# Catastrophe reinsurance and risk capital in the wake of the credit crisis

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## Abstract

**Purpose** – Property and casualty ("P&C") insurance companies rely on "risk capital" to absorb large losses that unexpectedly deplete claims-paying resources and reduce underwriting capacity. The purpose of this paper is to review the similarities and differences between two different types of risk capital raised by insurers to cover losses arising from natural catastrophes: internal risk capital provided by investors in insurance company debt and equity; and external risk capital provided by third parties. The paper also explores the distinctions between four types of external catastrophe risk capital: reinsurance, industry loss warranties, catastrophe derivatives, and insurance-linked securities. Finally, how the credit crisis has impacted alternative sources of catastrophe risk capital in different ways is considered.

**Design/methodology/approach** – The discussion is based on the conceptual framework for analyzing risk capital developed by Merton and Perold.

**Findings** – In 2008, the P&C insurance industry was adversely affected by significant natural catastrophe-related losses, floundering investments, and limited access to capital markets, all of which put upward pressure on catastrophe reinsurance premiums. But the influx of new risk capital that generally accompanies hardening markets has been slower than usual to occur in the wake of the credit crisis. Meanwhile, disparities between the relative costs and benefits of alternative sources of catastrophe risk capital are even more pronounced than usual.

**Originality/value** – Although many insurance companies focus on how much reinsurance to buy, this paper emphasizes that a more important question is how much risk capital to acquire from external parties (and in what form) *vis-à-vis* investors in the insurance company's own securities.

**Keywords** Risk management, Reinsurance, Credit

**Paper type** Conceptual paper

## 1. Introduction

In 2008, two completely uncorrelated series of events impacted the property and casualty ("P&C") insurance industry almost simultaneously: the North Atlantic Basin saw an above-average period of hurricane activity (with 16 named storms, of which four made landfall in the USA), and the credit crisis went from bad to worse. Not only was the insurance industry hit by historic catastrophe-related losses, but also by floundering investments. And capital that was once readily accessible in many

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forms rapidly became constrained and expensive. As a result, P&C reinsurance premiums have risen and capacity has shrunk.

Risk capital is an essential component of a P&C insurer's economic balance sheet – especially in years like 2008 – because it helps insurers cover unexpected losses that jeopardize the capacity of insurers to honor their claims payment obligations and preserve their ability to underwrite new business. "External" risk capital is provided by firms like reinsurance companies, whereas "internal" risk capital is provided by investors in the debt and equity securities issued by the insurance company. Although both external and internal risk capital provide similar reassurance to policyholders that their claims will be paid, the benefits and costs of external and internal risk capital to shareholders can differ significantly, as can the relative benefits and costs of alternative sources of external risk capital.

Section 2 provides an introduction to risk capital and review the fundamental similarities between internal and external risk capital. In Section 3, we consider the costs and benefits of internal *vis-à-vis* external risk capital both to insurance company policyholders and shareholders. Section 4 then compares and contrasts four alternative sources of external risk capital – traditional reinsurance, catastrophe derivatives, industry loss warranties (ILWs), and insurance-linked securities (i.e. catastrophe bonds). Section 5 explores the impact of the credit crisis on the reinsurance market and other alternative sources of risk capital and Section 6 concludes.

## 2. Capital structure and risk capital for P&C insurance companies

P&C insurance companies incur two kinds of liabilities in the normal course of business: contingent insurance liabilities to policyholders (i.e. "customer liabilities"), and obligations to investors in the firm's securities (i.e. "financial capital"). Financial capital is paid-in capital in which security holders provide the insurer with cash in exchange for a claim on the future net cash flows of the business. Insurance companies issue securities both to finance their operations and allocate the business and financial risks of the insurance business across different groups of investors.

### *2.1 Statutory vs economic balance sheets for P&C insurers*

P&C insurers generally have three kinds of balance sheets that indicate the values of assets and liabilities. Book values appear on both accounting and statutory balance sheets, where the former conform to traditional accounting rules (e.g. generally accepted accounting principles (GAAP)) and the latter are prepared in accordance with local regulatory accounting policies[1]. A third type of balance sheet – known as the economic balance sheet – reflects economic assets and liabilities (including off-balance-sheet and contingent items) at current market values.

A simplified statutory balance sheet for a typical P&C insurance company is shown in Figure 1. On the left-hand side of the statutory balance sheet is the insurer's asset portfolio, which consists primarily of cash and investments. Customer liabilities arising from P&C insurance policies appear on the right-hand side of the statutory balance sheet along with debt (both loans and securities).

Insurance companies have both hard and soft capital. Hard capital includes two primary components:

(1) Loss reserves, or reserves that reflect actual or probable losses on existing policies or loss adjustment expenses associated with those policies.

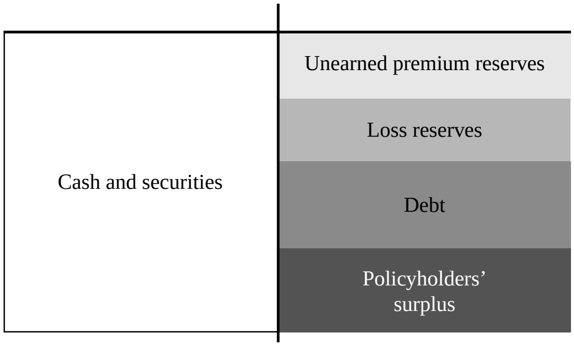


**Figure 1.**
Statutory balance sheet of a typical P&C insurance company

(2) Policyholders' surplus, which is the net worth of the insurance company (including paid-in share capital)[2].

Soft capital, in turn, includes:

- Unearned premium reserves (UPR), or reserves that reflect premium written and collected but not yet recognized as income. As the time remaining on the insurer's policies shrinks, so does the risk. So, as time passes, premium is earned and is shifted out of UPR into the policyholders' surplus.
- Contingent financial capital that will become paid-in capital if a specified loss event occurs in the future, such as contingent securities facilities (i.e. facilities that enable insurers to issue new debt or equity following a trigger event).

A simplified economic balance sheet for a typical P&C insurer is shown in Figure 2. Like the statutory balance sheet, the economic assets of the insurance company include the cash and securities held by the insurer in its investment portfolio. In addition, the insurer's economic assets now include the value of any reinsurance or "synthetic reinsurance" acquired by the insurer. Synthetic reinsurance is any facility that is economically equivalent to traditional reinsurance in protecting policyholders from the risk of defaults by the insurer on its claims payment obligations.

The right-hand side of the economic balance sheet includes both customer liabilities and financial capital, as did the statutory balance sheet. But because these items are

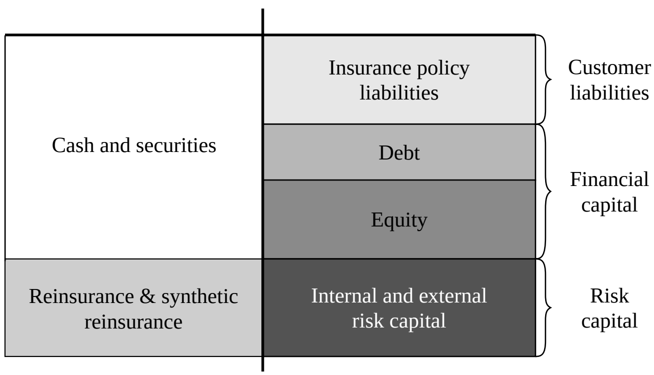


**Figure 2.**
Economic balance sheet of a typical P&C insurance company

now shown at their current market values, the specific items and their associated values can differ significantly from the statutory balance sheet.

The liabilities and capital on the economic balance sheet also differ from the statutory balance sheet in explicitly reflecting risk capital. Internal risk capital is provided by investors in the firm's debt and equity securities, and external risk capital is provided by third parties like reinsurance companies. The total value of risk capital shown on the right-hand side of the economic balance sheet should equal the total value of the reinsurance and synthetic reinsurance assets of the insurance company on the left-hand side.

*2.2 Synthetic reinsurance*

The most common providers of synthetic reinsurance to insurance companies are the investors in the debt and equity securities issued by the insurer. The nature of the synthetic reinsurance provided by investors is dictated by the financial capital structure of the insurance company.

If the value of a P&C insurance company's economic assets falls below the value of its liabilities, the firm becomes insolvent and goes into run-off mode[3]. The order in which investors are repaid following insolvency helps define the capital structure of the insurance company. Specifically, the seniority of a claim refers to the priority given to claim holders if the firm becomes insolvent and the proceeds from the liquidation of its assets are distributed to investors. The depth of subordination of a security is the inverse of its seniority, i.e. the most deeply subordinated securities are the most junior claims and have the lowest priority in insolvency proceedings. All else equal, more deeply subordinated securities expose investors to relatively greater risks. The reason is that investors in a security at one level of subordination cannot receive payments following insolvency until all holders of more senior securities are fully repaid.

Consider, for example, a P&C insurance company that has issued policies with an aggregate maximum policy liability of $1bn, for which the insurer has collected $100mn in premium. The insurance company's financial capital includes $500mn (face value) in senior debt, $250mn in subordinated debt, and common stock. As assets, the insurer is currently holding $900mn in cash. For simplicity, assume that interest rates are equal to zero, all debt is zero coupon, and all insurance policies expire on the same day that the debt matures.

Panel (a) of Figure 3 shows a hypothetical loss distribution indicating the probabilities of various cumulative policy claims payment obligations through the date on which the debt and insurance policies mature. Panel (b) of Figure 3 shows the firm's capital structure. If total claims for the year are less than $100mn, the premium collected more than covers the claims. In that situation, the firm's equity is worth $50mn plus whatever is left over from the premium income after all claims are paid, i.e. the residual of $900mn in cash less $750mn in debt less all actual insurance claims paid. If no claims have been paid, for example, equity is worth $150mn.

