payoff based on the losses of the company reinsured, the optimal mix of reinsurance and indemnity-trigger ILS, on the one hand, and index-linked financial contracts, on the other, 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 hedging strategy may involve a combination of index-linked financial instruments and indemnity-based reinsurance contracts to cover the basis risk "gap." Lee and Yu (2002) develop a mathematical pricing model for Cat bonds that incorporates both moral hazard and basis risk. They show that both types of risk have adverse effects on bond prices, supporting the argument that optimal hedging may involve a combination of indemnity and index-based instruments. Nell and Richter (2004) develop a model that predicts the substitution of index-linked ILS for reinsurance for large losses because of reinsurance market imperfections associated with reinsurer risk aversion, which is highest for large losses.

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 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.[3] These empirical analyses suggest that the basis risk is not a trivial problem for ILS, especially for relatively small insurers. 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.

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 that predicts that securities with near-zero market betas should have prices close to the risk-free rate of interest (Canter, Cole, and Sandor, 1996; Litzenberger, Beaglehole, and Reynolds, 1996). However, Cummins et al. (2004) found that Cat bond premia averaged nearly seven 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

[3]This finding is consistent with Major (1999), who, using simulation analysis, finds that contracts based on zip-code level loss indices provide better hedges than those based on statewide data.

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 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).[4] 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.

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 hurricane losses of 2004–2005. Industry analysts 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 ILS market has expanded from covering catastrophes to other perils such as extreme mortality risk, automobile insurance, liability insurance, as well as life insurance securitizations (Cowley and Cummins, 2005; Rooney and Brennan, 2006; Swiss Re, 2006).

Curiously, even as the Cat bond market has grown, so has the literature that tries to explain why Cat bonds have "not succeeded." In part, this reflects the publications lag in the academic literature. In any event, two papers in this category provide valuable insights into factors that could lead to the development of an even wider market in ILS. Gibson, Habib, and Ziegler (2007) 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 ILS, "financial markets have not displaced reinsurance" (p. 3). They find that the supply of information by informed traders in financial markets may be excessive relative to its value for insurers, causing reinsurance to be preferred. The model predicts that whether reinsurance or financial markets are ultimately selected depends crucially on the information acquisition cost structure and on the degree of redundancy in the information produced. The degree of redundancy depends upon the degree to which systematic and nonsystematic error components are present in information

[4]High spreads on catastrophe reinsurance are also documented in Froot and O'Connell (2008). Froot and Posner (2002) provide a theoretical analysis suggesting that parameter uncertainty does not appear to be a satisfactory explanation for high event-risk returns.

gathered on insurance risks. If the systematic (nonsystematic) component is dominant, then information redundancy is high (low) and reinsurance (securitization) will be preferred. This model helps to explain why securitization has been more prevalent in some market segments (low-frequency, high-severity events) than in others (more predictable, lower coverage layers).

Another paper theorizing about the allegedly limited growth of the Cat bond market is Barrieu and Loubergé (2009). They argue that the volume of Cat bond issues would increase if intermediaries issued hybrid Cat bonds, that is, 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 particular when investors are strongly risk averse, compared to issuers of cat bonds." The authors are correct that hedging against a joint event is cheaper than hedging against the events independently. Even though hedging against drops in equity prices may not be a major priority for (re)insurers, especially given the rapid inflow of new equity capital into the reinsurance market following KRW (Cummins, 2007), the theory may help to explain the attractiveness of dual trigger contracts such as industry loss warranties. The model could be generalized to analyze securities that combine catastrophe hedges with hedges against other events such as interest rate risk.

A third paper arguing that the ILS market has not yet reached the "tipping point" is Michel-Kerjan and Morlaye (2008). They argue that despite the growth in the Cat bond market following the 2004 and 2005 hurricane seasons, the Cat bond market remains quite small in comparison to other asset-backed securities and derivatives markets such as those for credit instruments and weather derivatives. They propose three primary ways to develop a larger, more liquid market: (1) increasing investor interest through tranching, (2) addressing basis risk through index-based derivatives, and (3) innovating through the development of new products such as derivatives based on equity volatility dispersion. The authors argue that insurers are exposed to large-scale risks such as catastrophes that simultaneously affect both underwriting results (huge claims) and equity investments (stock values of insurance companies drop following a major catastrophe). They argue that derivatives based on the volatility of a portfolio of insurance and reinsurance stocks could be used to hedge both types of risk. These papers reveal that there exists some difference of opinion in the literature concerning whether the current design of Cat bonds and other ILS are adequate or whether alternative instruments will be needed for the market to achieve its full potential.

A theoretical paper that helps to explain the coexistence 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, 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 coexistence of reinsurance and Cat bonds is Filke and Laux (2009). They argue that private information about insurers' risk affects competition in the reinsurance market. Nonincumbent 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 Filke and Laux (2009) reinforce the conclusion that Cat bonds have a role to play but are not expected to totally displace traditional reinsurance.

A recent paper provides a plausible explanation for why Cat bonds can be expected to trade at significant spreads over the risk-free rate. Dieckmann (2008) adapts an earlier model developed by Campbell and Cochrane (1999) to explain levels and term structures of CAT bond spreads. The intuition inherent in these models is that adverse shocks to consumption such as those provided by major catastrophes raise risk aversion and lead to asset prices that are relatively high for assets that do poorly during economic downturns. Dieckmann provides empirical evidence that consumption shocks of the magnitude of Hurricane Katrina are large enough to significantly affect bond spreads. Thus, although spreads have declined over time (see below), they are unlikely to converge to the risk-free rate.

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 financial market 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.

Risk Transfer Through Conventional Reinsurance

Traditionally, the primary method of risk transfer for insurers was to purchase reinsurance. 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.

The reinsurance contract structure that is used to transfer most "mega-risks" is nonproportional or *excess of loss* (XOL) reinsurance.[5] Payoffs on XOL reinsurance have the same mathematical structure as a *call option spread*, which is also the payoff structure used for most Cat bonds and options. The call option spread (XOL) payoff function is

[5]Other important types of reinsurance are discussed in Swiss Re (1997b, 2002) and various academic sources.

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

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

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

A loss-sharing proportion less than 1 (e.g., $\alpha = 0.9$) is usually present to control moral hazard, that is, to give the ceding insurer incentives for careful underwriting and claims settlement. Loss payoff triggers under nonproportional contracts can be defined in various ways, for example, per risk, per event, or per calendar period ("stop loss"). Catastrophe XOL contracts are usually per event.

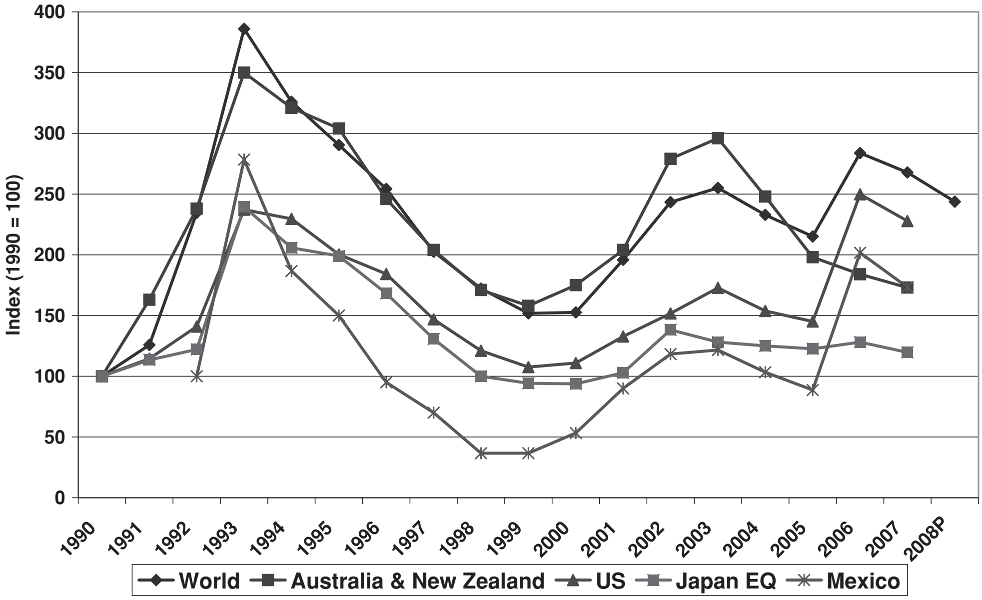
The other important parameters of conventional reinsurance that are useful in understanding the role of hybrid and financial market contracts are the time period covered by the contract and the perils covered. Conventional reinsurance contracts are typically negotiated and priced annually and are single-peril contracts. 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.

Inefficiencies in reinsurance markets constitute a primary driver for the development of ART. As mentioned above, reinsurance markets undergo alternating periods of *soft markets*, when prices are low and coverage is readily available, and *hard markets*, when prices are high and coverage supply is restricted. The reinsurance cycle is clearly evident in Figure 1, which plots the catastrophe reinsurance rate-on-line indices worldwide and for four important countries.[6] Two important conclusions to be drawn from Figure 1 are: (1) reinsurance prices are highly volatile and tend to spike following large loss events such as Hurricane Andrew, the September 11, 2001 terrorist attacks, and the 2005 hurricane season, and (2) prices are cyclical with the cycles being highly correlated across national markets.

ART has developed in part to respond to limitations in reinsurance risk-bearing capacity during hard markets. However, even during soft market periods, the supply of coverage for low-frequency, high-severity events is often limited. For example, Froot (2001) shows that the amount of a marginal dollar of industry-wide losses that is reinsured declines with the size of the event. The limitations of reinsurance markets have been documented in other sources as well (e.g., Berger, Cummins, and Tennyson, 1992; Froot and O'Connell, 2008). These sources confirm that reinsurance markets have limited capacity, especially for reinsuring catastrophic losses, and that reinsurance prices are highly volatile over the course of the cycle.

[6] The rate-on-line measures the price of XOL reinsurance as the ratio of the reinsurance premium to the maximum possible payout under the contract.

