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MODELS FOR CAPITAL REQUIREMENTS IN SWISS SOLVENCY TEST FOR UNDERWRITING PREMIUM RISK

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INTRODUCTION



Figure 1: 1844-06-20 - Onondaga County Mutual Insurance Company - Policies
Onondaga County New York Mutual Fire Insurance Co. 1844 policy, issued to Truman Woodford & Philip Alexander on June 1844. This policy is for coverage of Dwelling House & Barn. Handwritten name of town appears to be Tully located in the County of Onondaga.

“Each human activity is the result of a long chain of events, of the fate, opportunity, chances and the continuous modest work of millions of men: there is no human adventure which not involves risk.”¹

Early methods of transferring or distributing risk were practiced by Chinese and Babylonian traders as long ago as the 3rd and 2nd millennium BC, respectively. Chinese merchants travelling treacherous river rapids would redistribute their wares across many vessels to limit the loss due to any single vessel's capsizing. The Babylonians developed a system which was recorded in the famous Code of Hammurabi, c. 1750 BC, and

¹ <http://www.golinucci.it/>

practiced by early Mediterranean sailing merchants. If a merchant received a loan to fund his shipment, he would pay the lender an additional sum in exchange for the lender's guarantee to cancel the loan should the shipment be stolen or lost at sea.

Achaemenian monarchs of Ancient Persia were the first to insure their people and made it official by registering the insuring process in governmental notary offices. The insurance tradition was performed each year in Norouz (beginning of the Iranian New Year); the heads of different ethnic groups as well as others willing to take part, presented gifts to the monarch. The most important gift was presented during a special ceremony. When a gift was worth more than 10 000 Derrik (Achaemenian gold coin) the issue was registered in a special office. This was advantageous to those who presented such special gifts. For others, the presents were fairly assessed by the confidants of the court. Then the assessment was registered in special offices. The purpose of registering was that whenever the person who presented the gift registered by the court was in trouble, the monarch and the court would help him. Jahez, a historian and writer, writes in one of his books on ancient Iran: "*Whenever the owner of the present is in trouble or wants to construct a building, set up a feast, have his children married, etc. the one in charge of this in the court would check the registration. If the registered amount exceeded 10 000 Derrik, he or she would receive an amount of twice as much.*".

A thousand years later, the inhabitants of Rhodes invented the concept of the 'general average'. Merchants whose goods were being shipped together would pay a proportionally divided premium which would be used to reimburse any merchant whose goods were deliberately jettisoned in order to lighten the ship and save it from total loss.

The Greeks and Romans introduced the origins of health and life insurance c. 600 AD when they organized guilds called "benevolent societies" which cared for the families and paid funeral expenses of members upon death. Guilds in the Middle Ages served a similar purpose. The Talmud deals with several aspects of insuring goods. Before insurance was established in the late 17th century, "friendly societies" existed in England, in which people donated amounts of money to a general sum that could be used for emergencies.

Separate insurance contracts (i.e., insurance policies not bundled with loans or other kinds of contracts) were invented in Genoa in the 14th century, as were insurance pools backed by pledges of landed estates. These new insurance contracts allowed insurance to be separated from investment, a separation of roles that first proved useful in marine insurance. Insurance became far more sophisticated in post-Renaissance Europe, and specialized varieties developed.

Some forms of insurance had developed in London by the early decades of the seventeenth century. For example, the will of the English colonist Robert Hayman mentions two "policies of insurance" taken out with the diocesan Chancellor of London, Arthur Duck. Of the value of £100 each, one relates to the safe arrival of Hayman's ship in Guyana and the other is in regard to "one hundred pounds assured by the said Doctor Arthur Ducke on my life". Hayman's will was signed and sealed on 17 November 1628 but not proved until 1633. Toward the end of the seventeenth century, London's growing importance as a center for trade increased demand for marine insurance. In the late 1680s, Edward Lloyd opened a coffee house that became a popular haunt of ship owners, merchants, and ships' captains, and thereby a reliable source of the latest shipping news. It became the meeting place for parties wishing to insure cargoes and ships, and those willing to underwrite such ventures. Today, Lloyd's of London remains the leading market for marine and other specialist types of insurance, but it works rather differently than the more familiar kinds of insurance.

Insurance as we know it today can be traced to the Great Fire of London, which in 1666 devoured more than 13 000 houses. The devastating effects of the fire converted the development of insurance "from a matter of convenience into one of urgency, a change of opinion reflected in Sir Christopher Wren's inclusion of a site for "the Insurance Office" in his new plan for London in 1667." A number of attempted fire insurance schemes came to nothing, but in 1681 Nicholas Barbon and eleven associates, established England's first fire insurance company, the "Insurance Office for Houses", at the back of the Royal Exchange. Initially, 5 000 homes were insured by Barbon's Insurance Office.

The first insurance company in the United States underwrote fire insurance and was formed in Charles Town (modern-day Charleston), South Carolina, in 1732. Benjamin Franklin helped to popularize and make standard the practice of insurance, particularly against fire in the form of perpetual insurance. In 1752, he founded the Philadelphia Contributionship for the Insurance of Houses from Loss by Fire. Franklin's company was the first to make contributions toward fire prevention. Not only did his company warn against certain fire hazards, it refused to insure certain buildings where the risk of fire was too great, such as all wooden houses.

It's clear that one of the key elements of insurance is security, but what would happen if the insurance company is unable to pay the cost of the claim?

In this context, the solvency of insurance company is fundamental.

The pioneering works done by Cornelis Campagne in the Netherlands at the end of the 1940s and by Teivo Pentikäinen in Finland in the beginning of the 1950s are important, as they introduced the solvency research for insurance undertakings. Before the term solvency was introduced, a concept like statutory reserves was often used, which have been formed in the course of years and which serve as an extra guarantee for fulfilling the obligations undertaken. Initially, Campagne called this type of reserve for life insurance for a stabilization reserve. In Finland a special equalization reserve was introduced in 1953 to take account of the stochastic fluctuations in the annual claims amount in non-life insurance. During the 1950s Campagne enlarged the solvency assessment to non-life insurance. As Campagne's work became leading for the approach of assessing an extra minimum reserve for both life and non-life companies he was asked to present a report on solvency ("Minimum Standards of Solvency for Insurance Firms") in 1957 to the OEEC² Insurance Committee. As a chairman of a working group within the Insurance Committee his work was developed and a final report was presented in 1961.

In life insurance the approach adopted was the same as in the 1940s. As the risk on investments is the most important factor for life insurance companies and as the technical provisions are the most important invested amount, Campagne considered a minimum solvency margin as given by a percentage of the technical provisions. Campagne asked "how great has the extra reserve to be, so that with a probability smaller than 0.01 respectively 0.001 this can be expressed to be insufficient for the financing of investment losses and deviations of foundations; in which case furthermore distinctions have to be made between cases in which the stabilization reserve has to be sufficient for one year or more years.". Campagne concluded that an extra reserve of 6% of the technical provision would be adequate with a probability of 99%.

With a probability of 95% the percentage of the extra reserve became 4% and this was the extra reserve proposed by Campagne. It was implemented in the first life directive within the European Union in 1979.

In non-life insurance the model was simple but elegant. Let the net retained premium be 100%. From this we deduct a constant fraction equal to the average expense ratio³ (fixed to 42%). The remaining part is what remains for claims payment. With data from different European countries he estimated the Value-at-Risk⁴ of the loss ratio at 0.9997% as 83%.

² Organization for European Economic Co-operation;

³ Expenses divided by premiums;

⁴ Value at Risk (VaR) is a widely used risk measure of the risk of loss on a specific portfolio of financial assets. For a given portfolio, probability and time horizon, VaR is defined as a threshold value such

Thus the combined ratio⁵ will be $42\% + 83\% = 125\%$. In other words the company will need an extra 25% of the premium during 1 year to meet the requirements. After further works during the 1960s and political negotiations this framework became the base for the first non-life directive in Europe in 1973. Research on solvency assessment was initiated as many countries in Europe had got the non-life and life directives during the 1970s implicating minimum solvency margins. Work was done in e.g. United Kingdom, the Netherlands, but also in Finland.

The research and works done were all stepwise towards a risk based capital (RBC) approach.

The scope of this paper is to provide an overview of these risk based capital requirements.

In US the growing frequency and severity of insurer insolvencies in the mid-1980s led to concern about the adequacy of state insurance regulation and the accuracy of the methods used by regulators to provide early warning of insurer insolvencies. The National Association of Insurance Commissioners (NAIC) responded by adopting a “solvency policing agenda” in 1989. The agenda resulted in a number of changes in state solvency regulation, including the adoption of the Financial Analysis and Surveillance Tracking (FAST) solvency monitoring system and risk-based capital (RBC) requirements for both life and property-liability insurers. FAST was implemented in 1993, and the property-liability insurance RBC system went into effect in 1994. The NAIC risk-based capital (RBC) system, analyzed in Chapter 1, was created to provide a capital adequacy standard that is related to risk, raises a safety net for insurers, is uniform among the states, and provides regulatory authority for timely action. A separate RBC formula exists for each of the primary insurance types: Life, Property/Casualty, and Health. Each formula utilizes a generic formula approach rather than a modeling approach, although the Life RBC Formula has recently incorporated some modeling related to interest rate risk.

The generic formula setup typically pulls an amount from the statutory financial statement and assesses a factor, based upon relevant statistics, to calculate an RBC risk charge for every individual risk item included in the specific RBC formula.

that the probability that the mark-to-market loss on the portfolio over the given time horizon exceeds this value (assuming normal markets and no trading in the portfolio) in the given probability level.

⁵ The combined ratio is comprised of the claims ratio and the expense ratio. The claims ratio is claims owed as a percentage of revenue earned from premiums. The expense ratio is operating costs as a percentage of revenue earned from premiums. The combined ratio is calculated by taking the sum of incurred losses and expenses and then dividing them by earned premium.

The NAIC Risk-Based Capital system has two main components: 1) the risk-based capital formula, that establishes a hypothetical minimum capital level that is compared to a company's actual capital level, and 2) a risk-based capital model law that grants automatic authority to the state insurance regulator to take specific actions based on the level of impairment.

Prior to 1981 there had only been two small failures of property casualty companies in Canada, one of which was wound down without loss to policyholders. Since 1980 there have been failures associated with each bottom of the underwriting cycle. In 1981/82 two companies with a combined market share of 0.5% failed. In 1985/86 another four companies, with market share of 1.4% failed. A further two companies, with a market share of 0.3%, failed in the latest 1989/1990 trough. The shock of the first set of failures prompted a re-examination of solvency issues by regulatory authorities and was accelerated by the second set of failures in 1985/1986. The most visible regulatory initiatives were changes in the Canadian and British Insurance Companies Act in three key areas. First, the Surplus Test provisions were strengthened by providing for minimums based on written premiums and incurred claims as well as the existing margins on reserves. Second, regulations were issued to address the excessive use of reinsurance as well as the use of unregistered reinsurance. Third, actuarial certification of the adequacy of outstanding claims and unearned premium provisions was required for all companies' 1992 annual statements. Another initiative was the creation of the Property and Casualty Insurance Compensation Corporation (PACIC) which functions like the guarantee funds in many U.S. states.

In 1992 the Canadian Office of the Superintendent of Financial Institutions (OSFI) introduced a risk based system for life insurers, "Minimum Continuing Capital and Surplus Requirements" (MCCSR), which includes a risk based capital formula and a significant amount of direction on the calculation of amounts to be entered in the formula. For non-life companies, in 2003 "Minimum Capital Test" (MCT) was implemented (Chapter 2).

In Australia prior to the introduction of the Insurance Act 1973 there were virtually no supervisory requirements for companies wishing to conduct general (nonlife) insurance business in the Australian market place. All that was necessary to gain access to the market was the lodgment of a \$200 000 deposit with the Commonwealth Treasurer. During the three-year period to May 1973, 16 Australian general insurers collapsed,

causing major financial loss to policyholders and a widespread loss of confidence in the industry. The development of the Insurance Act was in response to these failures and to limit the possibility of future policyholder losses through company failures. Under the Insurance Act 1973, insurers were required to maintain allowable assets in excess of reported liabilities calculated as a percentage of net premium income or of net outstanding claims. This solvency structure went only part way to recognizing different risks faced by individual insurers. It was a blunt instrument which did not explicitly recognize the different levels of risk associated with different business lines, did not respond to inconsistency in the adequacy of reported liabilities, did not explicitly recognize the risks associated with the interaction of assets and liabilities and might not optimally recognize certain other risks, as asset valuation and concentration risk, risk of reinsurer default and catastrophe risk. In order to support its prudential role the Australian Prudential Regulation Authority (APRA) releases a small number of standards, the so called "Prudential Standards", concerning the capital adequacy, liability valuation and the quality requirements for operational risks and reinsurance contracts (Chapter 4).

