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The CAS *E-Forum,* Fall 2012-Volume 2

The Fall 2012, Volume 2 Edition of the CAS *E-Forum* is a cooperative effort between the CAS *E-Forum* Committee and various other CAS committees, task forces, or working parties.

This *E-Forum* includes reports 3 and 4 of the Risk-Based Capital Dependencies and Calibration Working Party. The first two reports are posted in *E-Forum,* Winter 2012-Volume 1.

This edition also includes a new feature called "Refresher Course." From time to time, the *E-Forum* Committee receives suggestions to reprint articles that have appeared in other CAS sources. This is done with the author's approval and, in some cases, the author's encouragement, because the subject matter of the article will benefit many more through wider dissemination. The first Refresher Course subject, "The Value of Risk Reduction" by Gary Venter and Alice Underwood, is part of the syllabus for Exam 7

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Solvency II Standard Formula and NAIC Risk-Based Capital (RBC)

Report 3 of the CAS Risk-Based Capital (RBC) Research Working Parties
Issued by the RBC Dependencies and Calibration Working Party (DCWP)

Abstract: The purpose of this paper is to describe the main features of the Solvency II Standard Formula when applied to a property casualty insurer and compare those features of the Solvency II Standard Formula to the U.S. National Association of Insurance Commissioners Risk-Based Capital formula. The comparison helps clarify the assumptions and methods used by the U.S NAIC RBC and Solvency II Standard Formula. This is one of several papers being issued by the Risk-Based Capital (RBC) Dependencies and Calibration Working Party and the Underwriting Risk Working Party (collectively known as the RBC Working Parties).

Keywords. Risk-Based Capital, Solvency, Capital Requirements, Insurance Company Financial Condition, Internal Risk Models, Solvency Analysis, Analyzing/Quantifying Risks, Assess/Prioritizing Risks, Integrating Risks.

1. Introduction

The Solvency II Standard Formula (Standard Formula) is part of a regulatory framework referred to as Solvency II. One part of the Solvency II framework requires that each insurer[1] calculates its Solvency Capital Requirement (SCR) using a Standard Formula, an internal model, or some combination of the two.

The purpose of this paper is to describe the main features of the Standard Formula as they would apply to a property/casualty insurer and compare these to corresponding features, if any, in the National Association of Insurance Commissioners (NAIC) Risk-Based Capital (RBC) formula.

As the Standard Formula is not final, this paper deals with the Standard Formula as presented in the Quantitative Impact Study Five (QIS5), with the exception of Table 4.1, which reflects a recent change in underwriting risk charges.

We provide comments comparing the Standard Formula to RBC in boxes such as the one around this paragraph.

[1] Solvency II refers to "insurance undertakings," "entities," and "(re)insurers" (to mean both insurers and reinsurers) in order to cover the variety of legal entities within the EU for life, non-life, and health business. For simplicity, in this paper we refer to "insurers" for those entities.

1.1 Terminology, Assumed Reader Background and Disclaimer

This paper assumes the reader is generally familiar with the property/casualty RBC formula.[2]

In this paper, references to "we," "our," "the working party," and "DCWP" refer to the CAS RBC Dependencies and Calibration Working Party.

We use the term "nonlife (NL) insurers" for insurers generally equivalent to U.S. property/casualty insurers.

The description of Solvency II and the comparisons to RBC aim to enhance our understanding of important features of both formulas. As such, we apologize in advance, and welcome feedback, from readers who might observe that the descriptions or comparisons are overly simplistic and do not properly represent important aspects of either formula.

The analysis and opinions expressed in this report are solely those of the authors, the Working Party members, and, in particular, are not those of the members' employers, the Casualty Actuarial Society, or the American Academy of Actuaries.

DCWP makes no recommendations to the NAIC or any other body. DCWP material is for the information of CAS members, policy makers, actuaries, and others who might make recommendations regarding the future of the property/casualty RBC formula. In particular, we expect that the material will be used by the American Academy of Actuaries.

This paper is one of a series of articles prepared under the direction of the CAS RBC Dependency and Calibration Working Party and the Underwriting Risk Working Party (collectively known as the RBC Working Parties).

2. Overview

The SCR, whether calculated from the Standard Formula or otherwise, is the capital level "correspond[ing] to the Value-at-Risk (VaR) of the basic own funds of an insurance or reinsurance undertaking subject to a confidence level of 99.5% over a one-year period."[3,4] This is

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[2] For a more detailed description of the formula and its initial basis, see Feldblum, Sholom, NAIC Property/Casualty Insurance Company Risk-Based Capital Requirements, *Proceedings of the Casualty Actuarial Society*, 1996.

[3] Directive 2009/138/EC of the European Parliament and of the Council of 25 November 2009, on the taking-up and pursuit of the business of Insurance and Reinsurance (Solvency II), Section 99 subsection 3.

[4] Directive, Introduction section 64 says, "The Solvency Capital Requirement should be determined as the economic capital to be held by insurance and reinsurance undertakings in order to ensure that ruin occurs no more often than once

sometimes referred to as the 99.5% one year VaR standard. This is a level intended to be sufficient such that the insurer could withstand a 1 in 200 year shock within one year with sufficient assets remaining to allow for the sale or transfer of its remaining liabilities to another insurer.

In addition to the SCR, each insurer also calculates a Minimum Capital Requirement (MCR). The MCR represents a threshold below which the national supervisor would intervene. The MCR is intended to reflect an 85% probability of adequacy over a one-year period and is bounded between 25% and 45% of the insurer's SCR.

The Standard Formula operates in a Solvency II-defined balance sheet structure that we refer to as Solvency II accounting in this paper. Assets and liabilities are valued based on a "mark-to-market" approach wherever possible and "mark-to-model" whenever mark-to-market is not available. Under Solvency II, loss and premium reserves are replaced for financial reporting by technical provisions that consists of the cash flows both inwards and outwards relating to premiums and claims. These cash flows are reduced (compared to nominal values) by a discount for the time value of money and increased (compared to nominal values) by addition of an explicit risk margin.[5] Stocks, bonds, and other assets are carried at market value. The statement values for receivables, including reinsurance recoverables, are reduced to reflect the probability of non-payments on an ultimate basis, i.e., not just reflecting reinsurers currently facing financial difficulties.

in every 200 cases or, alternatively, that those undertakings will still be in a position, with a probability of at least 99.5 %, to meet their obligations to policy holders and beneficiaries over the following 12 months."

[5] The cash flows in this process are expected values, including low probability events. The interest rate for discounting cash flows is the risk-free rate of appropriate maturity with an illiquidity adjustment. The risk margin is based on a per annum 6% cost (above risk-free interest rates) of holding capital to support the run-off of reserves, a risk margin method often referred as cost of capital approach. The technical provisions including the risk margin is the mark-to-model value intended to represent the price a buyer would require to accept the risk of assuming the liabilities from the company.

RBC also has several levels ranging from Company Action Level (CAL) to Mandatory Control Level (MCL).

There is no target probability safety level specified for the RBC action levels.

While the objective of CAL and MCL levels may not correspond to SCR and MCR levels, we note that RBC MCL is 35% of the RBC CAL, and thus in the middle of the range of ratios of Solvency II MCR to SCR.

U.S. Statutory Accounting reserves are not discounted (other than for tabular indemnity benefits such as workers compensation life table claims and structured settlements) and contain no explicit safety margin beyond the effect of not discounting. Investment grade bonds can be valued at amortized cost rather than market value[6] and the value of reinsurance recoverables are reduced for the risk of non-payment, but often only if non-payment is likely.[7]

3. Risks and Risk Charges

The Standard Formula has separate modules for life, health and non-life insurance. This paper is presented from the perspective of a stand-alone non-life insurer. Certain features of the Standard Formula that are minimally relevant or irrelevant to U.S.-type non-life insurance are noted in Appendix A.

For a non-life company, the main risk categories included in the Standard Formula are as follows:

Underwriting Risk, which includes:

- Premium (loss ratio) risk, excluding catastrophe risk
- Reserve (loss development) risk, excluding catastrophe risk
- Catastrophe risk

[6] Use of amortized cost rather than market value was more prevalent for non-life companies in the 1990s when RBC was implemented than is the case currently. Also use of amortized cost is standard for life insurance companies and the RBC factors for class 1 and 2 bonds are the same for life and non-life companies.
[7] Currently, some U.S. insurers anticipate ultimate uncollectibles in ceded reserves and some do not. When RBC was developed, insurers rarely reflected ultimate uncollectibles.

Default (Counterparty) Risk, which includes:

- "Non-diversified" counterparties, most significantly reinsurance counterparties
- "Diversified" counterparties, most significantly agents balances and other receivables

Market Risk, which includes:

- Interest rate risk
- Equity risk
- Real estate (Property) risk
- Spread risk
- Currency risk
- Concentration risk
- Illiquidity risk

Operational Risk

RBC has six main risk categories – R0 through R5.

R0 contains off-balance sheet risks and risks arising from insurance subsidiaries. Risks in R0 are not reduced by the covariance formula. The inclusion of insurance subsidiaries in R0, outside the covariance formula, approximates the result that would occur if the calculation were done on a consolidated basis (with regard to insurance subsidiaries). The result effectively allows any capital held by an insurance subsidiary above the RBC requirements to accrue to the benefit of the upstream parent.

In Solvency II there is no Standard Formula risk charge for subsidiaries, but to the extent that the insurer's net asset value (NAV) includes insurance or other financial service subsidiaries (full or partial ownership), the value of those subsidiaries in the parent company financial statement is adjusted to avoid over-counting of NAV between the subsidiary and the parent company.

Both RBC and the Standard Formula have special rules for dealing with valuation of financial subsidiaries in NAV or risk charges like R0 or both.

RBC R1 and R2 address invested asset risk, including investments in non-insurance affiliates, corresponding to the Standard Formula Market Risk.

R1 addresses invested asset risk for fixed-income investments; R1 primarily addresses default[8] risk. The fixed-income risk in Solvency II considers change in market value that includes change in interest rates and market measurement of default risk. The difference in risk treatment might be viewed as related to the difference in time horizon between Solvency II and RBC. Over the one year Solvency II time horizon, risk relates to change in market value. Over the longer RBC time horizon, the risk relates to default.

This difference in risk treatment is analogous to the difference in accounting treatment between SAP and Solvency II. In SAP, many fixed-income assets are valued at amortized cost, and that value does not change with interest rates. In Solvency II fixed-income assets are valued at market, and that value does change when interest rates change.

R2 corresponds to equity and real estate (property) risk.

[8] The R1 factors represent default risk over a 10-year holding period for class 1 and 2 bonds, net of expected recoveries after a default. For class 3+ bonds the risk factor was a judgmental market risk factor with no clear holding period.

R3 corresponds to default (counterparty) risk.[9]

R4 and R5, reserving and premium risk, correspond to Standard Formula Underwriting risk. The R4 and R5 provisions for growth are analogous to the growth component within the Standard Formula provision for Operational Risk.

The RBC provision for catastrophes is implicit in R4 and R5, primarily R5, although work is underway to develop separate RBC charges for hurricane and earthquake risk.

The risk charges for each of these Solvency II risk elements are intended to represent the 99.5% VaR for a one-year time horizon. Risk charges for each risk at this target safety level are determined by one of two methods: the "factor method" or the "scenario method."

For some risks, e.g., premium and reserve risk, the risk charge is calculated by applying a factor to a balance sheet value at the statement date. We refer to this as a factor method.

For other risks the risk charge is determined by taking the difference between the insurer's net asset value, or "NAV" (capital and surplus in U.S. statutory terminology), at the statement date and the insurer's NAV restated, at the same statement date, based on a scenario affecting one or more risk elements. We refer to this as a scenario method. For example, the interest rate risk charge is determined by measuring how specified changes to the interest rate term structures and interest rate volatility affects the NAV due to revaluation of all interest rate sensitive assets and liabilities, (e.g., discounted loss reserves).

The capital charges associated with each of the risks are combined with a "correlation matrix"[10] intended to produce the target of a 99.5% VaR level in total over a one-year time horizon. The correlation matrix values are "tail correlations" appropriate to the 99.5% VaR level and not the more commonly discussed "linear correlation" factors. The resulting capital requirement is compared to the company's actual capital and surplus subject to several adjustments.

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[9] Ceded reinsurance credit risk with R3 is split 50/50 between R3 and R4 when applying the RBC covariance formula. The 50/50 treatment is not applied for fronting companies that retain little to no underwriting risk. For such companies, all the ceded reinsurance credit risk is retained in R3 when applying the covariance formula.

[10] Solvency II "correlation matrices" are intended to represent the dependency relationship at the tail of the risk distribution. Technically these are not correlation matrices according to the assumptions required of linear correlation. These "correlation matrices" are useful approximations, but might be described as "weighting factor matrices." Nonetheless, to be consistent with Standard Formula terminology, we refer to them as correlation matrices. (All the Solvency II matrix values are rounded or selected to be multiples of 0.25.)

RBC target safety level is generally implicit and not the same for each risk element. The risk charge for reserve and premium risk in R4 and R5 has been calibrated to an 87.5% VaR over the claim run-off period (reserves) and 87.5% for one year of new business (premium).

RBC currently uses factor methods only, no scenario methods, although the hurricane and earthquake cat charges being developed would use catastrophe model results (which combine scenarios with probability estimates).

The RBC correlation structure is less extensive than that used by the Standard Formula.

In the remainder of this report, we discuss non-life underwriting risk (Section 4), default or counterparty risk (Section 5), and market risk (Section 6). In Section 7 we discuss how the risks are combined to produce the total SCR, reflecting dependency relationships between the risks and operational risk. In section 8 we discuss the adjustments to Solvency II capital that are made before capital is compared to the SCR result.

4. Non-Life Underwriting Risk Module

4.1 Overview

The main elements of non-life underwriting risk are premium risk, reserve risk, and catastrophe risk. Each of these is described in the sections below.

The underwriting risk charge is determined both net of reinsurance and gross of reinsurance. The risk charge net of reinsurance enters the Standard Formula directly. The difference between the risk charge net of reinsurance and the risk charge gross of reinsurance represents exposure to credit risk. As such, that difference is used in calculating the reinsurance counterparty default risk (credit risk) charge.

4.2 Premium and Reserve Risk Elements

Premium risk is intended to measure the variation in combined ratios, net of reinsurance recoveries and excluding catastrophe losses. Expense risk is implicitly included as part of premium risk.

Reserve risk is intended to measure variation in loss reserve development, net of reinsurance recoveries and excluding catastrophe losses.

The Standard Formula requires insurers to classify non-life business into 12 lines of business.[11] Table 4.1 below shows the standard deviations used to calculate risk charges for premium and reserve risk.

Table 4.1
Standard Deviations by Line of Business – Premium and Reserve Risk
(Updated Dec 2011)

LOB #	LOB	Standard Deviation	
		Gross Premium[12]	Net Reserves[13]
1	Motor vehicle liability	9.6%	8.9%
2	Other motor	8.2%	8.0%
3	Marine, aviation, transport (MAT)	14.9%	11.0%
4	Fire	8.2%	10.2%
5	3rd party liability	13.9%	11.0%
6	Credit and suretyship	11.7%	19.0%
7	Legal expenses	6.5%	12.3%
8	Assistance	9.3%	11.0%
9	Miscellaneous	12.8%	20.0%
10	NP reins (prop)	5.0%	5.3%
11	NP reins (cas)	8.5%	13.9%
12	NP reins (MAT)	8.0%	11.4%

Source: Report of the Joint Working Group on Non-Life and Health NSLT[14] Calibration, "Calibration of the Premium and Reserve Risk Factors in the Standard Formula of Solvency II," 12 December 2011.

The factors are the same for all jurisdictions across the EU.

Proportional reinsurance business is treated as if it were the corresponding primary line of business, based on the assumption that the risk standard deviations are the same for primary and proportional reinsurance business.

The underwriting risk charges are applied to premiums and reserves net of reinsurance (for net risk) and to premiums and reserves gross of reinsurance (for gross risk), with the difference

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[11] This paper does not compare the Solvency II risk charge values to RBC values. Any such comparison is complicated (or impossible) because the lines of business are not directly comparable.

[12] Premium factors were selected based on data gross of reinsurance.

[13] Reserve factors were selected based on data net of reinsurance.

[14] Health is separated into (a) business analyzed using techniques "similar to life insurance techniques" (SLT) and (b) health analyzed using techniques like non-life or not-SLT (NLST).

between the two risk charges (the "ceded risk exposure") used to determine reinsurance credit risk. For premium risk, the standard deviation in Table 4.1 can be reduced using a formula to reflect the extent the ceded reinsurance is non-proportional reinsurance.[15]

The factors in the table are *standard deviations*, applied separately for premium and reserve risk. There are several steps required to produce the combined premium and reserve risk charge by line of business and then for all lines combined.

First, for each line of business, the premium risk and reserve risk standard deviations are volume weighted together assuming a correlation coefficient of 50% between premium and reserves as follows:

σ_{LOB} = Square Root {(Premium^2 * $\sigma^2_{Premium}$ + Reserve^2 * $\sigma^2_{Reserve}$+ Premium * Reserve * $\sigma_{Premium}$ * $\sigma_{Reserve}$*)/ (Premium + Reserve)^2 }.

Second, the volume measure(s) for each line of business are adjusted to reflect geographic diversification as follows:[16]

Volume $_{LOB, r}$ = (Premium $_{LOB\ r}$ + Reserve $_{LOB, r}$) * (75% + 25% * Diversification $_{LOB ,r}$),

where the r subscript represents geographic segments, generally countries.

Geographic Diversification $_{LOB}$ = {Σ (Premium $_{LOB, r}$ + Reserve $_{LOB, r}$) ^{2} / (Σ (Premium $_{LOB, r}$ + Reserve $_{LOB, r}$)) ^{2}}.

Third, the standard deviation for all lines combined is determined with the following formula, summing over all pairs of LOB J and K, using the LOB Correlations from Table 4.2:

σ_{TOTAL} = Square Root {(1/(Volume $_{TOTAL}$)^2*[∑ Correlation LOB$_{LOB\ J, LOB\ K)}$ * $\sigma_{LOB\ J}$ * *$\sigma_{LOB\ K}$ * Volume $_{LOB\ J}$ * * Volume $_{LOB\ K}$]}.

[15] Insurers must assess whether net-to-gross ratio of premiums or reserves at the 99.5% level are less than (or at least not significantly greater than) the net-to-gross ratio of best estimate provisions. That might be the case due to loss ratio limits and the like. If so, the reduction in the capital charge resulting from reinsurance is reduced. (QIS 5 Technical Specifications SCR 13.9)

[16] Rather than adjusting the standard deviation to reflect this diversification, the formula adjusts the volume measure.