FIGURE 1
Catastrophe Reinsurance: World and Regional Rate on Line Indices



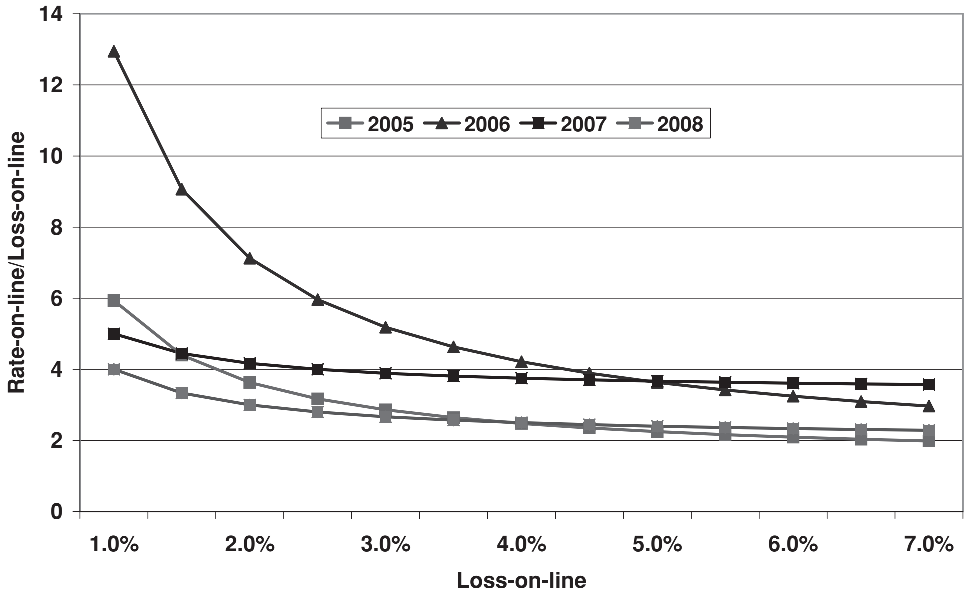
Source: Guy Carpenter (2008).

The fluctuations of reinsurance prices over time are further illustrated in Figure 2, which plots the ratio of the rate-on-line to the loss-on-line for U.S. property XOL reinsurance annually for 2005–2008.[7] The ratio of rate-on-line to loss-on-line clearly is highest for low-frequency, high-severity events; for example, the ratio ranges from 4 to 13 for a loss on line of 1 percent but ranges only from 2 to 4 for a loss on line of 7 percent. The rates-on-line also fluctuate dramatically depending upon the cycle phase; for example, for a 2 percent loss on line, the ratio of rate on line to loss on line went from about 7 during the hard market of 2006 to about 3 during the soft market of 2008.

The theoretical literature on the pricing of intermediated risks provides an explanation for the observed price patterns in the reinsurance market. Froot and Stein (1998) hypothesize that holding capital is costly for financial institutions and that such institutions face convex costs of raising new external capital.[8] Holding capital is costly due to frictional costs such as corporate income taxation, agency costs, and regulatory costs, and raising new external capital is costly because of informational asymmetries between firms and the capital market and for other reasons (Myers and Majluf, 1984). In addition, financial institutions invest in illiquid assets such as reinsurance policies that cannot be fully hedged in financial markets.

[7]The loss-on-line is the expected loss on the layer expressed as a percentage of the maximum possible payout.
[8]Convex capital costs as a motivation for risk management was introduced by Froot, Scharfstein, and Stein (1993).

FIGURE 2
Catastrophe Reinsurance Pricing Multiples Ratio of Rate on Line to Loss on Line, National Companies



Source: Guy Carpenter.

Under these conditions, Froot and Stein (1998) show that the hurdle rates and hence the prices of illiquid intermediated risk products are given by a two-factor model, consisting of the standard market systematic risk factor and a factor reflecting the covariability of the product's returns with the institution's preexisting portfolio of nontradable risks. The price of the latter covariability term depends upon the institution's effective risk aversion, which is a function of the capital structure of the institution. The price is inversely related to the amount of capital held by the firm because risk aversion declines as capital increases. Thus, the principal predictions are that the prices of intermediated risks will be positively related to their covariability with the institution's existing portfolio and inversely related to the institution's capitalization.

Froot (2007) extends the Froot–Stein model based on the observation that insurance companies are likely to be especially sensitive to insuring risks that adversely affect solvency.[9] He argues that insurers are especially averse to risks that create negatively asymmetric project return distributions because such asymmetries increase the probability of having to raise costly external capital. Froot adds a third factor to the Froot–Stein pricing model, which accounts for negatively skewed insurance risks. The model predicts that (re)insurance prices will rise following large loss shocks that

[9]Insolvency aversion arises because insurance pays off when the marginal utility of customer wealth is relatively high and because insurance customers face higher costs of diversification of insured risks than investors in traded financial assets (Merton, 1995).

deplete insurer capital and that prices will be especially high for risks that create asymmetrical return distributions.

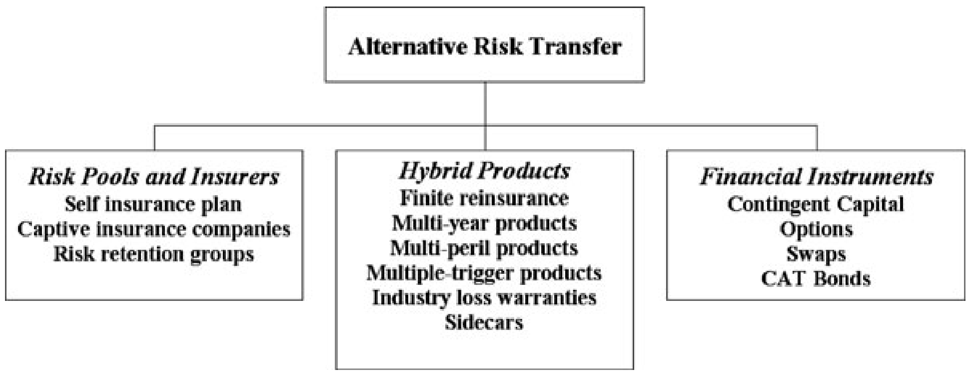
The observed reinsurance prices in Figure 2 are consistent with Froot's (2007) pricing model because low-frequency, high-severity events contribute significantly to negative return asymmetries and reinsurer capital was depleted following the disastrous 2005 hurricane season. The depleted capital led to sharp price increases, which were highest for low-probability layers of reinsurance that contribute the most to asymmetrical return distributions. These departures from conventional asset pricing theory represent imperfections in the market for reinsurance and help to explain why securitization is most prevalent for low-frequency, high-severity events, where reinsurance price multiples are high and coverage supply is more susceptible to hard markets.

In principle, reinsurance and ILS are only a subset of the financial instruments and strategies available to insurers for managing risk. For example, insurers are known to utilize financial derivatives to manage interest rate risk, asset volatility risk, and foreign exchange rate risk (Cummins, Phillips, and Smith, 2001). Indeed, reinsurance is a substitute for equity capital and the relative use of capital and reinsurance depends upon the costs and benefits of these two risk-management approaches (Hoerger, Sloan, and Hassan, 1990; Cummins et al., 2008). However, most of the existing literature has not adopted a portfolio approach to managing the risks faced by insurers, including interest rate risk, other financial risk, and catastrophic risk. Most papers that consider interest rate and other financial risk, such as Staking and Babbel (1995), Santomero and Babbel (1997), and Carson, Elyasiani, and Mansur (2008), give little consideration to reinsurance; papers analyzing catastrophe risk typically give little attention to interest rate and other financial risks (e.g., Froot, 2001; Cummins et al., 2004).

To some extent, the lack of attention in the literature to the portfolio approach arises because the instruments and techniques utilized to hedge purely financial risks such as derivatives are somewhat orthogonal to the XOL reinsurance and ILS contracts used to hedge catastrophe risk. Nevertheless, there is a trade-off between hedging different types of risks, and the firm should be considered as a whole from the risk-management perspective.

The recent literature has adopted a more holistic approach to risk management. For example, Cummins et al. (2008) analyze the trade-offs between reinsurance, capital structure, asset-liability risk management, and intermediation. Song and Cummins (2008) conduct a theoretical and empirical analysis of the use of financial derivatives and reinsurance in the insurance industry, and show that a substitution effect exists between derivatives and reinsurance. Lee and Yu (2007) develop a theoretical model of the use of Cat bonds and reinsurance in risk management for a reinsurer facing default risk, basis risk, catastrophe risk, and interest rate risk. The results show that the issuance of CAT bonds, even with basis risk, still raise the value of the firm's CAT reinsurance contract and lowers its default risk. The model is potentially important because it could be used to analyze trade-offs between interest rate risk and catastrophe risk. Clearly, holistic risk management represents an important area for future research.

FIGURE 3
Alternative Risk Transfer



ART: An Overview

An overview of ART approaches that are used in the insurance and reinsurance industries is shown in Figure 3, which illustrates how the various institutions and instruments fit into the ART marketplace. As discussed above, this article 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 ART market has developed steadily over the past 40 to 50 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 noninsurance corporations to seek lower cost solutions that mitigate inefficiencies. For example, noninsurance corporations were motivated to develop self-insurance programs because of the high transactions costs of dealing with the insurance industry, caused by adverse selection, moral hazard, and other imperfections. Due to informational asymmetries, firms with favorable loss experience often were not given full credit for their loss experience by insurers. Corporations with natural internal risk pools, such as fleets of vehicles, began to self-insure to reduce transactions costs.

Beginning in the 1960s, corporations began to recognize that further cost reductions might be possible by formalizing their self-insurance programs in subsidiary corporations known as *captive insurance companies* or *captives*. Captives formalize the primary cost advantages of self-insurance, that is, reducing transactions costs and giving the corporate parent investment control of premiums. 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 in self-insurance plans only the paid losses can be deducted.[10] Hence, captives provide a valuable tax

[10]The rules governing the deductibility of premiums paid by a parent corporation to a captive are complex. However, premiums now appear to be deductible for captives with a "sufficient" amount of business covering firms other than the parent, captives that cover other subsidiaries

deferral mechanism. The growth of the captive market has been remarkable—by 2007 there were 4,966 captives in existence worldwide (Cummins, 2008b).

The original captives were *single-parent captives*, which insured only the risks of the parent corporation. The market soon evolved to include *profit-center captives*, which also assume risks from unrelated third parties. *Group and association captives* were created to insure the risks of several firms from the same industry (e.g., the energy industry) or members of an association. Insurance intermediaries offer *rent-a-captives* to insure the risks of smaller firms, for which the formation of a single-parent captive is not cost effective. The most recent form of the rent-a-captive is the *segregated 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 percent came from single-parent captives, 34 percent from group and association captives, 26 percent from profit-center captives, 10.5 percent from rent-a-captives, and the balance from miscellaneous categories such as healthcare captives (Cummins, 2008b).

