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The Intermediation of Financial Risks: Evolution in the Catastrophe Reinsurance Market

Kenneth A. Froot

Introduction

Each time a major and costly catastrophic peril occurs, a chorus arises from within the insurance community and beyond. The critics claim that the reinsurance market is inadequate, even dysfunctional, in cheaply redistributing risks. They cite frustration with the high prices and limited availability of capacity that follows the catastrophe, with the limited choice of sometimes-questionable credit risks, etc.

Yet, in spite of these problems, the reinsurance market continues on. It doesn't appear to have been extinguished or even hindered by the unwillingness of insurers to cede their risks. Nevertheless, insurers rightly wish to know why it should be so expensive and rare to find reinsurers who are willing to take on extreme catastrophic risks. After all, natural perils are both objectively modelable and unsystematic in their occurrences–qualities that, if anything, should make it relatively more attractive to supply reinsurance capital.

Most recently, in the aftermath of Hurricane Katrina, the market has continued to show signs of trouble in providing capital cheaply and quickly. Why, with all the last decade's improvements in financial intermediation and risk sharing, aren't things easier? At times of excess demand, one would think there is an opportunity to add to reinsurance supply. A badly needed product that sells at prices well above the cost of production should be supplied aggressively. This conundrum of short supply combined with high prices makes the topic of financing catastrophes a fertile one for academics and practitioners alike.

In this article, I provide evidence concerning the imperfections in the reinsurance market. I try to get at some of the root causes of these imperfections—e.g., the behavior of ratings firms and the agency problems associated with the corporate form of ownership. I also summarize the recent evolution of intermediation for catastrophic risk. A simple framework for an integrated theory of optimal financial policy for insurers and reinsurers is discussed. Finally, policy implications for intermediation of financial risks in view of evolving financial solutions for catastrophic risk are proposed.

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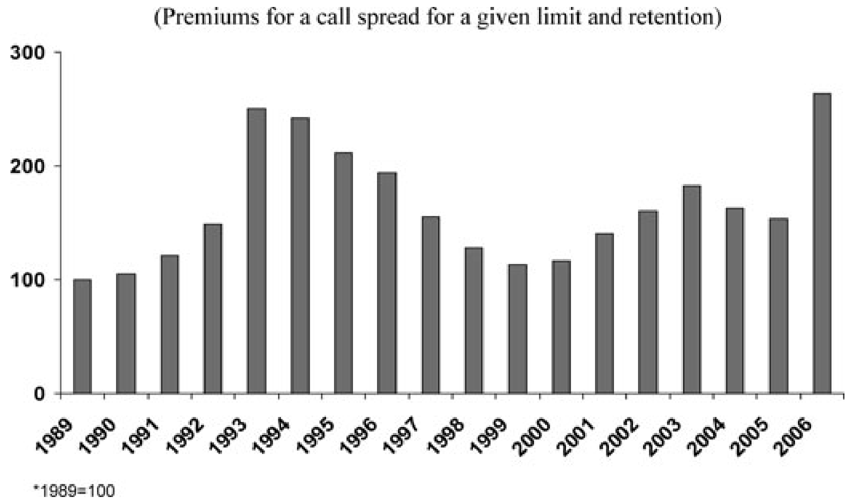
FIGURE 1
U.S. CAT Property: Rate-on-Line



THE REINSURANCE MARKET

Evidence that things sometimes go away in the reinsurance market can be gleaned from premiums and price data in the reinsurance market. Figure 1 contains an index (1989 = 100) of "rate-on-line" information for U.S. catastrophic risk from 1989 to 2006. Rate-on-line is found by dividing the contractual reinsurance premium by the reinsurance limit and converting the result into a percentage. The infamous cyclical nature of property–liability insurance is apparent from this figure. The spikes beginning in 1993 are attributable to Hurricane Andrew in 1992 and the Northridge earthquake in 1994. Rate-on-line rose again after 2001 and yet again after the devastation from Hurricanes Katrina, Wilma, and Rita (KWR) in 2005.

Although rate-on-line has some intuitive appeal, it is not a very accurate measure of price because it doesn't hold constant the likelihood of loss. In Figure 2, price (measured as premiums divided by expected loss) is portrayed for 1989–2000 as well as rate-on-line.[1] Clearly there is strong correlation between rate-on-line and price, but the correspondence is not perfect.

Figure 3 indicates that insureds cut back on their limits and/or increase their retentions in periods of high prices. In fact, insurance is being sold at a higher rate-on-line and an even higher price because there is less insurance being offered. A negative trade-off exists between the amount of insurance protection purchased versus the expected loss. That is, prices are high when quantity is low and insureds respond by adapting their purchasing behavior.