Table 4.2
Standard Formula Underwriting Risk Covariance Matrix for Premium and Reserves
(LOB numbers in the first column follow the numbering in Table 4.1)

LOB/ LOB	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
1	1.00											
2	0.50	1.00										
3	0.50	0.25	1.00									
4	0.25	0.25	0.25	1.00								
5	0.50	0.25	0.25	0.25	1.00							
6	0.25	0.25	0.25	0.25	0.50	1.00						
7	0.50	0.50	0.25	0.25	0.50	0.50	1.00					
8	0.25	0.50	0.50	0.50	0.25	0.25	0.25	1.00				
9	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	1.00			
10	0.25	0.25	0.25	0.50	0.25	0.25	0.25	0.50	0.25	1.00		
11	0.25	0.25	0.25	0.25	0.50	0.50	0.50	0.25	0.25	0.25	1.00	
12	0.25	0.25	0.50	0.50	0.25	0.25	0.25	0.25	0.50	0.25	0.25	1.00

Note that each of the correlation factors is 0.25, 0.50, or 1.00. These are tail correlations and are intended to represent the relationship between line of business outcomes (premium and reserves combined) at the one-year 99.5% VaR level.

The non-life underwriting risk charge is approximately as follows:

Underwriting Risk Charge $\approx$ [Volume (after geographic diversification) $_{\text{Total}}$] * (3.0 * σ_{Total}).

The factor 3.0 is the rough number of standard deviations required to reach the 99.5% level for a lognormal distribution.

RBC treats premium risk and reserve risk as independent. The Standard Formula treats them as having some degree of covariance.

RBC has a line of business diversification credit (dependency relationship) expressed by the 70% rule.[17] The Standard Formula specifies a covariance relationship between each pair of lines of business.

RBC does not have a specific credit for geographic diversification or charge for geographic concentration. RBC risk charges are derived from data that implicitly includes an average geographical diversification effect for U.S.-domiciled insurance companies. The Standard Formula geographical diversification credit has a 75% rule that is applied like the 70% rule for LOB diversification in RBC.

RBC uses the same factors for business regardless of the state in which the business is written. The Standard Formula takes the same approach.

RBC does not evaluate risk gross of reinsurance as that information is not used in the RBC credit risk calculation.[18]

For R4, RBC includes an investment income offset.[19] The Standard Formula does not include an investment income offset in that investment income is already reflected in the discounted unpaid claim reserves. Thus, investment income is treated as a reduction in the risk charge in RBC while it is treated as an increase in capital and surplus in the Solvency II accounting basis.

For R5, RBC measures the risk as potential operating loss net of the investment income offset. The standard formula measures premium risk based on an unexpected increase in the loss ratio. Thus, the RBC risk charge is net of expected profit while the Standard Formula is gross of expected profit.[20]

[17] For premium risk the concentration factor is 70% plus 30% times (premium for largest Schedule P line of business/total premium). For reserve risk the concentration factor is the same formula using reserves instead of premium. The result is 100% for a monoline company and approaches 70% for a hypothetical insurer evenly spread across an infinite number of lines. The minimum value for the factor is limited by the number of Schedule P lines. The 70% rule was selected considering observed risk for all-lines combined compared to risk by line of business.
[18] Ceded reinsurance risk is considered in the credit risk charge, R3.
[19] Applied to reserves "grossed up" for any company non-tabular discount.
[20] An offsetting factor is that under Solvency II accounting profits are recognized more quickly than under SAP. Under Solvency II accounting, underwriting profit is reflected as premium is written and investment income on assets corresponding to unearned premium and unpaid claims is recognized in part immediately and in part as the risk margin

Own-Company Experience

Subject to regulatory approval, an insurer can choose to use a credibility-weighted combination of its own specific parameters (such as standard deviations) or the industry standard parameters for premium and reserve risk under the Standard Formula. The insurer experience must be analyzed in a prescribed manner analogous to the manner in which the industry data was evaluated. Insurer-specific parameters for premium and reserve risk would be treated as 100% credible if sufficient years of data are available. Insurers with at least five years of experience in a line of business start with 34% credibility. The credibility weights increase to 100% for 10 years of experience (most lines of business) or 15 years of experience (for longer-tailed lines of business such as third-party liability, motor vehicle liability, and credit and suretyship).

RBC includes an own-company adjustment using the 50-50 rule in which company experience modifies the RBC charge based on the ratio of company loss ratios to industry loss ratios or company-incurred development to industry-incurred development, as long as the company has 10 years of experience and meets certain other requirements regarding consistency of volume over the 10n years.[21]

4.3 Catastrophe Risk

As with the non-catastrophe underwriting risk charges, the Solvency II catastrophe underwriting risk charge is determined both net and gross of reinsurance. The charge net of reinsurance is a component of the total underwriting risk charge. The difference between the gross and net risk charges is referred to as the catastrophe risk mitigation effect and is a measure of reinsurance credit risk used in the counterparty default risk calculation.

Catastrophe risk charges consider both natural catastrophes and man-made catastrophes. Natural catastrophes consist of windstorm, flood, earthquake, hail, and subsidence.[22] Storm surge is included with the windstorm peril. Man-made catastrophes include motor, fire, aviation, marine, liability, credit and suretyship, and terrorism.

reduces. Under SAP underwriting profit in the written premium is not reflected until the premium is earned and investment income is recognized as realized.

[21] The exact rule for including company experience is more complex. See NAIC instructions for precise statement of the rule.

[22] Not all perils apply to all countries.

The risk charges are based on a combination of scenarios and factor methods. Scenario methods (Method 1) are for use in calculating capital requirements for natural catastrophes in the EEA.[23] The Scenario methods are described later in this section.

Factor methods (Method 2) are used when application of Method 1 may not be appropriate, e.g., for natural catastrophe exposures outside of the European Economic Area (EEA), miscellaneous business, and non-proportional reinsurance business. For the factor method, the Standard Formula provides selected gross loss ratios by line of business.

With either Method 1 or Method 2, insurers calculate their gross catastrophe losses based on either the prescribed scenarios (Method 1) or the prescribed gross loss damage ratios and gross written premiums (Method 2).

Insurers then net down the calculated gross loss damages using their own reinsurance programs including any excess covers, any proportional covers, excess retentions and reinstatement premiums as well as recoveries from any national pools.

The aggregate capital requirement for non-life (NL) natural catastrophes is determined as:

$$NL\_CAT = \text{Square Root } \{(\text{Method } 1)^2 + (\text{Method } 2)^2\}$$

Thus, it is assumed that Method 1 and Method 2 apply to independent catastrophe exposures.

Scenario Methods—Natural Catastrophes

The Standard Formula provides tables showing the gross loss damage ratio ($Q_{country}$) for 1-in-200 year catastrophe events, by peril, within each CRESTA[24] zone, separately by country. The capital requirement for each CRESTA zone and each peril gross of reinsurance is $Q_{country}$ times the aggregated value of geographically weighted total insured value by peril for each country, where the weights are the zone relativity factors for each country provided by the Standard Formula.

[23] The only company data required to apply the scenario methods is Total Insured Value (TIV) by line of business, reflecting the company's proportional share if on a co-insurance basis, without allowance for deductible, limits, and sub-limits, See "CEIOPS-DOC-79-10-CAT-TF-Report" page 9) by CRESTA zone. As that level of data is expected to be commonly available, it is expected that companies can apply the scenario method within the EEA.

[24] CRESTA, the Catastrophe Risk Evaluating and Standardizing Target Accumulation organization (founded in 1977) is an independent body established for the technical management of natural peril coverage. CRESTA determines country-specific zones for the uniform and detailed reporting of exposure data relating to natural perils.

The capital requirements for each peril are aggregated across CRESTA zones within each country using a prescribed correlation matrix intended to reflect tail dependency for 1-in-200 year events. The correlation coefficients strongly depend on proximity and, for flood, the shape of river networks. The aggregation by-country-by-peril allows application of national pool arrangements. Then the capital charges are aggregated across countries, by peril and finally across perils using prescribed covariance matrices between countries and between perils.

Insurers must allow for multiple events for wind, flood, and hail as follows. Each insurer evaluates the effect of two scenarios, A (one large event plus a second smaller event, with initial loss A1 and subsequent loss A2) and B (two moderate events, with initial loss B1 and subsequent and loss B2), on a gross basis and then net down for reinsurance. For each peril, the insurer calculates a capital requirement as the maximum of A (net) and B (net). Specifically, the capital charge for each peril is the maximum value of capital charges for scenario A and B net of reinsurance; where the capital charge for scenario A is equivalent to A1%, say 80%, of the capital charge for scenario A1 plus A2%, say 40%, of capital charge for scenario A2 (80% + 40% is greater than 100% reflecting the chance of more than one event); and where the capital charge for scenario B is equivalent to B1%, say 100%, of the capital charge for scenario B2 plus B2%, say 20%, of capital charge for scenario B2. The standard formula provides the 1-in-200 $Q_{country}$ values for A1%, A2%, B1%, and B2% for each peril.[25] For example:

- Alternative A: 80% of the capital charge for the first windstorm (net) and 40% of the capital charge for subsequent windstorm (net).
- Alternative B: 100% of the capital charge for first windstorm (net) and 20% of the capital charge for subsequent windstorm (net).

The insurer would select the maximum catastrophe loss from these two scenarios.

Scenario Methods—Man-Made Catastrophes

For each man-made catastrophe, the Standard Formula describes specific incidents to illustrate what is considered to be a possible man-made catastrophe scenario (for example, an explosion in the oil refineries at the port of Rotterdam, a fire in a building housing a major

[25] "CEIOPS-DOC-79-10-CAT-TF-Report," page 11

armament company with 10 fighter jets destroyed) and the capital requirement for each such man-made catastrophe peril.

For example, the preferred method to determine the capital charge for fire man-made catastrophe as described above is 100% of the sums insured of largest known concentration of exposures for the fire and other damage line of business in a 150-meter radius, then reduced to reflect risk mitigation effects (option 1). If option 1 cannot be applied, the capital charge is the maximum value resulting from the largest single risk loss across all sub-lines or from the sum across all sublines of prescribed factors for subline X times the of total insured values for subline X (X=residential, commercial, and industrial), then reduced to reflect risk mitigation effects (option 2).

Assuming independence between each man-made catastrophe, the capital charge for total man-made catastrophe is the squared root of sum of squares of the capital charges for each man-made catastrophe peril reduced to reflect risk mitigation effects.

Scenario Methods—Total Capital Charge

The aggregate capital requirement net of reinsurance for natural and man-made catastrophes under scenario method (Method 1) is

Square Root [(Natural Cats net capital charge) ^{2} + (Man-made cats net capital charge) ^{2}].

Factor Methods—Cat Capital Charge Net of Reinsurance

For the factor-based method (Method 2), the capital requirement for gross of reinsurance is initially determined as the product of expected gross written premiums (in the relevant lines of business) and prescribed gross factors by event, including multiple perils if relevant, applicable to all countries. For example, flood events are estimated to result in losses equal to 113% of the gross written flood premiums. Similar calculations are done for all perils where Method 2 is being used. Losses are then combined by assuming events are independent, except for direct insurance and proportional reinsurance and the corresponding non-proportional reinsurance, which are 100% correlated.[26]

The total cat capital requirement net of reinsurance for Method 2 is obtained by netting down the gross capital requirement for the risk mitigation effect in the same way as under Method 1

[26] Details at "QIS 5 Technical Specifications," page 242-243, section 9.178-9.179.

and applying the dependency relationship for the Factor Method gross risk charges described in the paragraph above.

In RBC, catastrophe risk is implicit in premium risk and reserve risk, and it does not reflect the individual insurer's catastrophe exposure or the insurer's reinsurance protection and related credit risks.[27]

4.4 Combing the Non-Life Underwriting Risks—Treatment of Dependency

The Standard Formula combines the premium/reserve and catastrophe risk modules with the following specified tail correlation matrix:

Table 4.3
Non-Life Tail Correlation Matrix

	Premium+Reserve	Catastrophe
Premium+Reserve	1.00	0.25
Catastrophe	0.25	1.00

Total underwriting risk charge = Square root {(Premium/reserve charge)^2 + 0.25 * (Premium/reserve charge)*(Cat charge)+ (Cat charge)^2}.

5. Counterparty Default Risk Module

The counterparty default risk module reflects possible losses due to the unexpected default, or deterioration in credit standing, of counterparties and debtors of the insurer over the next 12 months. This includes default risks from risk-mitigating contracts (reinsurance), securitizations, derivatives, receivables from intermediaries, and any other credit exposures not covered in the credit spread risk sub-module (not usually applicable to property/casualty companies).

Types of Default Risk

There are two exposure types included in this module, which the Standard Formula refers to as "Type 1" and "Type 2."

[27] There may be some implicit reflection of the individual insurer's past cat exposure via the company experience adjustment, but only through its share of industry cat losses in the last 10 years. Note that a cat charge is currently in development that would utilize the results of third-party hurricane and earthquake cat models at the 1-in-100 aggregate annual loss exceedence level.

Type 1 exposures cover the exposures that may not be diversified and where the counterparty is likely to be rated. Most importantly, for non-life insurers, these exposures include reinsurance arrangements, securitizations and derivatives, and any other risk-mitigation contracts. Type 1 exposures also include cash in banks, deposits with ceding institutions (when there are relatively few, defined as up to 15 independent counterparties), and some forms of capital (and other similar commitments such as initial funds and letters of credit) called up but not yet paid (similarly, when there are relatively few, defined as up to 15 independent counterparties).

Type 2 exposures cover the exposures that are usually diversified and where the counterparty is likely to be unrated. These exposures include receivables from intermediaries, policyholder debtors (including mortgage loans), deposits with ceding institutions (16 or more independent counterparties), some forms of capital (and other similar commitments such as initial funds and letters of credit) called up but not yet paid (16 or more independent counterparties).

Capital Requirements—Type 1

The capital requirement for counterparty default can be considered in two steps: first determine the loss given default (LGD) and second determine the capital required given that exposure to loss. These are described below.

Loss given Default—Type 1 Exposure

Loss-given-default (LGD) is the loss of own funds if a particular counterparty defaulted.

For reinsurance arrangements (or securitizations), LGD has three parts:

1. The risk mitigating effect of reinsurance: the difference between the capital required for underwriting risk without and with the reinsurance contract(s).
2. Balance sheet risk: existing recoverables under the reinsurance contracts(s), (including the equivalent of recoverables on unearned premium).
3. Collateral: LGD implied by the above, is reduced by the amount of collateral supporting the contract(s).

The LGD is normally[28] 50% of [(1) + (2)- ()-(3)]. The 50% represents an estimate of the amount that the insurer would be unable to recover if the counterparty defaulted.

For reinsurance, the risk mitigating effect of reinsurance is calculated as described in the underwriting risk section 4.2. The underwriting risk charges are applied to premiums and reserves net of reinsurance (for net risk) and to premiums and reserves gross of reinsurance (for gross risk). The difference between the two risk charges is the risk mitigating effect of reinsurance. For premium risk, the underwriting risk net of reinsurance can be adjusted to reflect the extent the ceded reinsurance is non-proportional reinsurance.[29] This adjustment reduced the otherwise applicable premium risk but increases the risk-mitigating effect of reinsurance and the capital for reinsurance credit risk.

For derivatives, LGD is the difference between the capital required for market risk without and with the derivative(s). The balance sheet risk is the market value of the derivative. The risk is reduced by any collateral supporting the derivative(s). LGD is calculated as 90% of the total exposure.

For Type 1 exposures other than risk-mitigating contracts, the LGD is the value of the asset marked-to-market (or marked-to-model, if mark-to-market is not possible) for exposures not dependent on the credit rating of the counterparty. For those assets whose value is dependent on the credit standing of the counterparty, the LGD is the difference between the nominal value and the market value of the receivable.

Calculation—Type 1 Exposure

The Standard Formula includes an algorithm to calculate the standard deviation of the distribution of costs of Type 1 defaults, $\sigma_{\text{Type 1 default risk}}$. The value of $\sigma_{\text{Type 1 default risk}}$ depends on the probability of default per counterparty. That probability of default varies according to seven different credit ratings (AAA, AA, A, BBB, BB, B, and CCC or lower). A

[28] If the counterparty financial position is such that more than 60% of the counterparty assets would be required as collateral for its obligations, then the LGD is 90% of sum of (1)-(3), as less counterparty assets would be available to the insurer in the event of its default.

[29] Insurers must assess whether net-to-gross ratio of premiums or reserves at the 99.5% level are less than (or at least not significantly greater than) the net-to-gross ratio of best estimate provisions. That might be the case due to loss ratio limits and the like. If so, the reduction in the capital charge resulting from reinsurance is reduced. (QIS 5 Technical Specifications SCR 13.9)

common stress function is assumed to affect all counterparties and probability of default increases as the level of stress increases.

The counterparty default charge is based on the probability of default at the 99.5% probability level. As such, normally,[30] the capital requirement is 3[31] times $\sigma_{\text{Type 1 default risk}}$. The effect is that for a single counterparty of various expected default levels the risk charges are based on formula that produces risk charges as shown in Table 5.1.

Table 5.1
Probability of Default for Risk Charge Compared to Expected Average Probability of Default

Credit quality[32]	Expected Default Probability	Default probability used for counterparty credit risk
AAA	.002%	1.3%
AA	.010%	3.0%
A	.050%	6.7%
BBB	.240%	14.7%
BB	1.200%	54.5%
B	6.040%	100.0%
CCC or lower	30.41%	100.0%

Source: CEIOPS, "Advice for Level 2 Implementing Measures on Solvency II: SCR standard formula – Counterparty default risk module," October 2009

Thus, for a program covered by one A-rated reinsurer, the default probability for reinsurance credit risk evaluation is 6.7%, even though the long-term average default probability is .05%.

For ten A-rated counterparties, each with an expected default rate of 0.05%, the required capital would be 4.5% of LGD, rather than 6.7% of LGD, reflecting credit for diversification but recognizing that there is a systemic component to the risk.

Appendix B shows a counterparty risk calculation.

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[30] If the σ_Type_1_Default_Rrisk is greater than 5% of the total LGD, then the capital requirement is 5 times σ Type 1 default where 5 replaces 3 because the large standard deviation suggests that the LGD distribution may be more extreme than expected and the 99.5%-ile risk level would be more than 3 standard deviations from the mean.

[31] The factor 3.0 is the rough number of standard deviations required to reach the 99.5% target safety level for a lognormal distribution.