Another ART-type institution available for liability insurance risks in the United States is the *risk-retention group* (RRG). RRGs 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. 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, primarily for high-frequency, low-severity risks. Favorable tax treatment of premiums and obtaining access to the 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, most hybrid and purely financial instruments focus on low-frequency, high-severity risk transfer.

Hybrid Reinsurance-Financial Products

The types of risk-transfer mechanisms of primary interest in this article are hybrid products and pure financial instruments. Hybrid ART products tend to incorporate characteristics of both financial instruments and reinsurance, while the financial instruments more closely resemble products traded in capital markets. This section focuses on hybrid risk-transfer devices.

Finite Risk Reinsurance. Finite risk reinsurance is often used to provide income smoothing for primary insurers, with limited assumption of risk by the reinsurer.

owned by the same parent, and group captives jointly owned by several parents. For further discussion, see Wohrmann and Burer (2002) and Swiss Re (2003).

Finite reinsurance thus combines a multi-year banking transaction with limited reinsurance coverage and has five distinguishing features: (1) risk transfer and risk financing are combined in a single contract; (2) less underwriting risk is transferred to the reinsurer than under conventional reinsurance;[11] (3) finite risk contracts nearly always cover multi-year periods rather than being annually renewable; (4) investment income on the premiums paid by the primary insurer is explicitly included when determining the price, placing an emphasis on the time value of money not found in conventional reinsurance; and (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 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.

A *spread loss treaty* is a type of finite risk reinsurance designed to reduce the volatility of the ceding insurer's reported underwriting profit.[12] 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.[13]

The arrangement is distinguished from being merely a "savings account with a credit line" because the reinsurer usually 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 α = a proportion between 0 and 1, B = the experience account balance, and

[11]The term "finite" reinsurance is somewhat misleading in that conventional reinsurance is also finite, that is, 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 reinsurance must transfer significant underwriting risk to receive regulatory, tax, and/or accounting treatment as reinsurance. In the United States, the relevant GAAP accounting rule is SFAS 113 (Financial Accounting Standards Board, 1992). For further discussion, see Swiss Re (1997a, 2003).

[12]Other types of finite reinsurance include *finite quota share* reinsurance, which involves the proportionate sharing of the premiums and losses of a block of business. This serves a financing function for the ceding insurer, enabling it to recover the prepaid underwriting expenses on a block of business, thus reducing its leverage ratio.

[13]The off-balance sheet feature of these contracts runs afoul of U.S. GAAP accounting rules. Under FASB 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.

D = a cap on the reinsurer's obligation. Besides 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 contract period, the cedent is not vulnerable to unfavorable price fluctuations if the cycle enters a hard market phase.

Although finite reinsurance can serve legitimate business purposes, there is also a "dark side" to this product (Culp and Heaton, 2005). Because 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 manipulate their balance sheets in ways that mislead investors.[14] Thus, finite reinsurance is especially susceptible to unethical conduct, and market participants should proceed with caution.

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. 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.[15] 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 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

[14]For example, 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. Five executives of AIG and General Reinsurance Company, the counterparty to the AIG transactions, were convicted of conspiracy and securities fraud as a result of the incident (Roberts, 2008).

[15]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.

a "lemons" problem in which the insurer may have difficulties in raising capital due to uncertainty regarding its reserves. However, one of the core competencies of a reinsurer is the ability to evaluate the adequacy of loss reserves. The reinsurer can leverage this knowledge to create value for its owners by writing RXL reinsurance, signaling the 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.

Loss Portfolio Transfers. With RXL contracts, the insurer transfers reserve development risk to the reinsurer, but retains 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 an 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, thus reducing the cedent's leverage. LPTs accomplish 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.

Blended and Multi-Year, Multiline Products. Reinsurers also issue *blended covers* that 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 significant risk shifting, the principal objective of blended covers is to combine the nontraditional 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 recognition of the time value of money. Such contracts also may transfer foreign exchange rate risk and timing risk. However, multi-year contracts 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 toward contracts that protect the cedent against a wider variety of risks is represented by various types of *integrated* or *structured multi-year/multiline 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 predetermined 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. MMPs represent "cross-selling" at the wholesale financial services level. As in the case of retail financial services, however, "cross-selling" does not necessarily dominate "cross-buying," that is, buying from the best producer of each product purchased. In addition, because such contracts incorporate several elements usually covered separately, a lack of pricing transparency may impede market development. Thus, the ultimate success of MMPs in the risk transfer market remains uncertain.

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 and recognize that reinsurer payments to the cedent are worth more 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, payment under an MTP contract depends upon an insurance event trigger *and* a business event trigger, both of which must be activated to generate a payment. For example, an MTP might cover the cedent for catastrophic hurricane losses 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 losses resulting from the catastrophe but would not have to pay for protection covering circumstances where 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 (analogous to the contracts modeled by Barrieu and Loubergé, 2009). In the 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, enabling the cedent to direct its hedging expenditures to cover states of the world where the payoff of the hedges has the highest economic value.

Industry Loss Warranties. A type of multiple-trigger contract that has become particularly successful is the *industry loss warranty (ILW).* ILWs are dual-trigger contracts that pay off on the occurrence of a joint event in which 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 (McDonnell, 2002). 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 overcome regulatory objections to nonindemnity contracts and hence permit the contracts to qualify for reinsurance accounting treatment.[16] The indemnity trigger is usually set very low, such that the insurer is almost certain to recover if industry losses satisfy the index trigger.[17]

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. Hence, ILWs reduce the costs of moral hazard (Gatzert, Schmeiser, and Toplek, 2007). 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. The market has expanded to encompass multi-year ILWs and ILWs with multiple index triggers. Critics of ILWs cite high frictional costs, low liquidity, and lack of transparency in the secondary market as disadvantages, but these problems may be mitigated in the future by securitization and standardization. ILWs provided about $6 billion in risk capital in 2007 (GC Securities, 2008).

Although minimal volume data on ILWs are available, pricing statistics have recently become available. The ILW prices for the United States from April 2002 through July 2008 are shown in Figure 4. Rates-on-line are shown for contracts attaching at industry losses of $20, $30, and $50 billion. Rates-on-line are expressed as percentages of the maximum coverage limit; for example, a buyer of $100 million of protection triggered by an industry loss of $20 billion, would have paid about 15 percent or $15 million for the ILS in January of 2005. Prices are highest for the lowest attachment point ($20 billion) and decline for higher attachment points, which have lower probabilities of exceedance. The cyclicality in reinsurance prices carries over to the ILW market. Prices increased dramatically as a result of Hurricanes 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.[18] However, by 2008, prices had still not returned to pre-KRW levels, indicating the continuation of a relatively hard market for high coverage layers.

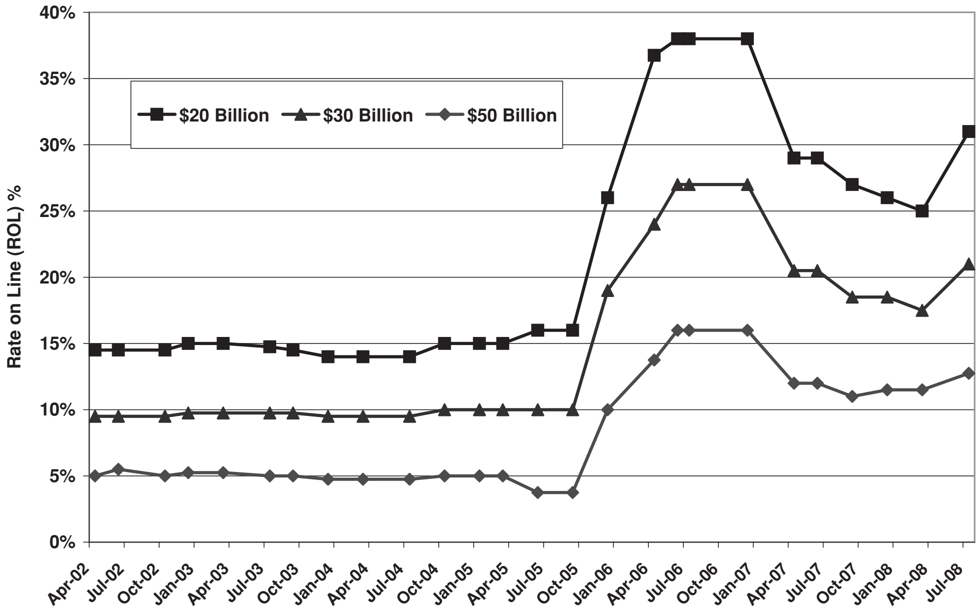
Sidecars. An innovative financing vehicle that is similar to conventional reinsurance but accesses capital markets directly through private debt and equity investment is the *sidecar*. Sidecars date back to at least 2002 but became much more prominent following the 2005 hurricane season (A.M. Best Company, 2006). About $7 billion in

[16] Insurance regulators sometimes object to nonindemnity products on the grounds that they expose insurers to excessive basis risk and potentially can be used for speculation rather than hedging.

[17] Several important contractual provisions must be defined in an ILW, such as the geographical regions and perils covered. The contract also specifies the warranty, that is, the magnitude of the index that triggers payment, the size of the indemnity trigger (e.g., $10,000), and the maximum limit of coverage (e.g., $10 million). In addition, the contract must specify the index that triggers the contract, such as one of the PCS indices. Index triggers are usually *binary*, whereby the contract pays 100 percent of value once losses breach the warranty, but can be *pro rata*, whereby the contract pays proportionately based on how much the index exceeds the warranty.

[18] An analysis of ILW prices in 2004–2005 by Lane (2006) also shows a price spike following the 2005 hurricanes.

FIGURE 4
ILW Pricing: U.S. All Perils



Source: Access Re.