Under these "Prudential Standards" emerges a statutory solvency regime which is responsive to the individual risk profiles of insurers, does not impose undue compliance costs on the industry, encourages the development and use of internal risk control and capital management systems and provides for cost effective prudential supervision.

In UK, the FSA thought that there has been a too high rate of failure among non-life insurers over the last twenty years and that a key contributing factor to the rate of failure has been the current capital requirements and practices. In response to this fact, during the summer of 2003, the FSA published "Consultative Paper 190" that addressed capital requirements and capital assessments for non-life insurers. The FSA believes that a higher and more risk-sensitive capital requirement will lead to a more transparent regime, an earlier regulatory intervention when financial problems develop, a closer alignment of capital with risks. CP 190 establishes a regulatory solvency regime with three key elements: the Enhanced Capital Requirement (ECR) which is a risk-based capital formula that provides the insurance company and the FSA with a formulaic benchmark of minimum capital required to support the underwriting operations, the Individual Capital Adequacy Standard (ICAS) which is a qualitative and quantitative risk assessment process undertaken by the insurance company to assess its overall capital adequacy and the

Individual Capital Guidance which is the FSA's view of the amount of capital an insurer should hold based on the insurers reported ECR and ICAS (Chapter 4).

In Europe the Life insurance directives (EEC 1979) and the non-life insurance directives (EEC 1973) can be considered the starting point of a formal set of solvency requirements that insurance companies were required to fulfill in a free market. The approach adopted those days were simple and straight forward to operate. Solvency assessment was based on simple factors and formulae that were applied on accounting results after adjustment for reinsurance. The findings of Müller report⁶ and the work done by a few other committees paved the way for the introduction of Solvency I in the EU in the year 2002. It introduced some additional parameters in solvency evaluation. Solvency I provided a simple, but robust mechanism to regulate insurer solvency. It has improvements over the early day regulations, but still maintained its simplicity. A positive consequence of this was that it made the administration and compliance management easy and inexpensive. In spite of its relative simplicity, Solvency I did significantly increase the protection of the policyholders. However significant changes had taken place in the insurance industry, creating the need to adapt the rules appropriately, in addition the working document for Solvency I had already indicated the need for a better system which recognizes the various risks that an insurance company is exposed to in a more holistic manner. In some sense, Solvency I had already paved the way for the development of a more sophisticated approach. In the beginning of 2000, the Commission Services together with Member States initiated a fundamental and wide-ranging review of the overall financial position of an insurance undertaking: "The Solvency II Project" (Chapter 5). One of the objectives for the project is to establish a solvency system that is better matched to the true risks of an insurance company.

The insurance regulator in Switzerland (Federal Office of Private Insurance – "FOPI") was assigned the goal to ensure that the receivables of policyholders are protected. Historically (as in many other countries) this goal has been achieved with a combination of measures. These include prudent reserving and pricing requirements as well as prescriptions over what assets are allowed to be held by insurance companies. On top of this, there is a requirement to meet a minimum solvency margin based on a simple standard formula.

⁶ H. Müller et al. (1997) Solvency of Insurance Undertakings, Conference of the Insurance Supervisory Services of the Member States of the European Union.

In Switzerland the financial stability of several insurers has been shaken in the past few years. Events which have had significant adverse effects include the crash in the equity markets in 2001 and 2002, the steady fall in bond yields as well as the impact of increased longevity. These events have significantly reduced market values of equity investments, and at the same time have increased the value of some embedded options and guarantees which have been sold by insurers in the past, leading to required reserve increases. For some insurers, the effects of the fall in the equity markets have been compounded by deteriorating technical results and large catastrophe claims.

This has led to a number of changes in the way insurance companies are being regulated, monitored and valued around the world. This includes changes to accounting rules, increased requirements for corporate governance within insurance companies, and enhanced solvency regulations and standards.

Herbert Lüthy, director of the FOPI, embarked on an analysis project for the reorientation of insurance supervision in autumn 2002 with the support of a task force. At the same time, a draft Insurance Supervision Act (ISA) was elaborated, submitted to the Federal Council and subsequently tabled in Parliament. In reference to solvency, the bill states that the solvency requirement should take account of the risks to which an insurance company is exposed.

In spring 2003 the director of the FOPI initiated the Swiss Solvency Test (SST) project (Chapter 6) with the aim of defining basic principles of a future system for determining solvency. This was done in cooperation with the insurance industry, consulting companies and academia.

In the following Chapters we will analyze the risk based solvency systems introduced above with particular focus on the “Swiss Solvency Test” and on its non-life standard model (Chapter 7).

In Chapter 8 we will calculate capital requirements of an insurance company under the “Swiss Solvency Test” standard model, two “Partial Internal Models”, and an “Internal Model”. For the same company we will recalculate the capital required under different Quantitative Impact Studies (Solvency II) in order to: understand the “Swiss Solvency Test” non-life standard model; make comparisons between this standard model and different approaches (Partial Internal Model and Internal Model); understand the changes

introduced in the different Quantitative Impact Studies; and make sensible comparisons between the “Swiss Solvency Test” and “Solvency II”.

Finally, in Chapter 9, we will examine the capital adequacy over different time horizons under the “Swiss Solvency Test” in order to understand the problematic related to a multi-year timeframe.

CHAPTER 1

THE NAIC RISK-BASED CAPITAL

Increases in the frequency and severity of insurer insolvencies in the mid-1980s led to concern about the adequacy of state insurance regulation and the accuracy of the methods used by regulators to provide early warning of insurer insolvencies. The National Association of Insurance Commissioners (NAIC) responded by adopting a “solvency policing agenda” in 1989. The agenda resulted in a number of changes in state solvency regulation, including the adoption of the Financial Analysis and Surveillance Tracking (FAST) solvency monitoring system and risk-based capital (RBC) requirements for both life and property-liability insurers. FAST was implemented in 1993, and the property-liability insurance RBC system went into effect in 1994.

Well-designed solvency monitoring systems should identify a high proportion of troubled companies early enough to permit regulators to take prompt corrective action and should minimize the number of financially sound insurers identified as being troubled.

The only prior tests of the FAST system were performed by GHK⁷ (1995, 1998). They tested the overall FAST score, a univariate summary statistic compiled by the NAIC based on the approximately 31 financial ratios comprising the FAST system. The NAIC assigns scores corresponding to a company’s ratios based on a subjective evaluation of the importance of the ratios and their relationship to solvency, and the scores are summed to obtain the company’s overall FAST score. Financial strength is considered to be inversely related to the overall FAST score. In their tests, the overall FAST score performs considerably better than RBC in predicting insolvencies, and the addition of the RBC ratio to the FAST- ratio prediction models leads to only modest improvements in predictive accuracy. A limitation of both the RBC and FAST systems is that they are

⁷ Grace, Harrington and Klein.

based on a “snapshot” of the firm at a given point in time, they are static rather than dynamic approaches to solvency testing.

The more modern approach to solvency testing is dynamic financial analysis (DFA), usually implemented using cash flow simulation. The NAIC risk-based capital (RBC) system was created to provide a capital adequacy standard that is related to risk, raises the safety net for insurers, is uniform across states, and provides regulatory authority for timely action (see NAIC 2009). There is a separate RBC formula for each of the principal types of insurance: life, property-casualty, and health. The RBC formulas utilize a “generic formula” approach rather than a deterministic or stochastic modeling approach. However, the life RBC formula incorporates some modeling elements relating to interest rate risk. The RBC system has two main components:

- the risk-based capital formulas, that establish minimum capital levels for insurers; and
- a risk-based capital model law that grants automatic authority to the state regulator to take specific actions based on the level of impairment, determined by comparing an insurer’s actual capital with its RBC.

The second part of the system was deemed particularly important because regulators previously had difficulty in closing down defaulting insurers because their actions could be challenged in court. During the solvency crisis of the late 1980s and early 1990s, some regulators also engaged in regulatory forbearance such that defaulting insurers were allowed to continue to run up deficits, which increased the required guaranty fund assessments.

RBC is calculated by multiplying risk-factor charges by various balance sheet and income statement quantities. A covariance adjustment is then applied to yield RBC for each firm.

The components of the RBC formula differ by industry segment. For property-casualty insurers, the following risk factors are included:

- R_0 - Asset risk for investments in subsidiary insurance companies; R_1 - asset risk for fixed income investment;
- R_2 - asset risk for equity investments;
- R_3 – asset risk, credit;
- R_4 - underwriting risk relating to reserves; and

- R_5 -underwriting risk relating to net written premiums.

For life insurance, the components are slightly different, with some overlap:

- C_0 - asset risk relating to affiliates;
- C_1 – credit risk of assets;
- C_2 – insurance risk;
- C_3 – interest rate risk; and
- C_4 – all other business risk.

The health insurance RBC formula consists of the following related components:

- H_0 – asset risk relating to affiliates;
- H_1 – other asset risk;
- H_2 – underwriting risk;
- H_3 – credit risk; and
- H_4 – business risk.

Thus, the property-casualty insurance RBC places more emphasis on reserving and underwriting risk, and life insurance is the only category with a separate charge for interest rate risk. The health insurance RBC places less emphasis on investment risk because health insurance is a much shorter-tail line of business than property-casualty or life insurance and hence does not generate invested assets to the same degree as the other two major lines of business.

After calculating the charges for the various risk factors in the RBC formulas, the next step is to combine the factor charges to come up with the overall RBC for each insurer. The designers of RBC recognized that it would not be appropriate simply to add up the charges to obtain overall RBC because it is unlikely that adverse experience would develop for all sources of risk simultaneously. Rather, it was anticipated that diversification exists among the risk factors, i.e., that adverse experience with one factor is likely to be offset by favorable experience with other risk factors. Thus, it was determined that a *covariance adjustment* should be applied. Because there was no general agreement on an approach for estimating correlations among the risk factors, the approach adopted was simply to assume that all risk factors, except the charge for asset risk relating to affiliates, were statistically independent. This assumption suggests a

square root approach to combining the factors. not used in the static systems and thus to lead to more accurate solvency prediction.

1.1 NAIC PROPERTY-LIABILITY RISK BASED CAPITAL SYSTEM

As explained in the previous section the NAIC property-liability risk-based capital system consists of a series of ratios that are multiplied by various balance-sheet and income statement variables to compute RBC “charges” for the principal risks facing insurers. The sum of the charges, reduced by a covariance adjustment, equals the insurer’s risk-based capital. The insurer’s actual capital is divided by its risk-based capital to obtain the RBC ratio, and regulatory action is prescribed for insurers whose RBC ratios fall below specified thresholds (see section 1.3).

The property/casualty risk-based capital formula was developed from the corresponding life insurance formula which groups risks into four categories, C-1 through C-4, which correspond roughly to asset risks, underwriting risks, interest rate risk, and other risks.

This structure was most evident in the first draft of the property/ casualty formula, which was released in April 1991, and it is retained in the NAIC “Risk-Based Capital Model Act”⁸.

The desire to have similar capital charges for life, health, and property/casualty insurers is referred to as a “seamless” capital requirement. In other words, the capital required to protect against any risk should not depend on whether the company is licensed as a life insurer or as a property/casualty insurer.

For asset risks, which were considered similar for life and property/casualty companies, the capital charge was adopted without modification from the life formula, and the statistical analysis for the charges was done by the life actuarial advisory committee.

Underwriting risks are entirely different between life and property/casualty products. The property/casualty capital charges were developed by the NAIC Working Group and by the New York Insurance Department staff.

Interest rate risk was not considered in the first draft of the property/casualty formula, though proposed capital charges have since been recommended by the AAA Task Force.

⁸See NAIC Risk-Based Capital Model Act, Section 2.C on pages 312-3 through 312-4.

The most important of the “other risks” is the credit risk charge for reinsurance recoverable.

A second draft of the formula, with significant changes from the earlier version, was released in June 1993, and it was adopted by the NAIC in December 1993 after several revisions. The most important change was the incorporation of a “covariance adjustment,” which necessitated a different structure for the capital charges. For instance, “asset risks” were divided into three categories:

- unaffiliated fixed-income investments;
- unaffiliated equity investments, which were assumed to be independent risks; and
- affiliated investments, which did not enter the covariance adjustment at all.

The risk-based capital requirements were first effective for the 1994 Annual Statement. Minor modifications continue to be made to the formula, though there are few significant differences to date between the 1994 and the subsequent formulas.