[32] For counterparties without a standard credit rating, the Standard Formula provides a table of expected default rates based on the ratio of own-funds to SCR.

RBC applies a 10% charge to the total ceded balances, reduced for any Schedule F penalty applicable to those balances. These balances include ceded loss reserves, unearned premium, and amounts billed but not yet collected.

The 10% charge is applied regardless of the quality of the reinsurers, except that a 0% charge is applied to ceded balances with U.S. affiliates and with mandatory pools (such as residual market pools), and does not vary based on whether the reinsurer has provided collateral. Those features were based on conscious decisions by the NAIC when RBC was developed.[33]

The RBC charge is the same for all types of reinsurance, e.g., quota share, excess, and catastrophe, and for all types of business, e.g., property vs. liability.

The RBC formula does not explicitly deal with the percentage of loss given default (LGD) in case of reinsurer failure, and it does not explicitly deal with the extent to which ceded balances (and therefore size of potential credit risk) would be higher in adverse circumstances than in normal circumstances. However, those features, which are explicitly recognized in the Standard Formula, could be viewed as being implicit in the selection of the 10% charge.

The reinsurance portion of the RBC charge is split 50/50 between two RBC components (R3 and R4), in the covariance formula. This is mathematically differently, but conceptually closely related to the Standard Formula, which has a 50% correlation between Credit Risk and Underwriting Risk.

Capital Requirements—Type 2

The capital requirement for counterparty default risk of Type 2 exposures is

- 15% of all Type 2 exposures, except for receivables from intermediaries due for over three months), plus
- 90% of the exposures due more than three months.

[33] It is beyond the scope of this paper to review the basis for those decisions and their current applicability.

With respect to Type 2 exposures, which, most significantly for nonlife companies, consist of "uncollected premium and agents balances in course of collection," RBC, operating in SAP, reflects a zero asset value for (i) agents balances and (ii) many other receivables over 90 days due. The Standard Formula includes a risk charge of 15% premium on non-overdue receivables and a risk charge of 90% on overdue receivables. Thus the risk of premium receivables is treated as a reduction to reported capital in RBC and as a risk charge in the Standard Formula.

RBC has 5% and 1% charges for a number of other categories of receivables. Solvency II accounting requires for provisions to reflect the probability of default on all receivables, however small.

Calculation of Total Capital Requirement for Counterparty Default—Type 1 + Type 2

Total capital for counterparty default reflects a 75% correlation between Type 1 and Type 2 exposures.

$$\text{Total Capital} = \text{square root}\left[(\text{Capital}_{\text{Type 1}})^2 + 1.5 * (\text{Capital}_{\text{Type 1}}) * (\text{Capital}_{\text{Type 2}}) + (\text{Capital}_{\text{Type 2}})^2\right].$$

The reinsurance portion of the RBC charge is split 50/50 between two RBC components (R3 and R4), in the covariance formula. This is mathematically different, but conceptually related to the Standard Formula, which has a 50% correlation between Credit Risk and Underwriting Risk.

In RBC the remaining reinsurance credit risk is combined with other credit risks as if they were 100% correlated.

6. Market Risk Module

6.1 Overview

The Standard Formula market risk includes seven sub-risks:

1. Interest rate risk reflecting an "up" rate and a "down" rate stress.
2. Equity risk reflecting prescribed decreases in equity values.
3. Real Estate (Property) risk reflecting a prescribed decrease in the value of real estate investments.
4. Currency risk reflecting changes of foreign currencies against the insurer's home country currency.

5. Spread risk reflecting changes in the level or volatility of credit spreads over the risk-free interest rate term structure (for bonds, structured capital products, and credit derivatives).
6. Concentration risk reflecting risk of accumulation of exposures with the same counterparty. The scope of concentration risk includes assets considered in the equity risk, spread risk and property risk sub-modules and excludes assets considered in the counterparty default module.
7. Illiquidity premium risk reflecting decreases in the value of the illiquidity premium. For non-life insurers this only affects loss reserve discounting.

6.2 Interest Rate Risk

Interest rate risk is calculated using a scenario approach. The Standard Formula prescribes specific upward and downward stress in interest rates that vary by years to maturity. Irrespective of the prescribed stress factors, the absolute change of interest rates in the downward scenario should be at least one percentage point (with interest rate not to be less than zero). The insurer calculates the change in NAV resulting from these rate stresses. The capital requirement for interest rate risk is derived from the up or down shock, whichever gives rise to the highest capital requirement.

The effect on NAV from an interest change is the combination of (a) the change in asset market values as interest rates change, and (b) the change in liabilities as discounted loss reserves are also affected by change in interest rates.

RBC determines asset charge, R1, for fixed-income securities by applying a factor to statutory annual statement balance sheet items. The factor varies by NAIC Classification of the investment.

NAIC R1 relates to default risk (on a loss given default basis) for investment grade bonds rather than change in market value (although the charges for non-investment grade bonds, which are higher, are supposed to reflect market value risk). R1 charges for U.S.-government securities, for example, are zero. The focus on default risk rather than risk of market value movements might be viewed as the difference in time horizon. RBC takes a run-off view, over which market value changes are less relevant as assets can be liquidated gradually over time. The Standard Formula measures risk based on market values one year ahead. Logically, the one-year market value risk charge in the Standard Formula should be larger than the run-off default risk charge in RBC.

Standard Formula does not have a separate charge for asset default risk as that is part of market value risk.

6.3 Equity Risk

The risk charge for equity risk is calculated as the change in an undertaking's NAV resulting from pre-defined stress scenarios:

- 30%[34] decline in the value of "global" equities (listed in regulated markets); and
- 40%[35] decline in the value of "other" equities (emerging markets, non-listed equity, hedge funds, and other investments not included elsewhere).

These two risk charges are combined with the assumption that global equities are 75% correlated with "other" equities.

The aggregate SCR for equity risk is calculated as:

Square Root {(global equity charge)^2 + 0.75 * (global equity charge) * (other equity charge) + (other equity charge) ^{2}}.

[34] The risk charge is 39% in normal conditions, and reduced to 30% after a stress event such as the financial crisis.
[35] The risk charge is 49% in normal conditions, and reduced to 40% after a stress event such as the financial crisis.

The equity risk is part of NAIC R2. R2 uses a 15% charge for unaffiliated common stocks and charges from 0.3% to 30% for various types of preferred stocks and hybrid securities. The lower R2 charges could be viewed as related to the difference in time horizon between RBC and Solvency II Standard Formula, as discussed above with respect to R1.

6.4 Property Risk

Property risk is calculated as the change in an undertaking's NAV resulting from a pre-defined scenario of 25% decrease in the value of real estate investments. Investments in companies engaged in real estate management, project development, or similar activities are considered in the equity risk sub-module.

Owned property risk is part of the NAIC R2 and has a 10% risk charge.

6.5 Currency Risk

Currency risk is calculated as the change in an undertaking's NAV resulting from a pre-defined scenario of an instantaneous rise (or fall) of 25% (-25%) of the foreign currency against the home country currency. The capital requirement for each currency risk is derived from the up shock or down shock, depending on the one that gives rise to the highest capital requirement. The capital requirement includes any investment in foreign instruments where the currency risk is not hedged. The stresses for interest rate, equity, spread and property risks have not been designed to incorporate currency risk. The total capital requirement is summed over all of currencies of the SCRs for currency risk.

Currency risk is not reflected in NAIC RBC. For the bulk of U.S. companies, currency risk is rare, arising perhaps in the international LOB, Canadian business or in some reinsurance companies. To the extent liabilities in a non-U.S. currency are supported by assets in that some currency, a common practice, currency risk is minimized.

6.6 Spread Risk

Spread risk is calculated as the change in an insurer's NAV resulting from specified changes in the level or volatility of credit spreads over the risk-free interest rate term structure. Separate calculations are done for bonds, structured credit products, and credit derivatives. The spread risk scenario depends on the credit rating of the assets. In cases where several ratings are available for a given credit exposure, the second-best rating is applied.

The spread risk on bonds reflects the immediate effect on the NAV expected in the event of an instantaneous decrease of values in bonds due to the widening of credit spreads. The calculations vary by issue quality and duration.

The spread risk on structured credit products equals the effect on the NAV in the event of an instantaneous decrease of values in structured products due to the worst of two shock scenarios prescribed in the Standard Formula: (1) the widening of credit spreads of bonds of the underlying assets and (2) the widening of credit spreads of the structured credit products. The calculations are determined based on issue quality/credit rating, tenure/duration, attachment point, and detachment point.

The spread risk on credit derivatives equals the effect on NAV in the event of an instantaneous widening (decrease) of credit spreads for credit derivatives due to the worst of two shock scenarios defined by the Standard Formula, whichever gives rise to the highest capital requirement: (1) widening of spreads (in absolute terms) and (2) decrease of spreads (in relative terms) that vary by issue quality.

There is no spread risk component of RBC. Spread risk is a market value issue rather than an issue for assets held to maturity. (See discussion of interest rate risk.)

6.7 Concentration Risk

Concentration risk includes assets considered in the equity risk, spread risk, and property risk sub-modules. Concentration risk excludes assets considered in the counterparty default risk. Concentration reflects concentration in a single entity rather than concentration by geography or industry segment. The calculation is performed in three steps.

(1) The "excess exposure" to each counterparty (i) compares the percentage of portfolio assets exposed to counterparty (i) to a "concentration threshold." The concentration threshold is 3% for counterparties rated A or better and 1.50% for counterparties rates BBB or lower.

For example, if 3.50% of assets are with an A-rated counterparty, there is a 0.50% excess exposure, 3.5% actual minus 3.0% threshold.

(2) The risk concentration capital requirement reflects the effect on the NAV of a decrease in the value of the "excess exposure" for each counterparty multiplied by a parameter that also varies with counterparty rating.

For example, if there is a 0.5% excess exposure, the related capital requirement for concentration risk is 0.1%, 0.50% "excess" times the 0.21 risk factor for excess concentration on to A-rated counterparties.

(3) Finally, the aggregate capital requirement for concentration risk assumes no correlation among the counterparties [aggregate = (sum (concentration^2)) ^ 0.50].

Concentration risk is considered in R1 through a bond size adjustment factor that decreases as the number of bond issuers increases.

Concentration risk is considered in R1 and R2 through an "asset concentration" adjustment that doubles the RBC charges for all the investments in a single issuer for the ten largest issuer exposures, with a maximum charge of 30% for any one security.

6.8 Illiquidity premium risk

Illiquidity premium risk reflects the immediate effect on the net value of assets and liabilities expected in the event of a 65% decrease in the value of the illiquidity premium observed in the financial markets. Except for the discounting of loss reserves, this risk is not relevant for non-life insurers.

There is no provision for this risk in RBC. The risk is not relevant for RBC unless loss reserves are discounted at a rate that depends on the liquidity premium.

6.9 Treatment of Dependency

The Standard Formula market risk capital requirement combines all seven risk types with a tail correlation matrix. There are two correlation matrices, one for an interest rate "up" stress and one for an interest rate "down" stress.

Table 6.1
"Down" Tail Correlation Matrix

Down	Interest	Equity	Property	Spread	Currency	Concentration	Il-liquidity
Interest	1.00						
Equity	0.50	1.00					
Property	0.50	0.75	1.00				
Spread	0.50	0.75	0.50	1.00			
Currency	0.25	0.25	0.25	0.25	1.00		
Concentration	0.00	0.00	0.00	0.00	0.00	1.00	
Illiquidity	0.00	0.00	0.00	-0.50(a)	0.00	0.00	1.00

Table 6.2
"Up" Tail Correlation Matrix

Up	Interest	Equity	Property	Spread	Currency	Concentration	Il-liquidity
Interest	1.00						
Equity	0.00	1.00					
Property	0.00	0.75	1.00				
Spread	0.00	0.75	0.50	1.00			
Currency	0.25	0.25	0.25	0.25	1.00		
Concentration	0.00	0.00	0.00	0.00	0.00	1.00	
Illiquidity	0.00	0.00	0.00	-0.50(a)	0.00	0.00	1.00

Note (a): The correlations for spread risk represent widening spreads, so a negative correlation between illiquidity premium risk and spread risk is set at -0.50.

The capital requirement for market risk is calculated as follows:

The maximum of

Square root (∑ correlated interest rate "up" scenarios), and

Square root (∑ correlated interest rate "down" scenarios).

RBC treats R1 and R2 as separate terms within its covariance formula, thereby assuming that these are independent risks over the run-off period.

R2 combines real estate (property) and equity risks as if they were 100% correlated.

7. Solvency Capital Requirement (SCR)

The overall standard formula capital requirement (SCR) for Non-Life insurers is determined by summing up the Basic Solvency Capital Requirement (BSCR) and Solvency Capital Requirement for Operation Risk (SCRop):

SCR = BSCR + SCRop.

Two steps are required to determine the BSCR.

First, the insurer combines the market, default, and underwriting risks using the correlation matrix in table 7.1.

Table 7.1
Market Risk Tail Correlation Matrix

	Risks Considered in this paper				
				For "composite" companies	
	Market Risk	**Default Risk**	**Non-Life U/W Risk**	**Life U/W Risk**	**Health U/W Risk**
Market	1.00				
Default	0.25	1.00			
Non-Life	0.25	0.50	1.00		
Life	0.25	0.25	0.00	1.00	
Health	0.25	0.25	0.25	0.25	1.00

Notes:
U/W risk is the "combined" reserve risk and premium risk discussed in section 4.
In this paper we have not discussed Life or Health U/W risks, as we have focused on a non-life company.

Second, to the extent the insurer includes the value of intangible assets[36] in its capital, there is a risk charge equal to 80% of that value.

The Basic Solvency Capital Requirement (BSCR) is the sum of these two items as follows:

BSCR = Intangible assets capital + Square Root [Sum over risk categories I, J of (Correlation $_{IJ}$* Required Capital $_{I}$ * Required Capital $_{J}$)].

The Solvency Capital Required for operational risk (SCRop) equals the minimum of:

(a) 30% of BSCR, calculated as described above, and

[36] See further discussion of intangible assets in section 9, "Capital."

(b) The maximum of solvency capital required for operational risk associated with premium and technical provisions, where:

(i) The premium based operational risk is (i) 3% of earned premium plus (ii) for an insurer whose earned premiums increase by more than 10% over the prior year, an additional 3% of the earned premium increase over 10%. (Where earned premium in those calculations is before deduction for ceded reinsurance.)

(ii) The technical provision based operational risk is 3% of technical provisions[37] without the risk margin.

RBC includes six risk types with one outside of the square root and only "squared" terms inside the square root, no explicit correlation coefficients terms as follows:

RBC = R0 + [(R1^2) + (R2^2) + (R3^2) + (R4^2) + (R5^2)] ^ (0.50), where

R0 = off-balance sheet risks and investments in insurance affiliates[38]

R1 = fixed-income securities

R2 = equity investments

R3 = non-reinsurance credit risk + half the ceded reinsurance credit risk (note 1)

R4 = reserving risk + half the ceded reinsurance credit risk (note 1)

R5 = written premium risk

In RBC intangibles would be valued based on statutory in NAV, and usually have lower than market value, often zero.

Note: For insurers with low reserve risk relative to ceded reinsurance credit risk (e.g., fronting companies), all the ceded reinsurance credit risk remains in R3.

[37] As outlined in this paper "Overview" (Section 2), technical provisions are analogous to unearned premium and loss reserves, discounted for interest.

[38] R0 will include Deferred Tax Asset risk charges beginning with year-end 2012.

8. Capital

The result of the Standard Formula is compared to the company adjusted "own funds" or adjusted "capital and surplus" in U.S. terminology.

Several points are important here.

First, the accounting structure within which the Standard Formula operates differs from SAP. Some key differences were identified in section 2, "Overview."

Second, there are adjustments to values of intangible assets to determine the NAV which is compared to the required capital from the Standard Formula. First the economic value of goodwill for solvency purposes is reduced to zero in the insurer's capital. Then, for all other intangible assets, capital includes a value for intangibles only where (a) it is probable that the expected future economic benefits will flow to the insurer and (b) the value of the assets can be measured reliably. If a fair value measurement of an intangible asset is not possible, then the asset is valued at zero in the insurer's capital. If there is a non-zero value for intangible assets, the risk capital requirement for intangible assets is 80% of the value of those intangibles.

Third, participations in other financial sector entities are generally consolidated through the equity method. Specific capital requirements for other financial sector entities are calculated separately according to the requirements of that other financial sector. These capital requirements are then added to the SCR without any recognition of diversification effects.

Fourth, capital available for "own funds" is classified into one of three tiers reflecting the availability of these sources of capital in stress situations. The Tier definitions address a number of issues that are relevant to EU life and non-life insurers. Tier 1 capital includes amounts that would correspond to capital and surplus under SAP and includes surplus notes with original maturity greater than 10 years. Tier 1 excludes the value of the insurer's participations in financial or credit institutions. Tier 2 includes contingent capital that would be available in distressed situations and includes and surplus notes with original maturity greater than five years. Tier 3 includes Deferred Tax Assets and surplus notes with original maturity greater than three years.

The use of different capital tiers to satisfy the SCR and MCR are limited such that:

Tier 1 must be at least 50% of the SCR and at least 80% of the MCR.

Tier 3 must be less than 15% of the SCR.

Only Tier 1 and Tier 2 are eligible to meet the MCR.

The result is an adjusted own funds that is compared to the results of the Standard Formula for SCR or MCR and determine whether the company meets the capital standards.

Capital for RBC purposes is based on Statutory Accounting Practices which, by comparison to Solvency II Own Funds, has the implications discussed below.

First, loss reserves are not generally discounted in SAP,[39] so that, if all else is unchanged, capital under SAP is lower than under Solvency II. However, in RBC, the reserving risk is reduced by the effect of discounting, so that, if all else is unchanged, risk charges under SAP are also lower than under Solvency II.

Second, insurance subsidiaries are recorded at statutory book value in capital and surplus, but there is a capital charge equal to the subsidiary RBC.

Third, intangibles are generally recorded as at zero value in SAP.[40]

RBC has a limitation on the amount of capital that can be provided by capital notes and surplus notes and uses conservatism in determining what assets and liabilities are reflected in capital.

[39] If reserves are discounted then statutory capital and surplus is adjusted downward for RBC purposes to remove the benefit of the discount

[40] Goodwill is a temporary exception as it is allowed as an asset, but is amortized down to zero over a 10-year period.

Appendix A—Aspects of Standard Formula not Relevant to U.S. Non-Life Business

In this paper we have focused on issues related to a stand-alone non-life insurer and we have not described aspects of the Standard Formula that would not be relevant to U.S.-type non-life business.