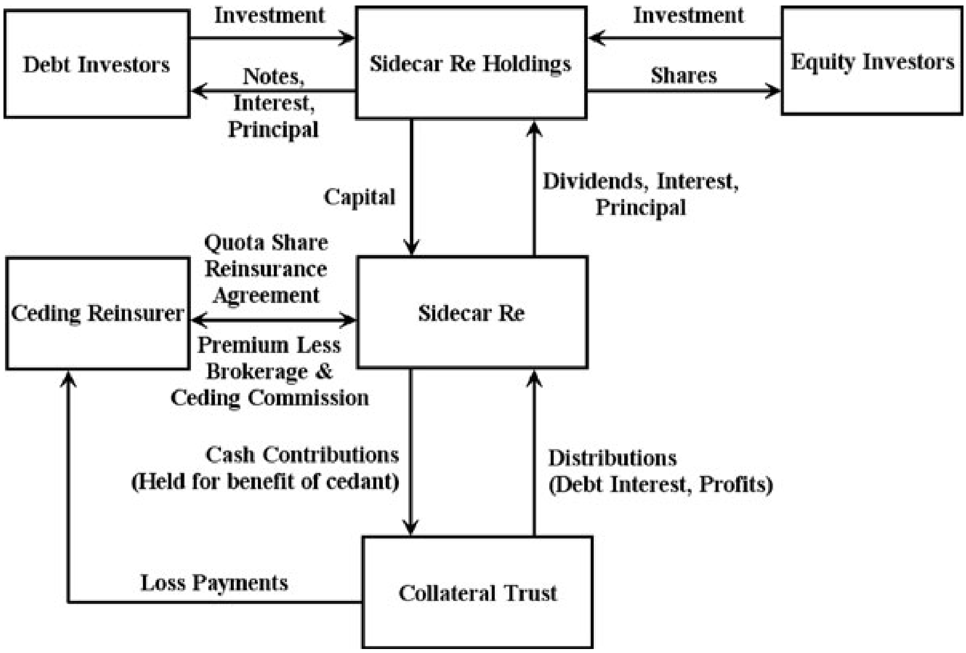
equity and debt capital was raised through sidecars from 2005 to 2007 (GC Securities, 2008). Nearly all sidecars to date have been established in Bermuda, for regulatory and tax reasons (Ramella and Madeiros, 2007).

The sidecar structure is diagrammed in Figure 5. Sidecars are *special purpose vehicles* sponsored by reinsurers to provide additional capacity, usually for property catastrophes and marine risks. The sidecar is formed by a ceding reinsurer, and its risk-bearing activities are typically confined to this specific reinsurer.[19] 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, usually 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 (Cummins, 2007; Lane, 2007).

The ceding reinsurer can earn profits on transactions with the sidecar through ceding commissions and sometimes 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, sidecars are usually formed off-balance-sheet and hence do not affect the issuing reinsurer's capital structure.

[19]Sidecars can also be "market facing," that is, directly issue reinsurance to third parties other than the sponsoring reinsurer. Some industry observers question whether such structures are true sidecars (Sclafane, 2007).

FIGURE 5
The Structure of a Typical Side Car



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. 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 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, which raises capital for the sidecar by issuing equity and/or debt. If debt securities are issued, a tiered structure can be used, similar to 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 nontraditional 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 the hedge fund's need to create its own reinsurance infrastructure.

ART Products: Conclusions. Hybrid ART instruments clearly extend traditional reinsurance and illustrate the convergence of insurance and financial markets. The contracts have evolved over time from those that 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 hybrids:

(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, many of these contracts would not be viable. For example, spread loss reinsurance would not be attractive if external capital were not more costly than internal capital. If priced in efficient financial markets, an LPT 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 toward 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 pay off 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.

FINANCIAL MARKET INSTRUMENTS

This 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.

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 and 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 securities backed by mortgages, corporate bonds, automobile loans, student loans, home equity loans, credit card receivables, etc., and (2) nonasset-backed products such as futures and options. Asset-backed securities are typically collateralized, that is, backed by underlying assets, whereas nonasset-backed products are guaranteed by the transaction counterparty and/or by an exchange. Both asset-backed securities and non asset-backed securities can be issued and traded on organized exchanges or over-the-counter. Most of the insurance securitizations to date have been patterned after asset-backed securities and non asset-backed securities design structures familiar from other financial markets (see Cummins, 2005).

Contingent Capital

Contingent capital is a securitization transaction similar to a put option, which allows 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.[20] 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 similar to Cat bonds but are usually in the form of options. 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. The development of the ILS market has enhanced the attractiveness of catastrophe risk exposure to capital market participants, but counterparty credit risk remains a concern for unfunded transactions. Approximately $1.2 billion in contingent capital was issued in 2007, the majority involving debt or hybrid debt (Benfield, 2008).[21]

Catastrophe Futures and Options

Hurricane Andrew in 1992 raised questions about the capacity of the insurance and reinsurance industries to respond to large catastrophes. 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 CBOT in 1992. As mentioned, they were redesigned in 1995 but eventually delisted in 2000 due to low trading volume. Various reasons have been proposed to explain the failure of the CBOT contracts, including excessive basis risk, lack of insurer expertise in options trading, low liquidity, counterparty credit risk, and uncertainty about regulatory accounting treatment (American Academy of Actuaries, 1999). Other efforts

[20] An early contingent capital transaction, issued over-the-counter by Aon, was called a CAT-E-Put, an abbreviation for "catastrophic equity put option." Contingent capital is discussed further in Culp (2002) and Aon (2008a).

[21] 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.

to launch catastrophe options, for example, by the Bermuda Commodities Exchange, also failed. 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 make sense from an economic and financial perspective and because insurers have become more comfortable in dealing with financial instruments as alternatives to reinsurance, there have been several recent efforts to relaunch options with payoffs triggered by catastrophic property losses. In 2007, futures and options contracts were introduced by the New York Mercantile Exchange (NYMEX), the Chicago Mercantile Exchange (CME), and the Insurance Futures Exchange (IFEX), whose contracts trade on the Chicago Climate Exchange (CCX) (Bruggeman, 2007). Deutsche Bank and Swiss Re have joined the IFEX effort as market makers. To date, there has been minimal trading in the new contracts. For example, the IFEX contracts have generated some trading volume—open interest in June 2008 exceeded 3,000 contracts, equivalent to about $30 million in policy limits (IFEX, 2009). 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 and therefore can be used to hedge ILW risk.[22] The contracts are designed to payoff on PCS insured catastrophe loss indices, for U.S. tropical windstorm losses in defined geographical regions. A contract is available covering the 50 U.S. states, the District of Columbia, Puerto Rico, and the Virgin Islands, and contracts are also available covering Florida and the Gulf Coast. The contacts currently available are 1st, 2nd, 3rd, and 4th event contracts, with triggers of $10, $20, $30, $40, and $50 billion. For example, suppose an insurer buys a 1st 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 1st event that breached the $10 billion limit as measured by PCS insured losses.[23] The contract coverage period is the calendar year. Because of the binary feature and the geographical areas covered, the IFEX futures are subject to substantial basis risk.

The NYMEX and CME contracts differ from the IFEX contracts in that they are not binary but instead are valued at $X times the value of the triggering index. NYMEX offers contracts covering U.S. losses nationally, losses for Texas through Maine (excluding Florida), and losses for Florida. The CME offers six U.S. regional contracts.

[22] Although ELFs generally resemble ILWs, they do not contain an indemnity trigger, and traders do not need to have underwriting exposure in order to utilize the contracts.

[23] Because of the "1st event binary" feature, the contact would not pay off if two catastrophes occurred, one causing damage of $5 billion and the next causing damage of $6 billion. If the 1st event contract is triggered, the insurer could obtain additional protection by purchasing 2nd event contracts.

TABLE 1
Principal Characteristics of Catastrophe Futures and Options

Exchange	IFEX	NYMEX	CME	CBOT-PCS
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 Islands; Gulf Coast, Florida	National Texas-Maine (ex Florida) Florida	Six U.S. regions	National, 5 regions, 3 states
Trigger	Annual aggregate losses from 1st, 2nd, 3rd, or 4th 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	Aggregate/European
Contract payoff	$10,000*If[I>T,1,0]	$10*Index	$1,000*CHI	$200 per index point
Maximum payout	$10,000 per option	No maximum	No maximum	No maximum

(*Continued*)

TABLE 1
Continued

Exchange	IFEX	NYMEX	CME	CBOT-PCS
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; I = index, T = trigger. European options can be exercised at contract expiration only; American options can be exercised at any time up to contract expiration.
Sources: Websites of IFEX, NYMEX, CME, and American Academy of Actuaries (1999).

The NYMEX contracts pay off on PCS insured property loss indices, and the CME contracts pay off on a parametric index developed by Carvill Corporation (Carvill, 2007). The contracts also differ in that the NYMEX contracts cover accumulations of losses, whereas CME contracts are available covering numbered events (e.g., 1st event, 2nd event), seasonal accumulations, and accumulations from seasonal maximum events.[24] The CME contracts potentially have less basis risk than the NYMEX and IFEX contracts because more 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 more recent contracts in that they primarily covered losses in calendar quarters rather than annually or during the hurricane season and covered 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"; that is, 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 noncatastrophe weather risk), and it seems clear that some sort of catastrophe derivatives market will succeed eventually.

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 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

[24]The NYMEX contracts have an annual coverage period, while the CME contracts cover the hurricane season (June 1 through November 30).

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 16 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, in press). 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. For further discussion of risk swaps, see Takeda (2002).

Cat Bonds

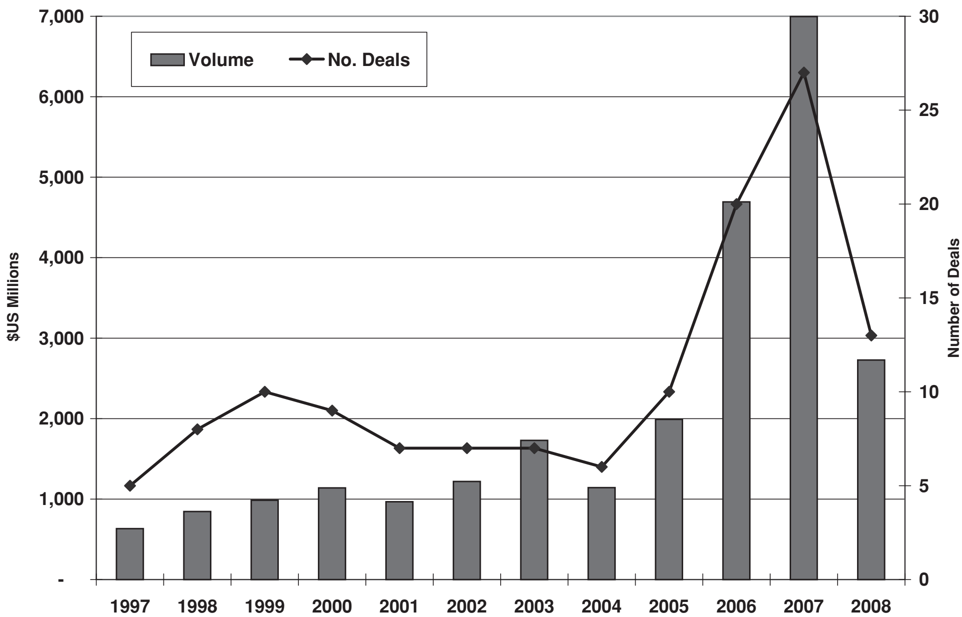
Insurance-linked bonds are by far the most successful nontraditional risk hedging instrument (Cummins, 2008a; Albertini and Barrieu, 2009). This section reviews the growth of the Cat bond market and the characteristics of Cat bonds and analyzes Cat bond pricing. Cat bonds are emphasized because they have generated much larger volume than other ILS.