In a well-functioning insurance market, one expects to see a large degree of risk sharing, especially for large losses. Figure 4 depicts the percent of industry-wide insured losses

[1] Accident year losses after 2000 are not fully developed yet.

FIGURE 2
Price Expressed as Premium/Expected Loss

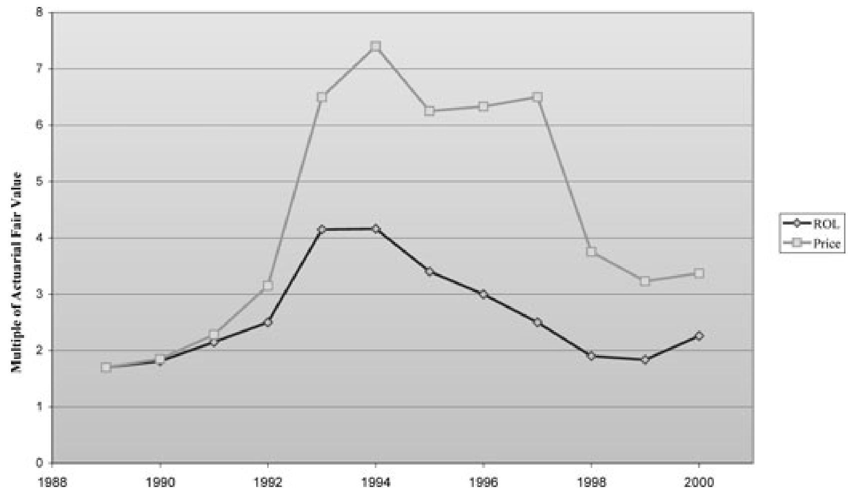
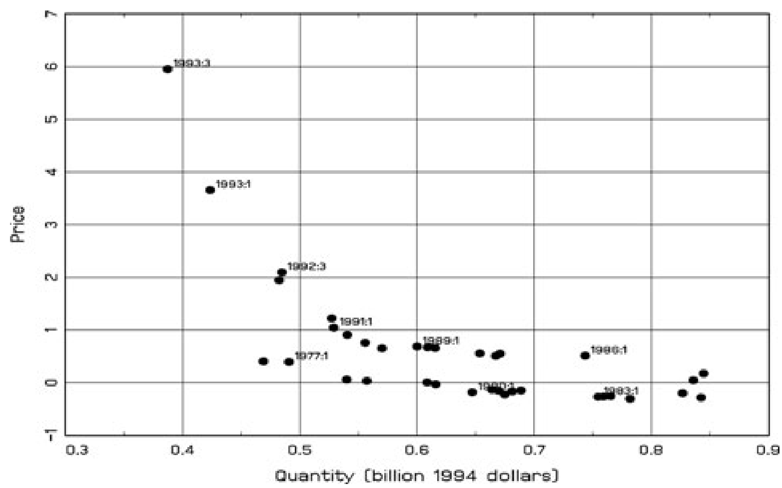


FIGURE 3
Reinsurance Price–Quantity Pairs



from an event that were reinsured in 1970, 1980, and 1994. The percent of insured losses from an event that are reinsured has been increasing, according to Figure 4. However, the largest events are associated with the lowest reinsurance percentage, in contrast to what would be expected in a well functioning market.

But catastrophe bond (CAT bond) prices are also very sensitive to events, and these events need not be natural catastrophes. CAT bond prices decline on days when the wind blows. Figure 5 shows CAT bond prices over the interval June 29, 2001 to November 23, 2001. Note the steep and severe drop in CAT bond prices associated with the September 11, 2001 terrorist attacks. The discount on these bonds increases from about 0.25 to