If claims exceed $100mn, however, cash that would otherwise be available to pay equity dividends and/or repay the firm's debt must be used instead to pay the more senior policy claims. Specifically, if claims are above $100mn but less than $150mn, the equity holders bear the entire loss, but all debt holders still get repaid. If policy liabilities exceed $150mn, however, the insurer goes bust: equity is worthless and debt holders experience losses. Losses between $150mn and $400mn result in a partial or total

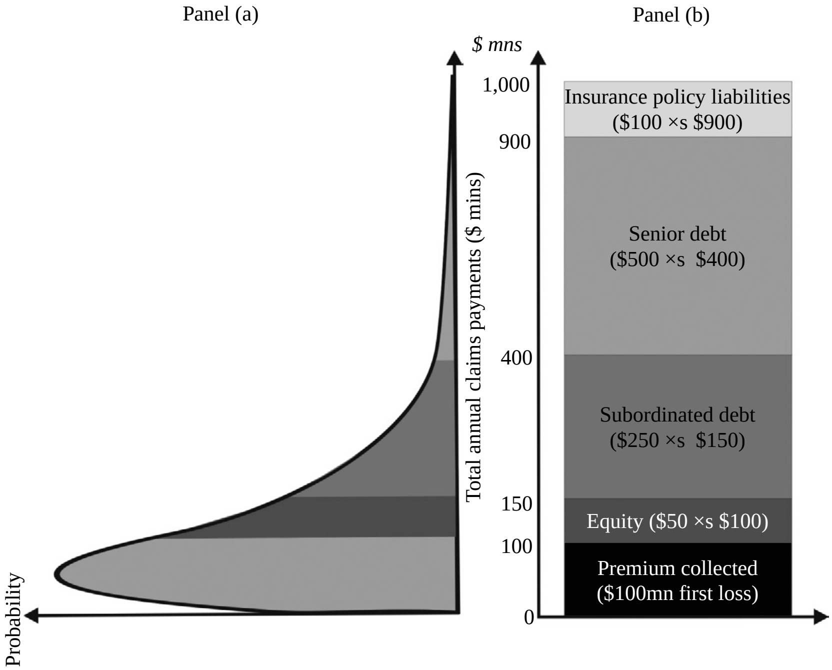


**Figure 3.**
Capital structure and risk

default on subordinated debt, but senior debt holders still get repaid fully. If losses exceed $400mn, equity and subdebt are both wiped out, and the senior creditors share a *pro rata* claim on whatever is left up to $900mn. If claims exceed $900mn, at least some insurance policy holders will experience a default on claims payment obligations up to a total of $100mn.

Figure 3 shows how the investors in the firm's securities are providing synthetic reinsurance. The $100mn first-loss layer is covered by premium collected. The equity investors provide the primary coverage layer of $50 XS $100. The size of that equity layer, moreover, depends on the current value of the firm's assets. If the firm in our example had assets currently worth $1bn, then the equity layer would provide coverage of $150 XS $100 and would be exhausted at losses in excess of $250mn.

Subordinated debt holders absorb losses in the $250 XS $150 excess layer in our example. Senior creditors absorb the $500 XS $400 catastrophic layer of losses. And only then do policyholders provide the final $100 XS $900 layer of protection. In other words, insurance policyholders will not experience a loss unless the insurer's policy claims exceed its current assets of $900mn. But in this example, policyholders could indeed experience such a loss. In order to reduce the risk of that happening, insurance companies hold risk capital.

## 3. Internal vs external risk capital

Merton and Perold (1993) define risk capital as "the smallest amount that can be invested to insure the value of the firm's net assets against a loss in value relative to a risk-free investment," where net assets are defined as gross assets minus customer liabilities assuming those customer liabilities are default-risk-free[4]. In other words, risk capital is the amount of reinsurance or synthetic reinsurance required to cover all possible insurance claims. As a practical matter, few insurance companies hold enough risk capital to make their policies completely default-risk-free[5]. Nevertheless, it is useful to think about risk capital in this way for conceptual purposes.

As noted earlier, risk capital may be internal or external, where the former is provided by investors in the securities issued by the insurance company and the latter is provided by an outside party like a reinsurance company. Risk capital may also either be paid-in or contingent. Paid-in risk capital functions like a dedicated risk reserve in which the insurer sets aside cash to cover unexpected insurance losses. If those losses do not materialize, the funds are released for distribution back to shareholders (along with any excess of premium above actual insurance claims if losses are below the total premium collected). By contrast, contingent risk capital does not tie up any cash up-front and only covers unexpected losses if they actually occur.

*3.1 Similarities between internal and external risk capital*

To demonstrate the similarities between various forms of risk capital, consider a P&C insurance carrier that underwrites $1bn in insurance. The expected loss on the policy line is $100mn, and we ignore all transaction costs, premium loading, and profit margins. The total premium charged to customers and collected by the insurer thus is equal to the $100mn expected loss. All premiums collected and any other cash received by the insurer, moreover, is presumed to be invested in default-risk-free bonds (which we assume have a zero interest rate). Apart from the UPR, all statutory reserves are ignored, along with any regulatory capital requirements or limits.

For ease of illustration, we also assume that all reinsurance and synthetic reinsurance costs and premiums are equal to the expected loss of the corresponding coverage layer. Specifically, Figure 4 shows our expected loss assumptions for various layers within the $1bn aggregate policy line that we consider in the five cases explored below[6].

*3.1.1 Case I: contingent internal risk capital.* Consider a P&C insurance company that is a wholly owned operating subsidiary of a default-risk-free parent corporation. The parent company has provided a guaranty to rectify any shortfall in the insurance company subsidiary's assets *vis-à-vis* its policy liabilities. The parent company thus provides $900 XS $100 in synthetic reinsurance to the insurance company.

As shown in Figure 4, the $900mn of synthetic reinsurance provided by the parent is worth $50mn to the insurance company. We thus could imagine that the parent company charges a $50mn fee to its subsidiary for providing the guaranty. The insurer, however, would then have to raise the $50mn through a cash infusion from the parent. Because the insurer would simply pay that $50mn right back to the parent, we assume for simplicity that the parent does not explicitly charge the insurance company for the $900mn contingent internal risk capital facility.

The statutory balance sheet for the insurer is shown in Table I. Although the customer policies are completely riskless thanks to the contingent parent guaranty, the only statutory asset of the insurance company is the cash premium received from customers. The insurer's total statutory assets are thus $100mn, and the surplus is $0.

Even though parent guaranty does not appear as an asset on the insurance company's statutory balance sheet, it is nevertheless a valuable economic asset

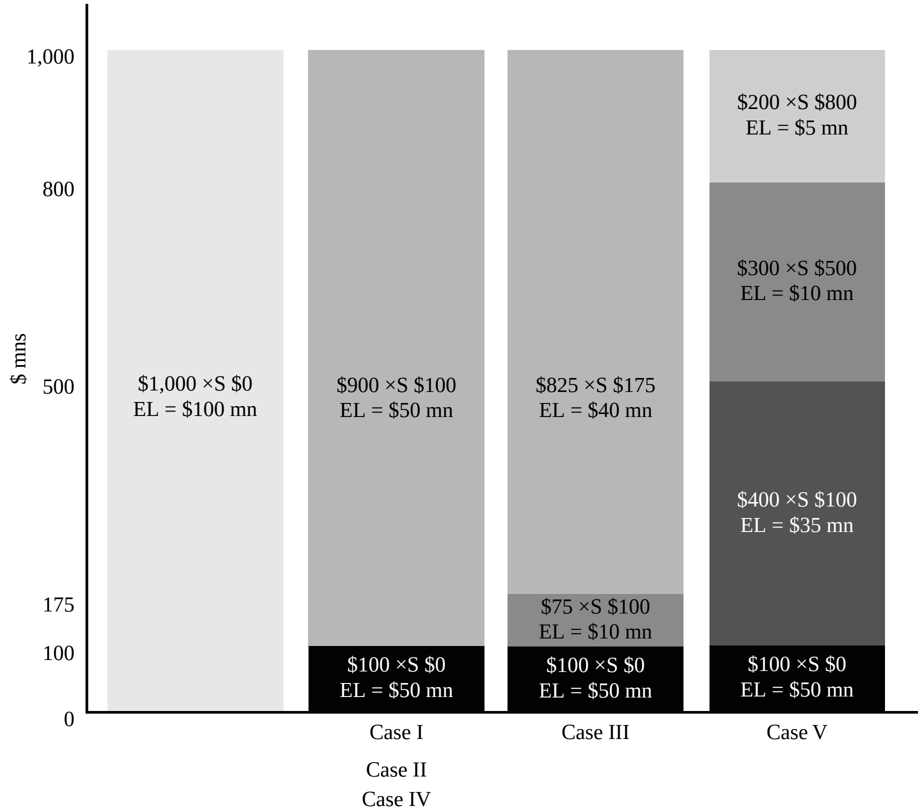


**Figure 4.**
Expected loss by layer

**Table I.**
Statutory balance sheet ($mn) – contingent internal risk capital

| | | | |
|---|---|---|---|
| Cash | $100 | UPR | $100 |
| | | Surplus | $0 |
| *Total assets*: | $100 | *Total liabilities and surplus*: | $100 |

to the insurer. The economic balance sheet of the insurer shown in Table II thus reflects the $50mn value of this $900 XS $100 synthetic reinsurance, and the total economic assets of the insurer are now higher than its statutory assets as a result.

Policyholders benefit from the synthetic reinsurance by having their claims payments guaranteed. But the parent shareholder also benefits as the sole residual

**Table II.**
Economic balance sheet ($mn) – contingent internal risk capital

| | | | |
|---|---|---|---|
| *Cash*: | | *Expected insurance claims*: | $100 |
| Premium collected | $100 | *Financial capital*: | |
| Total cash | $100 | Equity | $0 |
| *Synthetic reinsurance*: | | *Risk capital*: | |
| $900 XS $100 (parent guaranty) | $50 | Contingent internal risk capital (equity) | $50 |
| *Total assets*: | $150 | *Total liabilities and capital*: | $150 |

claimant on the insurer's net assets, which are now $50mn higher than expected losses. That benefit, however, is exactly offset by the cost to the parent of providing the synthetic reinsurance, as illustrated in Table III. Specifically, the value of the insurer's equity can be viewed as follows:

(1) the total financial capital contributed by shareholders; plus

(2) the total value of synthetic reinsurance; minus; and

(3) the cost of the synthetic reinsurance provided by shareholders.

In Cases IV and V explored later in Section III, shareholders do not provide all of the risk capital to the insurer. But when all of the insurer's risk capital is internal, items (2) and (3) exactly offset each other. The value of the insurer's equity thus is equal to the value of its financial capital contribution – zero in this case.