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 $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.[25]

The new issue volume in the Cat bond market from 1997 through 2008 is shown in Figure 6. The data in the figure apply only to nonlife 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. Figure 6 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

[25]Cat bonds can also be securitized through collateralized debt obligations (CDOs), which in theory do not have the "cliff risk" posed by principle-at-risk Cat bonds (Forrester, 2008). However, the recent problems in the CDO market and the general complexity and lack of transparency of CDOs relative to Cat bonds raise questions about the role of CDOs in financing catastrophe risk.

FIGURE 6
Cat Bond New Issue Volume



Source: GC Securities (2008), A.M. Best (2008), Swiss Re (2009).

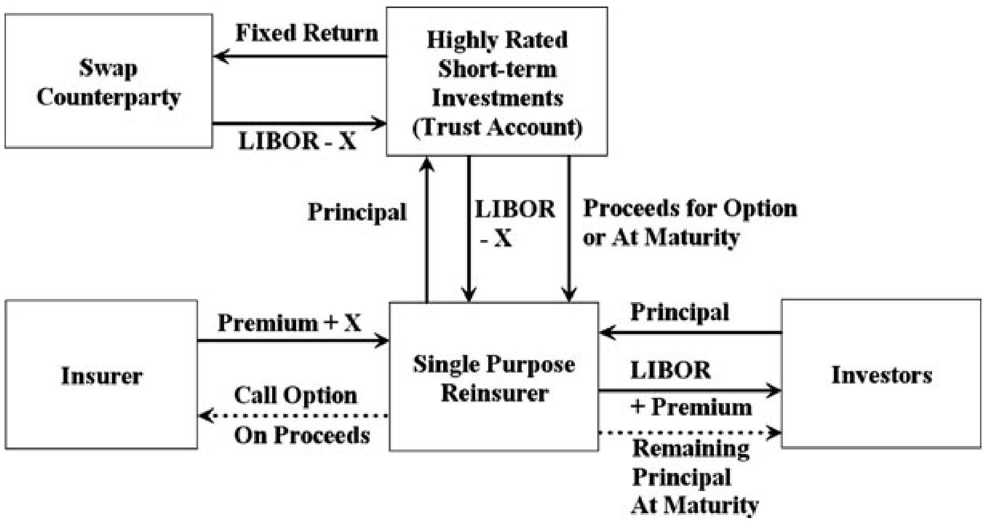
has been increasing, to 27 during 2007, many of which had multiple tranches and included "shelf registrations."[26] A substantial number of the issuers in 2005–2007 were first-time sponsors of Cat bonds, although established players such as Swiss Re continue to play a major role (GC Securities, 2008). Bond issuance declined sharply to $2.7 billion in 2008 due to the financial crisis, but 2008 was still the third leading year since market inception in new Cat bond issue volume. The amount of risk capital outstanding in Cat bond markets has also grown over time. Almost $14 billion of risk capital was outstanding in the Cat bond market by the end of 2007 (GC Securities, 2008), which had declined to about $12.5 billion by the end of 2008 (Swiss Re, 2009).

Putting these numbers in perspective, Cat bonds accounted for 8 percent of global property reinsurance policy limits in 2007 and 12 percent of U.S.-only property limits, compared to 88 percent and 82 percent, respectively, for traditional reinsurance and 4 percent and 6 percent, respectively, for ILWs (GC Securities, 2008). Because Cat bonds and ILWs tend to be used for higher layers of coverage, they represent much larger proportions of total limits for high-layer property reinsurance. Hence, Cat bonds are becoming an important part of the strategic arsenal of risk-hedging tools regularly used by insurers and reinsurers.

Cat Bond Structure. A typical Cat bond structure is diagrammed in Figure 7. The transaction begins with the formation of a single-purpose reinsurer (SPR), which issues bonds to investors (Mocklow, DeCaro, and McKenna, 2002). The proceeds are

[26]Shelf registration allows for additional issuances in future months.

FIGURE 7
Cat Bond with Single-Purpose Reinsurer



Note: X = the fee of the swap counterparty. LIBOR = London inter-bank offer rate.

typically invested in safe, short-term securities, 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 an event, proceeds are released from the SPR to help the insurer pay claims. The release of funds is usually proportional to event size rather than binary. In most Cat bonds, the principal is fully at risk, that is, the investors could lose their entire principal investment.[27] 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 another 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. If no contingent event occurs, the principal is returned to the investors upon the expiration of the bonds.

Insurers prefer to use a SPR to capture the tax and accounting benefits associated with traditional reinsurance. Investors prefer SPRs to isolate the risk of their investment from the general business and credit risk of the insurer, creating an investment that is a "pure play" in catastrophic risk. The bonds are fully collateralized, 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.

[27]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. Principal protected tranches have become relatively rare, primarily because they do not provide as much risk capital to the sponsor as principal-at-risk bonds.

The subprime mortgage crisis and the resulting financial sector crisis of 2007–2008 revealed some potential limitations of the Cat bond structure. In particular, a few Cat bonds had Lehman Brothers, which became insolvent in September 2008, as their swap counterparty. Others had invested trust assets in securities that were highly rated but proved to be unsound, either because they were too long term or their ratings were artificially high (Aon, 2008b). Although the vast majority of bonds were unaffected, the episode emphasized the need for more standardization and transparency in Cat bonds, more stringent restrictions on the investment of trust assets, more frequent "top ups" when trust assets decline in value, and stricter bond provisions regarding replacement of nonperforming swap counterparties (Lane, 2008).

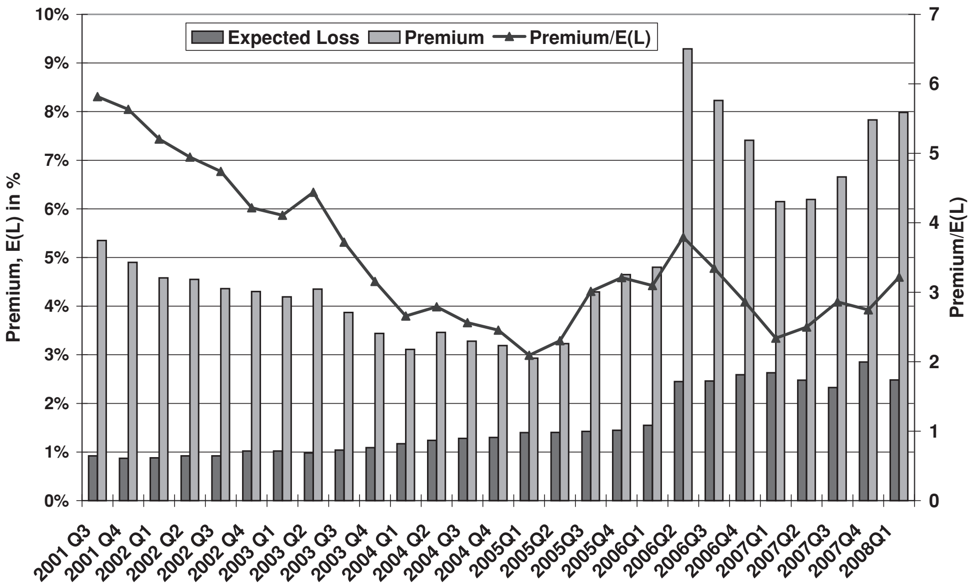
In general, however, Cat bonds performed much better than comparable corporate bonds or asset-backed securities during the crisis and seem to be "insulated" from most other segments of the securities market (GC Securities, 2008). Although there has been only one publicly announced wipeout of a Cat bond (KAMP Re, following Hurricane Katrina), there have reportedly been other wipeouts that were not publicly reported. The impact of the KAMP Re wipeout on the Cat bond market has been favorable. The smooth settlement of the bond established an important precedent in the market, showing that Cat bonds function as designed, with minimal confusion and controversy between the sponsor and investors. Thus, the wipeout served to, "reduce the overall uncertainty associated with this marketplace and therefore increase both investor and sponsor demand for these instruments" (Guy Carpenter, 2006, p. 4).

Cat Bond Characteristics. Although Cat bonds continue to evolve, the overall trend is toward a higher degree of standardization. Cat bonds differ in several respects, including triggering events, perils and regions covered, bond tenor (the length of time covered by the bond), and sponsoring organization.

The theoretical literature suggests that considerations of moral hazard might lead to minimal use of bonds with indemnity triggers (e.g., Doherty, 2000). Because of the higher moral hazard, spreads for bonds with indemnity triggers tend to be higher than for nonindemnity bonds. Bonds with indemnity triggers also tend to have higher transactions costs because more documentation is required regarding the issuer's exposures and underwriting standards. Finally, bonds with indemnity triggers may take longer to settle following an event because the issuer's losses need to be verified. In spite of these potential disadvantages, the choice of trigger really does seem to involve a trade off between the costs of moral hazard, frictional costs, and potential settlement delays, on the one hand, and the costs of basis risk, on the other. As a result, no single trigger type predominates. For the period 1997–2007, the percentages of Cat bond volume by trigger were 30.0 percent indemnity, 25.9 percent parametric, 21.5 percent industry index, 8.5 percent modeled, and 14.0 percent hybrid. For 2007, the percentage of indemnity triggers was even higher, 39 percent (GC Securities, 2008). In part, this may reflect incentive provisions included in Cat bonds, whereby the issuing insurer and bondholders share the risk in a specified proportion above the trigger.

The United States is the primary source of demand for Cat bonds with 29.6 percent of total volume from 1997 to 2007 covering U.S. earthquakes and 31.8 percent covering U.S. hurricanes. Other important perils/regions include European windstorm

FIGURE 8
Cat Bond Pricing



Source: Lane Financial. Premiums and expected losses are percentages of bond principal.