This part presents the risk-based capital formula as adopted in December 1993.

The various capital charges in the risk-based capital formula are first combined into six categories, termed R0 through R5, as follows:

- R0 :
 - investments in insurance affiliates;
 - non-controlled assets;
 - guarantees for affiliates; and
 - contingent liabilities.
- R1 :
 - fixed income securities;
 - cash;
 - bonds;
 - bond size adjustment factor;
 - mortgage loans;
 - short term investments;
 - collateral loans;
 - asset concentration adjustment for fixed income; and
 - securities.

- R2 :
 - equity investments;
 - common stocks;
 - preferred stocks;
 - real estate;
 - other invested assets;
 - aggregate write-ins for invested assets; and
 - asset concentration adjustment for equity investments.
- R3 :
 - credit risk;
 - reinsurance recoverables; and
 - other receivables.
- R4 :
 - reserving risk;
 - basic reserving risk charge;
 - offset for loss-sensitive business;
 - adjustment for claims-made business;
 - loss concentration factor; and
 - growth charge for reserving risk.
- R5 :
 - written premium risk;
 - basic premium risk charge;
 - offset for loss-sensitive business;
 - adjustment for claims-made business;
 - premium concentration factor; and
 - growth charge for premium risk.

Butsic recommended that the risk charges be combined by a square root rule.

Of the six risk categories listed above, R0 remains outside the square root rule and the remaining five risk categories are included inside the square root rule, or

1

$$RBC = R_0 + \sqrt{R_1^2 + R_2^2 + R_3^2 + R_4^2 + R_5^2}$$

The proper categorization of the risk charges is essential for determining the overall capital requirements. We must underline that:

- after the credit risk charge has been calculated, one half of this charge is removed from R3 and added to R4. This compensates for the inconsistency between (i) the interdependence of reserving risk and reinsurance collectability risk and (ii) the lack of a covariance term in the square root rule;
- the R0 term appears *outside* the square root rule, whereas all the other terms appear *inside* the square root rule. This makes it especially important to know which charges for affiliates appear in R0. Charges for insurance subsidiaries, whether U.S.-based subsidiaries or alien subsidiaries, are included in R0, so as to avoid a reduction of overall capital requirements by simple “layering” of the company’s legal structure. Charges for non-insurance subsidiaries or affiliates appear in R1 or R2, depending on whether the insurer owns bonds or stock of the affiliate; and
- the determination of which investments are considered for the asset concentration factor is done for all assets combined, not separately for R1 and R2. The asset concentration factor charges are then separated into their R1 and R2 components for inclusion in the square root rule.

1.1.1 ASSET RISK

The asset risk charges, which were largely adopted from the life insurance formula, stem from the charges in the life insurance Mandatory Securities Valuation Reserves (MSVR). The asset risk charges are the dominant piece of the life insurance risk-based capital formula, though they are of lesser importance for the property/casualty formula, for both practical and theoretical reasons.

Asset charges (“investment RBC”) accounted for about 21 percent of the total property-liability insurer RBC in 1992. The bond and preferred stock (for non-affiliates) factors are based on NAIC valuation categories, which generally parallel Moody’s and Standard & Poor’s. The bond factors range from 0 for Treasury bonds to 30 percent for

bonds in or near default. They are adjusted upward (downward) if the number of issuers reflected in its bond portfolio is less (more) than 1 300 to reflect the diversification of credit risk across issuers (Klein, 1995). There is a 15 percent charge for common stocks of non-affiliated corporations. An asset concentration factor increases the RBC charges for the 10 largest asset exposures grouped by issuer.

1.1.2 CREDIT RISK

The credit component of the formula ("credit RBC") applies a 10 percent charge to reinsurance recoverable from non-affiliates and affiliated alien insurers and smaller charges to various other receivables. Additional RBC charges are given to insurers with three-year average growth in gross premiums written in excess of 10 percent and for off-balance-sheet liabilities. We refer to these two components as "growth RBC." In 1992, credit RBC accounted for 10 percent of total industry RBC and growth RBC accounted for 1 percent of the total.

The first (April 1991) draft of the risk-based capital formula, as well as the final version adopted in December 1993 (with the exceptions noted below), contained a 10 percent charge for reinsurance recoverables. No statistical rationale for this factor was put forth, and many reinsurers and trade organizations argue that the charge is excessive.

1.1.3 UNDERWRITING RISKS

The charges for underwriting risks are the dominant portions of the risk-based capital formula. These charges have little similarity to the "C-2" charges in the life insurance formula. Most of the underwriting risk charges were developed by the staff of the New York Insurance Department or by the AAA RBC Task Force. Much controversy continues, both within the NAIC research department and among outside analysts, as to whether these charges accurately quantify the risks faced by insurance enterprises.

1.1.3.1 RESERVING RISK

The reserving risk charge in the risk-based capital formula measures the susceptibility of loss reserves to adverse developments.

The charge is quantified separately by line of business, using Schedule P⁹ data for the past ten years.

The reserving risk charge does not attempt to measure the adequacy of reported reserves. Measurement of a company's loss reserve adequacy is handled by state financial examinations and by analysis of Schedule P, not by the risk-based capital formula. For most companies, the reserving risk charge is the dominant part of the risk-based capital requirements. Because of the importance of this charge, numerous criticisms have been leveled against the quantification method, and alternatives have been proposed.

The reserving risk charge begins with the calculation of adverse loss development ratios by Schedule P line of business.

This calculation was done by the NAIC staff in 1993, and the resulting charges were "frozen." Individual ratios may be updated by the NAIC as the need arises; this component of the reserving risk charge is not recalculated each year.

We begin with adverse loss development ratios by company and by Schedule P line of business.

- The numerator of this ratio is the increase in estimated ultimate incurred losses between two statement dates.
- The denominator of the ratio is the held loss reserves at the earlier statement date. The held loss reserves are determined by subtracting paid losses from incurred losses.

These calculations are performed separately by:

- individual company (not company group);
- Schedule P line of business; and

⁹ Schedule P is a complex section of the Annual Statement, demanding much expertise to complete and to understand. Schedule P provides an analysis of losses and loss expenses, with 10 years of premiums earned, losses unpaid, and claims reported and outstanding.

- statement date (e.g., changes in incurred losses for accident years 1982 and prior between statement dates 1982 and 1991, changes in incurred losses for accident years 1983 and prior between statement dates 1983 and 1991, and so forth).

Individual company ratios are averaged to determine the base industry reserve charges which are promulgated by the NAIC. Individual companies need not perform these calculations. A high or low adverse development ratio for a specific company affects the industry charge in this part of the formula.

For each line of business, the individual company development ratios are averaged over all companies for each statement date. In other words, the derivation of the reserving risk charge begins with a three-dimensional matrix of adverse loss development ratios, with several thousand companies, nine statement dates, and fifteen Schedule P lines of business. The averaging across companies leaves a two-dimensional matrix, with nine statement dates and fifteen lines of business.

Simple averages are used, not weighted averages, so the adverse loss development for an insurer with \$100 000 of reserves is given the same weight as that for an insurer with \$10 billion of reserves.

The greatest average value is selected from among all the statement dates.

The risk-based capital standards imply: “This adverse development happened in the past, so it might happen again. Insurers need sufficient capital to withstand adverse loss reserve development of this magnitude.”

Statutory accounting requires that loss reserves be reported at undiscounted values. The “implicit interest margin,” or the difference between the discounted value of the reserves and the undiscounted value of the reserves, serves as an implicit “cushion” for solvency. Not taking this implicit “cushion” into account would double-count the required capital: an explicit capital requirement held as surplus and an implicit capital cushion held as reserves.

The implicit interest margin differs by line of business, depending on the loss payout pattern of the reserves. To quantify the loss payout pattern for most lines of business, the

risk-based capital formula uses the same method as employed by the IRS¹⁰ for its loss reserve discounting procedure. The payout pattern is determined by comparing paid losses to incurred losses by accident year and line of business.

The IRS and the risk-based capital formula use different discount rates. For determining taxable income of property/casualty insurance companies, the IRS uses a sixty-month moving average of the Federal Midterm Rate, which is the rate on outstanding Treasury securities with remaining terms between 3 and 9 years. The risk-based capital formula uses a flat 5% discount rate.

Companies differ both in their reserve estimation procedures and in the types of risks that they write. Some companies consistently report adequate full value reserves, and they show little adverse development in subsequent years. Other companies report less adequate reserves, as a result of either conscious management decisions or poor actuarial work, and they show significant adverse loss development in subsequent years.

The NAIC risk-based capital formula compares the company's own average loss development by line of business over the past nine years to that of the industry.

For example if the company's average adverse development is 4% and the corresponding industry average adverse development is 6.5% the ratio of company to industry average adverse loss development is $1.040/1.065=0.977$. Being the "worst case year" industry adverse development, before any adjustment for the implicit interest margin, equals to 25.4%, the factor 0.977 is applied to the industry "worst case year" adverse loss development to give a company-specific worst case year adverse development factor of 0.248 ($0.254*0.977$). A simple average is taken of the company-specific factor and the industry wide factor to give the "company risk-based capital percentage". This averaging may be conceived of as a credibility weighting of company adverse loss development and industry adverse loss development, with 50%credibility assigned to each component. In this illustration, the "company risk-based capital percentage" equals $(0.254+0.248)/2$, or 0.251. This figure, plus unity, is multiplied by the "implicit interest margin" of 0.921¹¹ to give a final charge of $1.251*0.921 = 1.152$, or 15.2% of carried reserves.

¹⁰ Internal Revenue Service. The federal agency responsible for administering and enforcing the Treasury Department's revenue laws, through the assessment and collection of taxes, determination of pension plan qualification, and related activities.

¹¹ The implicit interest adjustment, using the IRS discounting procedure with a flat 5% annual rate, implies that discounted reserves are only 92.1% of the undiscounted values.

1.1.3.2 WRITTEN PREMIUM RISK

The reserving risk charge guards against the risk that the company's past business will turn out to be less profitable than expected, that reserves will develop adversely. Equally important is the risk that the company's future business will be unprofitable, and that the company will have to cover underwriting losses with surplus funds.

One can develop capital charges to guard against potential underwriting losses over various time horizons, such as during the coming 12 months or during the coming five years. The risk-based capital formula uses a time horizon of one year: the potential underwriting losses to be considered are those that may occur during the next 12 months. Ideally, one would base the capital charge for future underwriting losses on the volume of business to be written during the coming year. As a proxy for the volume of business to be written during the coming year, the risk-based capital formula uses the volume of business written during the most recent calendar year. This future underwriting risk is termed "written premium risk."

The structure of the written premium risk charge is similar to that of the reserving risk charge. Average industry loss and loss adjustment expense ratios by accident year and by line of business are determined from Schedule P, Part 1, for the past ten years, by simple (unweighted) averages of individual company figures. The "worst case year," or the year with the highest average loss ratio, is selected.

The Schedule P loss ratios are "ultimate" figures (also termed "nominal" figures, or "undiscounted" figures). Particularly for the long-tailed lines of business, the expected investment income resulting from the time lag between premium collection and loss payment is an important consideration in the profitability of a book of business. The "worst case year" loss ratio is therefore multiplied by an investment income factor, which is derived from an IRS payment pattern and a 5% discount rate.

The "adjustment for investment income" used for the premium risk charge is not the same as the "adjustment for investment income" used for the reserving risk charge. The former reflects the expected investment income from policy inception to final loss payment for a newly issued block of business. The latter reflects the expected investment income on assets supporting the loss reserves currently held by the company for all accident years combined.

The relative magnitude of these two sets of figures depends on premium collection patterns and loss settlement patterns by line of business. The risk-based capital formula has greater premium risk “investment income adjustments” for workers compensation, medical malpractice, other liability, and products liability, but greater reserving risk “investment income adjustments” for homeowners, special liability, international, and reinsurance A and C.

Just as is true for the reserving risk charge, the premium risk charge is adjusted for the company’s own experience compared to that of the industry. Assume that the worst case year industry average loss ratio is 104.6%, and the average of all ten years’ industry average loss ratios is 94.7%. Suppose also that a given company has a worst case year loss ratio of 110% and a ten year average loss ratio of 85%. The individual company’s worst case year loss ratio is not used in the calculation; only the worst case year industry average loss ratio is used. However, the industry worst case year figure is adjusted for the individual company’s average loss ratio compared with that of the industry, with equal weight given to industry and company experience. In this illustration, the ratio of company to industry average loss ratios is 0.898 (0.850×0.947).

To give equal weight to industry and company experience, the industry worst case year loss ratio is multiplied by a factor of $(1 + 0.898) / 2 = 0.949$, giving an adjusted worst case year loss ratio of 99.3% ($104.6\% \times 0.949$).