These include the following:

1. Lapse risk, which is largely a life insurance risk in the U.S., while it does apply to some non-life companies in the EU.
2. Life or Health U/W risk, as those are usually part of separate companies.
3. An adjustment for "loss absorbance in technical provisions" as that applies to life insurance dividend arrangements.

RBC includes an adjustment for "loss absorbance in technical provisions" through the Loss Sensitive Contracts adjustment to premium and reserve risk. Retrospectively adjustable premium are not as common in Europe as in the U.S., particularly in that workers compensation, as such, is not a major line of business in Europe.

There is no Solvency II equivalent to the loss-sensitive reinsurance adjustment in RBC R4 and R5, even though loss-sensitive reinsurance contracts exist in Europe as in the U.S.

This paper also does not discuss captive insurance companies. There are simplifications to the Standard Formula that can apply for single parent captives meeting certain other criteria.

Appendix B—Counterparty Default Risk Example

The detailed calculation of counterparty default risk for a quota share reinsurance treated is shown below.

Table B.1
Counterparty Default Risk—Quota Share Reinsurance Example

#		Item		Amt in Million	Notes
A. Basic business data					
1		Gross premium		100	Assumption
2		Ceded premium		25	As if 25% quota share
3		Net premium		75	Line (1) – Line (2)
4		Gross OS claims		150	Assumption
5		Ceded OS claims		37.5	25% of Line (4)
6		Net OS claims		112.5	Line (4) – Line (5)
7		Total recoverable		50	Ceded OS plus 50% of ceded premium Line (5) + 0.5 * Line (2)
8		One A-rated reinsurer			

B. Solvency II risk characteristics					
9		$\sigma_{LOB,\ Prem}$		10%	Standard formula parameter
10		$\sigma_{LOB,\ Rsv}$		7%	Standard formula parameter

C. Risk mitigation calculation					
		C.1 – Premium term			
11		Ceded Premium		25	Line (2)
12		$\sigma_{LOB,\ Prem}$		10%	Line (9)
13		99.5% factor		3	99.5%-ile of lognormal
14		Term 1 - premium risk		7.5	Lines (11)*(12)*(13)
15		Term 1 squared		56.3	Square of Line (14)
		C.2 – Reserve term			
16		Ceded OS		37.5	Line (5)
17		$\sigma_{LOB,\ Rsv}$		7%	Line (10)
18		99.5% factor		3	99.5%-ile of lognormal
19		Term 2 - OS risk		7.875	Lines (16)*(17)*(18)
20		Term 2 squared		62.0	Square of Line (19)
		C.3 – Cross term			
21		Ceded OS		37.5	Line (5)
22		Ceded Prem		25	Line (11)
23		$\sigma_{LOB,\ Rsv}$		7%	Line (17)
24		$\sigma_{LOB,\ Rsv}$		10%	Line (12)
25		99.5% factor squared		9	99.5%-ile of lognormal
26		Term 3 - cross term		59.1	Lines (21)*(22)*(23)*(24)*(25)
		C.4 – Combined risk			
27		Sq Rt of Total		13.3	Sq Root of (Line 15+Line 20+Line 26)

D. Loss given default					
28		Recovery ratio		50%	Assumption
29		Collateral		0	Assumption
30		Risk mitigation		13.3	Line (27)
31		Recoverables		50.0	OS claims plus 50% of ceded premium
32		Loss given default (LGD)		31.7	Line (28)*(Line31+ Line30+-Line29)

E. Probability of default at 99.5% level					
33		p_i		0.05%	Probability of single default Standard Formula parameter
34		Γ		0.25	Coefficient reflecting systemic risk Standard Formula parameter
35		y_j		31.7	Total LGD - Line (32)
36		z_j		1,002.2	Sum of LGD squared - Line 32
37		v_i		0.030%	Intermediate calculation (See QIS 5 Technical Specifications, SCR 6.14, page 137 of 330)
38		u_{ij}		0.020%	Intermediate calculation (See QIS 5 Technical Specifications, SCR 6.14, page 137 of 330)
39		σ^2		0.5009	Line 36 * Line 36 + Line 35 * Line 35 * Line 38
40		Σ		0.71	Square root of line 39
41		99.5% factor		3	99.5%-ile of lognormal
42		$SCR_{def,1}$		2.12	Line 40 * Line 41
43		$SCR_{def,1}$ as % of LGD		**6.7%**	Risk charge % of LGD - Line 42/Line 32 (6.7% if Table 5.1 A-rated reinsurer row)
44		$SCR_{def,1}$ as % of recoverable		4.2%	Risk charge % of recoverables - Line 42/Line 7

Line 43 depends only on the nature of the counterparties (how many and what credit rating).
Line 44 depends on line 43 and the relative amounts of (a) balance sheet receivables (OS and UEP) and (b) risk mitigation.

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Glossary

CRESTA, Catastrophe Risk Evaluating and Standardizing Target Accumulation organization (founded in 1977).
DCWP, Dependencies and Calibration Working Party.
EEA, EU + Norway and Lichtenstein.
IFRS, International Financial Reporting Standards.
LGD, Loss Given Default.
NAV, Net asset value; largely equivalent to statutory and surplus for purposes of RBC.
NL, Non-life or property/casualty or general insurance.
Risk charge, the risk-based capital amount for a particular risk.
Risk margin, an addition to loss reserves or other balance sheet items.
Safety level, the level of probability VaR or other metric used calibrate risk charges for individual risks or groups of risks.
SCR, solvency capital required under Solvency II; determined from Standard Formula or internal model.
Standard Formula, a way to determine capital requirements under Solvency II.

A Review of Historical Insurance Company Impairments[1] (1996 – 2010)

Report 4 of the CAS Risk Based Capital (RBC) Research Working Parties
Issued by the RBC Dependencies and Calibration Working Party (DCWP)

Abstract: The purpose of this paper is to study historical insolvencies with emphasis on patterns that can be related to risk factors relevant to the NAIC P&C RBC formula. This is one of several papers being issued by the Risk Based Capital (RBC) Dependencies and Calibration Working Party (DCWP). Conclusions are qualitative – company size, concentration by state and line of business, and reinsurance usage seem to be relevant to the understanding of historical impairment patterns.

Keywords. Insolvency, Solvency, Impairment, Risk-Based Capital, Capital Requirements, Insurance Company Financial Condition.

1. INTRODUCTION

1.1 Charge

This study supports the DCWP's charge as described in the committee's first report "Overview of Dependencies and Calibration in the RBC Formula"[2]: to "research how to handle dependencies and calibration in the NAIC P&C RBC formula (RBC or RBC formula), including the extent to which risk diversification should be reflected in the P&C formula."

1.2 Background

We have reviewed past insolvency studies and obtained data related to historical insolvencies. The objective is to observe patterns of past insolvencies and assess the consistency of the experience with risk factors considered important to DCWP's study of the RBC formula. The patterns of interest relate to the rate of insolvency within categories such as company size, concentration by state and line of business, reinsurance usage, and regional focus.

Note that observations are made on these categories individually but with the understanding that the categories are related. In fact, there can be considerable overlap between categories. Nonetheless, this study does not attempt to quantify the extent of interconnections between the categories or the extent to which one category has more or less impact on the rate of insolvency

[1] In this report, the majority of impaired companies are those identified in A.M. Best's 1969-2010 P/C Impairment Review – Appendix B. Some additional companies not found in A.M. Best's report are included in this report based on a review of National Conference of Insurance Guaranty Funds data and a list of inactive companies provided by the NAIC.

[2] Casualty Actuarial Society *E-Forum*, Winter 2012-Volume 1.

than other categories. Furthermore, this study does not assess statistical significance. Insolvencies are relatively rare and for some categories there are few observations (in some cases there are none).

Finally, a note on terminology—most of the identified "insolvent" companies are those identified by A.M. Best in its 2010 annual report on financial impairments. A.M. Best's definition of impairment is described in the report and is broader than technical insolvency. In the remainder of this paper, insolvencies and impairments will generally be referred to collectively as impairments.

1.3 Disclaimer

In this paper, references to "we," "our," "the working party," and "DCWP" refer to the CAS RBC Dependencies and Calibration Working Party.

The analysis and opinions expressed in this report are solely those of the authors, the Working Party members, and in particular are not those of the members' employers, the Casualty Actuarial Society, or the American Academy of Actuaries.

DCWP makes no recommendations to the NAIC or any other body. DCWP material is for the information of CAS members, policy makers, actuaries and others who might make recommendations regarding the future of the P&C RBC formula. In particular, we expect that the material will be used by the American Academy of Actuaries.

This paper is one of a series of articles prepared under the direction of the CAS RBC Dependency and Calibration Working Party and the Underwriting Risk Working Party (RBC Working Parties).

1.4 Outline

With this objective, we have taken the following steps:

1. Reviewed recent studies of company impairments:
    - A.M. Best – 1969-2010 P/C Impairment Review (May 2, 2011)
    - AAA – Property/Casualty Insurance Company Insolvencies[3] (September 2010)
2. Investigated the availability of information related to impaired companies.
3. Obtained lists of impaired companies from three sources: A.M. Best, the National Conference of Insurance Guaranty Funds (NCIGF) and the NAIC.

[3] Developed by the Financial Soundness/Risk Management Committee of the American Academy of Actuaries.

4. Merged the information on impairments with 15 years of industry statutory data.

We have produced charts showing industry data categorized by the selected categories with the impaired companies separately identified. This paper reviews the rates of impairment within these categories. The methods and observations are described below.

2. DATA

We compiled a list of impaired companies from three sources and then matched these to companies included in 15 years of industry statutory data provided by A.M. Best. This produced the following matches:[4]

- A.M. Best – 359 companies
- NAIC – 259 companies
- NCIGF – 190 companies

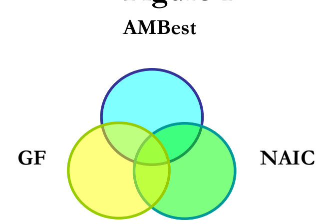
Using the A.M. Best list as the starting point with 359 company matches, the NAIC list adds 29 companies[5] and the NCIGF list adds 28 companies. This gives a total of 416 identified impaired companies. Note that A.M. Best's definition of impairment is described in its annual Impairment Review[6] and is broader than its financial strength "E" rating (under regulatory supervision). With this context, it makes sense that the A.M. Best list, having the broadest definition of impairment, is the largest.

There is considerable overlap between the different lists as shown in Table 1:

Table 1

Impairments - company on:	A.M. Best	NAIC	GF
A.M. Best List only	120		
all Lists	149	149	149
A.M. Best and NCIGF Lists Only	9		9
A.M. Best and NAIC Lists Only	81	81	
Subtotal A.M. Best	**359**	**230**	**158**
NCIGF and NAIC Lists Only	4	4	4
NAIC List only	25	25	
NCIGF List only	28		28
Grand Total	**416**	**259**	**190**

Figure 1



[4] The number of companies in each list before matching is larger: A.M. Best - 1,053 companies; NAIC – 624 companies, and NCIGF – 654 companies.

[5] This includes four companies also in the NCIGF list.

[6] See May 2011 P/C Impairment Review – page 9.

The seven rows in Table 1 correspond to the seven regions in the Venn diagram (not to scale) to the right in Figure 1.

An impairment attribute (a "flag") is then added to the industry data provided by A.M. Best. Also, for all companies, attributes related to the categories described above (company size, concentration, etc.) are added.[7] This category attribute is assigned at both a company and group level.[8] NAIC company code provides the key to add the impairment and category attributes to the companies in the A.M. Best industry data. Note that for some of the 416 companies identified by the above process, the data to assess their category attributes is not present in the industry database. The number of these companies is fairly small, generally less than 20.[9]

With these attributes added to the industry data, the sections that follow show impairment rates in table format. The impairment rate is the ratio of the number of impaired companies to the total number of companies, by category. In the remainder of the paper, this is referred to as the "mortality rate."

In total over the 15 years of experience, the 416 identified impairments out of 3,684 total entities represent roughly an 11% mortality rate or about a 0.7% rate per year. It is important to note that this rate is probably biased low since it is difficult to accurately identify all companies that became impaired from 1996 to 2010.

In addition, as stated previously, this study does not assess the statistical reliability of the observed mortality rates as estimates of population parameters. In particular, many of the observations relate to the differences in mortality rates of different categories. These observations are qualitative and statements regarding the statistical significance of these differences are out of our scope. Thus, the notion of reliability must be kept in mind when looking at the results. This is especially important for categories that are relatively small (few total companies) as well as categories where the rate of mortality is relatively rarer than others; both these factors affect reliability in a statistical context.

Finally, the results shown in the tables that follow are based on group level category assignments rather than individual company category assignments. For example, for state premium concentration, the direct earned premiums for all companies in a group are added together (keeping

[7] State and line attributes are developed using Annual Statement State Page data.

[8] Group is determined based on current data. As some impaired companies became part of other groups after their impairment, our grouping does not necessarily capture the category information prior to impairment.

[9] In the tables that follow, these 20 companies are identified in the line labeled "no data." Also, there is one company that is excluded from most tables because of some very unusual financial statements related to insolvency; so, in most cases the tables show a total of 415 impaired companies.

state detail) and the group's state premium concentration is then calculated from this total. In this example, the use of group categories eliminates the combining of single (or few) state companies that are part of a larger diversified group together with companies that are truly stand alone companies that are concentrated geographically.

2.1 State Concentration

Four state premium concentration categories are chosen: 0-25%, 25-50%, 50-75%, and 75-100%. To make company assignments to these categories, state page direct earned premiums for 15 years (1996-2010) are totaled by group and by state. The ratio of a group's largest state to its total is then calculated. This percentage specifies the concentration category to which all companies in a group are assigned.

The results are shown in the Table 2. The "mortality rate" is the ratio of impaired companies to total companies, by category. The "relativity" is the ratio of a category's mortality rate to the average mortality rate for all categories.

Table 2

State Premium Concentration Categories

Concentration	Impaired Companies	Unimpaired Companies	Total	Median RBC Ratio[10]	Mortality Rate	Relativity to Total	2010 Median RBC Ratio
0-25%	94	1,273	1,367	9.1	0.069	**0.61**	11.1
25-50%	77	477	554	8.7	0.139	*1.23*	9.7
50-75%	39	264	303	8.5	0.129	*1.14*	10.4
75-100%	188	1,115	1,303	9.1	0.144	*1.28*	10.0
Subtotal	398	3,129	3,527	9.0	0.113	**1.00**	10.4
No Data	17	140	157	10.4			9.9
Total	415	3,269	3,684	9.0	0.113		10.4

Relativity to Total – bold for below average; italic for above average

The mortality rate of the least concentrated group (0-25%) is 40% below the total and less than half that of the most concentrated group (75-100%). Note that the mortality rate does not increase monotonically with increasing concentration, but this could be random noise or possibly other factor effects that are coming into play. Nonetheless, what stands out is the pronounced lower rate in the least concentrated group.

The table, and subsequent tables, show the all year "Median RBC Ratio," as more highly

[10] As reported in the Annual Statement, this is the ratio of total adjusted capital to authorized control level risk-based capital. In this column, the median is taken over all RBC ratios reported over the 15-year experience period.

capitalized companies would be expected to have lower "mortality rates" than less well capitalized companies. In this table the RBC ratios are relatively similar among the group and less likely to be a factor in differences in mortality rates between concentration groups.

2.2 Line of Business Concentration[11]

Four lines of business premium concentration categories are chosen: 0-25%, 25-50%, 50-75%, and 75-100%. The company assignments to these categories are made analogously to the state concentration assignments, but rather than totaling the 15 years of data by state, the totals are by line. The ratio of direct earned premium for a group's largest line to its total is calculated and this percentage specifies the concentration category to which all companies in a group are assigned. The results are shown in Table 3.

Table 3

Line of Business Premium Concentration Categories							
Concentration	**Impaired Companies**	**Unimpaired Companies**	**Total**	**Median RBC Ratio**	**Mortality Rate**	**Relativity to Total**	**2010 Median RBC Ratio**
0-25%	8	277	285	8.0	0.028	**0.25**	8.9
25-50%	87	932	1,019	9.0	0.085	**0.76**	10.8
50-75%	91	616	707	10.1	0.129	*1.14*	13.2
75-100%	213	1,307	1,520	8.4	0.140	*1.24*	9.3
Subtotal	399	3,132	3,531	9.0	0.113	**1.00**	10.4
No Data	16	137	153	10.7			9.7
Total	415	3,269	3,684	9.0	0.113		10.4

Relativity to Total – bold for below average; italic for above average

Here the mortality rates increase monotonically with increasing concentration, however, the caveats about reliability must be kept in mind. The least concentrated category in particular has a small number of companies and a relatively lower mortality incidence. Combining the two lower concentration categories and two higher concentration categories gives mortality rates of .073 and .137, respectively. Thus, the mortality rate of the lower concentrations is more than 40% lower than that of the higher concentrations.

We would expect that concentration by state and line are related to each other and related to size. Section 2.3 shows mortality experience by premium size; section 2.4 then displays a cross tabulation that adds a size dimension to the state and line concentration results.

---

[11] Lines of business are based on those shown on the Annual Statement State Page (Page 14). See Appendix 1 for line of business definitions.

2.3 Premium Size Differences

Size is based on group average annual direct earned premiums (the same as those used for the state and line concentration categories). Group percentiles are calculated and the related companies are assigned to quintile categories. The results are shown in Table 4.

Table 4

Premium Percentile Categories							
Percentile[12]	**Impaired Companies**	**Unimpaired Companies**	**Total**	**Median RBC Ratio**	**Mortality Rate**	**Relativity to Total**	**2010 Median RBC Ratio**
0-20%	40	306	346	14.2	0.116	*1.02*	10.7
20-40%	56	305	361	9.9	0.155	*1.37*	9.6
40-60%	78	304	382	8.0	0.204	*1.81*	7.5
60-80%	89	400	489	7.6	0.182	*1.61*	9.1
80-100%	135	1,814	1,949	9.2	0.069	**0.61**	11.5
Subtotal	398	3,129	3,527	9.0	0.113	**1.00**	10.4
No Data	17	140	157	10.4			9.9
Total	415	3,269	3,684	9.0	0.113		10.4

Relativity to Total – bold for below average; italic for above average

The pattern here is interesting in that the mortality rates do not follow a consistent pattern relative to size. The mortality rates of the middle three quintiles are high: the combined mortality rate is .181, 60% higher than the average. The top and bottom quintiles have much lower rates than the middle three. The top quintile especially stands out with a rate less than half that of the middle three.