FIGURE 4
The Quantity of Risk Transfer Should Be High With Perfect Markets

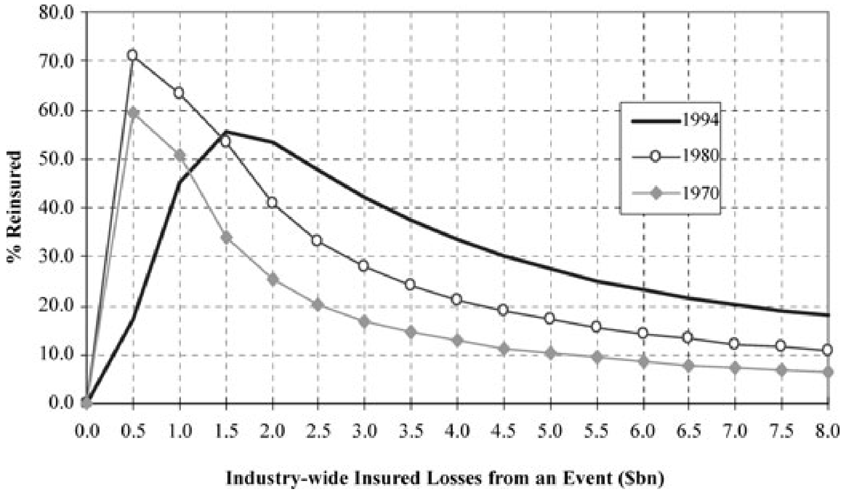
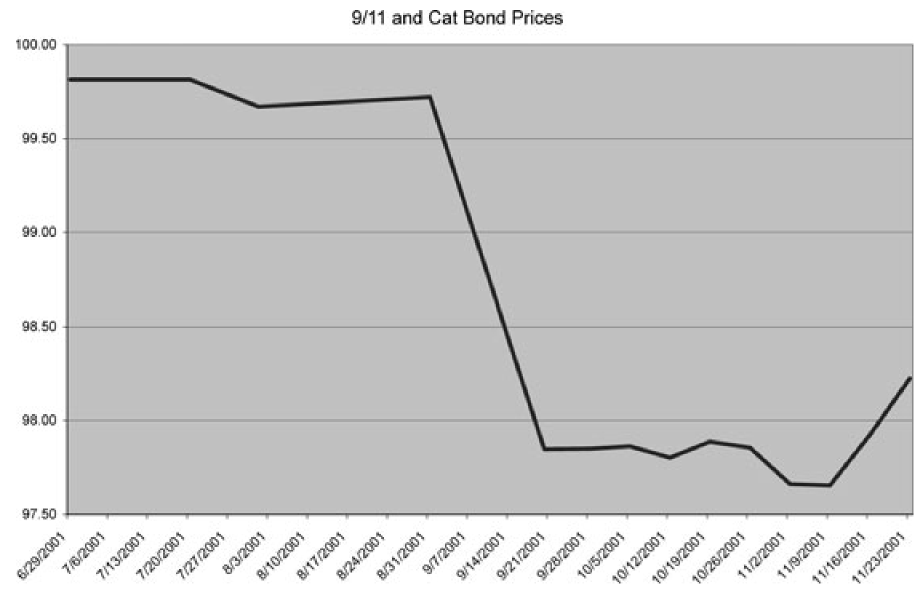


FIGURE 5
The Impact of Unrelated Perils on Prices



approximately 2.25. The increase is eight or nine times the size of the discount associated with this event. It is not surprising perhaps that prices of hurricane protection increase when there is a hurricane. But the cost of hurricane reinsurance—and reinsurance for other natural perils—also increases when there is a terrorist attack.

Table 1 provides more information about the sensitivity of prices for large events when unrelated events occur. In Table 1, hurricane and earthquake U.S. exposures are listed

TABLE 1
Impact of Hurricanes Katrina, Rita, and Wilma on Rate-on-Line

Region	Strike	Expected Loss	2005	2006
U.S. hurricane	$50B	2.5%	1.4x	6x
U.S. hurricane	$30B	4.9%	1x	5.1x
U.S. hurricane	$20B	8.1%	1.4x	4x
U.S. earthquake	$15B	4.3%	1.7x	3.5x
U.S. earthquake	$20B	3.2%	1.8x	3.6x
U.S. second event	$10B	5.2%	1.4x	4.8x
U.S. second event	$20B	1.2%	n/a	10.4x

Pricing shown as a spread to risk-free (typically 3 m UST).
Expected losses shown as market standard model output (not NCL estimates).

as well as the expected loss. The last two columns indicate the mark-up above expected losses used to obtain premiums in 2005 and 2006. The mark-ups associated with 2006 greatly exceed the mark-ups for 2005. The conventional wisdom is that wind models performed quite well in the case of Katrina, at least for the wind portion of losses. Nevertheless price increases of three- to four-fold occurred from 2005 to 2006 for hurricane-related coverage. Moreover, mark-ups for earthquakes approximately doubled from 2005 to 2006. Thus, it is clear that there are cross event spillovers occurring—regardless of one's view of what we learned from KWR about hurricane probabilities, there is little new information about earthquake probabilities in it.