Supposing that the “adjustment for investment income” factor is 0.924, the discounted worst case year loss ratio for this company’s risk-based capital calculations is therefore $99.3\% \times 0.924 = 91.8\%$:

The company’s (not the industry’s) average expense ratio is added to this loss ratio to give a worst case year combined ratio.

For instance, supposing that:

- the industry’s worst case year loss ratio, after adjustments for the individual company’s experience and for the interest discount (expected investment income), for a particular line of business, is 94%; and
- the company’s average expense ratio (for all lines combined) is 23%;

then the combined ratio used in the formula is 117% ($94\% + 23\%$). The written premium risk charge is calculated as the worst case year combined ratio minus unity. If the

company wrote \$50 million of business in this line in the most recent calendar year, then the capital requirement is $\$50 \text{ million} \times 17\% = \8.5 million .

1.1.3.3 UNEARNED PREMIUM RESERVES

The previous sections have dealt with reserving risk and with written premium risk, but there is a risk intermediate between these two: the risk that underwriting results may turn out to be worse than expected on coverage that has already been written but has not yet been earned. Just as the insurer holds loss reserves for coverage that has already been earned but for which claims are not yet fully settled, the insurer holds unearned premium reserves for coverage that has been written but has not yet been earned. Just as the reserving risk charge protects against unanticipated adverse development on the loss reserves, should there not be a similar charge to protect against the possibility that the unearned premium reserves may be insufficient to fund the claims that will arise on this coverage?

This is the underlying structure of the risk-based capital formula, and the first (April 1991) draft of the formula indeed had a charge applied to the unearned premium reserves. In fact, if insurance companies held “net” unearned premium reserves - that is, “net” of prepaid expenses - the factors used to compute the unearned premium reserves charge would be about the same size as the factors used to compute the written premium risk charge.

But statutory accounting requires insurance companies to hold unearned premium reserves *gross* of all prepaid expenses. Unlike GAAP¹², statutory accounting does not allow a deferred policy acquisition expense asset.

The objective of statutory accounting for unearned premium reserves is conservatism. For most companies, the gross unearned premium reserve is about 20% to 25% greater than the amount actually needed to fund future claims. This statutory margin is referred to as the “equity” in the unearned premium reserves.

¹² Generally Accepted Accounting Principles (GAAP) is a term used to refer to the standard framework of guidelines for financial accounting used in any given jurisdiction which are generally known as Accounting Standards. GAAP includes the standards, conventions, and rules accountants follow in recording and summarizing transactions, and in the preparation of financial statements.

For almost all lines of business, this margin is more than sufficient to guard against unexpectedly poor underwriting results on the unexpired portions of policies that have already been written.

Just as the reserving risk charge and the written premium risk charge contain offsets for expected investment income, the unearned premium reserves risk charge in the first (April 1991) draft of the risk-based capital formula contained an offset for prepaid acquisition expenses. With this offset, the charge was either zero or insignificant for almost all lines of business.

To simplify the formula, the unearned premium reserves risk charge was deleted, since it did not contribute significantly to the final capital requirements. In the final draft of the formula, no relic of this charge remains, because statutory accounting already contains a more than sufficient margin for this risk.

1.2 THE FAST SYSTEM

The NAIC's financial analysis and surveillance tracking (FAST) system and the older insurance regulatory information system (IRIS) were designed to prioritize insurers for further regulatory action.

The IRIS system consists of 12 audit ratios with published ranges that are deemed acceptable by the regulators. The FAST system consists of approximately 30 ratios and corresponding scores for each ratio (Klein, 1995). The ultimate output from the FAST system is the overall FAST score equal to the sum of the individual insurer's audit ratios multiplied by the corresponding scores. Companies performing poorly in terms of the IRIS and FAST test results are given a higher priority by regulators in deciding upon subsequent regulatory attention. The FAST system was introduced in part as a result of the allegation that insurers were able to "game" the IRIS system because it is based on only a few ratios, for which the regulatory action cutoffs are specified in advance and rarely changed (Klein, 1995). In contrast to the IRIS system, the FAST scores are not revealed by the NAIC, and both the ratios and the scores could change over time as new information becomes available. Thus, the FAST system is expected to provide more accurate solvency predictions than the IRIS system. Even though not all of the IRIS ratios appear in the FAST system in precisely the same form, nearly all of the relevant information captured by IRIS is also incorporated in FAST, and FAST captures a significant amount of information not

reflected in IRIS (Grace, Harrington, and Klein, 1995). We focus on the FAST system rather than the IRIS system. Grace, Harrington, and Klein (1995) tested FAST against alternative specifications and with additional scoring methods. After an exhaustive investigation, the authors concluded that changes in the scoring methodology and other alternative specifications did not lead to better predictions than a logistic regression model based solely on the FAST ratios and other firm characteristic variables (such as total assets and a mutual versus stock dummy variable). Thus, the authors concluded that there are diminishing returns to examining additional audit ratios based on financial statement data and that other approaches that add new types of information to solvency analysis, such as cash flow simulation, should be explored. However, as mentioned above, their tests are subject to potential bias because the scores and ratios they used were modified after the fact by the NAIC and thus contain information that would not have been known in a true ex ante test of predictive accuracy.

1.3 REGULATORY ACTION

Some regulators argue that insurance departments must be afforded great discretion in their dealings with domestic insurance companies. Other regulators have argued that certain actions must be required of regulators, particularly when the needed action is unpleasant.

The risk-based capital requirements are a compromise between these two viewpoints. There are four levels of regulatory action, depending on the relationship between the “adjusted surplus” held by the company and the “risk-based capital surplus.” This ratio is termed the “risk-based capital ratio”.

1.3.1 THE ACL LEVEL

The levels of regulatory action actually depend not on the risk-based capital ratio but on the relationship of the company’s adjusted surplus to the risk-based capital “authorized control level” (ACL) benchmark. At first glance, this seems a superficial distinction, since the authorized control level is a percentage of the risk-based capital standard. In practice, it is easier to change the authorized control level than the risk-based capital formula itself, and thereby implicitly change all the regulatory action levels.

For example, during the first half of 1993, the ACL benchmark was expected to be 50% of the risk-based capital standards.

This would have forced many companies into rehabilitation or liquidation, and may have led to substantial opposition to the new risk-based capital standards.

However, the June 1993 draft of the risk-based capital formula defined the ACL benchmark as 40% of the risk-based capital standards. At this level, only about half as many companies would have been forced into rehabilitation or liquidation; as a result, opposition to the new standards was muted.

In October 1993, the NAIC shifted back to a 50% ACL benchmark, with a two-year phase-in from 40% to 50%, thereby giving time to companies to strengthen their capital positions. By this time, the industry waters were placid, and in December 1993 the risk-based capital formula was adopted without significant opposition.

The NAIC envisions four levels of regulatory or company action, depending on the relationship of the company's actual (adjusted) surplus to its risk-based capital surplus. A property/ casualty insurance company's actual surplus is adjusted for risk-based capital purposes by removing the amount of non-tabular loss reserve discounts from surplus (and adding them to reserves). Tabular loss reserve discounts do not affect the company's reported surplus for risk-based capital purposes.

1.3.1.1 COMPANY ACTION LEVEL

The company action level is 75% to 100% of the risk-based capital standard, or 150% to 200% of the authorized control level benchmark (the figures here assume an ACL benchmark equal to 50% of the risk-based capital surplus). If the company's adjusted surplus is within the company action range, no action is required of the state insurance department. Rather, the company must submit a plan of action to the insurance commissioner of the domiciliary state, explaining how the company intends to obtain the needed capital or to reduce its operations or risks to meet the risk-based capital standards.

1.3.1.2 REGULATORY ACTION LEVEL

The regulatory action level is 50% to 75% of the risk-based capital standard, or 100% to 150% of the ACL benchmark. The company's action is the same as at the "company action level": it must submit a plan to the insurance commissioner explaining how it intends to raise its risk-based capital ratio. If the company's adjusted surplus is within the regulatory action level range, then the commissioner has the right to take corrective action against the company, such as by restricting new business.

However, all action by the state insurance department is discretionary; nothing is mandated by the risk-based capital formula or associated statutes.

1.3.1.3 AUTHORIZED CONTROL LEVEL

The authorized control level is 35% to 50% of the risk-based capital standard, or 70% to 100% of the ACL benchmark. If the company's adjusted surplus is within the ACL range, regulatory action is still discretionary, but the insurance commissioner is "authorized" to take control of the company.

1.3.1.4 MANDATORY CONTROL LEVEL

The extreme level of regulatory action, the mandatory control level, is below 35% of the risk-based capital requirements, or below 70% of the ACL benchmark. If the company's (adjusted) actual surplus is below 70% of the authorized control level, then the insurance commissioner of the domiciliary state must rehabilitate or liquidate the company.

CHAPTER 2

THE CANADIAN MINIMUM CAPITAL TEST

Canadian insurance companies may be registered either with a provincial government or with the federal government. Companies must also be licensed in each province in which they conduct business. The provinces have exclusive power to regulate rates, insurance contracts and claim settlements. Insurers must satisfy the solvency requirements of their jurisdiction of incorporation and each province in which they are licensed. However, as the federal Office of the Superintendent of Financial Institutions (OSFI) is not involved in rate and contract regulation, the provinces (with occasional exceptions especially Quebec) have chosen to let OSFI take a leading role in the regulation of solvency. Relevant federal legislation includes an act establishing the powers of OSFI, the Canadian and British Insurance Companies Act, the Foreign Insurance Companies Act and an act which essentially defines actuaries as Fellows of the Canadian Institute of Actuaries. The Canadian and British Insurance Companies Act and the Foreign Insurance Companies Act have similar provisions, as do provincial acts respecting insurance. Federal - provincial co-ordination is enhanced by the use of uniform annual statements. Federal solvency regulation in Canada has been based on three complementary pillars. The first is the minimum asset test. The test basically compares surplus, determined on a liquidity basis, to a margin which is the greater of:

- 15% of outstanding claim reserves;
- 15% of gross written premium (with a credit for reinsurance of up to 50%);
- 22% of gross incurred claims (with a similar credit of up to 50%).

Prior to 1981 there had only been two small failures of property casualty companies in Canada, one of which was wound down without loss to policyholders. Since 1980 there have been failures associated with each bottom of the underwriting cycle. In 1981/82 two

companies with a combined market share of 0.5% failed. In 1985/86 another four companies, with market share of 1.4% failed. A further two companies, with a market share of 0.3%, failed in the latest 1989/1990 trough. The shock of the first set of failures prompted a re-examination of solvency issues by regulatory authorities and was accelerated by the second set of failures in 1985/1986. The most visible regulatory initiatives were changes in the Canadian and British Insurance Companies Act in three key areas. First, the Surplus Test provisions were strengthened by providing for minimums based on written premiums and incurred claims as well as the existing margins on reserves. Second, regulations were issued to address the excessive use of reinsurance as well as the use of unregistered reinsurance. Third, actuarial certification of the adequacy of outstanding claims and unearned premium provisions is required for all companies' 1992 annual statements. Another initiative was the creation of the Property and Casualty Insurance Compensation Corporation (PACIC). This corporation functions like the guarantee funds in many U.S. states. Membership in this national organization is mandatory for all insurers operating in participating jurisdictions. PACIC co-operates with the liquidators of insurance companies, usually a regulatory authority, to ensure that all covered claims between \$500 and \$200 000 are paid. Expenses and claims are covered by member companies on a post-assessment basis and by recoveries from the failed insurer. For life companies, Minimum Continuing Capital and Surplus Requirements (MCCSR) was introduced in 1992 while, for non –life companies, in 2003 Minimum Capital Test was implemented (analyzed in section 2.3).

2.1 DEFINITION OF CAPITAL

The risk-based capital adequacy framework assesses the riskiness of assets, policy liabilities, structured settlements, letters of credit, derivatives and other exposures, by applying varying factors. P&C insurers are required to meet a Capital Available to Capital Required test. The three primary considerations for defining the capital of a P&C insurer for purposes of measuring capital adequacy are:

- its permanence;
- its being free of any obligation to make payments from earnings; and

- its subordinated legal position to the rights of policyholders and other creditors of the institution.

The integrity of capital elements is paramount to the protection of policyholders.