The relatively more favorable experience in the smallest size group was not anticipated. This may be a result of the smaller companies holding more capital relative to their ACL capital than larger companies. This is evidenced by the higher median RBC ratio of the 0-20% quintile over the 15-year experience period: 14.2, compared to an average of 9.0 overall.

[12] Note that the company counts in the quintiles are not even. This is because the assignment to quintile is done on a group basis.

2.4 Cross Tabulation of Premium Size, Line, and State Concentration

The mortality rates and mortality rate relativities for the previous three categories are shown together in Table 5: state concentration, line concentration, and premium size. For premium size, the quintiles have been summarized to show the smallest 20%, the middle 60%, and the largest 20%:

Table 5

Mortality Rates

	By Group Line Concentration					By Group State Concentration				
by Group Premium Percentile Group	**75-100%**	**50-75%**	**25-50%**	**0-25%**	**Total**	**75-100%**	**50-75%**	**25-50%**	**0-25%**	**Total**
0-20%	0.116	0.122	0.000	0.000	0.113	0.104	0.080	0.286	0.105	0.113
20-80%	0.167	0.218	0.178	0.500	0.181	0.177	0.178	0.240	0.129	0.181
80-100%	0.110	0.065	0.062	0.025	0.069	0.092	0.072	0.079	0.061	0.069
Total	0.139	0.129	0.085	0.028	0.113	0.144	0.126	0.139	0.069	0.113

Mortality Rate Relativities

	By Group Line Concentration					By Group State Concentration				
by Group Premium Percentile Group	**75-100%**	**50-75%**	**25-50%**	**0-25%**	**Total**	**75-100%**	**50-75%**	**25-50%**	**0-25%**	**Total**
0-20%	*1.03*	*1.08*	**0.00**	**0.00**	1.00	**0.92**	**0.71**	*2.54*	**0.93**	1.00
20-80%	*1.48*	*1.93*	*1.58*	*4.44*	*1.61*	*1.58*	*1.58*	*2.13*	*1.14*	*1.61*
80-100%	**0.98**	**0.58**	**0.55**	**0.22**	**0.62**	**0.81**	**0.64**	**0.70**	**0.54**	**0.62**
Total	*1.24*	*1.14*	**0.76**	**0.25**	1.00	*1.28*	*1.12*	*1.23*	**0.61**	1.00

This display shows that the higher than average mortality rates observed in section 2.3 for the middle three premium size quintiles crosses all the line and state concentration categories. Also, for this middle 20-80% category, there is no consistent pattern of the mortality rate relative to concentration.

In contrast, the largest 20% category shows a noticeable pattern of higher mortality rates at higher concentrations, particularly for line concentration: the mortality rate relativity of the highest line concentration category, 0.98, is over four times the mortality rate of the lowest line concentration category, 0.22.

The next tables show the numbers of impaired and total companies in each cell of the table above. Table 6A shows the number of impaired companies by size group/line concentration group and by size group and state concentration group. Table 6B shows the same information for all companies.

Table 6A

	Number of Impairments									
	By Group Line Concentration					By Group State Concentration				
by Group Premium Percentile Group	**75-100%**	**50-75%**	**25-50%**	**0-25%**	**Total**	**75-100%**	**50-75%**	**25-50%**	**0-25%**	**Total**
0-20%	34	5	0	0	39	29	2	6	2	39
20-80%	124	61	37	1	223	135	27	43	18	223
80-100%	53	25	50	7	135	24	9	28	74	135
Total	211	91	87	8	397	188	38	77	94	397

Table 6B

	Total Companies									
	By Group Line Concentration					By Group State Concentration				
by Group Premium Percentile Group	**75-100%**	**50-75%**	**25-50%**	**0-25%**	**Total**	**75-100%**	**50-75%**	**25-50%**	**0-25%**	**Total**
0-20%	293	41	10	1	345	280	25	21	19	345
20-80%	742	280	208	2	1,232	761	152	179	140	1,232
80-100%	480	386	801	282	1,949	262	125	354	1,208	1,949
Total	1,515	707	1,019	285	3,526	1,303	302	554	1,367	3,526

These tables show the degree of overlap between the state and line concentration categories. For example, for the 397 impaired companies shown in Table 6A, 211 are in the most concentrated line category and 188 are in the most concentrated state category. A comparison (not displayed) of the 211 companies to the 188 companies shows that there are 126 companies that are common to both highest concentration categories.

Looking at all companies, Table 6B, the largest size company group of 80%-100%, with 1,949 companies, has the most distinctly different distribution of companies by concentration, state vs. line. For that size category, having a higher line concentration (480 companies) is much more common than having a higher state concentration (262 companies).

2.5 Reinsurance Usage

Four reinsurance usage categories are chosen: 0-25%, 25-50%, 50-75%, and 75-100%. To make company assignments to these categories, Underwriting and Investment Exhibit, Part 1B – Premiums Written, columns 1, 3, and 5 are used.[13] The all-lines written premiums for 15 years (1996-2010) are totaled by group. The ratio of a group's ceded written premium to its gross written premium is then calculated. This percentage specifies the ceded percentage category to which all companies in a group are assigned. The results are shown in Table 7.

Table 7

Written Premium - % Ceded to Gross Categories							
WP - % Ceded to Gross	**Impaired Companies**	**Unimpaired Companies**	**Total**	**Median RBC Ratio**	**Mortality Rate**	**Relativity to Total**	**2010 Median RBC Ratio**
0-25%	226	2,394	2,620	9.4	0.086	**0.76**	11.3
25-50%	105	525	630	7.7	0.167	*1.47*	8.0
50-75%	54	175	229	7.2	0.236	*2.07*	7.5
75-100%	22	77	99	7.6	0.222	*1.95*	6.1
Subtotal	407	3,171	3,578	8.9	0.114	1.00	10.4
No Data	8	98	106	15.5			14.1
Total	415	3,269	3,684	9.0	0.113		10.4

Relativity to Total – bold for below average; italic for above average

Here the mortality rate for the 0-25% category (least reinsurance usage) is only slightly more than half that of the next category, 25-50%. The two highest reinsurance usage categories have about twice the overall mortality rate.

We also observe that the RBC ratio is lower for companies with more reinsurance, and this lower RBC ratio may contribute to the higher mortality rate for the companies with higher reinsurance ratios.

---

[13] This excludes reinsurance with affiliates.

Breaking out size in the same way as section 2.4 shows:

Table 8

	Mortality Rates by Group Ceded Re % Category				
by Group Premium Percentile Group	**75-100%**	**50-75%**	**25-50%**	**0-25%**	**Total**
0-20%	0.067	0.029	0.110	0.140	0.116
20-80%	0.268	0.311	0.196	0.150	0.181
80-100%	0.364	0.211	0.146	0.048	0.070
Total	0.226	0.237	0.167	0.085	0.113

Corresponding relativities are shown in Table 9.

Table 9

	Mortality Rate Relativities by Group Ceded Re % Category				
by Group Premium Percentile Group	**75-100%**	**50-75%**	**25-50%**	**0-25%**	**Total**
0-20%	**0.59**	**0.25**	**0.97**	*1.24*	*1.02*
20-80%	*2.37*	*2.75*	*1.73*	*1.32*	*1.60*
80-100%	*3.21*	*1.87*	*1.29*	**0.42**	**0.61**
Total	1.99	2.09	1.47	0.75	1.00

Relativities – bold for below average; italic for above average

Recognizing that the number of companies in some cells is small (shown below in Table 10), what stands out quite dramatically in Table 9 above is the much lower relative mortality rate, 0.42, for the largest groups with lowest reinsurance usage (80-100% premium percentile; 0-25% reinsurance %): the rate for this cell is 58% (1-42%) lower than the overall average and 72% lower than the combined rate for all other cells in the table (value not shown). Also, within the largest size category, the mortality rate increases monotonically with increasing reinsurance usage.

Also notable is that within the smallest size category, the pattern is reversed. Within this category, the lowest reinsurance usage (0-25%) has the highest relative mortality rate, about 75% higher than the combined rate for the other cells in this size category.

Table 10 shows the number of companies used to calculate the ratio in Table 9.

Table 10

by Group Premium Percentile Group	**Number of Impairments** by Group Ceded Re % Category				
	75-100%	**50-75%**	**25-50%**	**0-25%**	**Total**
0-20%	2	1	8	29	40
20-80%	11	38	61	113	223
80-100%	8	15	35	77	135
Total	21	54	104	219	398

by Group Premium Percentile Group	**Total Companies** by Group Ceded Re % Category				
	75-100%	**50-75%**	**25-50%**	**0-25%**	**Total**
0-20%	30	35	73	207	345
20-80%	41	122	312	754	1,229
80-100%	22	71	239	1,608	1,940
Total	93	228	624	2,569	3,514

2.6 Regional Differences

This display is related to section 2.1 in that the state that determines a state concentration category is now used to assign a region designation to all companies in a group. Note that this does not correspond to state of domicile. The results are shown in Table 11.

Table 11

Largest State Region Categories							
Region[14]	**Impaired Companies**	**Unimpaired Companies**	**Total**	**Median RBC Ratio**	**Mortality Rate**	**Relativity to Total**	**2010 Median RBC Ratio**
Canada	0	8	8	7.6	0.000	**0.00**	10.8
Mid-Atlantic	91	785	876	8.1	0.104	**0.92**	9.4
Midwest	44	480	524	9.1	0.084	**0.74**	10.4
Northeast	13	98	111	10.9	0.117	*1.04*	14.5
Southeast	88	465	553	8.1	0.159	*1.41*	8.3
Southwest	53	293	346	11.3	0.153	*1.36*	13.2
West	109	1,000	1,109	9.2	0.098	**0.87**	12.2
Subtotal	398	3,129	3,527	9.0	0.113	1.00	10.4
No Data	17	140	157	10.4			9.9
Total	415	3,269	3,684	9.0	0.113		10.4

Relativities – bold for below average; italic for above average

The Southeast and Southwest regions stand out with higher than average mortality rates. Combined, these two regions have a mortality rate about 60% higher than the combined rate for the other regions (not shown).

Table 12 shows the breakout of mortality rates by size within region.

Table 12

	Mortality Rates by Group Region							
by Group Premium Percentile Group	**Canada**	**Mid-Atlantic**	**Midwest**	**Northeast**	**Southeast**	**Southwest**	**West**	**Total**
0-20%		0.070	0.122	0.143	0.069	0.194	0.159	0.116
20-80%	0.000	0.149	0.121	0.174	0.230	0.233	0.198	0.181
80-100%	0.000	0.083	0.032	0.069	0.091	0.051	0.070	0.070
Total	0.000	0.104	0.084	0.117	0.160	0.154	0.099	0.113

[14] See Appendix 2 for region definition.

Table 13 shows corresponding relativities.

Table 13

by Group Premium Percentile Group	Mortality Rate Relativities by Group Region							
	Canada	Mid-Atlantic	Midwest	Northeast	Southeast	Southwest	West	Total
0-20%	**0.00**	**0.62**	*1.07*	*1.26*	**0.61**	*1.71*	*1.40*	*1.02*
20-80%	**0.00**	*1.31*	*1.07*	*1.54*	*2.03*	*2.06*	*1.75*	*1.60*
80-100%	**0.00**	**0.73**	**0.28**	**0.61**	**0.80**	**0.45**	**0.62**	**0.61**
Total	**0.00**	**0.92**	**0.74**	*1.03*	*1.41*	*1.36*	**0.87**	1.00

Relativities – bold for below average; italic for above average

The relativities highlight that the high mortality rates in the Southeast and Southwest regions are concentrated in the middle-size quintiles where the rates are twice the average. However, within this size category the higher than average rates are spread broadly across all regions with the possible exception of the Midwest whose rate is only modestly above average. Outside of the middle-size quintiles the rates by region are quite variable, although for the largest premium quintile, the rates are lower than average across all regions. For the smallest premium quintile, the rates by region are more variable relative to the average.

The number of companies in each size/region cell is shown in Table 14.

Table 14

by Group Premium Percentile Group	Number of Impairments by Group Region							
	Canada	Mid-Atlantic	Midwest	Northeast	Southeast	Southwest	West	Total
0-20%		7	9	1	4	12	7	40
20-80%		45	28	8	65	34	43	223
80-100%		39	7	4	19	7	59	135
Total	0	91	44	13	88	53	109	398

by Group Premium Percentile Group	Total Companies by Group Region							
	Canada	Mid-Atlantic	Midwest	Northeast	Southeast	Southwest	West	Total
0-20%	0	100	74	7	58	62	44	345
20-80%	2	303	232	46	283	146	217	1,229
80-100%	6	469	217	58	209	136	845	1,940
Total	8	872	523	111	550	344	1,106	3,514

2.7 Selected Financial Information by Year

This section shows selected financial information by year for all identified impaired companies and also for a subset of the impaired companies where impairments identified in 2002 and prior are excluded. The latter display thereby shows pre- and post-impairment financial information for a group of companies now known to have become impaired, but where the 1996-2002 years in the bold box include no known impairments. Table 15 shows the numbers of companies included in each of these displays:

Table 15

	Impaired Companies (all sources)			Impaired Companies (A.M. Best) excluding 2002 & Prior Impairments		
Annual Statement Year	Total Entity Count	Count of Reporting Entities	Count by Year of First Impairment (A.M. Best)	Total Entity Count	Count of Reporting Entities	Count by Year of First Impairment
1996	415	345	55	**136**	**94**	**0**
1997	415	329	23	**136**	**97**	**0**
1998	415	330	11	**136**	**103**	**0**
1999	415	306	13	**136**	**107**	**0**
2000	415	279	37	**136**	**107**	**0**
2001	415	259	43	**136**	**111**	**0**
2002	415	227	40	**136**	**107**	**0**
2003	415	202	31	136	101	31
2004	415	189	16	136	96	16
2005	415	182	10	136	86	10
2006	415	171	14	136	79	14
2007	415	171	5	136	80	5
2008	415	170	12	136	78	12
2009	415	155	15	136	65	15
2010	415	131	16	136	49	16
		Total:	341			119
		2011 Impairments:	17			17
		Total from A.M. Best:	358			136

The total entity count reflects all impaired companies included in the 15-year period regardless of whether financial information was reported in any particular year. The count of reporting entities only includes companies that reported financial information (note that this number goes down over time). The count by year of first impairment only includes companies on the A.M. Best list since only that list includes year of impairment. This last count is the only one that corresponds to impairments by year.

On the right of the Table 15, the counts reflect the removal of companies that became impaired in 2002 and prior. Only companies on the A.M. Best list are included in this display.

Tables 16A and 16B show the medians of selected financial amounts from the Annual Statement for impaired vs. unimpaired companies. These tables include all identified impairments.

Table 16A

	Annual Statement Data							
			$millions					
Annual Statement	Number of Companies Reporting		Median Total Net Loss & Exp Unpaid		Median Net Admitted Cash & Invested Assets		Median RBC Ratio	
Year	Impaired	Unimpaired	Impaired	Unimpaired	Impaired	Unimpaired	Impaired	Unimpaired
1996	345	2,335	5.9	6.5	18.2	25.7	5.1	7.7
1997	329	2,388	5.5	6.7	18.6	27.5	5.4	8.1
1998	330	2,418	5.0	6.1	19.6	27.1	5.9	8.8
1999	306	2,415	5.9	5.9	18.3	27.7	5.6	9.1
2000	279	2,411	4.6	5.7	15.7	28.5	4.8	9.4
2001	259	2,429	4.2	5.4	16.5	28.9	5.2	9.3
2002	227	2,450	4.1	5.8	17.8	31.0	5.0	8.4
2003	202	2,496	4.2	6.5	20.1	32.5	5.4	8.3
2004	189	2,541	3.4	6.4	18.1	34.4	5.5	8.5
2005	182	2,584	2.0	6.1	20.2	34.7	5.7	9.2
2006	171	2,619	2.8	6.2	21.7	37.1	6.2	9.9
2007	171	2,652	2.6	6.1	23.3	38.3	6.1	10.4
2008	170	2,671	3.9	6.7	25.2	37.4	5.5	10.3
2009	155	2,674	7.2	7.5	26.0	38.2	6.2	10.7
2010	131	2,659	7.3	8.3	28.7	40.1	6.9	10.6

Table 16B

Annual Statement Year	Number of Companies Reporting		Median Direct Premiums Written		Median Surplus as Regards Policyholders		Premium to Surplus Ratio	
	Impaired	Unimpaired	Impaired	Unimpaired	Impaired	Unimpaired	Impaired	Unimpaired
1996	345	2,335	9.3	13.8	7.6	14.0	1.2	1.0
1997	329	2,388	10.1	14.5	8.5	15.5	1.2	0.9
1998	330	2,418	10.5	14.4	9.2	15.9	1.1	0.9
1999	306	2,415	11.2	15.1	9.2	16.6	1.2	0.9
2000	279	2,411	15.2	16.9	8.5	17.5	1.8	1.0
2001	259	2,429	12.1	18.9	7.2	17.6	1.7	1.1
2002	227	2,450	12.1	21.2	7.0	17.6	1.7	1.2
2003	202	2,496	9.8	22.6	8.3	18.5	1.2	1.2
2004	189	2,541	6.1	21.8	8.6	19.2	0.7	1.1
2005	182	2,584	5.6	21.6	9.9	19.9	0.6	1.1
2006	171	2,619	6.1	21.8	10.5	21.1	0.6	1.0
2007	171	2,652	7.4	22.6	11.3	22.6	0.7	1.0
2008	170	2,671	7.6	22.5	11.4	22.4	0.7	1.0
2009	155	2,674	7.3	21.6	12.0	23.5	0.6	0.9
2010	131	2,659	8.4	22.6	16.0	24.3	0.5	0.9

Tables 16A and 16B suggest that the impaired companies tend to be smaller than the unimpaired companies as measured by surplus/reserves/assets. Also noticeable is the ratio of direct written premium to surplus. For the unimpaired companies, it hovers near 1.0. For the impaired companies, it starts out a little above 1.0, increases to around 1.7-1.8 nearer to the impairment date, and then falls sharply in 2003. Presumably, the sharp fall reflects the decline in premium as the adverse effect of impairments reduced the companies' ability to conduct business. Similarly, the median RBC ratios are much lower for the impaired companies as one would expect.

Table 17 shows the same information but excludes all companies known to be impaired prior to 2002. Thus the 1996-2001 rows show the pre-impairment characteristics of the companies that become impaired in 2002 and subsequent compared to the characteristics of the remaining companies that did not become impaired in 2002 and subsequent.