(15.2 percent of volume), Japanese earthquake (11.0 percent), and Japanese typhoon (8.5 percent). Multiple peril bonds have grown in popularity, accounting for 44.6 percent of total issue volume from 1997 to 2007 and 52.3 percent in 2007. Multiple-year bond tenors are most common, reflecting the desire for issuers to avoid the reinsurance underwriting cycle and spread the fixed costs of bond issuance over time. Since 1997, 77.5 percent of Cat bonds by number of issues have been for more than 1 year, and 62.5 percent have had tenors of 3 years or more.

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. However, current spreads are not especially high, such that Cat bonds are now competitive with conventional reinsurance.

Although Cat bonds are not publicly traded, there is an active nonpublic 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 8. Figure 8 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.[28]

There are two primary conclusions to be drawn from Figure 8: (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 et al. (2004)

[28]The data in Figure 8 are from Lane and Beckwith (2005, 2006, 2007, 2008).

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 2005. 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—bond premia and spreads increased significantly as the market tightened in 2005 and 2006. However, spreads returned to lower levels, trading in the range of 2.5 to 3 during 2007 and early 2008.[29] Analyses of spreads in reinsurance markets indicate that ratios of premiums to expected loss in the range of 3 to 5 or higher are to be expected for the higher layers of coverage targeted by most Cat bonds (Froot and O'Connell, 2008; Cummins and Mahul, in press). Thus, Cat bonds are no longer significantly more expensive than reinsurance. Comparison of Figures 2 and 8 reveals that Cat bond prices seem to have reacted somewhat less to the 2005 hurricanes than reinsurance prices for comparable layers.

The cyclical behavior of Cat bond prices might seem to be puzzling in view of the fact that securities markets are not exposed to the reinsurance market imperfections discussed above. Cat bond cycles seem to be driven by two primary factors: (1) increasing uncertainty about the accuracy of loss models following a large event and (2) time lags in the development of expertise required to participate in the Cat bond market following a surge in demand. Because the Cat bond market is currently small relative to other securities markets, the number of traders with the requisite expertise to create markets in Cat bonds is also relatively limited. Therefore, if demand shifts, it takes time for additional traders to enter the market. Hence, it is not a shortage of capital but a shortage of expertise that contributes to Cat bond cycles. As market volume continues to grow, this problem should become less important, and Cat bond pricing cycles can be expected to diminish.

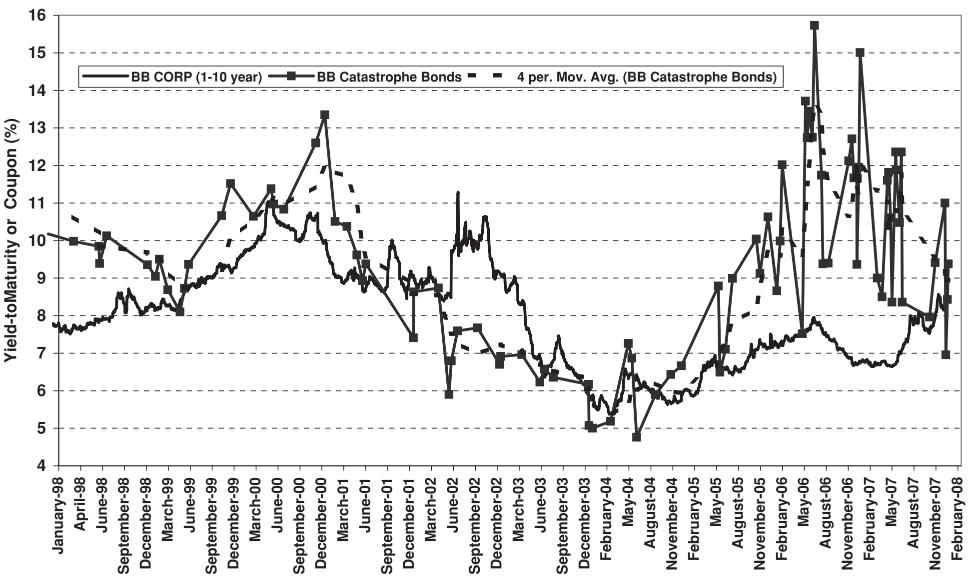
It is also relevant to compare Cat bond yields to yields on comparably rated corporate bonds. This comparison is shown in Figure 9, which compares the returns on BB Cat bonds with returns on the Merrill-Lynch BB corporate bond index from January 1998 through February 2008. The results show that BB Cat bond yields were comparable to yields on BB corporate bond yields from 2001 up until the time of Hurricane Katrina in 2005. Around the time of Katrina, Cat bond returns increased relative to corporate bonds and became much more volatile, although the return gap had been reduced considerably by the end of the period. Thus, even though Cat bonds are now price competitive with reinsurance, the market remains relatively thin and vulnerable to the effects of mega-catastrophes.

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 securitizations have expanded to encompass new types of private sector risks as well as sovereign risks, for example, the 2006 Mexican Cat bond, designed to provide earthquake disaster relief funding to the Mexican government (Cardenas et al., 2007). Bond prices have declined and the market has become more liquid, with an expanding investor base. Nevertheless, the market

[29] Lane and Mahul (2008) find a long-term spread ratio ranging from 2.33 to 2.69, reinforcing this conclusion. Dieckmann (2008) finds average CAT bond spreads of 4.3 times expected losses with a median of 3.8, but his analysis focuses on Hurricane Katrina and is limited to a relatively small sample of bonds in existence when Katrina made landfall.

FIGURE 9

Catastrophe Bonds Versus Comparable Corporate Bonds, 1997–2007



Source: Guy Carpenter.

remains small relative to other asset-backed securities markets and is susceptible to price volatility from catastrophic events and reinsurance cycles. 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.

Demand and Supply for ILS

This section focuses on the demand and supply sides of the market for insurance-linked securities, where the demand (buyer) side consists of firms or governments with exposure to various types of insurable risks and the supply (seller) side consists of providers of protection. Because most trading to date has taken place in Cat bonds and industry loss warranties (ILWs), the discussion focuses on these contracts, with a brief discussion of swaps and futures.

A key element in the development of any securitized financial market is the generation of sufficient volume of trading to justify traders' investment in the information needed to trade the securities. On the demand side, the buyer (hedger) needs extensive information on risk exposures, underwriting standards, probability of loss distributions, and other information. Much of this information is routinely generated by insurers and reinsurers and, in fact, such information represents a core competency for such firms. However, the costs of information investment may help to explain the limited volume of noninsurance corporate issuance of Cat bonds, with most corporate issuers preferring to rely on the (re)insurance industry to provide protection, except perhaps for unusual exposures to mega-catastrophes.

On the supply side, the volume of transactions must be sufficient to justify investment in information for sellers of protection, including investment banks, other institutional investors, hedge funds, dedicated mutual funds, etc. Noninsurance sellers basically need to start from the ground up and invest in information technologies (e.g., catastrophe simulation models, computer equipment, etc.) and hiring and training personnel to run their trading desks. The anticipated volume needs to be sufficient to offset the fixed costs of establishing a trading desk and the ongoing variable costs of operating the desk over time. Hence, sellers must be convinced of the ultimate success of the market such that a "critical mass" of trades will be available to justify the operation. This critical mass has been attained in the market for Cat bonds and ILWs but has not yet materialized for futures and options.

The demand side of the ILS market mainly consists of primary insurers and reinsurers. From 1997 to 2007, primary insurers initiated 49.0 percent of Cat bonds by volume and reinsurers initiated 46.6 percent. There were only 6 corporate issues during the period 1997–2007, compared to 110 issues by insurers and reinsurers (GC Securities, 2008). The corporate issues included bonds sponsored by Oriental Land Company (the operator of Tokyo Disneyland) in 1999, Vivendi Universal in 2002, Electricite de France in 2003, and East Japan Railway in 2007. It is likely that future corporate issues will be mainly focused on low-frequency, high-severity, targeted events rather than general risk-management needs. It is usually more efficient for corporations to rely on insurers and reinsurers for risk management rather than making significant investments in the expertise needed to effectively utilize ILS. More sovereign issues are expected in the future, particularly from developing countries seeking to finance disaster relief and reconstruction.

The success of the Cat bond market in developing critical mass on the supply side is illustrated by an analysis of investors in Cat bonds in 1999 versus 2007, based on unpublished data from Swiss Re. In 1999, for example, 55 percent of Cat bond purchases by volume were by primary insurers (30 percent) and reinsurers (25 percent), with 30 percent of the market provided by money managers and smaller shares (about 5 percent each) provided by Cat mutual funds, hedge funds, and banks. By 2007, the market had broadened significantly, with insurers and reinsurers accounting for only 7 percent of Cat bond purchases. The primary buyers of Cat bonds in 2007 were dedicated Cat mutual funds (55 percent), money managers (19 percent), and hedge funds (17 percent). Hence, the Cat bond market has truly "gone mainstream" during the past few years.

Although statistics are not available, industry observers report that the seller side of the ILW market has gone beyond (re)insurers to include hedge funds, sidecars, and other institutional investors because of the attractive returns and low barriers to entry in this market (Benfield, 2008). In addition to accessing broader capital markets, some sellers have begun to securitize ILWs. The market for risk swaps seems to be confined more significantly to insurers and reinsurers (Swiss Re, 2006), although a broader market in swaps also can be envisioned.

The market for insurance-linked futures and options has not yet reached critical mass, for reasons discussed above, including basis risk and contract design. The presence of market makers such as Swiss Re seems largely responsible for most of the trading in IFEX futures. The CME reports $500 million in risk capital provided in 2008, but this remains a very small market, considering that a single reinsurance contract or ILW can easily provide $100 million or more in risk capital. The demand for futures and options will need to increase significantly in order to attract significant trading activity from noninsurance investors, who will find it difficult to justify the informational investments in the absence of larger volume.