*3.1.2 Case II: paid-in internal risk capital.* Continuing to assume that the insurance company is a wholly owned subsidiary of a default-risk-free parent, suppose now the parent contributes $900mn in cash to the insurer that is set aside to cover claims in excess of the $100mn premium collected. In this case, no subsequent cash contribution is required from the parent; all possible claims up to the $1bn aggregate limit have already been pre-funded.

As the insurance company's sole shareholder, the parent has a residual claim on whatever cash is left over after all insurance claims have been paid and all policies have expired. If, for example, no unexpected losses occur during the policy year, the parent will receive its entire $900mn capital contribution back. Conversely, any insurance losses in excess of $100mn reduces the residual cash available to the parent dollar-for-dollar. So, the shareholder absorbs any insurance losses in the $900 XS $100 layer, just as in Case I. The only difference in this case is that the risk capital contributed by the parent is now paid-in internal risk capital.

The statutory balance sheet of the insurer is shown in Table IV. The insurer's assets now consist of the $100mn in premium collected plus the $900mn in cash invested by the parent. Total statutory assets are now $1bn, with a policyholders' surplus of $900mn.

Table V shows the economic balance sheet of the insurance company. The $900mn in financial capital represents the cash contribution of the parent. We also see a $50mn economic asset that reflects the value of this $900mn cash as $900 XS $100 in synthetic reinsurance. This may seem a bit like double counting, so it may help to think of the

**Table III.** Equity investment of shareholder ($mn) – contingent internal risk capital

| | |
|---|---|
| Financial capital | $0 |
| + Total value of risk capital | $50 |
| − Premium for providing internal risk capital | ($50) |
| *Total cash invested* | *$0* |

**Table IV.** Statutory balance sheet ($mn) – paid-in internal risk capital

| | | | |
|---|---|---|---|
| Cash | $1,000 | UPR | $100 |
| | | Surplus | $900 |
| *Total assets*: | $1,000 | *Total liabilities and surplus*: | $1,000 |

parent shareholder's capital investment as having two distinct components (Merton and Perold, 1993):

(1) $900mn in default-risk-free financial capital; and

(2) $900 XS $100 in synthetic reinsurance with a value of $50mn.

In other words, the insurance company has received two valuable assets from the parent – $900mn in risk-free cash plus the right to use that cash to cover $900 XS $100 in insurance claims instead of returning that cash to shareholders.

Table VI summarizes the value of the insurer's equity contribution. The parent's share capital is worth $900mn (its default-free financial capital contribution) plus the value to the insurance company of being able to use that cash to finance insurance claims in excess of $100mn minus the cost to the parent company of providing the insurer that $900 XS $100 in synthetic reinsurance. Just as in Case I, the asset value of the synthetic reinsurance to the insurer offsets the cost to the parent of providing that risk capital. So, the value of the parent's investment is exactly equal to its $900mn paid-in cash financial capital contribution.

*3.1.3 Case III: paid-in and contingent internal risk capital.* As long as the parent company is not cash-constrained, a comparison of Cases I and II shows that the parent should be completely indifferent to providing paid-in or contingent internal risk capital to its subsidiary. Not surprisingly, the parent will be equally indifferent to any combination of paid-in and contingent risk capital that replicates $900 XS $100 in synthetic reinsurance coverage.

Suppose the parent makes an initial cash contribution of $75mn that is set aside in a risk reserve to pre-fund insurance losses in the $75 XS $100 layer. In addition, the parent provides the insurer with a guaranty to cover all claims in excess of $175mn and up to the aggregate policy limit of $1bn. From Figure 4, we can see that the values of these $75 XS $100 and $825 XS $175 covers are $10mn and $40mn, respectively.

The statutory and economic balance sheets of the insurance company are shown in Tables VII and VIII, and the equity investment of the parent shareholder is shown in Table IX. As in Cases I and II, the value of the economic assets of the insurer exceed the value of its statutory assets by exactly the $50mn value of internal risk capital provided by the parent. Similarly, the value of the parent's equity investment is exactly

**Table V.** Economic balance sheet ($mn) – paid-in internal risk capital

| | | | |
|---|---|---|---|
| *Cash*: | | *Expected insurance claims*: | $100 |
| Premium collected | $100 | *Financial capital*: | |
| Proceeds from securities issuance | $900 | Equity | $900 |
| Total cash | $1,000 | | |
| *Synthetic reinsurance*: | | *Risk capital*: | |
| $900 XS $100 (paid-in) | $50 | Paid-in internal risk capital (equity) | $50 |
| *Total assets*: | $1,050 | *Total liabilities and capital*: | $1,050 |

**Table VI.** Equity investment of shareholder ($mn) – paid-in internal risk capital

| | |
|---|---|
| Financial capital | $900 |
| + Total value of risk capital | $50 |
| − Premium for providing internal risk capital | ($50) |
| *Total cash invested* | *$900* |

equal to its $75mn financial capital contribution – the $50mn value of $900 XS $100 in synthetic reinsurance to the insurer once again offsets the $50mn cost of providing that internal risk capital.

*3.1.4 Case IV: external risk capital.* Now let us suppose that the P&C insurance company is a standalone corporation with no parent to guarantee any claims payments in excess of premium collected. Instead, the insurance company enters into a $900 XS $100 excess of loss (XOL) reinsurance treaty to make its customer liabilities default-risk-free. This reinsurance is external risk capital because it is provided by a third-party reinsurance company and not through the insurer's financial capital claims[7].

We assume the reinsurer is default-risk-free and that the reinsurance treaty is bound at the same time that the original policies are underwritten. We further assume that the reinsurance treaty has a $50mn premium, which is the expected loss on the $900 XS $100 layer (Figure 4). The insurance company, moreover, must now issue $50mn in equity to finance the $50mn reinsurance premium payment.

The statutory and economic balance sheets shown in Tables X and XI are virtually identical to the statutory and economic balance sheets we saw in Tables I and II. In both cases, the insurance company obtains $900 XS $100 in contingent risk capital. The main difference on the balance sheets is whether that risk capital is internal

**Table VII.** Statutory balance sheet ($mn) – contingent and paid-in internal risk capital

| | | | |
|---|---|---|---|
| Cash | $175 | UPR | $100 |
| | | Surplus | $75 |
| *Total assets*: | $175 | *Total liabilities and surplus*: | $175 |

**Table VIII.** Economic balance sheet ($mn) – contingent and paid-in internal risk capital

| | | | |
|---|---|---|---|
| *Cash*: | | *Expected insurance claims*: | $100 |
| Premium collected | $100 | *Financial capital*: | |
| Proceeds from securities issuance | $75 | Equity | $75 |
| Total cash | $175 | | |
| *Synthetic reinsurance*: | | *Risk capital*: | |
| $75 XS $100 (paid-in) | $10 | Paid-in internal risk capital (equity) | $10 |
| $825 XS $175 (parent guaranty) | $40 | Contingent internal risk capital (equity) | $40 |
| *Total assets*: | $225 | *Total liabilities and capital*: | $225 |

**Table IX.** Equity investment of shareholder ($mn) – contingent and paid-in internal risk capital

| | |
|---|---|
| Financial capital | $75 |
| + Total value of risk capital | $50 |
| − Premium for providing internal risk capital | ($50) |
| *Total cash invested* | *$75* |

**Table X.** Statutory balance sheet ($mn) – external risk capital

| | | | |
|---|---|---|---|
| Cash | $100 | UPR | $100 |
| | | Surplus | $0 |
| *Total assets*: | $100 | *Total liabilities and surplus*: | $100 |

(i.e. provided by the parent shareholder as in Case I) or external (i.e. provided by a reinsurance company as in Case IV).

One important difference between Cases I and IV pertains to the initial cash investment required from shareholders. In Case I, no initial investment was required by the parent company to cover the cost of contingent risk capital because the parent was also the sole provider of that contingent capital. In Case IV, by contrast, an initial investment of $50mn from shareholders is required to cover the reinsurance premium.

In Table XI, the initial cash investment of $50mn shows up as "external risk capital." Financial capital contributed by equity, however, is $0. The reason is that the $50mn cash investment by shareholders is used entirely to cover the external reinsurance premium. Shareholders have no opportunity to recover that cash later. So, unlike Case I in which the total equity investment by the parent was $0, Table XII shows that shareholders now invest a total of $50mn in the insurance company, used to purchase external risk capital.

Although the value of the $900 XS $100 reinsurance is the same as the value of the $900 XS $100 parent guaranty in Case I, the risk profile of the insurance company – and, hence, the risks borne by its shareholders – is different in the two situations. Purchasing reinsurance guarantees that shareholders do not bear any costs of unexpected claims payments in excess of $100mn. Reinsurance thus enables shareholders to lock in a known and fixed cost of $50mn.

The $50mn value of the contingent parent guaranty, by contrast, is just the expected value of the parent's payments in the $900 XS $100 risk layer. Actual losses in the latter case could be as high as $900mn. So, the $50mn cost of equity in Case IV exceeds the cost of equity in Case I by precisely the value of the risk borne by the shareholder in Case I and shifted to the reinsurance company in Case IV.

*3.1.5 Case V: internal and external risk capital providers*. Finally, suppose the insurance company is a stand-alone corporation that issues both common stock and zero-coupon bonds. The bonds have a $200mn face value and mature at the same time the insurance policies expire. To cover insurance losses in the $400 XS $100 layer, the insurance company buys reinsurance at a cost of $35mn (Figure 4). Losses in excess of $500mn are then covered with a risk reserve funded by the proceeds from the securities issuance. The insurer thus must raise a total of $535mn by issuing debt and

**Table XI.**
Economic balance sheet ($mn) – external risk capital

| | | | |
|---|---|---|---|
| *Cash*: | | *Expected insurance claims*: | $100 |
| Premium collected | $100 | *Financial capital*: | |
| Proceeds from securities issuance | $50 | Equity | $0 |
| Reinsurance premium paid | ($50) | | |
| Total cash | $100 | | |
| *Reinsurance*: | | *Risk capital*: | |
| $900 XS $100 (reinsurance treaty) | $50 | External risk capital | $50 |
| *Total assets*: | $150 | *Total liabilities and capital*: | $150 |

**Table XII.**
Equity investment of shareholders ($mn) – external risk capital

| | |
|---|---|
| Financial capital | $0 |
| + Total value of risk capital | $50 |
| − Premium for providing internal risk capital | ($0) |
| *Total cash invested* | *$50* |

equity – \$35mn to finance the reinsurance premium for the \$400 XS \$100 layer and \$500mn to fund the risk reserves covering the \$500 XS \$500 layer.