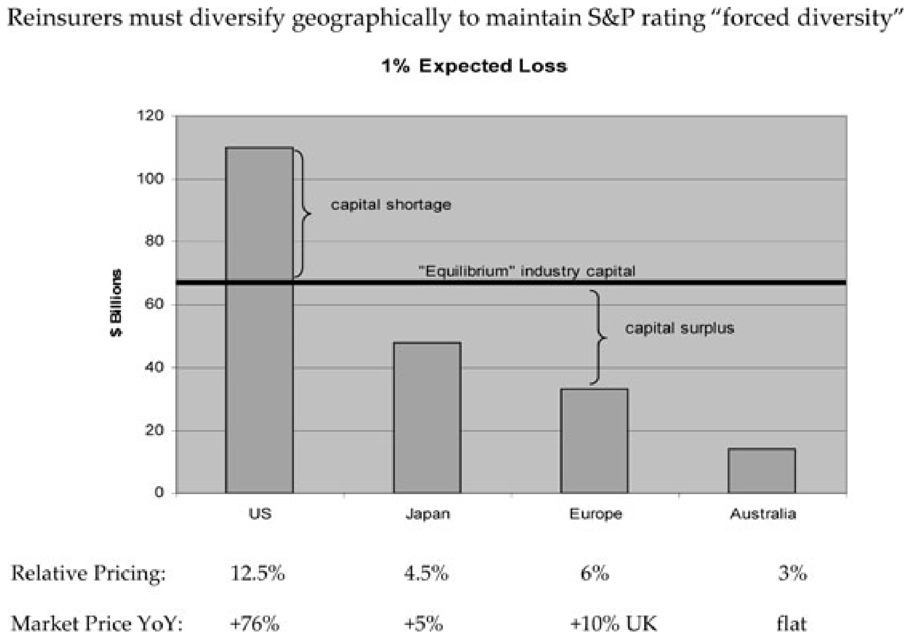
THE ROLE OF RATING AGENCIES IN REINSURANCE MARKET PROBLEMS

Price behavior such as this might easily lead to the suggestion that the reinsurance market is not functioning well. The obvious and much written-about problem is that a capital shortage occurs in the industry after a large event, leading to higher prices. The reinsurance industry does not seem to be channeling capital effectively or quickly enough to eliminate shortfalls and maintain disciplined prices.

Several mechanisms are at work in the reinsurance industry that lead to this result. Rating agencies play a role in this process. Rating agencies are concerned with the protection of customers and with providing shareholders with some discipline on management. As a consequence, rating agencies focus relatively more on risk than expected return. Meaningful measures of risk are easier to generate than those of expected return. But of course, in the investment world, risk and return are inextricably related. Both factors must be taken into account to achieve efficient capital allocation.

In the U.S. market there is a great need to manage large CAT exposures associated with hurricane and earthquake. In order to diversify these, one often looks to Japanese, European, and Australian wind and earthquake exposures. To achieve good diversification of risk, rating agencies encourage re(insurers) to spread their capital across all of these areas. But in doing so, they provide relatively too much capital to these diversifying exposures, which are smaller in size, and relatively too little capital to the larger U.S.

FIGURE 6
Capacity Shortage in U.S. Exposures, Excess Elsewhere



perils. The result is that inadequate capital is left for the U.S. market where the need is actually greatest. This problem is depicted in Figure 6, which shows a capacity shortage in the U.S. relative to Japan, Europe, and Australia.

This capacity shortfall would explain the large increase in prices from 2005 to 2006 portrayed in Table 1—i.e., price increases are greatest in the places where there appears to be a greater capital shortage. Meanwhile, exposures in other areas of the world do not experience such dramatic price increases because relatively more capital is available there. Thus the intermediation process—with its emphasis on diversification across natural perils—seems to supply an inadequate amount of capital at certain points of time, and this distorts pricing. U.S. insureds are not really being provided a good value in these circumstances. Naturally, because U.S. hurricane and earthquake losses are uncorrelated with financial market returns—and not just losses from perils abroad—investor diversification of these exposures should be relatively cheap and easy to provide. These exposures are automatically diversified in the context of far larger and broader investor portfolios.

The market distortions described above appear to be more supply than demand related. To see this, Figure 3 shows a set of demand–supply equilibrium points, graphed in terms of price and quantity of reinsurance provided, at different points in time. A strong negative correlation between price and quantity supplied emerges. This suggests that supply shocks are the main driver—a decline in supply (following, say, an event) results in an increase in price and decline in quantity of risk transfer. Demand shocks would have the opposite effect, affecting in the same direction both price and quantity.

And certainly demand might be expected to increase after a large hurricane. But as Figure 3 shows, demand cannot not the main driver of the phenomena observed in the reinsurance market, rather it is the supply of capital.

PRICING DISTORTIONS FROM THE CORPORATE OWNERSHIP FORM

The corporate form of ownership also plays into supply problems in the reinsurance market. Insurers and reinsurers, like other corporations, face costs associated with depleting and hoarding capital. Costs are associated with depleting capital because it is expensive to raise capital from capital markets. Capital markets are concerned with providing funding to a company that has a large amount of debt and little excess capital because of adverse selection problems and fear that such companies may go out of existence.