Table 17

AS	Annual Statement Data - Excluding Companies Impaired Prior to 2003							
			$millions					
	Number of Companies Reporting		Median Total Net Loss & Exp Unpaid		Median Net Admitted Cash & Invested Assets		Median RBC Ratio	
Year	Impaired*	Unimpaired	Impaired*	Unimpaired	Impaired*	Unimpaired	Impaired*	Unimpaired
1996	94	2,335	4.8	6.5	20.3	25.7	5.9	7.7
1997	97	2,388	4.9	6.7	19.1	27.5	5.3	8.1
1998	103	2,418	4.0	6.1	20.4	27.1	6.2	8.8
1999	107	2,415	3.3	5.9	17.8	27.7	6.2	9.1
2000	107	2,411	3.3	5.7	17.2	28.5	5.5	9.4
2001	111	2,429	4.1	5.4	17.3	28.9	5.6	9.3
2002	107	2,450	4.2	5.8	19.0	31.0	3.9	8.4
2003	101	2,496	3.9	6.5	21.0	32.5	4.2	8.3
2004	96	2,541	2.3	6.4	13.6	34.4	3.9	8.5
2005	86	2,584	0.9	6.1	20.2	34.7	4.3	9.2
2006	79	2,619	1.1	6.2	21.1	37.1	4.8	9.9
2007	80	2,652	2.2	6.1	19.9	38.3	4.5	10.4
2008	78	2,671	2.5	6.7	21.2	37.4	3.6	10.3
2009	65	2,674	9.2	7.5	22.8	38.2	4.1	10.7
2010	49	2,659	12.1	8.3	23.6	40.1	4.6	10.6

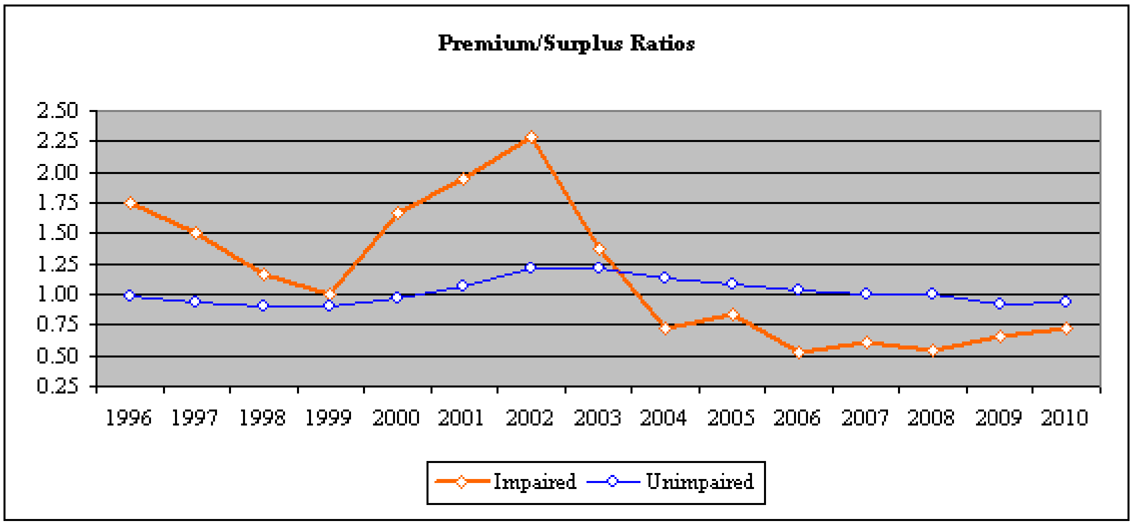
AS			$millions					
	Number of Companies Reporting		Median Direct Premiums Written		Median Surplus as Regards Policyholders		Premium to Surplus Ratio	
Year	Impaired*	Unimpaired	Impaired*	Unimpaired	Impaired*	Unimpaired	Impaired	Unimpaired
1996	94	2,335	13.3	13.8	7.6	14.0	1.8	1.0
1997	97	2,388	12.6	14.5	8.4	15.5	1.5	0.9
1998	103	2,418	11.4	14.4	9.7	15.9	1.2	0.9
1999	107	2,415	10.2	15.1	10.2	16.6	1.0	0.9
2000	107	2,411	15.3	16.9	9.2	17.5	1.7	1.0
2001	111	2,429	15.3	18.9	7.8	17.6	2.0	1.1
2002	107	2,450	17.0	21.2	7.4	17.6	2.3	1.2
2003	101	2,496	12.1	22.6	8.8	18.5	1.4	1.2
2004	96	2,541	5.2	21.8	7.1	19.2	0.7	1.1
2005	86	2,584	8.2	21.6	9.8	19.9	0.8	1.1
2006	79	2,619	5.2	21.8	9.7	21.1	0.5	1.0
2007	80	2,652	5.8	22.6	9.4	22.6	0.6	1.0
2008	78	2,671	4.8	22.5	8.9	22.4	0.5	1.0
2009	65	2,674	5.2	21.6	7.9	23.5	0.7	0.9
2010	49	2,659	7.0	22.6	9.7	24.3	0.7	0.9

* Includes only A.M. Best impairments with year of first impairment.

A couple of the observations relating to the previous table appear more pronounced in Table 17, in particular the increase and sharp fall in the premium to surplus ratio. Also, the difference in RBC ratios is bigger and the ratio for 2002 (the year before the emergence of these impairments) shows a bigger drop for the impaired companies - about 30% vs. a 10% drop for unimpaired companies.

Figure 2 shows the premium-to-surplus ratios from the Table 17.

Figure 2

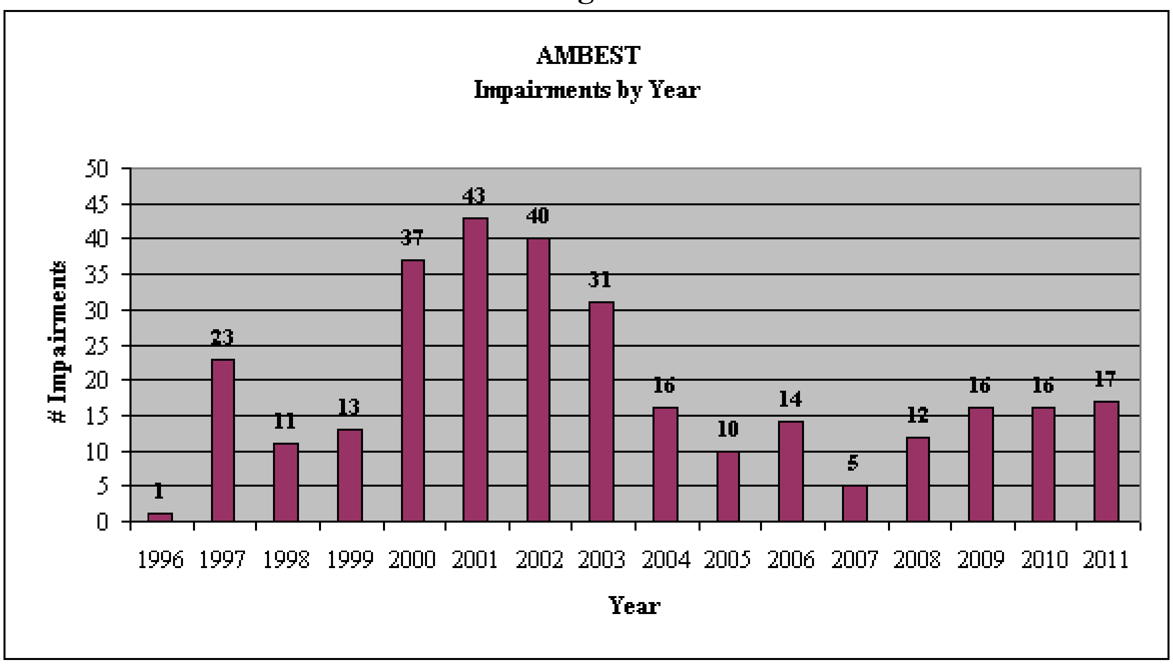


2.8 Other Observations

The primary source of this paper's impairment information comes from A.M. Best. It is a subset of the data included in A.M. Best's annual impairment review that includes more companies and extends back into the 1970s. Nevertheless, we consider the sample of impaired companies included in this study large enough to be useful for the purpose of the study—to make qualitative observations about historical patterns of insolvencies within categories of interest to the DCWP work.

Figure 3 shows A.M. Best impairments included in the study by year of first impairment, from 1996 - 2011.

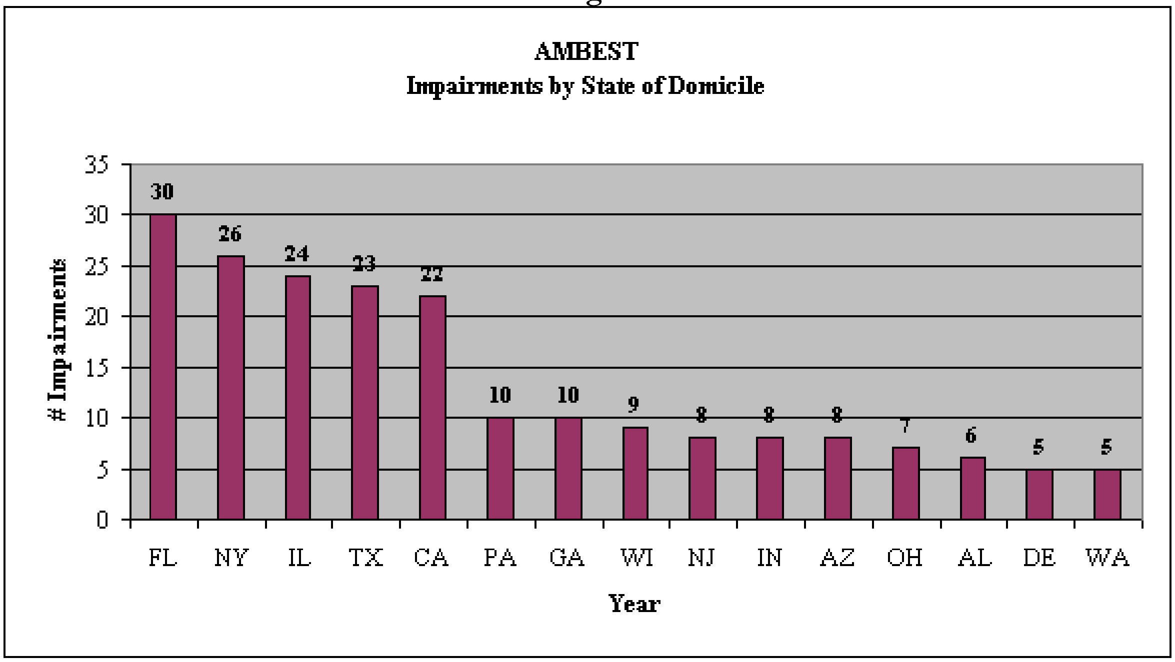
Figure 3



Note that this graph shows a total of 305 companies (out of the A.M. Best total of 359). The remaining A.M. Best companies have impairment years before 1996 and are not shown. Also, there are 17 companies included in the study that were identified as impaired in 2011. Even though the industry data used for the study is 1996 – 2010, the 17 companies are reflected in the various tables and figures presented in this study.

Figure 4 shows impairments by state of domicile for the top 15 states. These 15 states account for 201 of the 305 companies shown in Figure 3.

Figure 4



Finally, another relevant question is to what extent the impairments studied in this paper are of a particular kind or relate to specific notable events such as the California workers compensation crisis, Florida windstorm events, or the financial crisis. To address this, Figure 5 uses the state and line concentration categories described earlier.

Figure 5

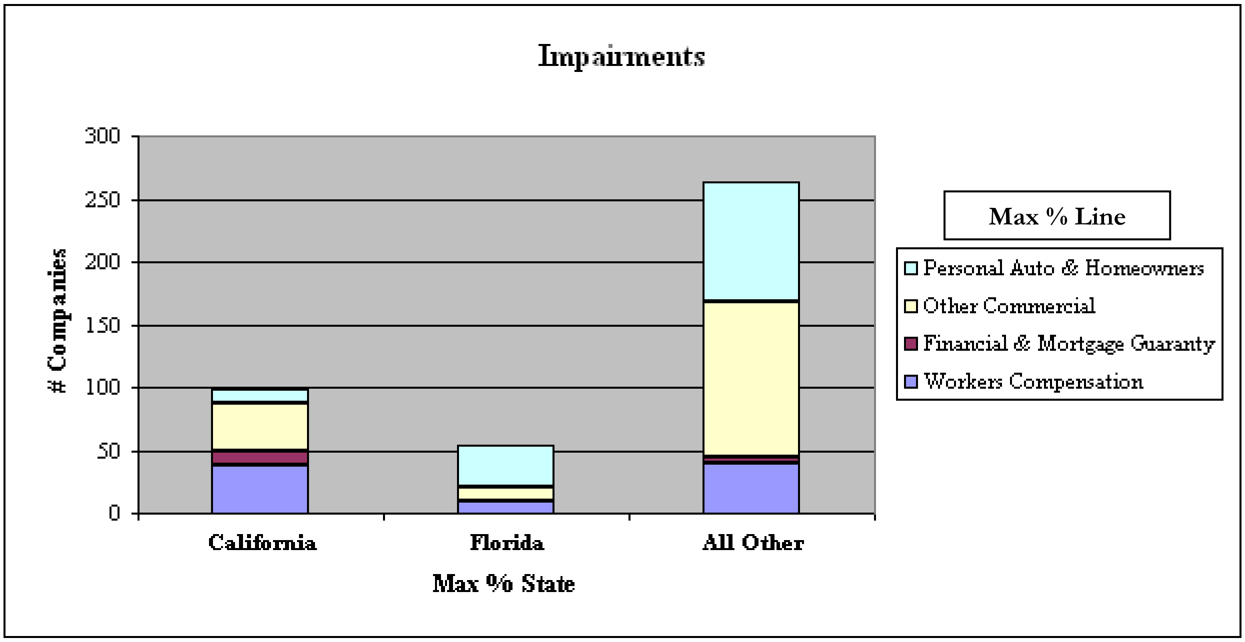


Table 18

	by Group Max % Line				
by Group Max % State	**Workers Compensation**	**Financial & Mortgage Guaranty**	**Other Commercial**	**Personal Auto & Homeowners**	**Total**
California	**38**	12	37	11	98
Florida	9		**12**	**33**	54
All Other	39	6	124	94	263
Total	86	**18**	173	138	415

Table 18 and Figure 5 show that the number of impairments in categories that would be expected to have a high exposure to these notable events is substantial, particularly for California workers compensation and Florida windstorm, however, these events do not appear to dominate the sample of impairments included in this study. The study includes these events and all other factors contributing to company impairments.

3. CONCLUSIONS

Wikipedia describes the scientific method as follows:

> The chief characteristic which distinguishes a scientific method of inquiry from other methods of acquiring knowledge is that scientists seek to let reality speak for itself, supporting a theory when a theory's predictions are confirmed and challenging a theory when its predictions prove false.[15]

This paper contributes to the study of insolvency by presenting "reality" through a qualitative review of historical impairment patterns.

In reviewing these patterns, note that they are the outcomes of possibly many factors contributing to company impairments. The study does not attempt to determine the underlying causes. Furthermore, the study does not attempt to differentiate the relative importance of the various categories presented.

Nevertheless, the study shows that size, concentration and reinsurance usage seem to be relevant to the understanding of historical impairments. The scientific method is an on-going process and, clearly, more work needs to be done.

4. AUTHORS

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[15] http://en.wikipedia.org/wiki/Scientific_method (Accessed November 15, 2012).

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5. REFERENCES

A. M. Best Company, Inc., "Special Report: U.S. Property/Casualty – 1969-2010 P/C Impairment Review," May 2011.

American Academy of Actuaries, "Property/Casualty Insurance Company Insolvencies," September 2010.

CAS Research Working Party on Risk-Based Capital Dependencies and Calibrations, "Report 1: Overview of Dependencies and Calibrations in the RBC Formula," Casualty Actuarial Society *E-Forum,* Winter 2012-Volume 1.

National Conference of Insurance Guaranty Funds, "Financial History and Assessment Liability Information,"www.ncigf.org/assessment (Excel spreadsheets).

Abbreviations and Notations:

ACL	Authorized control level
DCWP	Dependency and Calibration Working Party
NAIC	National Association of Insurance Commissioners
NCIGF	National Conference of Insurance Guaranty Funds
RBC	Risk-Based Capital

Appendix 1
Line of Business Definitions
(based on Annual Statement State Page lines)

Fire & Allied Lines 1 - Fire 2.1 - Allied lines 2.2 - Multiple peril crop 2.3 - Federal flood 12 - Earthquake	**Homeowners/Farmowners** 3 - Farmowners multiple peril 4 - Homeowners multiple peril
Commercial Multiple Peril 5.1 - Commercial multiple peril (non-liability portion) 5.2 - Commercial multiple peril (liability portion)	**Financial & Mortgage Guaranty** 6 - Mortgage guaranty 10 - Financial guaranty
Inland/Ocean Marine 8 - Ocean marine 9 - Inland marine	**Medical Professional Liability** 11 - Medical professional liability
Accident & Health 13 - Group accident and health 14 - Credit A&H (group and individual) 15.1 - Collectively renewable A&H 15.2 - Non-cancelable A & H 15.3 - Guaranteed renewable A & H 15.4 - Non-renewable for stated reasons only 15.5 - Other accident only 15.6 - Medicare Title XVIII exempt from state taxes or fees 15.7 - All other A & H 15.8 - Federal employees health benefits program premium	**Workers Compensation** 16 - Workers compensation
Other & Products Liability 17.1 - Other liability - occurrence 17.2 - Other liability - claims made 17.3 - Excess workers compensation 18 - Products liability	**Private Passenger Auto** 19.1 - Private passenger auto no-fault (personal injury protection) 19.2 - Other private passenger auto liability 21.1 - Private passenger auto physical damage
Commercial Auto 19.3 - Commercial auto no-fault (personal injury protection) 21.2 - Commercial auto physical damage 19.4 - Other commercial auto liability	**Aircraft** 22 - Aircraft (all perils)
Fidelity & Surety 23 - Fidelity 24 - Surety	**Other Commercial Lines** 26 - Burglary and theft 27 - Boiler and machinery 28 - Credit 30 - Warranty 34 - Aggregate write-ins for other lines of business

Appendix 2
Region Definitions

Northeast	Mid-Atlantic	Midwest	Southeast	Southwest	West	Canada
CT	DC	IA	AL	CO	AK	Canada
MA	DE	IL	AR	LA	AZ	
ME	MD	IN	FL	NM	CA	
NH	NJ	KS	GA	OK	GU	
RI	NY	KY	MS	TX	HI	
VT	PA	MI	NC	UT	ID	
	PR	MN	SC		MT	
		MO	TN		NV	
		ND	VA		OR	
		NE	VI		WA	
		OH	WV		WY	
		SD			Other	
		WI			Alien	

Refresher Course

VALUE OF RISK REDUCTION

Gary Venter

Alice Underwood

This article was first published as a study note for CAS Exam 7.