Once the premium and reinsurance coverage are exhausted, stockholders (as the most subordinated claimants in the insurer's capital structure) absorb insurance losses in the \$300 XS \$500 layer. If total claims exceed \$800mn, the insurer becomes insolvent. At that point, the remaining \$200mn in cash is used to finance any claims from \$800mn up to \$1bn. Instead of receiving their \$200mn back, bond holders thus receive a pro rata allocation of whatever is left of the \$200mn after all insurance claims are paid.

Bond holders will, of course, demand compensation for bearing default risk. The bonds thus issue at a discount to their \$200mn par value. In effect, bond holders make a default-risk-free loan of \$200mn to the company and simultaneously write \$200 XS \$800 of synthetic reinsurance. Because the value of that reinsurance is \$5mn (Figure 4), the bonds will issue at a \$5mn discount to par, or \$195mn (see Merton and Perold, 1993, for an additional explanation). The \$200mn default-risk-free loan is the financial capital contributed by debt, and the \$5mn discount of the bonds to par reflects the premium demanded by bondholders for providing \$800 XS \$200 in synthetic reinsurance, i.e. for giving the company the right to use its \$200mn financial capital to finance outstanding insurance claims instead of repaying the debt.

Equity investors are providing the insurance company with \$300mn in default-free financial capital to pre-fund the \$300 XS \$500 risk reserve. In addition, shareholders contribute \$35mn in cash to finance the reinsurance premium. Because bond investors are only willing to pay \$195mn for the \$200mn face value bond, moreover, shareholders must also invest an additional \$5mn so that the \$200mn risk reserve covering the \$200 XS \$800 layer is fully funded. So, a total of \$340mn in equity must be issued (i.e. \$300mn + \$35mn + \$5mn).

The statutory balance sheet of the insurance company is shown in Table XIII. As in all four previous cases, the only statutory asset of the insurance company is cash. Total cash is \$600-100mn in policyholder premiums paid, and \$500mn from the proceeds of securities issued (after subtracting the \$35mn paid to the reinsurance company). The value of debt is shown at its \$195mn issuance price, and the policyholders' surplus is the residual of \$305mn (i.e. \$340mn equity issued – \$35mn reinsurance premium).

On the economic balance sheet shown in Table XIV, the \$500mn of financial capital is contributed to pre-fund the \$500 XS \$500 loss layer. Of the \$500mn total financial capital, \$200mn comes from debt and \$300mn from equity. In addition, debt holders and shareholders provide \$5mn and \$10mn in internal risk capital, respectively, (Figure 4). The remaining \$35mn in risk capital is the external risk capital provided by the reinsurance company.

Although there are three different providers of the insurer's risk capital, shareholders bear the entire \$50mn risk capital cost. Because the debt issues at a \$5mn discount to par to reflect the value of risk capital provided by bond holders, shareholders must contribute another \$5mn to fund the \$200 XS \$800 synthetic

**Table XIII.** Statutory balance sheet (\$mn) – internal and external risk capital

| | | | |
|---|---|---|---|
| Cash | \$600 | UPR | \$100 |
| | | Debt | \$195 |
| | | Surplus | \$305 |
| *Total assets*: | \$600 | *Total liabilities and surplus*: | \$600 |

reinsurance provided by bond holders. Similarly, equity holders must put up another $35mn to cover the reinsurance premium paid for external risk capital.

Table XV shows the breakdown of the $340mn in total cash invested in the insurance company by shareholders. In effect, equity investors provide $300mn in default-free financial capital to pre-fund the $300 XS $500 loss layer plus $50mn to cover the insurance company's total cost of risk capital minus $10mn to reflect the cost of internal risk capital provided directly by shareholders.

*3.1.6 Summary comparison of Cases I-V.* Table XVI provides a summary of the balance sheets we have explored in the five preceding scenarios, from which we can make the following observations:

- In all cases, the insurance company has a total of $900 XS $100 in actual or synthetic reinsurance. The insurer's customer liabilities thus are always default-risk-free.

**Table XIV.**
Economic balance sheet ($mn) – internal and external risk capital

| | | | |
|---|---|---|---|
| *Cash*: | | *Expected insurance claims*: | $100 |
| Premium collected | $100 | *Financial capital*: | |
| Proceeds from securities issuance | $535 | Debt | $200 |
| Reinsurance premium | ($35) | Equity | $300 |
| Total cash | $600 | Total financial capital | $500 |
| *Reinsurance*: | | *Risk capital*: | |
| $400 XS $100 (reinsurance) | $35 | Paid-in internal risk capital (equity) | $10 |
| $300 XS $500 (from equity) | $10 | Paid-in internal risk capital (debt) | $5 |
| $200 XS $800 (from debt) | $5 | External risk capital | $35 |
| Total reinsurance | $50 | Total risk capital | $50 |
| *Total assets*: | $650 | *Total liabilities and capital*: | $650 |

**Table XV.**
Equity investment of shareholders ($mn) – internal and external risk capital

| | |
|---|---|
| Financial capital | $300 |
| + Total value of risk capital | $50 |
| − Premium for providing internal risk capital | ($10) |
| *Total cash invested* | *$340* |

**Table XVI.**
Summary of Cases I-V balance sheets ($mn)

| | Case I | Case II | Case III | Case IV | Case V |
|---|---|---|---|---|---|
| Premium collected | $100 | $100 | $100 | $100 | $100 |
| Financial capital | $0 | $900 | $75 | $0 | $500 |
| Total assets (statutory) | $100 | $1,000 | $175 | $100 | $600 |
| Total assets (economic) | $150 | $1,050 | $225 | $150 | $650 |
| Total equity investment | $0 | $900 | $75 | $50 | $340 |
| Financial capital | $0 | $900 | $75 | $0 | $300 |
| Risk capital | $0 | $0 | $0 | $50 | $40 |
| Total risk capital | $50 | $50 | $50 | $50 | $50 |
| External risk capital | $0 | $0 | $0 | $50 | $35 |
| Internal risk capital | $50 | $50 | $50 | $0 | $15 |
| Maximum shareholder loss | $900 | $900 | $900 | $50 | $340 |

- The $900 XS $100 in actual and synthetic reinsurance is a $50mn economic asset for the insurance company that increases enterprise value by $50mn. The total economic assets of the insurer, moreover, exceed total statutory assets by the $50mn value of the risk capital.
- The up-front investment required by shareholders is equal to the financial capital provided by shareholders plus the insurer's total cost of risk capital minus the value of the synthetic reinsurance sold to the insurer by shareholders.

One obvious difference in the five cases is the initial investment required from shareholders. The amounts of cash that shareholders must invest differ in these five cases for two main reasons:

(1) the size of the pre-funded risk reserves affects the insurer's need for paid-in financial capital; and

(2) risk capital provided either by debt holders or external reinsurance companies necessitates an upfront infusion of cash by shareholders to cover risk capital procurement expenditures.

If total claims are less than $1bn, shareholders can recover some or all of their financial capital investment, as well as cash provided to cover the cost of internal risk capital provided by debt.

Cash invested by shareholders to cover reinsurance premiums, however, is an unrecoverable expense paid to an external risk capital provider. As such, reinsurance is often viewed as "too expensive" relative to other forms of risk capital. But reinsurance, of course, also shifts the risk of unexpected insurance losses from shareholders to the reinsurance company, as shown in the last row of Table XVI.

### *3.2 Distinctions between internal and external risk capital*

All of the examples discussed in Section 3.1 assumed that an insurance company would hold enough risk capital to eliminate completely any risk of default on its customer liabilities. In reality, virtually no P&C insurance carrier would procure external risk capital or hold pre-funded cash risk reserves to cover 100 percent of all possible claims.

Because insurance company shareholders ultimately bear the total cost of risk capital, those shareholders must carefully evaluate the benefits of that risk capital relative to the costs in order to decide how much risk capital to hold and from where to acquire it. If the only benefit of risk capital is protecting customers, then an insurance company would only need to hold risk capital in an amount sufficient to ensure that policyholders remain unconcerned with the credit risk of the insurer. But insurance policyholders are not the sole beneficiaries of risk capital. Shareholders can also benefit.

The benefits of risk capital to shareholders, however, depend on whether the risk capital is internal or external. We discuss some of the potential benefits and costs of risk capital to shareholders in the sections below.

*3.2.1 The cost of risk capital.* Our assumption in Section 2 was that the cost of risk capital is the same across all facilities and always exactly equal to expected loss. In fact, reinsurance is often less expensive than internal risk capital. External risk capital may seem more expensive than internal risk capital because reinsurance rates are transparent and the premium must be paid in cash. Internal risk capital, by contrast, requires no explicit premium payment by the insurer. Instead, the cost of internal risk capital is subsumed in the insurance company's equity cost of capital and thus is far from transparent.

How do we estimate the cost of internal risk capital in order to compare it with the cost of external risk capital? Merton and Perold provide one possible answer. They define the cost of risk capital as the cost of putting an absolute floor on the shortfall of assets *vis-à-vis* insurance policies (i.e. the market value of the surplus), which we can define at any time $t$ as follows[8]:

$$S(t) = A(t) - L(t)$$

where $A(t)$ denotes the market value of the insurer's assets and $L(t)$ denotes the market value of its insurance policy liabilities. To eliminate any risk of a net asset shortfall, risk capital thus functions like an option contract with the following payoff at time $t + 1$:

$$\max[S(t)(1 + r) - S(t + 1), 0]$$

where $r$ is the risk-free rate. This is identical to the payoff on a put option written on the company's net assets with a strike price equal to the floor on the surplus that we have required, i.e. the starting value of the surplus invested at the risk free rate. We can also easily substitute different floors (i.e. strike prices) into the above equation to isolate more specific loss layers for which risk capital is being evaluated.