Capital Available includes instruments with residual rights that are subordinate to the rights of policyholders and which will be outstanding over the medium term. It also includes an amount to reflect changes in the market value of investments. Capital Available is restricted to the following, subject to requirements of the regulator:

- Equity
 - shares treated as equity under GAAP;
 - contributed surplus;
 - retained earnings;
 - reserves;
 - general and contingency reserves; and
 - consolidated non-controlling interests (see note below).¹³
- Subordinated indebtedness and preferred shares whose redemption is subject to regulatory approval;
- certain components of Accumulated Other Comprehensive Income:
 - accumulated net after-tax unrealized gains(losses) on available-for-sale equity securities;
 - accumulated net after-tax unrealized gains (losses) on available-for-sale debt securities; and

¹³Consolidated non-controlling interests:

- Companies will generally be permitted to include in Capital Available, non-controlling interests in operating subsidiaries that are consolidated for MCT purposes, provided that the capital in the subsidiary is not excessive in relation to the amount necessary to carry on the subsidiary's business, and the level of capitalization of the subsidiary is comparable to that of the insurance company as a whole.
- If a subsidiary issues capital instruments for the funding of the company or that are substantially in excess of its own requirements, the terms and conditions of the issue, as well as the intercompany transfer, must ensure that investors are placed in the same position as if the instrument were issued by the company in order for it to qualify as capital on consolidation. This can only be achieved by the subsidiary using the proceeds of the issue to purchase a similar instrument from the parent. Since subsidiaries cannot buy shares in the parent property and casualty company, it is likely that this treatment will only be applicable to the subordinated debt. In addition, to qualify as capital for the consolidated entity, the debt held by third parties cannot effectively be secured by other assets, such as cash, held by the subsidiary.

- accumulated net after-tax foreign currency gains (losses), net of hedging activities.

The following amounts are deducted/adjusted from the total of Capital Available:

- amounts receivable and recoverable from unregistered reinsurers to the extent that they are not covered by deposits held as security from assuming reinsurers;
- deferred policy acquisition expenses that are not eligible for either the 0% capital factor or the 35% capital factor;
- net after-tax impacts of shadow accounting;
- future income tax assets that are not eligible for the 0% capital factor;
- goodwill and other intangible assets;
- other assets in excess of 1% of Total Assets;
- accumulated net after-tax fair value gains (losses) arising from changes in a company's own credit risk;
- adjustment to own-use property valuations:
 - subtract unrealized fair value gains (losses) reflected in retained earnings at conversion to IFRS; and
 - add accumulated net after tax revaluation losses in excess of gains that are reflected in retained earnings for accounting purposes.
- IFRS¹⁴ phase-in adjustment:
 - institutions may elect to phase in the impact of IFRS 1 when calculating regulatory capital. The election is irrevocable and its impact on regulatory capital must be disclosed. Although FRFI¹⁵'s should be taking steps in advance of conversion to IFRS to minimize the impact of IFRS 1, the phase-in period for regulatory capital purposes begins at the date of conversion to IFRS and must be completed by the quarter ending on or after December 31, 2012. Phase-in is made on a straight-line basis.

No asset factor is applied to items that are deducted from Capital Available.

¹⁴ International Financial Reporting Standards (IFRS) are principles-based Standards, Interpretations and the Framework (1989) adopted by the International Accounting Standards Board (IASB).

¹⁵ Federally regulated financial institution.

The Capital Available treatments for investments in subsidiaries, associates and joint ventures are as follows:

Investment	Capital Available
1. Consolidated Subsidiaries	Included via full consolidation
2. Non-Qualifying Subsidiaries	Excluded
3. Substantial Investments in Associates and Joint Ventures (> 10% ownership interest)	Excluded
4. Joint Ventures ≤ 10% ownership interest	Included using the equity method

Table 1: Capital Available treatments for investments in subsidiaries, associates and joint venture.

2.2 CAPITAL REQUIREMENTS FOR LIFE COMPANIES

For life companies, Minimum Continuing Capital and Surplus Requirements (MCCSR) was introduced in 1992, and since then, has been modified annually. Nowadays, consistently with the “Draft Guideline” published in March 2010 by OSFI, a life insurer's minimum capital requirement is determined as the sum of the capital requirements for each of the following five risk components:

- asset default risk, C1, which is the risk of loss resulting from on-balance sheet asset default and from contingencies in respect of off-balance sheet exposure and related loss of income, and the loss of market value of equities and related reduction of income;
- mortality/morbidity/lapse risks, C2, which is risk that assumptions about mortality, morbidity and lapse will be wrong;
- changes in interest rate environment risk, C3, which is the risk of loss resulting from changes in the interest rate environment other than asset default and interest margin pricing risks;
- segregated funds risk, C4, which is the risk of loss arising from guarantees embedded in segregated funds; and
- foreign exchange risk, C5, which is the risk of loss resulting from fluctuations in currency exchange rates.

Four types of approaches are used to find MCCR:

- a factor approach based on assets or on liabilities is used for credit, market (interest rate) and pricing risks;
- a formula approach (using current policies future cash flows and risk assumptions based on experimented values) is used for the mortality insurance risks;
- a scenario approach (one scenario) is used (based on current policies' future cash flows and risk assumptions from experimented values) for the insurance lapse risks; and
- a mixed approach (company model or factors based on industry model) is used for Segregated Funds guarantees.

For what concerning the definition of capital, it comprises two tiers, tier 1, core capital, and tier 2, supplementary capital, and involves certain deductions, limits and restrictions. The definition encompasses available capital within all subsidiaries that are consolidated for the purpose of calculating the capital requirement.

For the purpose of calculating the MCCR tier 1 ratio, the measure of available capital used is adjusted net tier 1 capital, after the application of all limitations. For the purpose of calculating the total MCCR ratio, the measure of available capital used is adjusted net tier 1 capital plus net tier 2 capital, after the application of all limitations to both components.

Notwithstanding the capital requirement described, Canadian life insurance companies will be required to maintain a minimum amount of available capital of \$5 million or such amount as specified by the Minister.

2.3 CAPITAL REQUIREMENTS FOR NON-LIFE COMPANIES

Capital Required is based on the same consolidation methodology as is used in determining Capital Available.

A P&C insurer's minimum capital requirement is the sum of:

- capital for Assets;
- margins for Unearned Premiums, Premium Deficiencies and Unpaid Claims ;

- catastrophe Reserves and Additional Policy Provisions;
- margin for Reinsurance Ceded to Unregistered Reinsurers; and
- capital for Structured Settlements, Letters of Credit, Derivatives and Other Exposures.

Notwithstanding the stated requirements, in any case where the regulator believes that the capital treatment is inappropriate, a specific capital charge would be determined.

P&C insurers will be expected to maintain Capital Available equal to at least the minimum Capital Required. The regulator may prescribe a higher capital requirement, including for an individual P&C insurer, taking into account such factors as operating experience, diversification of the asset or insurance portfolios, and retention limits.

Mortgage insurers are expected to maintain core capital (Capital Available as defined for MCT purposes, but excluding subordinated debt) sufficient to cover 100% of Capital Required. This requirement currently applies only to federally regulated insurers.

The MCT measures the capital adequacy of a P&C insurer. It is one of several indicators that the regulator uses to assess financial condition and should not be used in isolation for ranking and rating insurers.

2.3.1 DESCRIPTION OF THE ASSET RISKS

The Capital Required for assets covers:

- the potential losses resulting from asset default and the related loss of income;
- the loss of market value of equities and the related reduction in income.

To determine the risk-based capital requirement for assets, P&C insurers must apply a factor to the balance sheet value of each asset. For loans, the factors are applied to amortized cost (no asset factors are applied to assets deducted from Capital Available).

The total of these amounts represents the Capital Required for asset risks.

2.3.2 CAPITAL REQUIRED FOR POLICY LIABILITIES

This risk component reflects the insurer's consolidated risk profile by individual classes of insurance and results in specific margin requirements on policy liabilities.

For the MCT, the risk associated with policy liabilities is divided into four parts:

- variation in claims provisions (Unpaid Claims);
- possible inadequacy of provisions for Unearned Premiums;
- possible inadequacy of provisions for premium deficiencies; and
- occurrence of catastrophes.

2.3.2.1 MARGINS FOR UNEARNED PREMIUMS, PREMIUM DEFICIENCIES AND UNPAID CLAIMS

Given the uncertainty that balance sheet provisions will be sufficient to cover the anticipated liabilities, margins are added to cover the potential shortfall. The margins establish a balance between the recognition of varying risks associated with different classes of insurance and the administrative necessity to minimize the test's complexity.

From a regulatory perspective, these margins are included to take into account possible abnormal negative variations in the amounts calculated by actuaries, given the fact that the margins added by actuaries in their valuation are primarily intended to cover expected variations.

Margins on Unpaid Claims and Unearned Premiums are applied to the net amount at risk (i.e., net of reinsurance, Salvage and Subrogation, and Self Insured Retentions) by class of insurance.

The Unearned Premiums margin is applied to the greater of the net Unearned Premiums or 50% of the net written premiums in the last 12 months. The margins are as follows:

Class of Insurance	Margin on Unearned Premiums	Margin on Unpaid Claims
Personal property & commercial property	8%	5%
Automobile-Liability & personal accident	8%	10%
Automobile-Other	8%	5%
Liability	8%	15%
Accident and Sickness	- ¹⁶	-
Mortgage	-	15%
All others	8%	15%

Table 2: Margins for unearned premiums and unpaid claims.

¹⁶ For this values see Appendix A of Office of the Superintendent of Financial Institutions Canada, "Minimum Capital Test (MCT)", <http://www.osfi-bsif.gc.ca/>, 2010;

A margin of 8% applies to premium deficiencies.

2.3.2.2 CATASTROPHES

For Earthquake and Hurricanes provisions, insurers have the option of using the default or the model-generated amounts. An insurer may move from using the default calculation to the model-generated computation but may not go back to using the default method without the prior approval of the Commission.

Companies that choose to use computer models are expected to demonstrate an understanding of the model employed in estimating the company's Probable Maximum Loss (PML)¹⁷ including an understanding of the type of data and assumptions used in the model as well as the manner in which data and assumptions are incorporated. Companies need to have a sound understanding of the assumptions included in their PML estimates and the sensitivity of the estimates to changes in assumptions.

Computer models developed externally or internally, must meet the Commission's criteria.

- **DEFAULT METHOD:**

Insurers issuing policies for the coverage of hurricanes or earthquakes are required to record a provision of 30% of net premium earned (i.e. net of reinsurance) on policies that provide catastrophe protection. A breakdown of premiums by class of insurance and catastrophe protection must be included in the Notes to the MCT Schedule.

- **MODEL-GENERATED METHOD:**

Provision = (Greater of (PML500, Hurricane - Reinsurance Collectable ,Hurricane) and (PML500,Earthquake – Reinsurance Collectable, Earthquake)) - Retention

Provision must be greater than or equal to zero.

PML500 is the Gross Probable Maximum Loss from wind storm or earthquake estimated using a 500 year event return period¹⁸ at a 75 per cent damageability confidence level for

¹⁷ PML is the threshold dollar value of losses beyond which losses caused by a major catastrophe are unlikely.

¹⁸ Event return period corresponds to the reciprocal of the probability of a catastrophe occurring. For example, an event period of 500 years equates to a 0.2 percent (1/500) probability of a particular event occurring in a given year. Lower magnitude events occur more frequently than higher

deterministic models or a 500 year loss return period at a 50 percent damageability confidence level for probabilistic models.

Damageability confidence level is the probability that the actual damage ratio will be less than or equal to the damage ratio calculated by the model. For example, a 98% damageability confidence level indicates that there is a 2% probability that the actual damage to the building(s) will exceed the estimated damage given the catastrophe has already occurred.

Companies using deterministic computer models to estimate PMLs will be expected to demonstrate that they have tested at several different scenarios for event return periods. They will also be expected to demonstrate that they have used different wind storm paths or earthquake locations with a view to selecting an appropriately conservative scenario vis-à-vis their portfolio mix.

Gross Probable Maximum Loss is PML after policyholders' deductibles but before reinsurance protection.

Reinsurance Collectable are amounts that would be collectable under the company's current documented reinsurance program if it were to sustain wind storm or earthquake losses that match the 500 year event return standard.

Retention is the amount the company is currently using to manage its windstorm and earthquake exposure subject to a maximum of 5% of Capital and Surplus.

Capital and Surplus is the total capital, surplus and reserves reported on the company's latest annual filings

Insurers issuing nuclear risk policies are required to record an additional provision of 100% of net premiums written, less commissions. In the absence of meaningful statistical data on the severity and frequency of losses, the regulator considers it appropriate for insurers to reverse this provision after twenty years.

The risk of default for recoverables from reinsurers arises from both credit and actuarial risk.