Value of Risk Reduction

When does it make sense for a firm to incur costs to mitigate risk?

The results of Modigliani-Miller (1958) are still frequently referenced today. In broad outline, MM theory indicates that for a firm owned by diversified investors, any risk that can be diversified against broader holdings is irrelevant to the owners – and thus it is not worthwhile for the firm to incur mitigation costs for such risks. However, this result is based on numerous simplifying assumptions, including the assumption that distressed firms have access to unlimited new capital with no extra costs or conditions. Clearly, this is not the case. Froot et al. (1993) is a widely cited reference for the difference in cost of raising new capital vs. retaining earnings, and its conclusion is that firms with ongoing capital needs should protect their earnings stream through risk transfer. Subsequent empirical studies have supported their ideas. Overall, the assumptions behind the MM framework simply do not hold, so this framework is not appropriate for the practice of Enterprise Risk Management. However, due to information lags many insurance CFOs have been brought up within this background, so actuaries need to understand it and be able to discuss it coherently.

An actuarial theory of firm value was developed in the late 1950's by Bruno de Finetti, a one-time compatriot of Modigliani. The capital assumptions used by de Finetti (1957) are almost exactly opposite those of MM: in de Finetti's model, a firm has no means to raise capital except for retained earnings. While in the real world this assumption generally does not apply to healthy firms, it is a fair approximation of the situation for distressed firms. In this theory, firm value is the present value of future dividends to owners. Avoiding insolvency maintains the firm's earnings ability and so increases its value. Paying a cost to mitigate, offset, or transfer diversifiable (sometimes called "specific" or "idiosyncratic") risk in order to avoid distress may therefore make sense. This is very much in the spirit of the actuarial theory of probability of ruin.

This study note starts with the recent financial theory of risk transfer for firms in general in Section 1, and considers issues specific to the insurance industry in Section 2. The actuarial theory is reviewed in Section 3. These sections provide arguments for why risk reduction may be worth the costs, and discuss implications for risk management. Section 4 discusses efforts that have been made to quantify these effects in practice, and Section 5 presents an illustrative example.

1. General motivations for risk reduction

There are numerous reasons why it can be worthwhile for firms to reduce or transfer specific risk, even at a cost. These include but are not limited to

- Costs of financial distress
- Agency issues
- Regulation and taxation
- Relationships with stakeholders

A growing body of empirical research supports the value of risk management in these contexts.

Financial distress can be costly

Contrary to the assumptions of MM, it can be difficult and costly for distressed firms to raise new capital. Issuing high-yield bonds means a substantial recurring expense. New equity shares usually must be issued at a discount – sometimes a large discount – to the current price; this reduces the already-reduced value of existing shares, unwelcome news to shareholders even if they have the first right to purchase the new shares. Even if the shares are not issued at a discount, the effect is dilutive for existing shareholders. Furthermore, assets (such as subsidiaries) offered for sale may attract less favorable prices than before.

Andrade and Kaplan (1998) examine banks from highly leveraged buyouts that ended up distressed. Although in this study the distress was usually a result of the high leverage, the effects observed are more general. Distressed firms experience reduction in earnings, reduction in capital expenditures, forced sale of assets at depressed prices, and delay in restructuring. These in turn mean curtailed growth and lost opportunities.

In a classic paper on risk transfer, Smith and Stultz (1985) identify costs of financial distress that "leak out of" financial markets – they may end up as profits or salaries for someone (law firms, liquidation bureaus, etc.), but out of the realm of publicly traded firms. For example, many of the costs of bankruptcy fall into this category. They also point out that bonds often have covenants that require specific firm action in the case of financial distress, which can restrict the firm's flexibility in responding to the distress.

The difficulty and cost of raising capital for a distressed firm implies that firms with greater capital needs will gain more value from risk management. Testing this requires a publicly available proxy for risk management activities as well as an indicator of capital need. Although engaging in hedging transactions is only a small part of most companies' risk management activities, it is a publicly available statistic. Firms with greater capital needs are generally those with better growth prospects; thus, higher market-to-book ratio or higher research and development expenditures might indicate elevated capital need. High leverage ratios could also indicate greater capital need and would increase the frictional costs of financial distress. Several studies [Geczy et al. (1997); Nance et al. (1993); He and Ng (1998); Dolde (1995); Samant (1996)] have found relationships between the use of hedging and these predictor variables. Though not every study has found such effects, there is an increasing amount of empirical evidence for the value of risk management as related to external financing costs.

To understand the costs of financial distress, the concept of agency conflicts is useful.

Agency theory explains potential changes in risk behavior

In the terminology of agency theory, an "agent" is an entity to whom you give control of some portion of your funds for your mutual benefit. For instance, the managers of a company are agents of the shareholders, and the shareholders are agents of the bondholders. The key aspect of agency theory is the potential conflict between agent and principal.

Absence or reduction of "skin in the game" tends to lower the agents' risk aversion relative to the principals they represent. Therefore, shareholders would like to establish a management compensation program that aligns their interests with those of management. In practice, this alignment is imperfect. Usually debtholders have less control over what shareholders do with the debt funding, although given the possible need to issue new bonds in the future the firm would be unwise to act against the bondholders' interests. Reducing risk through hedging or other strategies can be a signal to bondholders, potential creditors, and future investors that the firm will not take excessive risks with their money.

When a firm goes into distress, but remains solvent, shareholders and management may become less risk-averse. The loss of funds that caused the distressed state decreases the shareholders' stake, but not that of the debtholders. Such a highly leveraged situation heightens agency conflicts.

Shareholders may prefer high-risk gambles with the joint funds, which they control but of which they own little. They may in fact decline less risky investment possibilities, because these would help debtholders more than shareholders. This conundrum is referred to as "the underinvestment problem." A related issue is that the firm's survival prospects may be enhanced by issuing new shares – but the main beneficiaries of that would again be the debtholders, who have little say in the decision.

Taxation and regulation can provide motivations for hedging

Dolde (1995) reports a positive relationship between tax loss carry forwards and the use of risk management instruments. This indicates that taxes provide an incentive for risk management. Furthermore, when the corporate tax rate is higher at higher incomes, maintaining a stable income might lower total taxes paid over time [Smith and Stulz (1985)]. In such cases, the costs of risk offset to accomplish income stability might enhance long-term earnings. However, there is not a great deal of evidence that firms are in the right place on the tax schedule to make this worthwhile in practice.

In regulated industries, the regulator may specifically require a certain level of risk management or impose other burdens on riskier firms. For example, banks and insurance companies are typically required to satisfy certain leverage ratios. Hedging may be necessary to meet these requirements.

Relationships with stakeholders can be damaged by excessive risk

Smith and Stulz (1985) highlight the effect of risk on stakeholders other than shareholders. These include debtholders, customers, employees, and suppliers. All of these prefer predictable outcomes for their relationships with the firm. Carrying higher risk can drive up costs for all of them, endangering relationships that the firm must maintain for continued success.

2. Insurance-specific issues

In addition to the general considerations discussed above, insurers face special issues. These include:

- Agency theory complications: policyholders as debtholders and/or owners
- Special vulnerability to effects of financial distress
- Reinsurance as the dominant form of hedging

For these and other reasons, using risk management to avoid financial distress appears to increase insurers' market value [Staking and Babbel (1995)].

Agency issues and the influence of policyholders

Mayers and Smith (1990) examine risk transfer specifically for insurers. In addition to the general reasons for risk transfer discussed above, they find issues particular to the insurance industry. For one thing, the principal debtholders are in fact the customers (policyholders). Loss reserves and unearned premium reserves are supported by funds held for payments to policyholders. This complicates the agency relationship between shareholders and debtholders, and gives the debtholders more relative power in the relationship. Insurers must maintain lower levels of risk because the relationship with debtholders is ongoing, and customer relationships would be threatened if their risk attitudes were ignored.

For mutual companies, policyholders are owners as well as debtholders. This puts an interesting spin on the agency issues, further reducing tolerance for risk. In addition, a firm with this structure has very limited access to capital markets and so there are fewer options in case of financial distress.

Many studies support the idea that insurers benefit from managing risk for the sake of policyholders. Empirical evidence indicates that policyholders are not willing to pay as much for insurance from a less stable or weakly-capitalized insurer [Sommer (1996)]. The profit load insureds are willing to pay decreases as the ratio of insurer capital to assets declines, and also decreases as the volatility of that ratio increases. The price discount that insureds demand for accepting a higher expected cost of insurer default is greater than the economic value of the default put value [Phillips, Cummins and Allen (1998)], perhaps because insureds do not diversify this risk. Insurer security affects buying decisions for homeowners' insurance [Grace et al. (2004)]. Furthermore, growth rates are higher for insurers with greater financial strength as measured by rating agencies [Epermanis and Harrington (2006)].

Insurers are particularly vulnerable to financial distress

In general, riskier firms tend to lose market share and shrink in relative market capitalization during periods of downturn in their respective industries [Opler and Titman (1994)]. The insurance industry is not unique in this regard. However, the insurance product is a promise of payment contingent upon certain future events. When an insurer encounters financial distress, its promise of future payment becomes less valuable. Empirical studies and case histories all suggest that a distressed insurer can lose many of its customers. This can create motivation to fight for market share by cutting price; and, as observed above, those customers who remain are likely to expect discounted premium costs, setting into motion a vicious cycle. The costs of financial distress for an insurer therefore include substantial loss of future earnings potential, and its viability may be threatened.

Equity markets tend to react quite adversely to an insurer's financial distress. In many cases, the resulting reduction in market capitalization is a significant multiple of the drop in book value that resulted in the financial distress. This also contributes to the vicious cycle that may imperil the insurer's ability to continue as a going concern.

Reinsurance reporting offers a window into insurers' risk management

Reinsurance – the contractual agreement by which a reinsurer undertakes to offset a specified portion of insurance losses – is the dominant means of hedging insurance risk. Because reinsurance is recorded in financial statements, the insurance industry is more transparent than others in its use of risk transfer.

Mutual insurers make greater use of reinsurance; this is consistent with their ownership by policyholders and their lack of access to capital markets [Mayers and Smith (1990)]. Smaller insurers, and insurers with lower ratings from rating agencies, also buy more reinsurance; this is in accord with the previous discussion of the costs of financial distress and avoiding agency issues with policyholders.

3. The actuarial theory of the value of insurance risk reduction

A direct way to quantify the value of risk transfer is to create a model of firm value that responds to risk issues. De Finetti (1957) formulates the value of a firm as the present value of all future dividends paid to shareholders. He does not allow for any access to capital markets once the firm has been set up, so distress can be very costly and bankruptcy ends the dividend stream. Thus, risk does affect firm value in this model.

Gerber and Shiu (2006) present a well-developed form of de Finetti's model. They use a fairly general severity distribution that could approximate many actual distributions. They focus on the problem of determining a dividend-paying strategy that would optimize firm value for a predetermined underwriting portfolio. It turns out that the optimal strategy is to pay no dividends if capital is below a certain target level, and pay out any capital beyond that level. The optimization is rather complex, using a dynamic programming approach [Bellman (1954)].

Other authors [Bather (1969); Asmussen et al. (2000)] have extended this model to include the possibility of buying reinsurance. More recently the actuarial and financial paths have come together by bringing in the possibility of refinancing in the capital markets [Peura (2003); Major (2007) also includes the effects of policyholder risk aversion]. The cost of distress financing is an input for such a model. One study on this is Myers and Majluf (1984). Agency dynamics between policyholders and shareholders are another needed input. Panning (2006) argues in general for using financial value as the basis of risk-transfer decisions in insurance, and illustrates with a simple conceptual example.

Insurers and reinsurers have started to use models like this to optimize value by optimizing the level of capital and risk. The next section provides an overview of various methods.

4. Quantifying the value of risk transfer for insurers

As we have seen in the prior three sections, there is strong evidence that offsetting risk via hedging or reinsurance can provide value to a firm – and particularly to an insurer. However, quantifying the benefits of risk transfer for insurers is still an emerging discipline. As yet there is no broad consensus and further work in this area is needed. Some possible approaches include:

- Simple multiplier methods

- Efficient frontier comparison
- Cost of allocated risk capital
- Estimates of firm value under different strategies

Simple multiplier methods can provide a rough estimate

In the financial literature, the calculation of the value of risk management generally starts by quantifying historical distress costs for distressed firms. Andrade and Kaplan (1998) estimate these costs as 10% - 23% of pre-distress capital for their over-leveraged banks, and then multiply by the probability of going into distress. Using distress probabilities risk-adjusted for market risk reactions produces a much greater impact – Almeida and Philippon (2008) show that the cost to the bank shareholders after risk adjustment can be more than three times as large as the cost calculated ignoring this. The market value of corporate bonds can be viewed as coming from default probabilities adjusted to reflect market risk attitudes (and liquidity); therefore, an approximation to the necessary probability transformation could be derived from the firm's bond ratings.

For distress of various levels, it would be possible to estimate the loss of future earnings capacity using the historical impact on actual earnings of insurers in financial distress, or using market capitalization as a proxy. For insurers in distress, the market cap reaction is often a multiple of the financial loss, which is similar to what Almeida and Philippon found for banks. The probability of distress could be estimated from internal models and then risk-adjusted. This would enable comparison of the expected cost of distress to the costs of reinsurance or other risk management strategies.

Efficient frontier comparisons are useful, but where along the frontier is best?

Under current market practice, some portions of this approach are typically considered when reviewing potential reinsurance alternatives. The first step is using a simulation model to compute the probability distribution of financial results under each proposed reinsurance program. From the simulated results, estimates of the probability of various levels of distress can be estimated. For instance, "distress" could be defined as failure to achieve estimated earnings, suffering negative earnings, capital falling below twice the regulatory target, or capital falling below the desired rating-agency target. The percentage of capital lost at various probability levels can be tabulated across programs. The cost of each reinsurance alternative can be measured as expected payments to reinsurers less expected recoveries.

Such analysis allows an "efficient frontier" comparison to be made for each distress threshold. A reinsurance program is inefficient if a less costly program, or linear combination of programs, gives a more favorable result at the selected threshold. Different distress thresholds can have different sets of efficient reinsurance alternatives, and this method does not clarify how to select among efficient alternatives. However, it may be possible to eliminate a number of possibilities via efficiency considerations. At this point management might be able to select its favored reinsurance program from the remaining alternatives using other criteria.

Cost of allocated risk capital offers one metric

One such criterion, which also offers a way to quantify the benefit of risk transfer in a single number, is cost of allocated risk capital; see Exley and Smith (2006) for a comprehensive overview of the theory of capital costs and application to financial firms.

In this approach, an economic capital model is applied to the simulated results net of reinsurance alternatives. The difference in cost of the reinsurance programs can then be compared to the difference in cost of risk capital.

This begs the question of which capital measure is most appropriate. Commonly used capital measures include Value at Risk (VaR) and Tail Value at Risk (TVaR). With these and other measures based on the tail of the probability distribution, there is the additional question of what threshold probability to select.

One approach could be to use the current program as a benchmark, and seek to maintain a comparable ratio of VaR / TVaR levels to capital. This would indicate the company's required capital under each program. Alternatively, capital metrics that are not tail-based can be used. Naturally, results may vary depending on the capital standard selected.

More robust models of firm value take the next step

Directly addressing the question of value added by any risk management strategy requires a more complete model of firm value. Models such as those described in [Major (2007) and Panning (2006)] reflect risk issues. However, such models can be complex and the inputs themselves must be quantified. This is an emerging approach.

5. Illustrative Example

Let's consider a concrete example to illustrate the concepts discussed in the previous section. In this example, a firm that writes earthquake insurance is considering the benefit of its current reinsurance program as compared to three possible alternatives. In the coming year 201X, the firm expects to write \$100M of premium, with expected losses of \$18.6M and acquisition expenses of \$12.5M. Due to the extreme volatility of its business, the firm holds \$200M of capital.

Methods used to derive the insurance loss model are outside the scope of this discussion, as are the mechanics of simulating and applying specific reinsurance structures to the modeled losses. Instead, we will focus on the output produced by the simulation model: a distribution of financial outcomes on a gross basis as well as net after each of the reinsurance alternatives. The expected values are as follows:

Expected Underwriting Profit & Loss Summary for Projected Year 201X ($M)

	Gross	Current	Option 1	Option 2	Option 3
(1) Gross Premium	100.0	100.0	100.0	100.0	100.0
(2) Reinsurance Premium	-	60.8	55.1	49.5	40.2
(3) = (1) – (2) Retained Premium	100.0	39.2	44.9	50.5	59.8
(4) Gross Losses	18.6	18.6	18.6	18.6	18.6
(5) Reinsurance Recoveries	-	11.0	10.0	9.0	7.6
(6) = (4) – (5) Retained Losses	18.6	7.7	8.6	9.6	11.0
(7) Gross Expenses	12.5	12.5	12.5	12.5	12.5
(8) Reinsurance Commission Received	-	-	-	-	-
(9) = (7) – (8) Retained Expenses	12.5	12.5	12.5	12.5	12.5
(10) = (3) – (5) – (9) Retained Underwriting Result	**68.9**	**19.0**	**23.8**	**28.4**	**36.3**
(11) = (2) – (5) – (8) Net Cost of Reinsurance	0.0	49.9	45.1	40.5	32.6

Because insurance losses are driven by infrequent earthquakes, in most years the insurer suffers no losses – but when losses occur they can be very severe. The probability distribution of underwriting results is shown below, along with selected statistics from the simulation that will be used in later calculations.