In a perfect world, market values of insurers would rise on a one-to-one basis with their surplus. In a world in which managers may exploit private benefits from an insurer's capital, insurers' market values would rise less than $1 from each $1 increase in surplus. But when an insurer begins to deplete its capital, the drop in market value accelerates. Insurers in this situation face the problem of sustaining themselves with relatively low amounts of capital to take on risk. Finance theory and empirical observation suggest that when capital falls below target levels, bankruptcy, or underinvestment costs occur. Many studies suggest that firms cut back on profitable investment and other spending when cash is tight (Gilson, 1995; Lamont, 1997; Zingales and Kaplan, 1997).

Customers are also sensitive to an insurer's relative amount of capital. Customers want a riskless insurance product (i.e., certainty of loss payment), not a probabilistic payment in the event of a personal loss. Indeed, risky payoffs appear to be discounted more severely by customers than by rational investors. Several theories support this proposition. Zeckhauser's famous Roulette Introspection and the body of Prospect Theory support this preference of consumers for certain, not probabilistic, insurance. Also, purely frictional models suggest that because the cost of customer diversification across insurers is high, customers are less willing than investors to diversify among insurance providers. Hoerger, Sloan, and Hassan (1990), Taylor (1995), Cummins and Sommer (1996), Cummins and Danzon (1997), and Zanjani (2002) incorporate customer sensitivity to an insurer's insolvency risk in their insurance models.

There is evidence in corporate valuations that these stakeholders—capital providers and customers—prefer an insurer to be sufficiently capitalized. Empirical research links low levels of insolvency risk with relatively higher property–liability insurer premiums. Evidence exists that profitability is positively related to surplus and assets (Sommer, 1996). Also, New York and Florida homeowners pay higher premiums to better rated insurers (Grace, Klein, and Kleindorfer, 2004). Higher Best-rated firms grow faster after ratings change (Epermanis and Harrington, 2006). All these studies are consistent with the idea that lower amounts in internal capital reduce an insurer's value increasingly rapidly when capital is low.

Hoarding capital leads to other sorts of agency problems that are well-documented in the finance and insurance literatures. It is inefficient to warehouse unused capital in taxable corporations. Also, it can be dangerous and risky to provide managers with discretionary control of too much capital. Managers incentives may not be perfectly aligned with shareholders and these differences become exacerbated at extreme levels (both low and high) of internally available capital. Capital markets often prefer limits on managerial discretion imposed by using less capital and/or more debt financing.

Empirical evidence supports this view of hoarding capital. Firms with greater managerial discretion seem to diversify too much (Wruck, 2000). The stock prices of bidders fall and those of targets rise in takeovers (e.g., Ruback, 1982). The value of firms increase on a less than one-for-one basis when well-funded firms receive surprise legal awards (Shleifer and Vishny, 1997). And closed-end funds are worth less on average than their net assets (Lee, Shleifer, and Thaler, 1990; Hardouvelis, La Porta, and Wizman, 1994; Bodurtha, Kim, and Lee, 1995; Pontiff, 1997).

A SIMPLE FRAMEWORK FOR COSTS OF DEPLETING AND HOARDING CAPITAL

In this section, I present a simple model depicting deadweight costs of hoarding and depleting capital. I discuss what I call the "M curve"—the market value of an insurer or reinsurer as a function of internal capital. I link this to formulas (derived in Froot, 2007) that explicitly take account to of the distortions above to solve for required returns on individual risks positions and for optimal risk positions in under special distributional assumptions.

Deadweight costs of hoarding capital are depicted in Figure 7. The line in the figure with a slope of 1 is consistent with classical finance. That is, there are no costs of depleting or hoarding capital. Hurdle rates are equivalent to required returns in the capital market. The costs of hoarding capital are depicted by the line with slope $\delta < 1$. With costs of hoarding capital, each additional dollar of surplus contributes less than an additional dollar of market value. Expected returns inside the firm differ from those in the capital market.

In Figure 8, the effect of capital depletion is portrayed. The value of the firm falls off increasingly quickly as surplus reaches levels too low to support firm-wide risk. And