Credit risk relates to the risk that the reinsurer will fail to pay the insurer what it is owed. Actuarial risk relates to the risk associated with assessing the amount of the required provision. The capital factor applied to recoverables from registered reinsurers is treated

magnitude events and generally are expected to produce lower damage figures. A higher event return period translates into a lower probability of occurrence, but a higher potential dollar value of loss.

as a combined weight under the MCT, reflecting both the credit risk and the risk of variability or insufficiency of Unpaid Claims and Unearned Premiums. A 2% capital factor is to be applied to Unpaid Claims recoverable from registered reinsurers and a 0.5% capital factor is to be applied to Unearned Premiums recoverable and to all receivables from registered reinsurers.

2.3.3 MCT SUPERVISORY TARGET

Federally regulated P&C insurance companies are required, at a minimum, to maintain an MCT ratio of 100%. OSFI believes that each institution should establish a target capital level that provides a cushion above minimum requirements, both to cope with volatility in markets and economic conditions, innovations in the industry, consolidation trends and international developments, and to provide for risks not explicitly addressed in the calculation of policy liabilities or the MCT. Such risks include systems, data, strategic, management, fraud, legal and other operational and business risks. An adequate target capital level provides additional capacity to absorb unexpected losses beyond those covered by the minimum MCT and to address capital needs through ongoing market access.

OSFI expects each institution to establish a target capital level, and maintain ongoing capital, at no less than the supervisory target of 150% MCT. However, the Superintendent may, on a case-by-case basis, establish in consultation with an institution an alternative supervisory target level based upon an individual institution’s risk profile.

Institutions are required to inform OSFI immediately if they anticipate falling below the supervisory target capital level and to lay out their plans, for OSFI approval, to return to their target level. OSFI will consider any unusual conditions in the market environment when evaluating institutions’ performance against their target level.

	MCT ratio
Minimum	100%
Supervisory Target	150%

Table 3: Minimum and supervisory capital targets

2.4 DYNAMIC CAPITAL ADEQUACY

Dynamic capital adequacy testing has been practiced in Canada for more than a decade, with its evolution going back even further.

Work on Canadian risk-based capital requirements for life insurance companies began in the mid-1980s and trial calculations of required capital were made in the late 1980s.

As work on capital requirements was progressing, the Canadian Institute of Actuaries (CIA) came to the view that a static test, such as the MCCSR, was not sufficient for the life insurance industry's needs. Risk-based capital requirements were seen as retrospective in nature.

The CIA sought a forward-looking and dynamic approach to assessing financial needs.

As a result of this investigation, the CIA developed Dynamic Capital Adequacy Testing (DCAT), originally called Dynamic Solvency Testing (DST). It is a process whereby the company's capital position is analyzed through projections under a variety of generally unfavourable scenarios.

At the time DST was being introduced, around 1990, a number of actuaries were concerned that this process would require additional staff and computing resources that might not be available to them. The CIA suggested that companies would be more forthcoming with these resources if it were the regulator, OSFI, which imposed the requirement for an annual study, rather than the actuarial profession. OSFI supported this recommendation, and the Canadian Insurance Companies Act, introduced in 1992, provides that the Superintendent may require actuaries to report to management and directors on the company's expected future financial condition.

The Superintendent has issued annual instructions to actuaries of life insurance companies to complete such reports since 1992. Similar reports have been required of property and casualty insurance companies since 1998. It is understood that DCAT is the primary tool to be employed in meeting this requirement.

2.4.1 DCAT PROCESS

There are several key activities in the process of conducting a DCAT:

- development of the base scenario;

- identification and examination of possible threats to solvency;
- development of plausible adverse scenarios;
- projection and analysis of capital adequacy; and
- reporting of the results.

The study begins with a base scenario, which is usually the company's business plan. All scenarios must incorporate projections of inforce policies, future sales and the results of any non-insurance operations. Canadian standards for the valuation of policy liabilities require the actuary to use assumptions that are appropriate to the circumstances of the company. The DCAT modeling is expected to follow this requirement. Therefore, a projection model requires calculation of policy liabilities based on assumptions consistent with the company's developing experience.

Projections are made for a period extending several years into the future. Generally, the projection period is five years for life insurance companies and two years for property and casualty insurance companies. The length of the projection period is intended to allow sufficient time for the effects of a scenario to fully develop and to allow for the modeling of a mitigating response by the company. The shorter projection period for property and casualty insurers recognizes the ability of these companies to more quickly adjust premiums to emerging experience.

Note that the liabilities at the end of the projection period reflect an expectation that the experience dictated by the scenario will continue in effect in the future. Therefore, although the projection period is limited, the results of the projection incorporate a continuation of the scenario well beyond that period.

Vendors, usually actuarial consulting firms, have developed a variety of commercial software modeling packages to facilitate DCAT. Many companies have realized that this software and DCAT techniques are useful not only in satisfying the requirement to do DCAT but also in corporate planning.

DCAT is intended to identify and test the impact of adverse, but plausible, assumptions about matters to which an insurance company's financial condition is sensitive. The choice of scenarios to be tested is left to the company's actuary. However, when the CIA's professional standard of practice on DCAT was first introduced, it required every actuary to test a specific set of scenarios involving unfavourable experience, as well as any others that the actuary thought were relevant. Over time, it was recognized that, since all companies were different, no fixed set of scenarios would be universally meaningful. The

CIA subsequently changed its standard of practice to require the actuary to choose appropriate scenarios.

Stress testing, along with professional judgement, may be required to determine the plausibility of a potential threat. Stress testing of a risk category involves determining just how far the assumption relating to the risk in question has to be changed in order to drive the company's surplus negative during the forecast period, then evaluating if that degree of change is plausible or not. If stochastic testing were used on a risk category, an adverse scenario would be considered plausible if there was at least a one percent chance of it occurring. The CIA's standard of practice lists a number of sources of risk that should be tested. The actuary is required to select from this list those that are most relevant for the company, while also considering other potentially significant risks. Naturally, the most significant risks will differ from one company to another, depending on the nature of their business and their risk management practices. Furthermore, the key threats for a particular company could well change over time, with changes in its business profile or the external environment in which it operates.

The sources of risk that are suggested by the CIA standard for consideration with respect to life insurance companies are:

- mortality;
- morbidity;
- persistency;
- cash flow mismatch;
- deterioration of asset values;
- new business;
- expense;
- reinsurance;
- government and political action; and
- off-balance sheet items.

For property and casualty companies, it is suggested that the actuary consider the following sources of risk:

- frequency and severity;
- pricing;

- misestimation of policy liabilities;
- inflation;
- interest rate;
- premium volume;
- expense;
- reinsurance;
- government and political action; and
- off-balance sheet items.

In addition to the basic scenarios, the actuary would create additional scenarios based on combinations of risks, e.g., if the probability of an adverse scenario with respect to one risk is high, or ripple effects caused by the primary risks. Ripple effects could include:

- The impact of occurrence of a risk on other base assumptions;
- The company's response to an adverse situation;
- Regulatory action, e.g., where minimum capital requirements are not met; and
- Policyholder actions.

Care must be taken to model company reactions in a manner that is not improperly optimistic.

The results under all other scenarios are usually compared to those of the base scenario.

2.4.2 REPORTING

The DCAT report is addressed primarily to the company's board of directors and senior management. It is in the nature of a risk management report and is intended to give those responsible for the direction of the company the benefit of a professional analysis of any plausible threats to the company's financial health. Many members of company management and boards of directors have indicated that they find the annual DCAT reports to be very helpful and informative.

OSFI also receives a copy of each report, which is very useful in the supervision of insurance companies.

DCAT reports are required to include the results under at least the base scenario and the three most risky scenarios. The actuary is required to include a professional opinion as part of the report. In order to provide a satisfactory opinion, actuarial standards require that minimum regulatory capital requirements be met under the base scenario and that the company can meet all future obligations under both the base scenario and all plausible adverse scenarios described in the report.

It should be noted that the standards for this opinion fall below OSFI's general requirement that companies maintain acceptable levels of capital at all times. Therefore, OSFI would encourage active discussions amongst the actuary, the board of directors, and senior management of any scenarios where minimum capital requirements would not be met.

CHAPTER 3

THE AUSTRALIAN PRUDENTIAL STANDARDS

Prior to the introduction of the Insurance Act 1973 there were virtually no supervisory requirements for companies wishing to conduct general (nonlife) insurance business in the Australian market place. All that was necessary to gain access to the market was the lodgment of a \$200 000 deposit with the Commonwealth Treasurer. Some 484 insurers were registered by way of such deposits to operate in the Australian general insurance market prior to the introduction of the Insurance Act in 1973. During the three-year period to May 1973, 16 Australian general insurers collapsed, causing major financial loss to policyholders and a widespread loss of confidence in the industry. The development of the Insurance Act was in response to these failures and to limit the possibility (or minimize the extent) of future policyholder losses through company failures.

The prudential regime under the Insurance Act imposes a minimum solvency requirement on general insurers which were required to maintain allowable assets (reported at market value) in excess of reported liabilities by at least the greatest of:

- \$2 million;
- 20% of net premium income; or
- 15% of net outstanding claims.

Certain assets were excluded for this purpose. In addition, insurers were required to satisfy certain reinsurance requirements. The most significant for solvency purposes was a requirement to hold assets in excess of the statutory minimum (described above) of at least the amount of the maximum event retention.

This solvency structure went only part way to recognizing different risks faced by individual insurers. It was a blunt instrument which:

- did not explicitly recognize the different levels of risk associated with different business lines;
- did not respond to inconsistency in the adequacy of reported liabilities;
- did not explicitly recognize the risks associated with the interaction of assets and liabilities; and
- might not optimally recognize certain other risks, eg asset valuation and concentration risk, risk of reinsurer default, catastrophe risk.

Significantly, as a balance sheet test, it could only be a proxy for any truly prospective, company-specific test of claims paying ability.

During the 26 years since the Insurance Act was introduced, the insurance industry has rationalized - there were some 160 general insurers authorized under the Insurance Act - and stabilized. There have been 19 general insurance failures since 1973, none of which resulted in major policyholder losses. Those failures which have occurred can be attributed to a range of factors, including: fraud; rapid premium growth; underwriting and operating losses; cash flow and capitalization problems; poor management and underwriting practices; competition in particular market sectors; and poor asset spread.

While the failure rate in itself was not all that high, some of the underlying factors in these cases could be addressed by making the supervisory regime more responsive to the individual risk profiles of general insurers and by a greater emphasis on disclosure and transparency than occurs as a result of accounting standards alone.

In March 1995, the then Insurance and Superannuation Commissioner (ISC), Mr. George Pooley, raised publicly the issue of whether a measure of technical or adjusted solvency of general insurers can or should be disclosed. A discussion paper was subsequently issued to the general insurance industry.

Consultations arising from the discussion paper raised the question as to whether the existing measures of capital and solvency contained in the Insurance Act were adequate. As a result, the ISC wrote to the Institute of Actuaries in Australia (IAA) seeking its assistance in the development of practical minimum solvency standards which meaningfully reflect the variations in risk facing general insurers. In response to this request, the IAA established two working groups. One to examine ways of achieving greater consistency and reliability of companies' outstanding claims provisions and the

other to consider how solvency standards could be updated and better reflect the business line risks of insurers. These working groups reported to APRA¹⁹ early this year.

During September 1999, APRA published three discussion papers which outlined the structure of new and modern monitoring requirements, taking into account risks never considered before in non-life insurance like asset risk, liability risk, ALM risk and operational risk.

In April 2000, APRA released a discussion paper based on the comments emerged from the “September papers”. With regard to the structure of the solvency, APRA’s preferences pointed towards a small number of standards, the so called “prudential standards”, concerning the capital adequacy, liability valuation and the quality requirements for operational risks and reinsurance contracts.

We now focalize on the prudential standards relating to capital adequacy.

3.1 PRUDENTIAL STANDARDS

These Prudential Standards aims to ensure that the security of policyholder obligations of all insurers is established at an appropriate level by requiring that each insurer maintain at least a minimum amount of capital. Capital is the cornerstone of an insurer’s strength. It provides a buffer against losses that have not been anticipated and, in the event of problems, enables the insurer to continue operating while those problems are addressed or resolved. In this way, the maintenance of adequate capital resources can engender confidence on the part of policyholders, creditors and the market more generally in the financial soundness and stability of the insurer.

Beyond the minimum levels of capital specified by these Standards, it is the responsibility of an insurer’s Board and senior management to ensure that the insurer’s capital resources are appropriate to the size, business mix and complexity of its business. Accordingly, the insurer must have suitable systems in place to identify, manage and monitor the risks associated with its business activities, and to hold capital commensurate with its overall risk profile. Such capital must, of course, be no less than the minimum specified by these Standards.