Once we recognize that risk capital can be viewed as a put option, we can then employ option pricing modeling to estimate the cost of internal risk capital. All else equal, the insurance company should obtain the risk capital with the highest marginal capital efficiency. In other words, for a given potential loss layer against which the insurance company wishes to hold risk capital, the question of whether or not to reinsure explicitly should be based on a comparison of the cost of synthetic reinsurance provided by investors in the firm's securities (estimated in a manner described above) *vis-à-vis* quoted reinsurance rates.

*3.2.2 Avoidance of costly financial distress*. In a perfect world, investors in an insurance company's securities would not care much about the insolvency of the insurer. Whatever assets are left, after all, will just be divided up amongst the firm's investors in the order of the priority of claimants in the firm's securities capital structure. The prices of the securities issued by the insurance company should already reflect this risk.

In practice, however, insolvency is costly, and investors in a firm's securities prefer to avoid exposure to "firm-killer" risks, such as natural catastrophe risks. Consider, for example, some of the costs of financial distress:

- When a company approaches insolvency, its management is forced to concentrate more and more on managing its financial distress (e.g. mitigating the prospect of bankruptcy, dealing with regulators, communicating with rating agencies, etc.) than on the strategic aspects of its actual business.
- Insurance companies that experience catastrophic losses can experience severe crises of confidence that result in a loss of reputation, capital and franchise value. This is difficult and time consuming for a firm to replace and can result in significantly attenuated revenue-generating opportunities and prospects for earnings growth.

- Many policyholders presumably prefer to deal with an insurer that is expected to remain an ongoing business enterprise. Even if policyholders expect to be paid whatever they are due, plans to renew coverage and the accumulated value of a good commercial relationship with a reinsurance company become irrelevant if the reinsurer goes out of business. Insurance customers, moreover, do not like dealing with run-off solutions, much less conservatorships and receiverships.
- Insolvency itself is expensive. From the lawyers' fees to the resolution of pension liabilities to the need to deal with disenfranchised former employees, the "deadweight costs" of bankruptcy can be high. No matter what is left over in the assets of an insolvent firm, its security holders are only entitled to those assets after the expenses of bankruptcy have been paid.

Reinsurance and other forms of external contingent risk capital protect shareholders in the above manner in a way that internal capital does not. In particular, external risk capital pays off before the insurance company's equity is completely depleted and the firm is insolvent. Although the insurance company's shareholders may retain a first-loss exposure, at least some portion of the company's equity is usually senior to reinsurance in the firm's risk capital structure. Reinsurance thus provides insurance companies with cash to cover policy claims before the firms' own internal cash is depleted and the insurers are driven into insolvency. All else equal, shareholders thus benefit more from external than internal risk capital.

*3.2.3 Preserving underwriting capacity*. Large claims payments and losses can reduce an insurance company's underwriting capacity and inhibit the underwriting of new policies. A reduction in underwriting capacity can be especially costly following a natural catastrophe that depletes industry-wide aggregate capital and puts upward pressure on premiums.

Of particular importance to an insurer following a catastrophic loss is its large-line capacity, i.e. the insurer's ability to absorb an extremely large loss on a single policy. In order to underwrite such a policy following a significant depletion of capital, the insurance company needs to know that it will not have to retain all of the risk to which the new large policy exposes the firm.

Reinsurance can help insurers avoid the significant opportunity costs of being unable to write new business following catastrophic losses. Reinsurance is particularly effective at preserving large-line capacity and helping the insurer retain valuable commercial customers that it would be costly for the primary carrier to lose.

Internal risk capital can also help preserve underwriting capacity. By issuing additional stock and investing the proceeds in risk reserves, the insurance company preserves its ability to write new business following a catastrophic loss. Contingent internal capital also achieves a comparable result.

*3.2.4 Preserving debt capacity and credit ratings*. All else equal, an insurance company with a larger equity cushion has higher debt capacity, i.e. the ability to borrow without incurring distressed borrowing costs. An insurance company with a rating of AAA, for example, has little or no difficulty securing a new bank line of credit, whereas a BB-rated insurer would encounter more problems (not to mention higher borrowing rates).

P&C insurance underwriters can maintain a large equity cushion and preserve debt capacity either by simply issuing a lot of stock (i.e. having large amounts of internal risk capital provided by shareholders) or by buying reinsurance that allows the firm to sustain losses without eroding the value of existing equity. Both help the insurer preserve the credit ratings on its debt, which enhances the insurer's debt capacity and allows the firm to maintain a reasonable cost of debt capital.

*3.2.5 Managing liquidity risks*. Some insurance company shareholders may value risk capital because it helps them preserve their financial flexibility and manage their liquidity and funding risks more effectively. Excessive cash flow volatility and illiquidity can cause several types of problems for insurance companies that can impact shareholders adversely:

- Large unexpected depletions of cash can lead to "underinvestment problems," i.e. situations in which companies are unable to pursue positive net present value investment and business opportunities because of insufficient access to cash.
- Inadequate cash reserves can be problematic for insurance companies that have derivatives positions with mark-to-market collateral or premiums.
- Insurance companies with excessive cash flow volatility and insufficient cash reserves are more likely to experience problems with debt capacity and threats of downgrades from the rating agencies.

For managing short-term liquidity risks, paid-in internal risk capital is likely to be more valuable to insurance companies than either contingent internal risk capital or reinsurance, provided, however, that the proceeds from the internal risk capital have been invested in cash. Because reinsurance may take several weeks (or months) before putting cash in the hands of an insurance company, it is a less effective tool for managing short-term cash flow volatility.

P&C insurance companies, however, rarely face short-term liquidity risks arising from P&C insurance claims given the typical length of claims processing, adjustment, and payment periods. And for managing all but the most short-term liquidity risks, any form of risk capital can be beneficial.

*3.2.6 Managing run-off solutions*. Reinsurance can help primary carriers economically discontinue a policy line without actually having to sell or retire outstanding policies. Suppose, for example, that a primary carrier decides that the risks of providing windstorm coverage are too high and beyond its shareholders' risk tolerances. The firm can really only leave the business by terminating any new windstorm underwritings and then allowing its outstanding contracts to policies to run off. Or the carrier could purchase reinsurance, thereby economically closing the business line virtually overnight.

Internal risk capital does nothing to facilitate run-off solutions per se. As noted in Section 4.1, moreover, significant amounts of internal debt capital with too little external or internal equity risk capital may well force policyholders to deal with a run-off agent in the event the insurer's equity is exhausted and the insurer becomes insolvent. Although insurance customers may be protected from losses by the internal debt risk capital, they are not protected from the disruptions and hassles of run-off solutions themselves.

## 4. Alternative sources of external risk capital

Once a P&C insurer decides to procure external risk capital, the question still remains as the form that external risk capital should take and who is best-suited to provide it.

Traditional reinsurance is the most familiar type of external risk capital procured by P&C insurers to cover catastrophic P&C claims. But reinsurance is not the only form of external risk capital available to cover such losses. Non-traditional reinsurance structures can also be used to cover catastrophic risks. Examples include ILWs, finite risk and finite reinsurance, integrated multi-line covers, and multi-trigger reinsurance (Culp, 2006), In addition, capital market alternatives to traditional reinsurance have become significantly more prevalent in recent years.

*4.1 Catastrophe-based external risk capital*

In this section, we review three specific alternatives to traditional reinsurance as sources of external risk capital: catastrophe derivatives, ILWs, and insurance-linked securities (a.k.a. catastrophe or "cat" bonds). Our discussion in this section is limited to the mechanics of these alternatives. We explore the major distinctions between traditional reinsurance and these three other sources of external risk capital in Section 4.2.

*4.1.1 Catastrophe derivatives*. A derivatives contract is a financial instrument whose cash flows are based on some underlying asset price, reference rate, index value, or event. The most popular types of derivatives contracts are futures, forwards, options, and swaps. Derivatives may either be customized, bilateral, off-exchange contracts (known as "over-the-counter" or "OTC" derivatives) or exchange-traded contracts listed on organized futures and options exchanges.

Catastrophe derivatives are contracts in which the cash flows are based in some way a natural catastrophe – either on some attribute of the catastrophe itself, or on insurance claims arising from the catastrophe. The former are known as "event derivatives." The Chicago Mercantile Exchange (CME), for example, lists derivatives on a hurricane index that measures a tropical cyclone's strength. CME hurricane futures are based on six regions and have a value equal to $1,000 times the index, so that an insurance company going "long" CME hurricane futures makes $100 for every 0.1 index point increase.

Catastrophe derivatives based on insurance losses are known as "insurance derivatives." Catastrophe swaps, for example, are swap contracts in which one party pays a premium to the other party in exchange for receiving payments based on some measure of insured losses[9]. Payments may be indemnity-based or based on an index of industry losses.

Many catastrophe derivatives are "binary" products in which one party pays a premium to buy protection against catastrophic losses in return for a fixed cash payment if a specific event occurs, much like the ILWs discussed in the next section. The trigger event is usually an insurance loss of some kind. Some catastrophe swaps, for example, require a protection buyer to make an upfront premium payment to the protection seller in return for receiving a fixed cash payment if an industry index of P&C losses occurs in excess of a chosen threshold amount. Exchange-traded catastrophe derivatives have also taken this same form.

*4.1.2 Industry loss warranties*. ILWs are dual-trigger reinsurance contracts in which the catastrophic loss protection purchaser receives a payment only if:

- the protection purchaser experiences a loss; and
- industry losses exceed a certain threshold amount.

The first trigger is indemnity-based and thus resembles traditional reinsurance, whereas the second trigger is index-based and thus resembles a derivatives contract. If both trigger conditions are satisfied, ILWs generally require the reinsurer to provide a cash payment to the ILW purchaser equal to the stated policy limit underlying the ILW.

Historically, ILWs were provided by reinsurance companies as an alternative to traditional reinsurance, and the primary users of ILWs were generally reinsurers seeking retrocession capacity. In more recent years, ILWs have also been used by primary insurance carriers seeking an alternative or supplement to traditional reinsurance. Depending on how ILWs are structured, they can also be provided by hedge funds and other investors outside the reinsurance industry.