FIGURE 7
A Simple Framework for Costs of Hoarding Capital

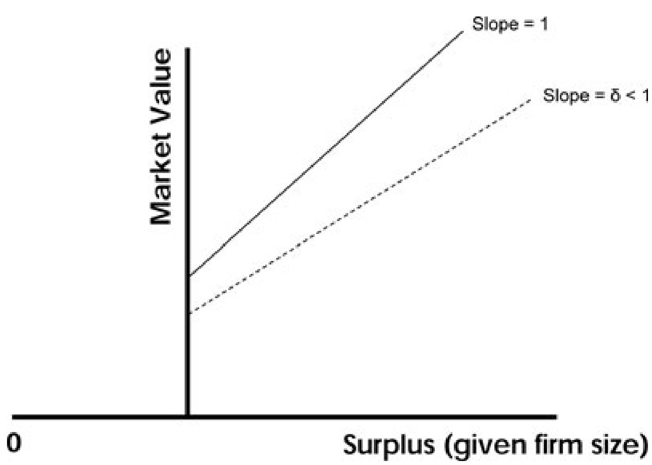


FIGURE 8
A Simple Framework for Costs of Depleting and Hoarding Capital

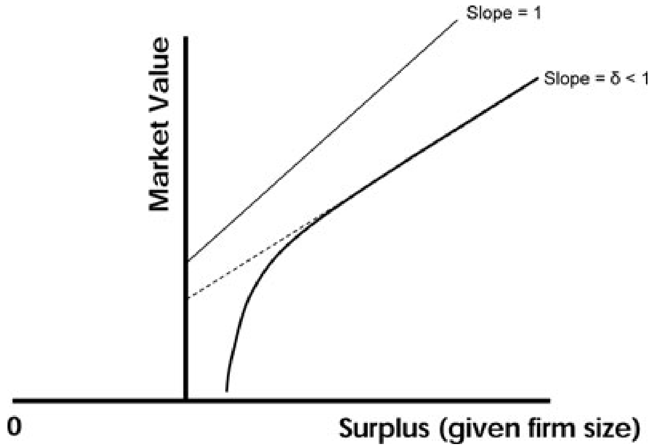
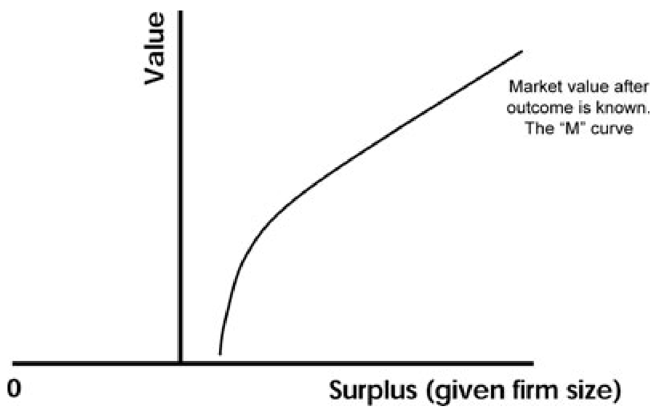


FIGURE 9
A Simple Framework for Costs of Depleting and Hoarding Capital, Final



the required returns inside the firm exceed those in the capital markets for low amounts of capital.

Figure 9 indicates the market value of the firm *after* the outcome is known, the so-called M curve. The market value of the firm *before* the outcome is known is referred to as the "EM curve," and it is depicted in Figure 10. The EM curve is just the probability weighted average of market values before the outcome is known. Each new financial decision of the firm represents a revision of the EM curve. The EM curve effectively shows the company's risk aversion; it indicates how much return is required to offset risk. Note that the M and EM curves merge at very high levels of capital.

The ideas expressed in the M and EM curves become more statistically tractable if normality is assumed. In this case, formulas for incremental rates of return can be derived in the presence of the distortions discussed above (see Froot, 2007, for a full

FIGURE 10
A Simple Framework for Market Value Before and After Outcome Is Known

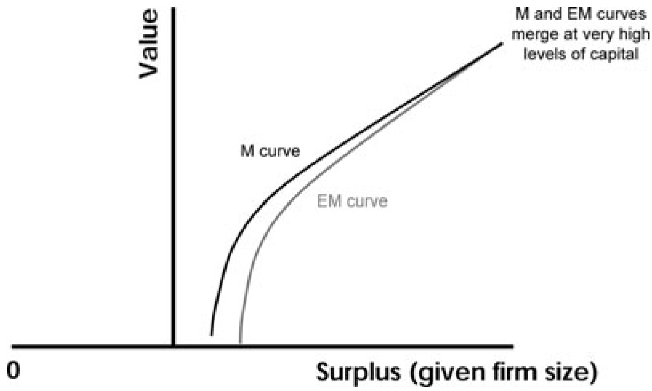
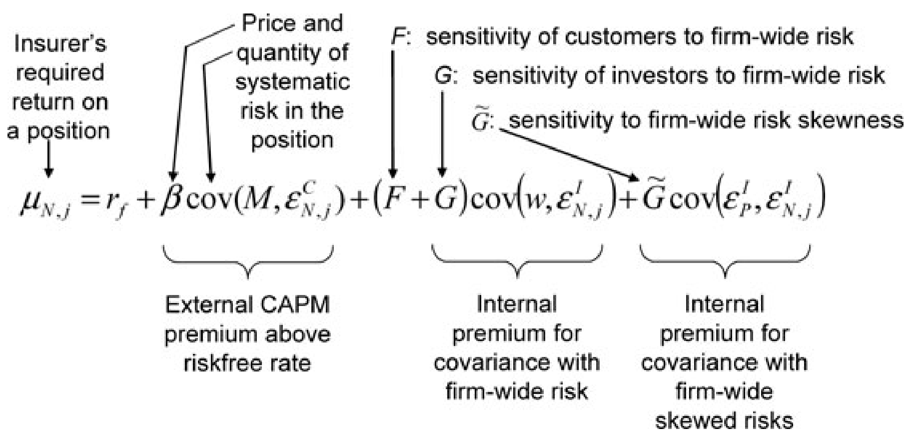