The key requirements of these Prudential Standards are:

¹⁹ The Australian Prudential Regulation Authority.

- an insurer may choose one of two methods for determining its Minimum Capital Requirement (MCR). Insurers with sufficient resources are encouraged to develop an in-house capital measurement model to calculate the MCR (this is referred to as the Internal Model Based (IMB) Method). Use of this method will, however, be conditional on APRA's and the Treasurer's prior approval and will require insurers to satisfy a range of qualitative and quantitative criteria. Insurers that do not use the IMB Method must use the Prescribed Method;
- regardless of which method is used to calculate the Minimum Capital Requirement, an insurer's MCR is determined having regard to a range of risk factors that may threaten the ability of the insurer to meet policyholder obligations. Under the Prescribed Method, these fall under three broad types: insurance risk, investment risk and concentration risk. An insurer using the IMB Method will be expected to include at least these risks, but also all other relevant risk factors, within its calculation methodology;
- an insurer must, at all times, have eligible capital in excess of its MCR. To achieve this APRA expects the insurer to maintain a buffer above the MCR. Eligible capital is comprised of Tier 1 and Tier 2 capital: broadly, Tier 1 capital is permanent, and does not impose on-going servicing costs on the insurer, while Tier 2 instruments may be of limited life and/or have on-going servicing obligations. Within an insurer's eligible capital, Tier 2 capital cannot exceed Tier 1 capital;
- foreign-incorporated insurers authorized to operate in Australia as branches (foreign insurers) have slightly different requirements than those applied to locally-incorporated insurers. Specifically, foreign insurers are required to maintain assets in Australia in excess of their liabilities in Australia, of an amount in excess of their MCR; and
- disclosure and transparency are important allies of the supervisory process. To improve policyholder and market understanding of its capital adequacy position, an insurer should disclose, in its published annual report, details of its eligible capital and MCR.

3.1.1 DEFINITION OF CAPITAL

In assessing the adequacy of an insurer's capital resources, attention must be paid not only to the types of events or problems that it might encounter, but also the quality of the support provided by various types of capital instruments. The following matters are relevant to whether a capital instrument is adequate for supervisory purposes, namely the extent to which each instrument:

- provides a permanent and unrestricted commitment of funds;
- is freely available to absorb losses from business activities;
- does not impose any unavoidable servicing charges against earnings; and
- ranks behind the claims of policyholders and other creditors in the event of the winding-up of the insurer.

Not all types of capital instruments meet these criteria equally. Due to the need to ensure that the capital base of an insurer provides adequate support, APRA imposes some restrictions on the composition of capital eligible to meet the MCR.

Capital, for supervisory purposes, is considered in two tiers. Tier 1, or core capital, comprises the highest quality capital elements that fully meet all the essential characteristics of capital described in GPS 110 Capital Adequacy²⁰. Tier 2, or supplementary capital, includes other instruments that, to varying degrees, fall short of the quality of Tier 1 capital but nonetheless contribute to the overall financial strength of an insurer. A locally-incorporated insurer's capital base is defined as the sum of Tier 1 and Tier 2 capital, less some deductions. An insurer must ensure that its capital base exceeds its MCR, at all times. Tier 1 capital comprises the proceeds of instruments that are both permanent and non-cumulative in nature. Tier 1 capital must constitute at least 50% of an insurer's capital base.

Tier 1 capital comprises:

1. paid-up ordinary shares;
2. general reserves;
3. retained earnings;

²⁰ APRA, "Prudential Standard GPS 110", <http://www.apra.gov.au/>, 2010.

4. current year's earnings net of expected dividends and tax expenses;
5. technical provisions in excess of those required²¹;
6. non-cumulative irredeemable preference shares; and
7. other "innovative" capital instruments (issued by the insurer or through special purpose vehicles).

Items 1 to 5 listed above may be included as part of the insurer's capital base without the need for APRA's prior approval. If an insurer wishes to have instruments covered by items 6 and 7 listed above included in its Tier 1 capital, this will require APRA's approval which may revoke its approval in relation to an instrument if it becomes aware that the instrument does not meet the relevant criteria.

A capital instrument is not eligible for inclusion in Tier 1 capital to the extent that its inclusion will result in the aggregate amount of items 6 and 7 exceeding 20% of aggregate Tier 1 capital (before deductions).

Any amount ineligible for inclusion as Tier 1 capital as a result of this limit will be eligible for inclusion as Upper Tier 2 capital.

Unless otherwise approved by APRA, an insurer's total servicing obligations on Tier 1 capital instruments must not exceed the insurer's after-tax earnings in the year to which they relate. That is, there should be no dividend or interest payments out of retained earnings without APRA's prior approval.

Tier 2 capital is limited to a maximum of 100% of an insurer's Tier 1 capital (net of deductions).

Tier 2 capital consists of instruments that, to varying degrees, fall short of the quality of Tier 1 capital but nonetheless contribute to the overall strength of an insurer. Such instruments include some forms of hybrid capital instruments.

Tier 2 capital is divided into Upper Tier 2 and Lower Tier 2 capital.

Upper Tier 2 instruments include:

- cumulative irredeemable preference shares;
- mandatory convertible notes and similar capital instruments;

²¹ See APRA, "Prudential Standard GPS 310 Audit and Actuarial Reporting and Valuation", <http://www.apra.gov.au/>, 2005.

- perpetual subordinated debt; and
- any other hybrid (debt/equity) capital instruments of a permanent nature (e.g. capital amounts that are ineligible for inclusion as Tier 1 capital).

Lower Tier 2 instruments include:

- term subordinated debt;
- limited life redeemable preference shares; and
- any other similar limited life capital instruments.

All capital instruments that an insurer wishes to include in Tier 2 capital will require APRA's approval. APRA may revoke its approval in relation to an instrument if it becomes aware that the instrument does not meet the relevant criteria.

A capital instrument is not eligible for inclusion in Tier 2 capital to the extent that its inclusion will result in the aggregate amount of Lower Tier 2 capital exceeding 50% of eligible Tier 1 capital (net of deductions).

Capital instruments with a limited life (i.e. Lower Tier 2 Capital) must have an original maturity greater than 5 years. These instruments will also be subject to amortization over the last four years of their life according to the following schedule:

Term to Maturity	Issued Amount Eligible for Inclusion in Tier 2 Capital
4 years or more	100%
3 to less than 4 years	80%
2 to less than 3 years	60%
1 to less than 2 years	40%
Less than 1 year	20%

Table 4: Issued amount eligible for inclusion in Tier 2 Capital depending on the maturity term.

The amount of Tier 1 capital to be included in an insurer's capital base will be net of the following deductions²²:

- goodwill;
- other intangible assets;
- deferred tax assets (net of provisions for deferred tax liabilities);

²² For more information see APRA, "Guidance Note GGN 110.1", <http://www.apra.gov.au/>, 2005.

- during the second and third transitional periods, all recoveries on all reinsurance contracts if the insurer has not met the transitional reinsurance documentation requirements;
- after the third transitional period, recoveries under each reinsurance contract that does not meet the reinsurance documentation test; and
- for reinsurers, the premiums receivables deduction on any proportional reinsurance treaty calculated.

In addition some reductions are possible. A reduction in an insurer's capital includes, but is not limited to: share buybacks; the redemption, repurchase or early repayment of any eligible capital instruments issued by the insurer or a special purpose vehicle; trading in own shares; or where aggregate interest and dividend payments on Tier 1 capital exceed the insurer's after-tax earnings in the year to which they relate (i.e. dividend and interest payments on Tier 1 capital wholly or partly funded from retained earnings).

An insurer must seek APRA's prior approval before making a reduction in its capital base. APRA's approval may be subject to conditions.

Where APRA's prior approval is required, the insurer should provide APRA with a capital plan extending for at least three years. The insurer will need to satisfy APRA, on the basis of the capital plan provided, that the company's capital base after the proposed reduction will remain adequate for its future needs. In deciding whether or not to approve a reduction in capital, APRA will have regard to all relevant considerations, including whether the insurer's capital plan shows that the insurer will maintain an adequate level of capital, taking account of factors such as the immediate capital position, commitments to raise capital, and core profitability.

For what concerns foreign insurers they are nevertheless required to meet a variant of the MCR. Specifically, foreign insurers are required to maintain assets in Australia in excess of their liabilities in Australia, of an amount in excess of the MCR determined.

3.1.2 MINIMUM CAPITAL REQUIREMENT

An insurer's capital resources must be adequate for the size, business mix and complexity of its business. To this end, the Prudential Standard establishes a risk-based approach to the measurement of capital adequacy of all insurers. The MCR is intended to be broadly commensurate with the full range of risks to which an insurer is exposed (including risks

relating to insurance claims, investments, counterparty default, asset-liability mismatches, catastrophes, and operational errors and problems).

The MCR may be determined using either:

- an internal model developed by the company to reflect the circumstances of its business – the Internal Model Based (IMB) Method;
- the Prescribed Method; or
- a combination of 1 and 2 as appropriate to the mix of business of the company.

Regardless of the outcome of calculations made under this Prudential Standard, an insurer's MCR cannot be less than \$5 million.

It is recognized that any measure of the adequacy of an insurer's capital involves considerable judgment and estimation, and requires the quantification of risks even where it may be difficult to do so. As a result, APRA may adjust an insurer's MCR where it believes that the amount determined under the Standard does not adequately reflect the risk profile of an individual insurer.

That is, an individual insurer may be required by APRA to maintain a specified level of eligible capital in excess of that calculated using the applicable risk measurement methodology outlined below. This might be the case, for example, for a newly established insurer, an insurer that has encountered financial or operational difficulties, or for an insurer that is deemed by APRA to have a disproportionate exposure to a particular type of risk, or where particular risks faced by an insurer are not adequately dealt with by the prudential standards.

In the normal course of business, an insurer must have in place capital management processes. These must be set out in the insurer's Risk Management Strategy in accordance with Prudential Standard GPS 220 Risk Management²³.

3.1.2.1 INTERNAL MODEL BASED METHOD

The Internal Model Based (IMB) method is intended to allow an insurer to calculate its Minimum Capital Requirement (MCR) based on the output of its in-house capital allocation model. Hence, each insurer will have the flexibility to develop a methodology

²³ APRA, "Prudential Standard GPS 220 Risk Management", <http://www.apra.gov.au/>, 2005.

that is best suited to its business, provided that the model chosen is comprehensive, rigorous and broadly consistent with comparable segments of the industry. Use of the IMB method will, however, be strictly conditional on APRA's and the Treasurer's approval.

To ensure that the MCRs calculated by insurers using the IMB method are sufficiently prudent, comparable and consistent across the industry, model approval will require that the insurer's risk management system and the methodology underlying the capital calculation meet certain criteria.

APRA will, in consultation with industry, refine these criteria over time to ensure that they are consistent with the evolution of industry modeling capabilities. In broad terms, however, the insurer should satisfy some quantitative and qualitative requirements.

Each insurer will have discretion to determine the precise nature of its modeling approach. However, an insurer must be able to demonstrate that its internal model:

- operates within a risk management environment that is conceptually sound and supported by adequate resources;
- is based on a set of quantitative parameters, including a required probability of default and a modeling time horizon over which that probability is to be measured. These parameters will be set at a level that ensures insurers achieve and maintain a minimum level of financial soundness;
- addresses all material risks to which the insurer could be reasonably expected to be exposed and is commensurate with the relative importance of those risks, based on the company's business mix;
- is closely integrated into the day-to-day risk management process of the insurer; and
- is supported by appropriate audit and compliance procedures.

In addition to the quantitative and qualitative requirements insurers seeking approval to use the IMB method must have in place adequate processes for validating the accuracy of the capital measurement model, and for monitoring and assessing its on-going performance. A proven track record of reasonable accuracy in measuring risk will also be required.

It is important that insurers using the IMB method have risk management systems and capital measurement models that are conceptually sound and implemented with integrity.

Accordingly, there are a number of qualitative criteria that APRA will have regard to in deciding whether to approve an internal model for capital adequacy purposes.