Distribution of Modeled 201X Underwriting Profit

Percentile	Return Period	Gross	Current	Option 1	Option 2	Option 3
50.00%	2	87.5	26.7	32.4	38.0	47.3
75.00%	4	87.5	26.7	32.4	38.0	47.3
80.00%	5	83.9	23.1	28.8	34.4	43.7
90.00%	10	57.9	(2.9)	2.9	8.5	17.7
95.00%	20	(15.3)	(18.8)	(24.1)	(32.9)	(45.4)
98.00%	50	(161.1)	(37.4)	(42.7)	(51.5)	(68.2)
99.00%	100	(300.3)	(56.0)	(63.0)	(71.7)	(85.9)
99.50%	200	(468.6)	(82.2)	(94.8)	(112.8)	(110.8)
99.60%	250	(532.4)	(101.2)	(113.7)	(131.8)	(132.0)
99.75%	400	(669.8)	(211.3)	(217.7)	(228.9)	(241.6)
99.80%	500	(729.7)	(274.6)	(281.2)	(291.9)	(302.9)
99.90%	1,000	(951.2)	(483.1)	(488.6)	(500.3)	(518.2)
	Mean	68.9	19.0	23.8	28.4	36.3
	Probability of Negative UW Profit	5.6%	10.5%	9.6%	8.9%	7.9%
	Probability of UW Profit ≤ -100M	3.26%	0.41%	0.47%	0.66%	0.72%
	E[Profit | Profit ≤ -100M]	(332.2)	(206.8)	(215.8)	(189.5)	(193.8)
	1-in-100 VaR	300.3	56.0	63.0	71.7	85.9
	1-in-250 VaR	532.4	101.2	113.7	131.8	132.0
	1-in-100 TVaR	566.3	187.4	196.7	209.3	217.9

If the company buys no reinsurance at all, the probability of fully exhausting surplus in the coming year is between 1% and 2%. A one-year ruin probability in excess of 1% is likely to find disfavor with regulators, so it is likely that the company needs to engage in risk transfer for regulatory reasons – as well as for the reasons discussed above. Customers might expect the likelihood of an earthquake loss to be in the 1% to 2% range, and if the insurer is bankrupt with the same probability, they might not want to buy insurance. The table above indicates that the current structure reduces the one-year ruin probability to approximately 0.25%, i.e. complete exhaustion of surplus is roughly a 1-in-400 year event.

But what *value*, if any, does risk transfer offer to the purchaser in this case? In order to apply the methods discussed in Section 4, we must have a criterion for "distress." As revealed in Sections 1 and 2, financial distress can set in well before capital is fully exhausted. In this example we assume that a net underwriting loss of $100M or more (i.e. a loss of 50% of capital) puts the company in distress, but any situation less severe than this does not create distress. (In practice, this would be quite a high pain threshold: an insurance company is likely to suffer at least some effects of distress if 10% – 20% of surplus is depleted.)

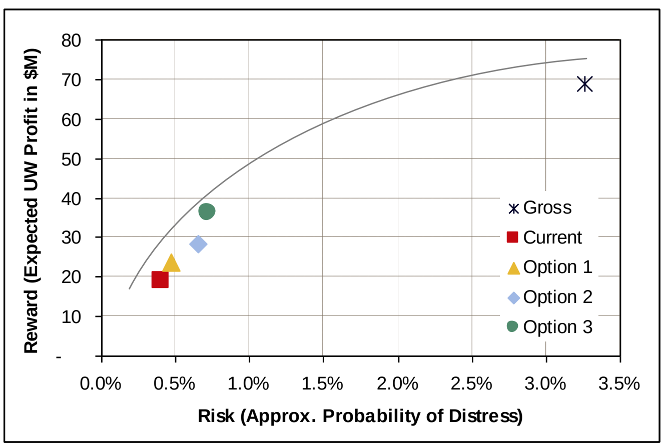
Review of efficient frontier comparisons

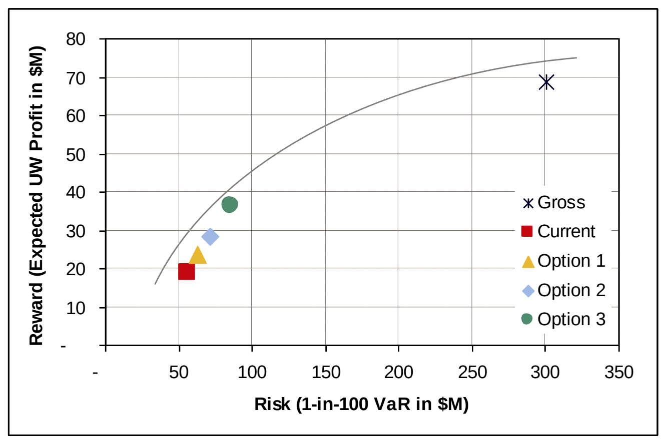
An efficient frontier chart compares risk and reward. Various risk measures are available from the table of simulation results: we might consider the probability of distress as well as the VaR and TVaR at different return thresholds. For "reward" we will use net retained underwriting profit.

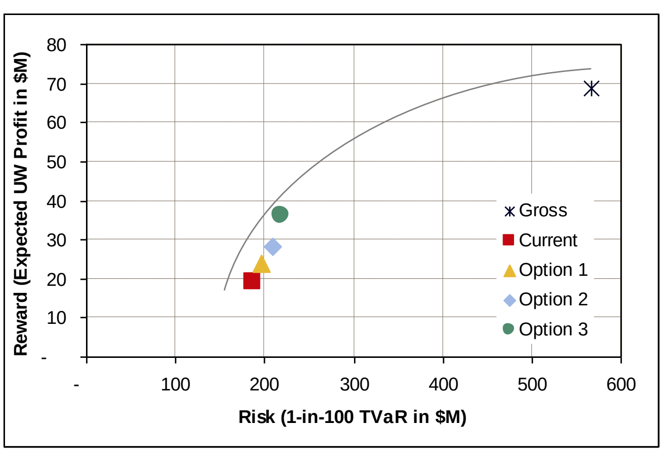
Comparison of Risk and Reward Measures

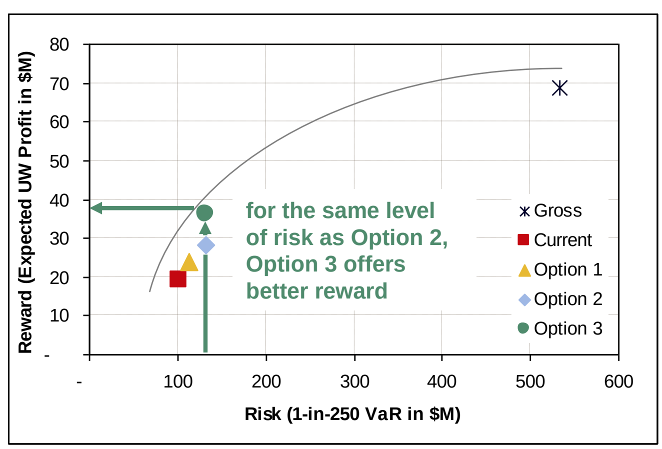
	Gross	Current	Option 1	Option 2	Option 3
Interp. Probability of Distress	3.26%	0.41%	0.47%	0.66%	0.72%
1-in-100 VaR	300.3	56.0	63.0	71.7	85.9
1-in-250 VaR	532.4	101.2	113.7	131.8	132.0
1-in-100 TVaR	566.3	187.4	196.7	209.3	217.9
Expected Net UW Profit ($M)	68.9	19.0	23.8	28.4	36.3

It may be useful to examine the efficient frontiers graphically. In each case, we show risk increasing along the horizontal axis and reward increasing along the vertical axis, so in each case the northwest corner of the graph is the most desirable region (highest reward, lowest risk).









The 1-in-250 VaR risk metric indicates that Option 2 is inefficient compared to Option 3, but this is less clear using the other metrics. And none of these comparisons enables us to choose between Current or Option 1 (less risk, less reward) vs. Option 3 (more risk, more reward).

Cost of allocated risk capital

An allocated risk capital methodology can assist in this choice. We observe that the held capital of $200M is approximately twice the 1-in-250 VaR and roughly equal to the 1-in-100 TVaR under the current reinsurance structure. We can use these as benchmarks for required risk capital, and calculate the cost of risk capital at (say) 10%.

Comparison of Allocated Risk Capital Costs to Net Cost of Reinsurance

	Gross	Current	Option 1	Option 2	Option 3
Net cost of Reinsurance	-	49.9	45.1	40.5	32.6
Risk Capital Estimate A: 2 x (1-in-250 VaR)	1,064.9	202.3	227.4	263.6	263.9
Capital Cost at 10%	106.5	20.2	22.7	26.4	26.4
Savings in Capital Cost	-	86.3	83.7	80.1	80.1
(Savings in Cap. Cost) – (Net Cost of RI)	**-**	**36.4**	**38.7**	**39.7**	**47.5**
Risk Capital Estimate B: 1-in-100 TVaR	566.3	187.4	196.7	209.3	217.9
Capital Cost at 10%	56.6	18.7	19.7	20.9	21.8
Savings in Capital Cost	-	37.9	37.0	35.7	34.8
(Savings in Cap. Cost) – (Net Cost of RI)	**-**	**(12.0)**	**(8.1)**	**(4.8)**	**2.2**

Using the first estimate of risk capital, twice the 1-in-250 VaR, any of the reinsurance options offers a savings in capital costs that exceeds the net cost of reinsurance: in other words, using this capital measure any of the purchases is a good buy. The current structure offers somewhat less benefit than Option 1 or Option 2, but Option 3 is superior to all.

Using the second estimate of risk capital, the 1-in-100 TVaR, only Option 3 offers a positive benefit. This is reassuring in that Option 3 is preferred using both methods, but unsettling in that the TVaR capital metric views the other three possibilities as destructive to value while the VaR metric shows them as additive to value.

This leaves us in doubt about the "right" way to allocate capital. Twice the 1-in-250 VaR is in line with some regulatory and rating agency targets. However, this metric disregards the extreme tail of the distribution as well as events with return periods more remote than 1-in-250. The TVaR method, which at least reflects the shape of the tail of the probability distribution, still requires selection of an arbitrary return threshold. There are many more possibilities for capital allocation in the ERM literature, but these go beyond the scope of this note.

Applying a simple model of firm value

The best way to test the value added by any of the reinsurance strategies is to apply a model of firm value that reflects risk effects. Here we will use a highly simplified version of the method outlined in Panning (2006), and define the firm's value as the risk-adjusted present value of all future earnings. The risk adjustment is implemented by assuming that going into distress (sustaining a net underwriting loss of $100M or more) is fatal to the firm and eliminates all earnings from that point forward. For simplicity, we assume no growth or change in the portfolio; we further assume that at year's end, any profits are released as a dividend to shareholders and any depletion of capital is replenished at no cost by the shareholders. This means that if the firm does not become distressed, the financial results for each subsequent year are identically distributed. Denote

E = expected annual earnings

d = probability of distress

r = risk-free interest rate

$D = (1 - d) / (1 + r)$ = one-year discount factor

The discount factor D reflects both time value of money and probability of distress. Now the value of the firm can be expressed as

$$V = ED + ED^2 + ED^3 + \dots$$

$$= ED\,(1 + D^2 + D^3 + \dots)$$

$$= E \times [D / (1 - D)]$$

In this framework we call $M = D/(1 - D)$ the perpetuity value multiplier, so $V = E \times M$.

We are now in a position to calculate the value of the firm under each of the different reinsurance strategies. The figures below assume a risk-free interest rate of 1.5% and a 3% investment rate of return. It is assumed that reinsurance premium and expenses are paid at the beginning of the year and losses at the end of the year, so that assets available for investment at the beginning of the year are the surplus of $200M, plus retained premium, minus expenses.

Simplified Firm Value Calculation

	Gross	Current	Option 1	Option 2	Option 3
(1) Expected UW Profit	68.9	19.0	23.8	28.4	36.3
(2) Invested Assets = Surplus + Retained Prem – Expenses	287.5	226.7	232.4	238.0	247.3
(3) = (2) × 3.0% Expected Investment Income	8.6	6.8	7.0	7.1	7.4
E = (1) + (3) = Total Earnings	77.5	25.8	30.8	35.5	43.7
d = Probability of Distress	3.26%	0.41%	0.47%	0.66%	0.72%
D = (1 – d) / (1+r)	0.953	0.981	0.981	0.979	0.978
M = D/(1 – D)	20.335	52.250	50.546	46.091	44.772
V = E × M	1575.9	1348.8	1552.1	1638.1	1956.1
Benefit to Value	**-**	**(227.1)**	**(23.8)**	**62.2**	**380.2**

This model indicates that Option 3 enhances the total value of the firm significantly more than Option 2, while the current structure and Option 1 reduce the value of the firm by transferring too much risk. In other words, the model confirms that Option 3 is more efficient than Option 2 – and also reveals that the firm should position itself further towards the high risk / high reward portion of the efficient frontier.

In this example, the order of the reinsurance alternatives from most to least beneficial is the same whether done using the simplified firm value model, or the 1-in-250 VaR or 1-in-100 TVaR calculations with 10% cost of capital. However, this need not be the case. Replacing the 10% cost of capital with an extremely high value, for example, can render the less risky strategies relatively more attractive under the VaR / TVaR criteria. On the other hand, one might question whether the relatively low risk free rate and the rate of investment return used in the firm value model could be consistent with a much higher cost of capital – although the unusual market conditions prevailing after the 2008 financial crisis suggest this is at least possible. Clearly, the input values deserve careful consideration.

6. Final remarks

Understanding of the value of risk reduction, including risk transfer, has advanced considerably in recent years. For firms in general and insurers in particular, there are clear reasons why risk reduction can add value. Key issues are avoiding financial distress and the need to re-capitalize. Quantification of the value of risk transfer in particular situations can be done in various ad-hoc ways, but the science is still under development and industry practice varies widely.

REFERENCES

[1] Almeida, H. and T. Philippon, 2008. "Estimating Risk-Adjusted Costs of Financial Distress." *Journal of Applied Corporate Finance*, Fall: 105-111.

[2] Andrade, G. and S. Kaplan, 1998. "How Costly is Financial (not Economic) Distress? Evidence from Highly Leveraged Transactions that Become Distressed," *Journal of Finance* 53: 1443-1493.

[3] Asmussen, S., B. Højgaard, and M. Taksar, 2000. "Optimal Risk Control and Dividend Distribution Policies: Example of Excess-of Loss Reinsurance for an Insurance Corporation." *Finance and Stochastics* 4(3): 299–324.

[4] Bather, J.A., 1969. "Diffusion Models in Stochastic Control Theory." *J. Royal Statistical Society A*. 132: 335–352.

[5] Bellman, R.E., 1954. *The Theory of Dynamic Programming*. Santa Monica, Calif.: The RAND Corporation.

[6] De Finetti, B., 1957. "Su un' impostazione alternativa della teoria colletiva del rischio." *Transactions of the XVth International Congress of Actuaries* 2: 433-443.

[7] Dolde, W., 1995. "Hedging, Leverage, and Primitive Risk," *Journal of Financial Engineering*, Vol. 4, 1995, pp. 187-216.

[8] Epermanis, K. and S.E. Harrington, 2006. "Market Discipline in Property/Casualty Insurance: Evidence from Premium Growth Surrounding Changes in Financial Strength Ratings." *Journal of Money, Credit, and Banking* 38(6): 1515–1544.

[9] Exley, C.J. & Smith, A.D., 2006. "The cost of capital for financial firms." *British Actuarial Journal,* Volume 12, Number 1, pp. 229-283.

[10] Froot, K., D. Scharfstein, and J. Stein, 1993. "Risk Management: Co-ordinating Investment and Financing Problems," *Journal of Finance*, 48: 1629-1658.

[11] Geczy, C., B.A. Minton, and C. Schrand, 1997. "Why Firms Use Currency Derivatives," *Journal of Finance* Vol. 52, 1997, pp. 1323-1354.

[12] Gerber, H.U. and E.S.W. Shiu, 2006. "On Optimal Dividend Strategies in the Compound Poisson Model." *North American Actuarial Journal* 10(2): 76–93.

[13] Grace, M.F., R.W. Klein, and P.R. Kleindorfer, 2004. "The Demand for Homeowners Insurance with Bundled Catastrophe Coverages." *The Journal of Risk and Insurance*. 71(3): 351–379.

[14] He, J. and L. Ng, 1998. "The Foreign Exchange Exposure of Japanese Multinational Corporations," *Journal of Finance*, Vol. 53: 733-753.

[15] Major, J., 2007. "Measuring the Market Value of Risk Management: An Introduction to FLAVORED Models." In *Enterprise Risk Management for Property & Liability Insurance Companies*. Brehm, P.J., Perry, G.R., Venter, G.G., and Witcraft, S.E. (eds.). New York: Guy Carpenter & Company. A later discussion is available at: http://www.cb.wsu.edu/aria2009/ARIA2009Papers/Full%20Papers/session1D_Major.pdf

[16] Mayers, D. and C. Smith. 1990. "On the Corporate Demand for Insurance: Evidence from the Reinsurance Market," *Journal of Business* 63(1.1): 19-40.

[17] Modigliani, F. and M. H. Miller. 1958. "The cost of capital, corporation finance and the theory of investment," *American Economic Review* 48: 261-297.

[18] Myers, S.C. and N.S. Majluf, 1984. "Corporate Financing and Investment Decisions when Firms Have Information that Investors Do Not Have." *Journal of Financial Economics* 13: 187–221.

[19] Nance D.R., C.W. Smith, and C.W. Smithson, 1993. "On the Determinants of Corporate Hedging," *Journal of Finance*, 48: 267-284.

[20] Opler, T. and S. Titman, 1994. "Financial Distress and Corporate Performance," *Journal of Finance* 49(3): 1015-1040.

[21] Panning, W., 2006. "Managing the Invisible: Measuring Risk, Managing Capital, Maximiz-

ing Value." Available at SSRN: http://ssrn.com/abstract=913682, and also at http://www.actuarialfoundation.org/pdf/Panning-Sept06.pdf

[22] Peura, S., 2003. "Essays on Corporate Hedging." Academic Dissertation, University of Helsinki.

[23] Phillips, R.D., D. Cummins, and F. Allen, 1998. "Financial Pricing of Insurance in the Multiple-Line Insurance Company." *The Journal of Risk and Insurance* 65(4): 597–636.

[24] Samant, A., 1996. "An Empirical Study of Interest Rate Swap Usage by Nonfinancial Corporate Business," Journal of Financial Services Research, Vol. 10, 1996, pp. 43-57.

[25] Smith, C. W. and R. M. Stulz. 1985. "The Determinants of Firms' Hedging Policies," *The Journal of Financial and Quantitative Analysis* 20(4): 391-405.

[26] Sommer, D.W., 1996. "The Impact of Firm Risk on Property-Liability Insurance Prices." *The Journal of Risk and Insurance* 63(3): 501–514.

[27] Staking, K. and D. Babbel, 1995. "The Relationship between Capital Structure, Interest Rate Sensitivity, and Market Value in the Property-Liability Insurance Industry," *The Journal of Risk and Insurance* 62(4): 670-718.