*4.1.3 Catastrophe bonds*. Catastrophe bonds or "cat bonds" are types of insurance-linked securities in which insurance companies obtain external risk capital from investors in the bonds. Figure 5 shows the structure of a typical cat bond. Specifically, a special purpose entity (SPE) is established to provide reinsurance to the insurance company sponsor of the transaction. The SPE is not an affiliate of the sponsor, but rather is an independent reinsurance company whose sole purpose is to issue the cat bonds to investors and use the proceeds to finance reinsurance claims by the sponsor.

Contingent payments to the sponsoring insurance company in a cat bond may be actual insurance losses incurred by the sponsor. In lieu of providing traditional indemnity reinsurance cover, the SPE may also sell reinsurance-like protection to the sponsor using a "cat swap," i.e. a financially settled catastrophe swap in which the sponsor pays premium to the SPE in return for a contingent financial payment of some kind[10].

Although cat swaps are sometimes based on actual losses incurred by the insurer, many cat swaps (and the cat bonds in which they are found) rely on alternative triggers and require contingent payments by the SPE that do not necessarily reflect the sponsor's actual losses. Such alternatives include the following:

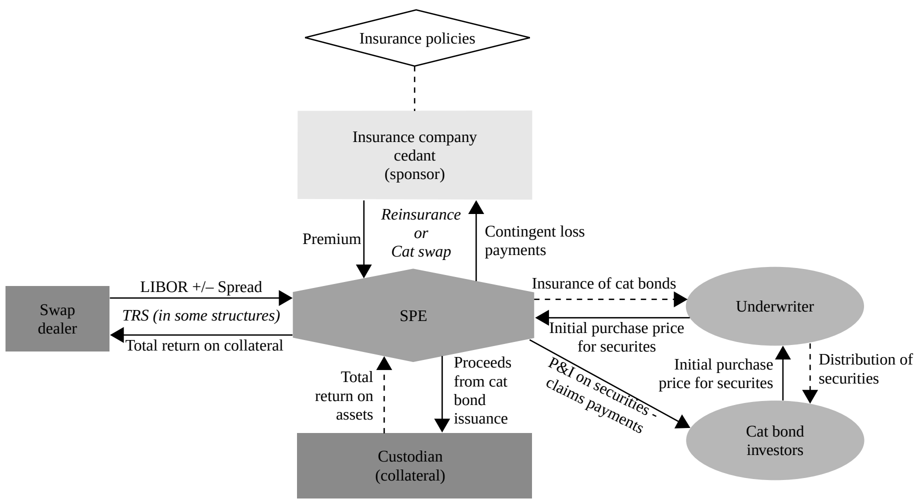


**Figure 5.**
Typical cat bond structure

- industry-indexed losses;
- "parametric" payments to the insurance company based on some parameter that indicates the strength of the underlying natural catastrophe; and
- "modeled loss" payouts in which a parametric variable (e.g. maximum wind velocity) is fed into a model of the insurance sponsor's portfolio of insurance exposures to derive an expected insurance liability.

Potential insurance payments by the SPE to the sponsoring insurance company are pre-funded by the proceeds of cat bond issuers to investors. Those investors receive an interest payment periodically reset to the London Interbank Offered Rate (LIBOR) plus a fixed spread that is equal to the reinsurance premium paid by the sponsor minus fees[11]. Any reinsurance payments to the sponsor are then subtracted from the interest (and perhaps principal) paid or payable to investors.

Proceeds from the cat bond issue are generally used to purchase securities that are pledged to the sponsor as collateral for the reinsurance agreement or cat swap sold by the SPE to the sponsor. Because interest earned on the collateral may be paid at different times (and with a different rate basis) than interest payable to cat bond investors, cat bond structures usually also include a total return swap (TRS), as shown in Figure 5. The TRS obligates the SPE to make periodic payments to the swap dealer equal to the total return on the collateral. In return, the swap dealer pays LIBOR plus or minus a spread to the SPE on scheduled cat bond interest payment dates.

*4.2 The benefits and costs of the alternatives*

Some of the alternative sources of external risk capital noted above are virtually identical to reinsurance except for the identity of the external risk capital provider and the transaction costs of the deal. Other products discussed in the previous section, however, can be significantly different from traditional reinsurance. In this section, we explore some of those key similarities and distinctions.

*4.2.1 Basis risk.* Basis risk is the risk that cash payments received by protection purchasers may not be sufficient to cover the insurer's actual policy liabilities. Traditional reinsurance exposes insurance companies to virtually no basis risk almost by definition[12]. Both proportional and XOL treaties (and, of course, facultative cessions) are indemnity contracts in which both the trigger and the payout are based on the cedant's actual loss experience.

Although indemnity-based reinsurance involves no basis risk, it does give rise to moral hazard and adverse selection problems. As a result, indemnity reinsurance may contain more contractual exclusions and may have a higher premium to compensate the external risk capital provider for bearing those informational costs. So, the trade-off between indemnity and non-indemnity sources of external risk capital is often the trade-off between basis risk and the costs of moral hazard and adverse selection.

Cat bonds and cat swaps that have indemnity payouts and triggers also expose cedants to minimal basis risks and thus are little different from reinsurance in this context. In the early days of the cat bond market, the vast majority of structures were indemnity-based. But since 2005, less than half of newly issued cat bonds have been indemnity products (Lane, 2008a).

If either the trigger or the payment in a cat product is not based on actual losses incurred by the insurance company, significant basis risk can result. A parametric cat bond that pays its sponsor based on the strength of a hurricane, for example, may generate relatively low payments if the hurricane is "weak" based on the parameter to which cat bond payments are indexed. But the insurer may still be liable for paying significant claims following such a storm, in which case the cat bond will provide ineffective coverage.

Exchange-traded catastrophe derivatives, index-based or parametric OTC cat swaps, and ILWs also expose their users to basis risk. As concerns the latter, for example, the insurer may experience large losses when the industry as a whole does not, in which case the ILW may not be triggered. The insurer thus may be left with no payment at all despite its own large losses[13]. And even if the ILW is triggered, the fixed payout may not be sufficient to cover the actual loss.

*4.2.2 Risk coverage*. External risk capital facilities may differ significantly in terms of underlying catastrophic risk coverage. Traditional reinsurance can be customized to cover virtually any peril(s), region(s), or exposure(s). ILWs and cat bonds can (and frequently do) provide coverage for multiple perils. In the 2007Q2-2008Q1 period, for example, about 45 percent of all insurance-linked security (ILS) issues were multi-peril (Lane, 2008a).

Cat bonds, however, generally lack the flexibility of traditional reinsurance in defining specific risk coverage areas and terms. Because cat bonds are sold to investors, they must be homogenous enough for investors to analyze how the cat bonds will perform in their own portfolios. Excessively customized risk coverage is much harder for investors to analyze, and thus generally harder for underwriters to place.

*4.2.3 Coverage periods*. Traditional reinsurance has a one-year policy term. Similarly, ILWs often have a one-year coverage period. Since, their first appearance in the late 1990s, by contrast, over half of the cat bond issues have had maturities of more than a year. Only about 15 percent of the nearly $7.5bn in new insurance-linked securities issued in the period from April 2007 to March 2008 had maturities of a year or less, and only about 10 percent had maturities of a year or less in April 2008-March 2009 period (Lane, 2008a; Lane and Beckwith, 2009).

Structures with longer coverage periods have both advantages and disadvantages *vis-à-vis* the traditional one-year coverage period. In particular, multi-year structures like cat bonds do not require annual renewals and thus enable reinsurance purchasers to lock in a single annualized premium for several years. This can facilitate the insurance company's insurance and risk management budgeting activities, and helps protect insurers from the risk of hardening reinsurance markets. On the other hand, if reinsurance markets soften, insurers that have locked in multi-year coverage will be unable to realize the cost savings.

Some view the annual renewal process itself as costly and time consuming and thus as a drawback of reinsurance. Yet, reinsurance is a relationship-based business, and the renewal process is an important part of the communications process between an insurer and reinsurer (and their brokers). Over time, reinsurers can learn the risk appetite and exposure profile of their repeat customers, better enabling them to anticipate the needs of regular commercial clients. Cat bonds, by contrast, are one-off transactions in which investors and the insurance purchaser do not necessarily have any ongoing commercial relationship. Purchasers of reinsurance from cat bond investors thus get no benefits from long-term repeat-business relationships.

In addition, multi-year cat bonds do not always save insurers time and costs even though they eliminate the need for annual renewals[14]. Securitization can be very costly and time consuming, with some of those costs including the need to obtain ratings for certain cat bond issues, the solicitation of counsel on legal, accounting, and regulatory matters, and the time spent on the design of the structure itself (including risk modeling, documentation, disclosure, etc.; Hartwig *et al.*, 2008). Traditional reinsurance requires significantly less time, attention, and expenditure on all of the foregoing. The brokerage and arrangement fees on reinsurance that is renewed annually, moreover, are often no greater than the fees involved in a complex cat bond structure.

*4.2.4 Reinstatement*. If a significant loss exhausts catastrophic coverage early in the life of a contract, the insurance company may be forced to remain uncovered or to procure new protection at higher post-loss prices. Contracts with reinstatement provisions allow insurance companies in this situation to reinstate the original coverage limit in return for an additional premium payment. The reinstatement premium is often equal to the premium for the original coverage, but may be higher or lower in some structures.

Traditional reinsurance and ILWs frequently include reinstatement provisions. In fact, the premium on coverage without a reinstatement option is often higher than the same coverage with a reinstatement option. Cat bonds, by contrast, do not allow for reinstatements of limits – once the limit is exhausted, the structures essentially unwind.

*4.2.5 Credit risk*. Insurance companies that purchase reinsurance or ILWs generally bear the credit risk of the reinsurer or syndicate[15]. Yet, the credit exposure of insurance companies to their reinsurance providers is limited to the term of the policy, which as we have discussed is only one year in traditional reinsurance. So, for well-capitalized and highly rated catastrophic reinsurance companies, insurers' concerns over credit risk are generally minimal.

In a typical cat bond structure, the insurance company is directly exposed to the credit risk of the SPE that sells protection to the sponsor. Unlike reinsurance and cat swaps, however, the maximum potential payment to the cedant by the SPE has in principle been fully pre-funded through the issuance of the cat bonds to investors. Nevertheless, credit risk can still arise in a cat bond structure.