Impediments to Market Expansion

Earlier discussions of alternative risk finance have indicated that regulatory and accounting treatment of Cat bonds and other risk financing solutions pose impediments to the growth of the market. However, industry experts interviewed by the authors indicate that regulatory and accounting issues do not pose a material impediment to the growth of the Cat bond market at the present time, and the statistics on market size and growth clearly seem to bear this out. Such impediments may be a somewhat more serious problem for markets in futures and options, although issues such as basis risk and contract design seem to be more serious. This section briefly outlines some of the impediments to expansion of the ILS market.[30]

One set of potential impediments is the regulatory, accounting, tax, and rating agency treatment of ILS. The principal regulatory and accounting issues are whether the transaction is treated as reinsurance for regulatory accounting purposes and the effect of the transactions on solvency capital. Although these issues do not appear to have significantly impeded the growth of Cat bonds, they remain potential obstacles that should be resolved in the coming years. Transactions such as Cat bonds and ILWs that transfer significant risk and do not have excessive basis risk generally are treated as reinsurance for regulatory and accounting purposes. However, contracts such as futures and options tend not to be treated as reinsurance and hence do not impact accounting statements or regulatory capital unless income is realized from the transaction. Regulatory movement toward "a more economic view of financial risk mitigation" would be of great assistance in the development of futures and options markets (World Economic Forum, 2008). Inconsistency of regulatory and accounting treatment across jurisdictions also creates uncertainties and raises transactions costs for all types of ILS.[31]

Inconsistent treatment of ILS transactions by rating agencies also provides an impediment to market expansion. For example, rating agencies do not always give full credit to ILS transactions in determining insurer and reinsurer capital adequacy standards and sometimes impose ratings caps on ILS that do not fully reflect the quality of particular issues. The development of more standardized methodologies for quantifying and rating ILS transactions would remove these inconsistencies and facilitate market development.

Transactions costs are also often mentioned as an impediment to the development of the ILS market. Transactions costs of Cat bonds include actuarial, legal, investment

[30] Further discussion of impediments is provided in World Economic Forum (2008) and Yago and Reiter (2008).

[31] A detailed comparison of ILS regulation in the United States and E.U. is provided in Klein and Wang (2009). Regulatory issues are also discussed in Albertini and Barrieu (2009).

banking, accounting, and auditing fees as well as Cat modeling costs and the costs of setting up SPVs. From 1997 to 2005, the transactions costs amounted to about 1.5 percent of the principal of the Cat bond. However, as the market has developed, the costs of issuing a Cat bond have declined significantly (GC Securities, 2008). An important mechanism used by sponsors to reduce transactions costs is the *shelf offering*, first implemented in 2002. Shelf offerings allow sponsors to create a single set of offering documents summarizing the general characteristics of an offering, which then provide the basis for issuing additional bonds (*takedowns)* (up to a maximum limit) over the course of a stated risk period. In addition to enabling sponsors to spread the fixed costs of a transaction over multiple issues, shelf offerings also allow sponsors to access capacity on an as-needed basis, rather than having to make an estimate of their capacity needs several years in advance. Cat bond investors tend to view shelf offerings favorably as they tend to be a reliable source of transaction flow and increase investor confidence by building up a track record of successful transactions (MMC Securities, 2007).

The lack of standardization of transactions also has been a market impediment, although standardization has increased in recent years, particularly for nonindemnity Cat bonds. The development of new standardized loss indices would help in developing the market, particularly outside the United States (Swiss Re, 2007). Increased standardization also would facilitate secondary market trading and thus enhance liquidity. Solving problems with basis risk and contract size would facilitate the development of ILS futures and options markets; that is, with the current contract design, basis risk is arguably too high (Cummins et al., 2004) and contract size is too small, requiring hedgers to buy large numbers of contracts to duplicate reinsurance, Cat bonds, or ILWs. Finally, lack of knowledge and experience with securitization in the insurance industry provides a barrier to expansion of the ILS market. One way to overcome this problem would be for buyers of protection to develop internal risk-management functions that integrate traditional reinsurance with capital market solutions. This would require an investment in technology and personnel development to enhance and expand the insurer's capital management capabilities.

Comparison of Financial Market and Hybrid Risk-Transfer Products

The hybrid and financial market risk-transfer products discussed in this article are summarized in Figure 10, which compares these risk-transfer mechanisms along several dimensions. Also included in the figure for comparison are (re)insurance and captives. The figure shows that the alternative products differ in several important ways, including credit risk, basis risk, moral hazard, transparency, and whether broader capital markets are accessed.

One noteworthy finding from Figure 10 is that the level of liquidity is generally quite low in the market for insurance risk transfer. Liquidity in the secondary market for Cat bonds is currently moderate in comparison with broader financial markets, and futures and options markets have potential future liquidity but very low trading volume to date. The other types of instruments shown in the figure seem to be inherently illiquid, with the possible exception of ILWs and swaps. The reinsurance-hybrids tend to be especially opaque and illiquid.

FIGURE 10
Risk-Transfer Products

Products	Credit Risk	Basis Risk	Moral Hazard	Trans-parency	Multi-year	Multi-risk	Standard-ization	Liquidity	CapMkt Access
Insurance/Reinsurance	Yes	No	Yes	Low	Rarely	Rarely	Low	Low	No
Captive Insurer	Yes	No	No	High	Yes	Yes	Low	Low	No
Hybrid Products:									
Finite Reinsurance	Yes	No	Yes	Low	Often	Rarely	Low	Low	No
Retrospective XOL Covers	Yes	No	Yes	Low	Often	Rarely	Low	Low	No
Multi-year, Multi-peril Products	Yes	No	Yes	Low	Yes	Yes	Low	Low	No
Multiple Trigger Products	Yes	Yes	Yes	Low	Often	Rarely	Low	Low	No
Industry Loss Warranties (ILWs)	F	Yes	No	High	No	No	Moderate	Low	Yes
Sidecars	S	Minimal	Moderate	High	Often	Sometimes	Low	Low	Yes
Financial Market Instruments:									
Contingent Capital	F	T	T	High	Yes	Often	Low	Low	Yes
Futures and Options	Yes	Yes	No	High	No	Rarely	High	Potential	Yes
Swaps	Yes	T	Low	High	Often	Varies	Moderate	Low	No
CAT Bonds: Indemnity	C	No	Yes	High	Yes	Varies	Moderate	Moderate	Yes
CAT Bonds: Non-indemnity	C	Yes	No	High	Yes	Varies	Moderate	Moderate	Yes

T = depends on trigger. Basis risk is low for company loss (indemnity) triggers but moderate to high for index and parametric triggers. Moral hazard is moderate to high for indemnity triggers but low for index and parametric triggers.
S = depends upon structure and collateral arrangements.
F = depends upon whether capital is prefunded or unfunded for contingent capital and whether limit is collateralized under ILWs.
C = usually minimal but depends upon investment restrictions, swap counterparty arrangements, topping up rules, etc.

Credit risk remains a problem for most of the hybrid contracts due to the potential for counterparty (reinsurer) default. Cat bonds can virtually eliminate credit risk if properly structured. Credit risk for ILWs, sidecars, and contingent capital depends upon structuring, collateral, and prefunding arrangements. The variability in credit risk across the various financial instruments emphasizes the need for more standardization in this market. Basis risk is of minimal concern for reinsurance and reinsurance-based hybrids but of more concern for instruments that access capital markets directly, with the degree of basis risk depending on the trigger definition.

Most of the hybrid and financial market instruments tend to be multi-year contracts, giving them an advantage over traditional single-year reinsurance. Overall, Figure 10 reveals that the choice of risk-transfer instruments is complex, involving multicriteria decision making, but also shows that market participants have a wide range of available alternatives to meet various risk-financing needs.

CAT BONDS: CORRELATIONS WITH ALTERNATIVE INVESTMENTS

Proponents of Cat bonds have long argued that these securities provide a valuable new source of diversification for investors, and Cat bonds are often said to be "zero beta" investments (Litzenberger et al., 1996). In the past, little systematic empirical evidence has been presented to support the claim that Cat bonds have low investment betas. However, beginning in 2001, several Cat bond mutual funds were established, and Swiss Re began compiling Cat bond investment performance indices in 2007, based on secondary market trading, and has extended the indices back to 2002. The Swiss Re Cat bond index data and Cat bond mutual funds are analyzed in this article to provide evidence on the attractiveness of Cat bonds as investments.

Swiss Re maintains four total return ILS indices—an overall ILS index, a BB-rated index, a California earthquake index, and a U.S. windstorm index. The broadest indices are the overall and BB-rated indices, with the California earthquake and U.S. windstorm being subsets of both indices. We chose to analyze the broadest available indices because this would parallel a diversified Cat bond investment strategy. The overall and BB indices are highly correlated, so the analysis focuses only on the BB index.

Bivariate correlation matrices of returns on the Swiss Re BB-rated ILS index with several other investment indices and yield rates are shown in Table 2. Both total returns and coupon returns (yields) are shown in the table, for Cat bonds and other assets.[32] A range of alternative investment returns is presented, including the Merrill-Lynch BBB corporate bond index, a Barclays commercial mortgage-backed securities (CMBS) index, the Standard & Poor's (S&P) 500 stock index, the 3-month LIBOR rate, and three U.S. government bond yield rates.

To illustrate the correlation of Cat bonds with alternative investments under different financial scenarios, Table 2 presents two correlation matrices—one for the period prior to the subprime financial crisis that began in 2007 and one encompassing the crisis period. Because the onset of the crisis is usually traced to July 2007 (e.g., Frank, Gonzalez-Hermosillo, and Hesse, 2008), the precrisis matrix is for the period January 2002 through June 2007 (Panel A of Table 2), and the postcrisis matrix is for the period July 2007 through early January 2009 (Panel B of Table 2).[33]

The first conclusion to be drawn from Table 2 (Panel A) is that Cat bond total returns have almost no correlation with returns on alternative investments during the mostly normal market conditions represented by January 2002 through June 2007. Cat bond coupon returns are highly correlated with the LIBOR and U.S. government bond yields, but this is expected because Cat bonds are priced at spreads over LIBOR and SPV trust assets often consist of government bonds. Therefore, during normal conditions, Cat bonds are close to zero-beta with respect to stock and bond total returns.[34]

The picture is different during the subprime crisis (see Panel B of Table 2). Cat bond total returns during the crisis are significantly correlated with three of the total return indices—the Merrill-Lynch BBB corporate bond index, the Barclays CMBS index, and the S&P 500 stock index, with correlations ranging from 0.19 (for CMBS) to 0.465 (for BBB corporates). This provides further evidence of the extreme financial market contagion characterizing the subprime crisis. However, even during the crisis, the bivariate correlations indicate the Cat bonds would be valuable for diversification, for example, the correlations with stocks are still relatively low and Cat bonds are not significantly correlated with the Barclays government bond index. Hence, Cat bonds

[32]The total returns include both coupon and price returns for bonds and dividends and price returns for stocks.