FIGURE 11
Incremental Required Returns on Individual Risk Positions (Normality Assumed)



presentation of the model and derivation of the results). Consider a factor-pricing model that includes market risk (i.e., CAPM risk) as the first factor. Additional factors then consider the required return associated with the imposition of risk on internal funds. (This required return exists because internal funds are not easily substituted for external funds.) The extra return or premium associated with internal funds is augmented by the sensitivity of both customers and investors for worldwide risk. A three-factor model depicting incremental required return on individual risk positions under the assumption of normality is depicted in Figure 11. Note that the last factor indicates that incremental rates of return increase with covariance with firm-wide skewed risks. This means that incremental required rates of return are higher when a risk such as a Florida hurricane can occur when capital is already relatively low.

If risk distributions are normal, then the optimal amount of a risk position to hold will be driven by three factors. These factors are depicted in Figure 12. The first factor is the minimum-variance risk allocation. This is the risk allocation that is best if there

FIGURE 12
Optimal Risk Position Amount (Normality Assumed)

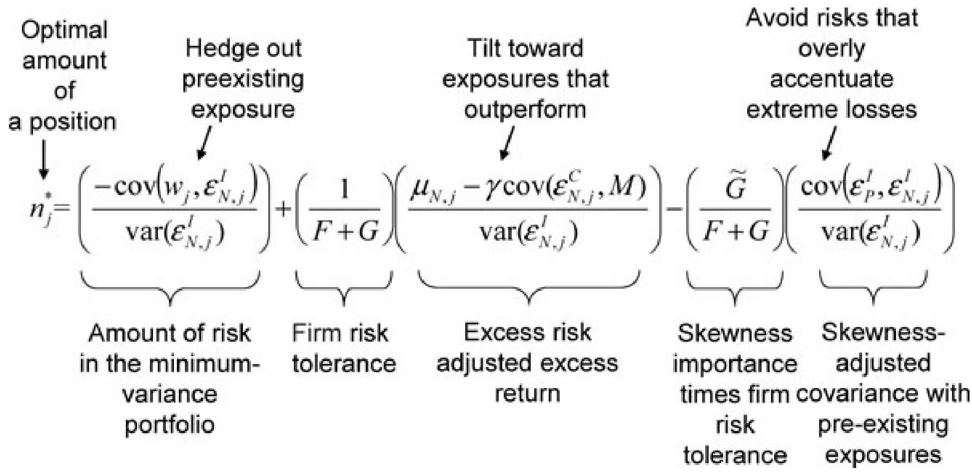


TABLE 2
Some Empirical Evidence From 9/11

A.M. Best Rating	*N*	Days (0, 1)	Days (0, 4)	Days (5, 30)
A++	6	−2.95	−2.62	7.80
A+	17	−6.74	−8.38	9.30
A	12	−3.37	−7.05	−0.88
A−	3	−2.06	−5.51	−8.75
Not Rated	5	−3.97	−7.29	9.18

Source: From Cummins and Lewis (2002, Table 4).

are no abnormal rates of return to be earned, considering the fact risk is costly for an insurer to bear. The second and third factors are the excess risk-adjusted return and the skewness-adjusted covariance with existing exposures. The firm is tempted to pull away from minimum variance allocations in order to capture excess return *and* also to further avoid negatively skewed risks that are particularly threatening to its existence. Thus minimum variance portfolios are only a starting point for effect allocation of risk within a corporate insurer or reinsurer.

Some empirical evidence from estimating the M curve is contained in Table 2. This table indicates the cumulative average abnormal returns (CAAR) for insurers in different financial condition after the September 11, 2001 event and is reproduced from an event study by Cummins and Lewis (2003). The results show that more poorly rated insurers experienced a more negative impact on their market value as a result of 9/11.

POLICY IMPLICATIONS

Several positive implications derive from the theory discussed here. The first implication is that financial models can provide an integrated theory of optimal financial policy decisions for insurers and reinsurers. Policy decisions include asset allocation, acquisitions, underwriting and pricing, and dividends and equity issues/repurchases. The M and EM curves can help insurers and reinsurers price business in view of the distortions discussed in this article. These implications are drawn out in more detail in Froot (2007).