Recall from Figure 5 that in the cat bond structure, the SPE usually enters into a TRS with a swap dealer in which the SPE pays the total return on the collateral assets and receives LIBOR minus a spread in return. The primary purpose of these swaps is to manage the SPE's liquidity risk arising from mismatches in the timing of interest earned on the collateral and payable on the cat bonds. But the swap dealer also assumes the risk of declines in the value of the assets held as collateral. If a default by the TRS counterparty occurs at a time when it has a significant net payment obligation to the SPE, the result could be potentially significant credit losses for the sponsor.

On September 30, 2008, S&P downgraded four cat bonds – not as the result of an underlying catastrophe, but rather because all four cat bond issuers had entered into TRSs with Lehman Brothers that terminated when Lehman filed for bankruptcy protection on September 15, 2008. Specifically, those cat bond issuers had invested their premium income and proceeds from securities issuance in collateral that experienced significant declines in mark-to-market value during the credit crisis. The TRSs would normally have covered that loss, but Lehman's default on its TRSs left the issuers with depressed collateral values and no TRS to cover those losses.

As a result, for example, Willow Re experienced an interest shortfall in February 2009 and announced that it would pay less than the full interest required to bond holders, resulting in an event of default for the Willow Re bonds – the first in the history of the ILS market (Lane, 2008b; Standard & Poor's, 2009).

*4.2.6 Timing of settlements*. All of the structures considered in this Section V differ on the timing of claims payments. Because there is a time value of money, these distinctions in the timing of cash flows can make a difference to some insurance companies in deciding which structure to use in securing external risk capital.

Reinsurance may involve a claims processing and adjustment period. This can result in delays of several weeks (or sometimes months) before claims payments are made by the reinsurance company. ILWs can also involve similar payment delays, especially when there is a dispute over the underlying claim.

The timing of settlements on protection sold by SPE cat bond issuers should generally reflect the terms of the underlying reinsurance or derivatives contract. In practice, however, any large payment obligations of the SPE to the insurance sponsor will require the SPE to liquidate (or instruct the custodian to liquidate) the collateral. If the market is volatile or illiquid at the time, the SPE may have difficulties liquidating enough collateral to make required payments on schedule, and this can result in payment delays.

*4.2.7 Accounting and disclosure*. One of the most significant differences between traditional reinsurance and catastrophe derivatives is the different accounting treatment afforded to each. Under both International Financial Reporting Standards and US GAAP, an insurance company may account for reinsurance in a manner consistent with its accounting for the corresponding insurance liabilities. Derivatives, by contrast, are generally marked to market at their current fair values. Insurers seeking catastrophic protection using derivatives that are subject to such mark-to-market accounting policies thus may have dramatically higher earnings volatility as a result of the inconsistent accounting treatment of the contingent insurance liability and contingent derivatives asset.

The accounting treatment for cat bonds depends on the nature of the protection sold by the SPE to the sponsoring insurance company. For cat bonds with indemnity triggers and contingent payment obligations documented as reinsurance, the insurance company can account for the risk capital using reinsurance accounting principles. For cat bonds with parametric, modeled loss, or industry index triggers and contingent payment obligations, the contract might be considered a derivative for accounting purposes.

Catastrophe derivatives with indemnity triggers and payoffs, however, are a murky area, whether used inside a cat bond structure or on a standalone basis. Some market participants view them as derivatives and mark them to market. Others view them as reinsurance that is simply documented as a derivatives contract and thus use reinsurance accounting. We are unaware of any clear guidance that resolves this question.

The accounting is also tricky for ILWs. Based on guidance issued by the US Financial Accounting Standards Board, for example, an ILW can only be accounted for as insurance or reinsurance when payment amounts are limited to the amount of the insurance liability (FASB, 2001). The appropriate accounting treatment for ILWs thus must be assessed on a case-by-case basis.

When it comes to disclosure, cat bonds typically require a much greater degree of detailed disclosure than reinsurance. Nevertheless, reinsurance providers and purchasers have the traditional "utmost good faith" requirements to engage in adequate disclosures. Accordingly, a reinsurance company will demand detailed risk disclosures from the cedant during the underwriting process. But risk disclosures demanded from cedants for the internal use of the risk capital provider are usually less burdensome than the disclosures required for compliance with securities issuance regulations. Nevertheless, as a result of the detailed disclosures required about cat bonds, the risk profile of cat bonds is generally more transparent to outsiders than reinsurance contracts.

By virtue of their simplicity and widely used industry loss indices, ILWs and catastrophe derivatives are generally fairly transparent.

*4.2.8 Regulatory capital and rating agency treatment*. As in the accounting treatment for external risk capital, the recognition of alternative external risk capital structures as "capital" for regulatory and ratings purposes depends on the exact solution and the perspectives of individual regulators and rating agencies.

In general, traditional reinsurance and ILWs are afforded full recognition as risk capital by most regulators and rating agencies. The credit given to external risk capital acquired through catastrophe derivatives or cat bonds based on catastrophe derivatives also depends on the regulatory or rating agency. Some insurance regulators, in particular, may not allow a cedant to count the catastrophe risk transfer agreement toward its risk-based capital and solvency requirements until a gain has been realized on the derivatives contract. (Hartwig *et al.*, 2008) Similarly, rating agencies may not afford the same treatment to non-indemnity contracts as they do to traditional reinsurance because of the higher basis risk of the former (Standard & Poor's, 2008).

In the European Union, the evolution of the new risk-based capital regulatory regime known as Solvency II will attempt to assess capital charges based on the economic and portfolio risks of insurance companies' assets and liabilities. On one hand, this promises a more consistent and equitable regulatory treatment of alternative sources of risk capital. On the other hand, the devil is in the details, and Solvency II is not yet far enough long to assess whether it will achieve all or most of its objectives to level the regulatory playing field.

## 5. Risk capital and the credit crisis

Large catastrophic insurance losses are usually followed by a contraction in capacity and a rise in catastrophe insurance premiums. But those higher premiums entice investors and reinsurers to provide more risk capital, which provides both capacity and premium relief.

In the wake of the credit crisis, P&C capacity has declined and premiums have risen, but an influx of new risk capital has not occurred (yet). In fact, as of this writing the market for catastrophic risk capital is plagued by significant uncertainties as to when the market will reach a new stable long-run equilibrium and where the resulting capacity/premium levels will end up.

### *5.1 Supply and demand adjustments following a typical catastrophic loss*

The price of reinsurance can be viewed as the expected loss to the reinsurer plus the premium loading and a profit margin. Premium loading may include loss adjustment expenses, administrative and operational expenses, and a capital charge that reflects the cost of risk capital for the reinsurer. The capital charge may reflect the reinsurer's own cost of raising new internal risk capital, or the cost of external risk capital like retrocession, ILWs, and the like.

Classic catastrophic P&C loss events such as 9/11 in 2001 or the Katrina/Rita/Wilma triple header in 2005 usually precipitate shifts in both the demand for and supply of external risk capital, as Figure 6 shows Before the event, the reinsurance market depicted in Figure 6 shows at a total underwriting level of $Q_0$ and a premium of $P_0$, where demand curve for external risk capital *DD* crosses with supply curve *SS*. After the loss occurs, large claims payments by reinsurers in excess of premium deplete capital in the reinsurance sector and precipitate an inward shift in the supply curve from *SS* to *S′S′*. That initially causes reinsurance supply to contract from $Q_0$ to $Q_1$ and market-clearing premiums to rise from $P_0$ to $P_1$, indicated in Figure 6 by the arrow labeled "1".

The demand for reinsurance is also affected by large losses. If the catastrophic loss results in large payouts by primary carriers on non-reinsured claims, their internal risk capital will be depleted. That increases primary carriers' effective leverage and expected financial distress costs, and may also put pressure on their credit ratings. Insurers thus will generally seek to replenish their risk capital through share recapitalizations and increased purchases of actual and synthetic reinsurance.

Whether insurers replace their attenuated internal risk capital with new internal risk capital, external risk capital, or a mixture of the two depends largely on the relative costs of internal and external risk capital following the loss event. Figure 6 shows the example of increased demand for external risk capital resulting from a shift in the demand curve from *DD* to *D′D′*. That causes external risk capital prices to rise to $P_2$ at the new reinsurance underwriting level $Q_2$, shown in arrow "2" on Figure 6.

The arrow labeled "3" in Figure 6 shows an important third stage of the adjustment process that typically occurs sometime after large catastrophic P&C insurance loss events, viz. the influx of new risk capital into the re-insurance sector. Large reinsurance

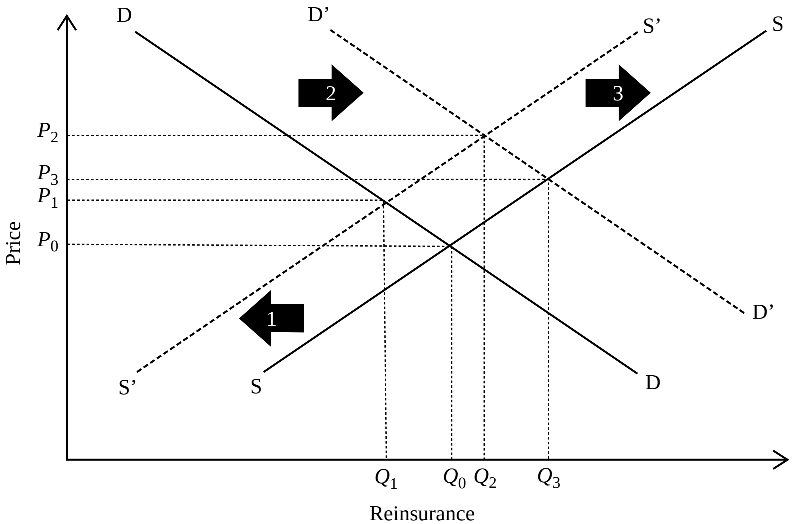


**Figure 6.**
Reinsurance pricing after a typical catastrophe loss event

claim payments can cause similar problems for reinsurers as just discussed for insurers, i.e. depleted levels of internal risk capital and shareholder equity, pressure on financial ratios, higher leverage, and the like. So, some of the new risk capital that flows into reinsurance markets serves to replace the old risk capital lost following the catastrophic event. In addition, the higher premiums which follow large catastrophe loss events represent opportunities for healthy reinsurance companies and other external risk capital providers to expand their relative market shares.