[33]Moving the breakpoint to June, August, September, or October 2007 does not materially affect the results.

[34]Empirical evidence that catastrophes are uncorrelated with the stock market in Japan is provided in an event study by Yang, Wang, and Chen (2008), which shows no significant catastrophe effect for the Japanese stock market as a whole, although catastrophes negatively affect insurance stocks and positively affect construction firm stocks.

TABLE 2
Correlations Matrix of Returns on Insurance-Linked Securities (ILS) and Other Asset Classes

	LIBOR 3 Month	Swiss Re BB ILS TRR	Swiss Re BB ILS Cpn Rate	ML Corp BBB Bond Index	Barclays CMBS Elig Index	S&P 500 Index	Gov Bond 3- mo Yld	Gov Bond 5- Yr Yld	Gov Bond 10- Yr Yld	Barclays 5–7 Year Govt Ind
Panel A: January 2002 through June 2007										
LIBOR 3 month	1.000									
Swiss Re BB ILS TRR	0.024	1.000								
Swiss Re BB coupon rate	0.960***	0.080	1.000							
ML Corp bond BBB index	−0.054	0.031	−0.018	1.000						
Barclays CMBS inv elig index	−0.061	0.024	−0.037	0.822***	1.000					
S&P 500 index	0.038	0.071	0.032	−0.173***	−0.330***	1.000				
Gov bond 3- mo yld	0.999***	0.032	0.962***	−0.055	−0.061	0.038	1.000			
Gov bond 5- yr yld	0.834***	0.048	0.800***	−0.090*	−0.024	−0.052	0.834***	1.000		
Gov bond 10- yr yld	0.512***	0.102*	0.531***	−0.076	0.021	−0.095*	0.514***	0.884***	1.000	
Barclays 5- to 7- yr gov bond index	−0.036	0.018	−0.014	0.808***	0.968***	−0.382***	−0.037	−0.010	0.026	1.000

(Continued)

TABLE 2
Continued

	LIBOR 3 Month	Swiss Re BB ILS TRR	Swiss Re BB ILS Cpn Rate	ML Corp BBB Bond Index	Barclays CMBS Elig Index	S&P 500 Index	Gov Bond 3- Mo Yld	Gov Bond 5- Yr Yld	Gov Bond 10- Yr Yld	Barclays 5–7 Year Govt Ind
Panel B: July 2007 through January 2, 2009										
LIBOR 3 month	1.000									
Swiss Re BB ILS TRR	0.067	1.000								
Swiss Re BB coupon rate	0.812***	0.239**	1.000							
ML corp bond BBB index	−0.055	0.465***	0.204*	1.000						
Barclays CMBS Inv Elig index	−0.002	0.190*	0.035	0.282**	1.000					
S&P 500 index	−0.080	0.305***	0.074	0.147	0.481***	1.000				
Gov bond 3- mo yld	0.862***	0.245**	0.763***	0.252**	0.094	0.082	1.000			
Gov bond 5- yr yld	0.830***	0.193*	0.581***	0.127	0.005	0.032	0.924***	1.000		
Gov bond 10- yr yld	0.797***	0.157	0.519***	0.056	−0.109	−0.024	0.850***	0.968***	1.000	
Barclays 5- to 7- yr gov bond index	0.034	0.133	0.183	0.563***	−0.050	−0.362***	0.014	−0.035	−0.011	1.000

Source: Government 3-month, 5-year, and 10-year bond yields are from the Federal Reserve Board of Governors. Three-month LIBOR is from Economagic.com. Standard & Poor's index is obtained from Yahoo finance. All other data from Bloomberg (Swiss Re and Merrill-Lynch series) and Datastream (Barclays). Barclays series are the former Lehman bond indices.

Note: LIBOR 3 month is the 3-month London Interbank Offer Rate; Swiss Re BB ILS TRR is the Swiss Re BB insurance-linked securities total return index; Swiss Re BB ILS Cpn Rate is the Swiss Re BB index coupon rate; ML is Merrill-Lynch; Barclays CMBS Inv Elig Index is Barclays CMBS Investment Eligible Total Return Index.

***Significant at 1% level; **significant at 5% level; *significant at 10% level.

could still be used effectively to diversify portfolios containing most types of stocks and bonds. Nevertheless, they were not zero-beta during this crisis; that is, like most other assets, they can be somewhat susceptible to systemic risk.

Summary statistics on the Cat bond mutual funds listed on Bloomberg are provided in Table 3. The table shows that the funds are relatively small, ranging in size from \$35 million to \$303 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 13 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 $\$10^4$, while the price of the other Cat Bond mutual funds reported are in the range of $\$10^2$.

Because the individual Cat mutual fund data are noisier than the Swiss Re data, we decided to conduct regression analysis rather than presenting a correlation table for the mutual fund returns. Specifically, the following panel data regression equation was estimated for the mutual fund total return series

$$\begin{aligned}\log(P_{i,t}/P_{i,t-1}) = \alpha + \beta_1 \log(I_{BI,t}/I_{BI,t-1}) + \beta_2 \log(I_{SP,t}/I_{SP,t-1}) \\ + \beta_3 \log(R_{BY,t}) + \omega_i + \varepsilon_t + \nu^{it}\end{aligned} \tag{2}$$

where

$P_{i,t}$ = price of mutual fund i in period t,

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

$I_{SP,t}$ = Standard & Poor's 500 stock index in period t,

R_{BYt} = Moody's seasoned Baa corporate bond yield,

ε_t = a random error term for period t,

ω_i = a unit (fixed-effect) coefficient for mutual fund i, and

ν^{it} = random error term.

The dependent variables in Equation (2) were converted into USD before running the regression. The sample consisted of monthly returns from fund inception to June 27, 2008. Regressions were run including each independent variable separately, all two-variable combinations of the three regressors, and all three regressors.

The regression was conducted as a panel data model with all funds pooled in a single regression.[35] Pooled regressions were used to expand the number of degrees of freedom and to explore relationships that might be obscured in individual fund

[35]Regressions conducted fund by fund were consistent with the panel results but noisier due to small sample size.

TABLE 3
Cat Mutual Fund Key Statistics

Panel A: No Institutional Investor Restrictions

Ticker symbol	ACATCHA	ACATEUA	ACATUSA	LPC2USD	LPC2CHF	LPC2EUR	LEUPCBC	LEUPCBE	LEUPCBU
Maximum return	0.92	1.04	1.15	1.34	1.11	2.35	0.81	0.96	1.14
Minimum return	−0.49	−0.32	0.00	0.00	0.00	−0.72	0.00	0.00	0.00
Average return	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	98.08	96.15	100.00	100.00	100.00	98.08	100.00	100.00	100.00
% Periods down	1.92	3.85	0.00	0.00	0.00	1.92	0.00	0.00	0.00
Skewness	1.49	1.65	1.79	1.53	1.69	2.43	1.73	1.58	1.73
Assets (USD mil)	189.908	188.908	188.91	34.87	103.731	54.705	303.234	252.363	159.22
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

(*Continued*)

TABLE 3
Continued

Panel B: Institutional Investors Only

	ACATCHI	ACATEUI	ACATUSI	ELNCTBD
Maximum return	0.96	1.09	1.19	0.25
Minimum return	−0.35	−0.41	0.00	−0.08
Average return	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	98.08	96.15	100.00	96.15
% Periods down	1.92	3.85	0.00	3.85
Skewness	1.74	1.57	1.75	−0.48
Assets (USD mil)	188.908	188.908	188.908	62.2817
Inception date	10/11/2004	4/29/2005	4/29/2005	12/22/2006

Note: All fund measures are average, annual absolute 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. Minimum and maximum returns and percents of periods up and down computed over the same periods as for average returns. 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); 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. Average annual returns are computed from 2/28/2007 for ELNCTBD and from 1/31/2002 to 5/30/2007 for LEUPCBC and LEUPCBE, respectively. Average annual returns are computed from 7/31/2001 to 5/30/2007 for LEUPCBU and from 2/27/2008 to 11/30/2007 for LPC2CHF. 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.

TABLE 4
Panel Data Regressions of Change in CAT Bond Mutual Fund Prices Monthly Data From Fund Inception to 5/30/2008: No Institutional Investor Restriction

	Δ(Merril-Lynch U.S. BBB Bond Index)		Δ(S&P Weekly Average Index)		Moody's Seasoned Baa Corp. Bond Yeild		Intercept			
	Coeff.	*t*-stat	Coeff.	*t*-stat	Coeff.	*t*-stat	Coeff.	*t*-stat	*N*	Adjusted R^2
No fixed effects										
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
Fixed effects										
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 US dollars. The symbol Δ signifies variable defined as ln(Xt) − ln(Xt − 1). 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 C; 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.

regressions due to the small number of time series observations per fund. Regressions were conducted separately for the institutional investor (high price) funds and the low price funds because the two sets of funds are likely to have different investment objectives.[36] To conserve space, only the regressions based on the low price mutual funds are discussed. The other regressions are available from the authors.

The results for the low-price mutual funds are shown in Table 4. Regressions with and without fixed effects are presented, but the fixed effects regressions are likely to be more reliable, given that statistical tests revealed that fixed effects are present in the data. The regressions 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-Lynch BBB total return index is also statistically significant in the fixed-effect regressions. Therefore, it is interesting to conclude that Cat bond total returns are correlated with total returns on BBB corporates, as suggested by Figure 9, even though the betas are low, in the range of 0.10–0.13. 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. Thus, based on the regressions results, even if Cat bonds are not truly "zero-beta," they are very close.

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 that 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 KRW 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 that 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 hybrid instruments, which combine features of reinsurance and securities, and pure financial market instruments such as 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.

[36] None of the funds included in the study has an objective of investing 100 percent in ILS. Most of the funds indicate they will invest at least 75 percent in this type of asset, and some of the funds just indicate that they will invest a high percentage of assets in bonds.

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, and RXLs. However, more evolutionary products also have been developed including 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, multitrigger 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 Cat bonds. The Cat bond market is thriving and seems to have reached "critical mass," achieving record bond issuance in 2005, 2006, and 2007, and withstanding the subprime crisis of 2007-2008. 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 ILS market. Cat bonds, swaps, sidecars, ILWs, 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 noncatastrophe coverages such as automobile, agricultural, and commercial-liability insurance. 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, counterparty credit risk, and contract design, as well as the need to educate insurance industry participants, are the primary impediments to success for these contracts.

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