The second implication is that the inefficiencies associated with corporate ownership distortions can be avoided through the use of alternative instruments and intermediaries. Alternative instruments include CAT bonds, industry loss warranties, and other insurance-linked securities. Figure 13 provides statistics on the growth of CAT bond holding and issuances and industry loss warranties. Both instruments have experienced substantial growth since Hurricane Katrina. Intermediary solutions to financing of catastrophes include sidecars, collaterized debt obligations (CDOs) and increased interest in catastrophe funding vehicles and reinsurers by investment managers. Figure 14 indicates that growth in shareholder funds for global reinsurers occurred over 1999–2005. It also lists some recent sidecar transactions.

Thus, financing opportunities for natural catastrophes have been growing, but the growth has been slow. The development of new financing mechanisms requires development and accumulation of substantial "soft" resources such as knowledgeable firms offering new investment products. Also, behavior patterns need to be altered on

FIGURE 13
Growth of New Forms of Intermediation: CAT Bonds and Industry Loss Warranties

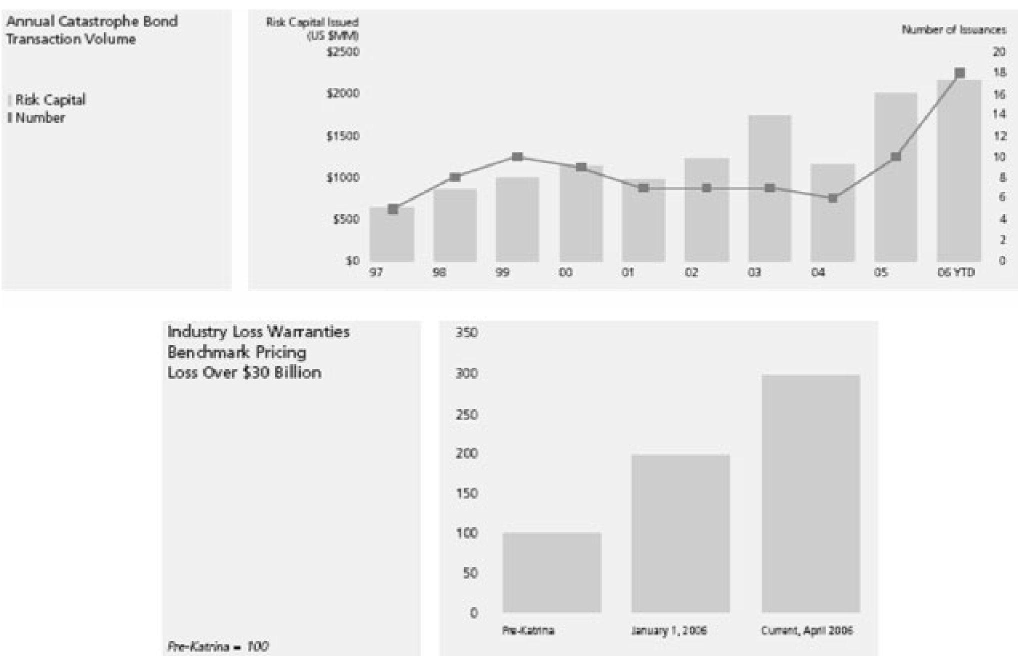
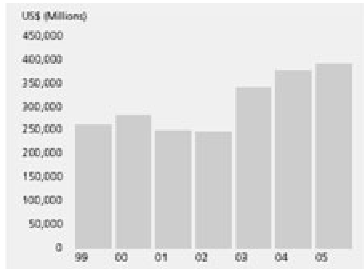


FIGURE 14
Growth of New Intermediation Forms Sidecars and Investment Management Firms

Global Reinsurers: Shareholder Funds

Source: S&P and Guy Carpenter



SIDECAR ARRANGEMENTS 2005-2006

SIDECAR ARRANGEMENTS 2005/2006	SPONSOR
Baypoint Re Ltd.	Harbor Point
Cyrus Reinsurance Ltd.	XL Capital, Highfields Capital
Flatiron Re Ltd.	Arch Capital, Goldman Sachs
Helicon	White Mountains
Petrel Re Ltd.	Validus, First Reserve Corp
Rockridge Re	West End Capital, Montpelier
Starbound Re	Ren Re

the investment side. For example, investment providers that are comfortable offering services through a mutual fund type structure rather than through a typical reinsurance structure are needed. This is not to say that reinsurers themselves cannot be involved in the transformation process, but the end result must be much more transparent and require less discretionary capital. More focused capital portfolios should develop over time to handle large event losses and these portfolios should be more efficient than what is available in the marketplace today.

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