Fresh sources of risk capital that flow into reinsurance markets after catastrophic events can include share recapitalizations of existing reinsurance companies, new entrants into the market (including alternative reinsurance vehicles like sidecars), and new issuance of cat bonds. This influx of new capital causes the supply curve to shift outward – from $S'S'$ to its original position in this example along curve $SS$, as shown in Figure 6. The new resulting equilibrium quantity of reinsurance supplied occurs at $Q_3$ and is commensurate with a new premium level of $P_3$.

*5.2 Supply and demand in the wake of the credit crisis*

In response to catastrophe insurance losses and investment losses precipitated by the credit crisis, signs of a hardening catastrophe reinsurance market emerged in the last half of 2008. Through the renewal cycles in the first two quarters of 2009, reinsurance premiums had risen significantly relative to prior-year levels, especially for specialty lines like catastrophic P&C coverage (*Reactions*, 2009). But unlike the classic scenario discussed in the previous section, the market has struggled to find a new long-run equilibrium in the wake of the ongoing credit crisis because the expected third phase of the adjustment process – the influx of new risk capital in the actual and synthetic reinsurance markets – has not yet occurred.

On the supply side, reinsurers entered 2008 with relatively strong balance sheets following several years of low losses. As a result of insurance losses and unrealized losses on reinsurers' investment portfolios in the wake of the credit crisis, however, reinsurers ended 2008 with estimated 15-17 percent depletions in capitalization levels[16]. In addition, market-wide declines in equity values have distorted financial and underwriting ratios and have reduced reinsurers' financial flexibility and bulk underwriting capacity.

The alternative forms of external risk capital we have reviewed in this paper have also contracted since the advent of the credit crisis. In 2008, only $2.8bn in ILSs was issued, compared to $13.72bn in 2007. Retrocession markets have also contracted and hardened, with average rates rising by about 15 percent in 2008 (Eeuwens, 2009). And in the ILW market, financial pressures on some hedge funds precipitated their exit from the market and caused a further reduction in the supply of external risk capital.

The significant depletion of reinsurance capitalization levels resulting from 2008 underwriting losses and the credit crisis shifted the external risk capital supply curve inward – from $SS$ to $S'S'$ as shown illustratively in Figure 7. Most importantly, the disruptions caused by the credit crisis have not led to the usual influx of new risk capital as discussed in the previous section. All else equal, that puts downward pressure on capacity and upward pressure on prices – say, from $P_0$ to $P_1$ as illustrated in Figure 7.

On the demand side, the credit crisis has precipitated greater interest in P&C reinsurance coverage, depicted in Figure 7 by a shift in the reinsurance demand curve

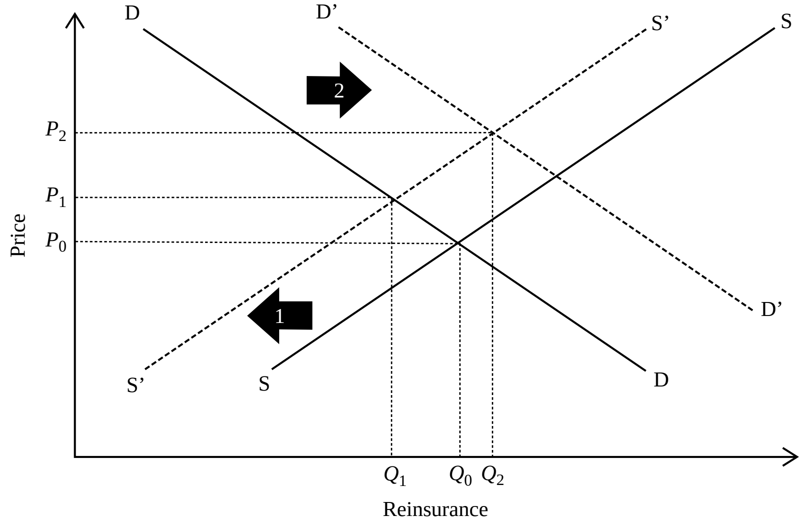


**Figure 7.**
Reinsurance pricing and the credit crisis

from $DD$ to $D'D'$. Some of the higher demand for risk capital resulted from a need for primary carriers to replace internal risk capital that was lost as equity markets crashed. In 2008, P&C insurers saw their shareholder equity values decline by about \$90bn, representing about 15-20 percent of US P&C insurance capacity. Actual and potential ratings downgrades put further pressure on primary carriers, forcing them either to replenish lost internal risk capital or take less underwriting risk. All else equal, the increased demand for reinsurance put upward pressure on prices – say, from $P_1$ to $P_2$ in Figure 7.

The reduced reinsurance capacity and increased demand for external risk capital that have accompanied the evolving credit crisis are consistent with the supply and demand factors we observe following any large-claim experience in the P&C (re-)insurance industry. But the general re-pricing of risk in the financial markets and the dark cloud of fear that continues to cast a shadow on the market have led most primary carriers, reinsurers, and investors to conclude that fresh risk capital is both more expensive and harder to obtain than it was before the crisis. In particular, concerns by reinsurers that capital markets might not be accessible when needed have fed similar fears amongst primary carriers about the availability of risk capital from their reinsurers.

In addition, insurers and reinsurers alike are paying much more attention to the quality of their premium float than they were in early 2007. Underwriting standards thus have become much tighter. Heightened ratings agency and regulatory scrutiny on primary carriers and reinsurers has further exacerbated the adoption of more conservative underwriting principles.

At the date of our writing, market participants thus still have significant uncertainties about reinsurance capacity and the reinsurance supply curve, i.e. when (and how much) capital will begin to return to the reinsurance industry. Fresh share capital would recapitalize reinsurers and shift the supply curve back to the right, thereby expanding capacity and putting downward pressure on premiums. An expansion in ILS issues would also help shift the reinsurance supply curve to the right. But the insurance-linked securities market has also not escaped the credit crisis unscathed. Although investor interest in ILSs and secondary market activity were strong throughout the first half of 2008, new issuance was down significantly for the year (Davidson, 2008; Standard & Poor's, 2009). As discussed earlier, moreover, the Lehman Brothers failure that precipitated several cat bond downgrades and defaults cast a shadow over the market and raised questions about the underlying design of certain cat bond structures.

So, the "fear premium" in the primary insurance market together with similar uncertainties in the reinsurance market have discouraged the influx of new risk capital. And as a result, reinsurance and synthetic reinsurance supply remains relatively depressed with little consensus on when the market will reach a new long-run equilibrium. The market is clearing as prices rise – reinsurance is available and getting written, albeit at higher prices – but premiums and expected returns have only now risen enough to begin attracting new providers of risk capital.

## 6. Conclusion

Although P&C policyholders derive significant benefits from risk capital held by insurance companies, those customers are rarely willing to pay higher premiums for reduced default risk. Insurance company shareholders, by contrast, bear all of the economic costs of risk capital. But shareholders also benefit from risk capital. As such, the decision of how much risk capital to hold and in what form must be weighed carefully by investors in P&C insurance company stocks.

At no time have these decisions been more important than in today's environment. The wild gyrations in global equity markets and significant losses incurred by some insurance companies have significantly increased their cost of internal risk capital. Happily, many reinsurers have weathered the storm and remain efficient and strong providers of external risk capital. Losses by several reinsurers, however, have precipitated ratings downgrades, balance sheet weakness, and capacity reductions, all of which also should impact an insurer's choice of an external risk capital provider.

In our view, it is critical for insurers to compare external and internal risk capital in a consistent conceptual framework. The essential first step in that undertaking is to frame properly the question to be answered. The right question to ask is not "How much reinsurance should we buy?," but rather "How much reinsurance should we buy from external parties instead of from investors in our own securities, from whom, and in what form?"

### Notes

1. Statutory accounting policies can vary across regulatory jurisdictions and accounting regimes.
2. Policyholders' surplus is generally defined as the insurer's assets less its customer liability reserves.
3. Economists typically define "insolvency" as a situation in which the market value of a firm's assets falls below the market value of its liabilities. Bankruptcy law, however, takes a somewhat different approach (Heaton, 2007). Insurance companies are even more complicated because insolvency is usually preceded by regulatory intervention and "rehabilitation."

4. We closely follow Merton and Perold's (1993) framework for analyzing risk capital throughout this paper.
5. Insurance companies often adopt willingness-to-lose constraints, run stress tests to compute "maximum tolerable losses," and the like. Although these topics are relevant, they take us too far afield for us to explore them here.
6. The expected losses shown in Figure 4 for different layers are actually conditional expected losses.
7. If the reinsurer happens to be holding securities of the insurance company, those holdings are independent of the external risk capital provided by the reinsurance itself. In that situation, the reinsurer would be providing both internal and external risk capital.
8. In our examples, the only source of risk was the insurance risk. But if the assets held by the insurer are not riskless, the net asset shortfall $S(t)$ should reflect risks to the net of assets and insurance liabilities.
9. Cat swaps may also involve an exchange of payments based on insurance losses.
10. Because cat swaps are not reinsurance contracts, the SPE need not be a licensed reinsurance company in that case.
11. In recent months, investors have pressured cat bond issuers to pay a spread over Treasuries in lieu of LIBOR (Standard & Poor's, 2009).
12. We ignore "non-financial" sources of basis risk, such as reinsurers that try to avoid paying legitimate claims.
13. Some have also argued that ILWs are also subject to basis risk arising from questions about the underlying coverage areas (Dyson, 2006).
14. Indeed, one reason that multi-year cat bonds are popular is that issuance costs can be amortized over several years.
15. There are exceptions. For example, ILWs in which the protection seller is an unrated non-reinsurance company (a hedge fund) typically must be fully collateralized by protection sellers. In addition, some regulatory regimes require collateralization. Until very recently, for example, Florida required foreign reinsurance companies (regardless of their financial strength) to collateralize unpaid catastrophic reinsurance losses.
16. Guy Carpenter estimates that about 65 percent of the total contraction in reinsurance capitalization levels was attributable to investment portfolio under-performance (Eeuwens, 2009).

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