The qualitative criteria are:

- the insurer should have an independent risk management unit that is responsible for the design and implementation of the insurer's capital measurement model. This unit could form part of the insurer's actuarial function, its financial control division, or other appropriate group within the insurer's organizational structure that is separate from the insurer's general business units. It is not APRA's intention to mandate a particular organizational structure for insurers, provided the designated unit has adequate independence, appropriate skills and resources, and direct reporting access to the senior management of the insurer. Amongst other things, this unit should produce and analyze the periodic results of the capital measurement model and conduct regular validation of the model against the actual experience observed by the insurer;
- the insurer's Board and senior management should be actively involved in the risk control process and must regard risk control as an essential aspect of the business to which significant resources need to be devoted. The periodic reports and validation results produced by the independent risk management unit must be reviewed by a level of management with sufficient seniority and authority to enforce restrictions on the insurer's overall risk exposure;
- the capital measurement model must be closely integrated into the day-to-day risk management process of the insurer. Accordingly, the output of the models should be an integral part of the process of planning, monitoring and controlling the insurer's risk profile;
- an independent review of the capital measurement model should be carried out periodically as part of the insurer's own internal audit process. A review of the overall risk management process should take place at regular intervals (ideally not less than once a year) and should specifically address, at a minimum:
 - the scope of the risks captured by the capital measurement model;
 - the integrity of the management information system;
 - the verification of the consistency, timeliness and reliability of data sources used to run internal models, including the independence of such data sources;

- the accuracy and appropriateness of volatility, correlation and distributional assumptions;
- the verification of the model's accuracy through periodic back testing or other validation process;
- the validation of any significant change in the capital measurement model;
- the adequacy of the documentation of the capital measurement model and accompanying risk management systems and processes;
- the organization of the risk management unit; and
- the integration of the capital measurement model into the broader risk management framework of the insurer.

The insurer's capital measurement model should calculate an amount of capital sufficient to reduce the insurer's probability of default over a one year time horizon to 0.5% or below.

An insurer may measure its capital requirement over a different combination of probability of default and time horizon, provided the insurer can demonstrate to APRA that the alternative parameters are appropriate for its business mix and produce a result which is consistent with the benchmark.

3.1.2.1.1 SPECIFICATION OF RISK FACTORS

An important part of an insurer's internal capital measurement model is the specification of an appropriate set of risk factors, ie the risks that impact on the value of the insurer's assets and liabilities. The risk factors contained in the capital measurement model must be sufficient to capture the risks inherent in the insurer's portfolio. The risks specified above are the ones suggested by APRA but the list is not intended to be exhaustive: there may be additional factors specific to an individual insurer's activities that will need to be built into any internal model before it can be used to calculate the insurer's MCR.

- Investment Risks

An insurer's capital measurement model must consider the risk that the amount or timing of the cash flows connected with the insurer's assets will differ from expectations or assumptions as of the valuation date.

Factors that should be considered include:

- default/counterparty failure;
- the future market value of assets;
- the liquidity of assets; and
- the impact of changes in interest rates on the value of asset cash flows (this includes cash flows from bonds, mortgages, real estate and dividends).

- Insurance Risks

An insurer's capital measurement model must consider the risk that the amount or timing of cash flows connected with the insurer's obligations will differ from expectations or assumptions as at the valuation date.

Factors that should be considered include:

- outstanding claims risk - the risk that the actual cost of claims for obligations incurred before the calculation date will differ from expectations or assumptions due to factors such as:
 - unexpected inflation in claim costs;
 - changes in interest rates;
 - changes in the legal environment in which claims will be resolved, including the environment in which claims are pursued by policyholders or third parties;
 - changes to the basic premises underlying the provisions for a particular coverage (such as has occurred with environmental impairment liability);
 - patterns of pricing adequacy which affect the payment of claims or the adequacy of case reserves;
 - currency fluctuations which affect the costs of losses when expressed in local currency;
 - the randomness of the claims process itself; and

- incompleteness of databases.
- premiums risk - the risk that premiums relating to post calculation date exposures, including premiums written after the calculation date, could be insufficient to fund the liabilities arising from that business due to changes in factors including:
 - changes in interest rates;
 - competitive pressures that do not allow the insurer to achieve assumed levels of exposure and/or rate adequacy;
 - regulatory intervention that restrains premium increases or decreases or requires business to be underwritten that would not be underwritten in the absence of such intervention;
 - retrospective premiums or dividends that differ from assumptions; and
 - amounts collectible from agents that differ from assumptions.
- loss projection risk - the uncertainty regarding assumptions about future claims costs. Loss projection risk is a function of the factors that affect reserve risk and also of the uncertainty regarding factors such as:
 - unanticipated changes in loss costs and exposures from the historical experience period;
 - loss costs for the mix of new policies being underwritten, including the effect of adverse selection; and
 - loss adjustment practices in the future that may differ from those in the past.
- concentration risk - the uncertainty regarding the cost of catastrophic events. Concentration risk can be considered a component of loss projection risk, and is a function of factors such as:
 - the coverages being written;
 - the concentration of insured values in specific geographic areas or legal jurisdictions; and
 - uncertainty regarding the frequency, severity and nature of events.

- reinsurance risk - uncertainty regarding the price and availability of desired reinsurance, and of the uncertainty regarding the collectability of reinsurance recoverables arising from the financial condition of the reinsurer or ambiguity about coverages provided. Reinsurance risk recognizes how reinsurance responds under stress, such as a large catastrophe or other strain on collectability, aggregates, reinstatements and other reinsurance parameters.
- expense risk - the risk that expenses will differ from projections due to factors such as:
 - contingent commissions to agents;
 - marginal expenses of adding new business; and
 - overhead costs, including the risk that overhead costs will be changed by regulatory intervention, and the risk that there may be periods of changing premium during which overhead costs will not change in proportion to premium.

- Operational Risk

As well as accurately measuring financial risks, an insurer's model for measuring capital adequacy must take into account the various operational risks that it also faces, ie the risk of financial loss occurring through error, fraud or failure to perform activities in a timely manner as a result of breakdown of people or systems, internal controls, corporate governance and external events. These risks, although difficult to quantify, have the potential to impose significant costs upon, and possibly seriously jeopardize, the financial soundness and on-going business of the insurer. An insurer's capital measurement model will therefore need to include a measure of operational risk within its capital calculation.

- Correlation Between Risk Classes

An insurer's capital measurement model must estimate the effects of the risks specified before individually on the financial position of the insurer, and evaluate the interrelationships between these risks and other risks.

3.1.2.1.2 STRESS TESTING

Stress testing is an important component of any modeling approach.

Insurers that use the IMB method for determining their MCR must have in place a comprehensive stress testing program to supplement their capital measurement calculations.

APRA will not impose standard stress scenarios on insurers, but will expect insurers using the IMB method to have developed a comprehensive range of scenarios against which its capital calculations can be compared. It is important that these scenarios are tailored to the particular circumstances of the insurer, and reflect low-probability but potentially high-impact events that might adversely affect the insurer's financial position. These scenarios will include, but should not be limited to, sensitivity analysis on the assumptions made within the capital measurement model, as well as the assessment of the impact of plausible stress scenarios (eg major catastrophe events or extreme market conditions).

Stress testing results should be incorporated into model validation procedures, and included as part of regular management reporting.

3.1.2.2 MODEL REVIEW PROCESS

An insurer must obtain APRA's prior approval before it will be able to use its internal capital measurement model to determine its MCR.

Approval will be subject to the outcome of a comprehensive model review process including:

- completion of a detailed questionnaire about the model and accompanying risk control environment; and
- one or more on-site visits to discuss the detail of the model, risk management systems, and surrounding organizational structure and controls.

Once APRA is satisfied with the extent to which the insurer has met the criteria outlined, APRA will (subject to obtaining the Treasurer's consent) approve the model.

APRA will require, as a minimum condition of its model approval, that the insurer undertake to advise APRA in advance of any material changes to its capital measurement model or surrounding controls, and that APRA be provided with any information necessary to satisfy itself that the insurer continues to meet the criteria outlined.

Once an insurer has commenced using the IMB method for the measurement of its MCR, the insurer will be required to continue using this method of capital measurement unless:

- APRA revokes model approval and directs the insurer to use the Prescribed Method for calculating its MCR; or
- the insurer seeks and receives approval from APRA to return to the Prescribed Method.

3.1.3 PARTIAL MODELS

APRA will consider applications by insurers to use the IMB method to calculate elements of its MCR, and to use the Prescribed Method for those parts of the insurer's business for which it does not have an internal model. However, recognizing that there is a range of factors which are not explicitly addressed within the Prescribed Method (eg operational risk), APRA may impose an additional capital requirement on the results of any partial model to compensate for this.

3.1.4 PRESCRIBED METHOD

For insurers using the Prescribed Method, the MCR will be determined as the sum of the capital charges for:

- insurance risk;
- investment risk; and
- concentration risk.

3.1.4.1 INSURANCE RISK CAPITAL CHARGE

The Insurance Risk Capital Charge is in response to the risk that the true value of net insurance liabilities is greater than the value determined under GPS 210 Liability Valuation²⁴. It has two components: a charge in respect of Outstanding Claims Risk and a

²⁴ APRA, "Prudential Standard GPS 210", <http://www.apra.gov.au/>, 2005.

charge in respect of Premiums Liability Risk. The total Insurance Risk Capital Charge is the sum of the capital charge for each of the two components.

3.1.4.1.1 OUTSTANDING CLAIMS RISK

The capital charge for Outstanding Claims Risk is in response to the risk that the true value of the net outstanding claims liabilities is greater than the value determined under GPS 210.

For the purposes of the Prescribed Method, Outstanding Claims Risk is considered to be broadly proportional to the value of the net outstanding claims liabilities. Because the extent of Outstanding Claims Risk will vary by class of business, a separate capital charge for Outstanding

Claims Risk must be calculated for each class of business.

The capital charge for each class of business is calculated by multiplying the net outstanding claims liabilities for that class by the relevant Outstanding Claims Risk Capital Factor. For these purposes, APRA classes of business have been divided into three categories with respect to direct insurance business and a matrix of three classes with four types of business with respect to inwards reinsurance. Classes of business within the same category are regarded as having broadly similar levels of Outstanding Claims Risk. The total capital charge for Outstanding Claims Risk is the sum of the capital charges for each class of business.

3.1.4.1.2 PREMIUMS LIABILITY RISK

The capital charge for Premiums Liability Risk is in response to the risk that premiums relating to post calculation date exposures, including premiums written after the calculation date, will be insufficient to fund the liabilities arising from that business. The need for a capital charge which relates, in part, to new business arises because of the time delay between calculation date and the time at which APRA is able to process information and take any action which may be necessary.

The value of the net premium liabilities is taken as the base value for the liabilities upon which the capital charge for Premiums Liability Risk is calculated.

For the purposes of the Prescribed Method, Premiums Liability Risk is considered to be broadly proportional to the value of the net Premiums Liabilities. As for Outstanding Claims Risk, the extent of Premiums Liability Risk will vary by class of business. However, in a stable portfolio, Premiums Liability Risk is likely to be greater than Outstanding

Claims Risk for the same class of business. A separate capital charge for Premiums Liability Risk therefore needs to be calculated for each class of business.

The capital charge for each class of business is calculated by multiplying the net premium liabilities for that class by the relevant Premiums Liability Risk Capital Factor.

Classes of business within the same category are regarded as having broadly similar levels of Premiums Liability Risk. The total capital charge for Premiums Liability Risk is the sum of the capital charges for Premiums Liability Risk for each class of business.

Where an insurer writes inwards reinsurance business and is unable to split this business into the classes and types listed below, they are to use the highest casualty factors on their outstanding claims liabilities and their premiums liabilities.

Where an insurer writes inwards reinsurance which spans multiple classes and the insurer cannot readily split the contract between classes, APRA suggests that the contract should be allocated using one of the following methods:

- allocate the contract to the category which represents the greatest exposure; or
- allocate the contract to the category representing the greatest premium income.

An insurer that writes inwards reinsurance is free to choose which of the above methods it uses, or may use another appropriate method provided the same method is used for all contracts and all subsequent periods.

Class of Business	Outstanding Claims Risk Capital Factor	Premiums Liability Risk Capital Factor
Householders		
Commercial Motor		
Domestic Motor	9%	13.5%
Travel		
Fire and ISR		
Marine and Aviation		
Consumer Credit		
Mortgage	11%	16.5%
Other Accident		
Other Accident		
CTP		
Public and Product Liability	15%	22.5%
Professional Indemnity		
Employers' Liability		

Table 5: Outstanding claims risk capital factor and premiums liability risk capital factor in direct insurance.

Class of Business	Outstanding Claims Risk Capital Factor	Premiums Liability Risk Capital Factor
Property:		
Facultative Proportional	9%	13.5%
Treaty Proportional	10%	15%
Facultative Excess of Loss	11%	16.5%
Treaty Excess of Loss	12%	18%
Marine and Aviation:		
Facultative Proportional	11%	16.5%
Treaty Proportional	12%	18%
Facultative Excess of Loss	13%	19.5%
Treaty Excess of Loss	14%	21%
Casualty:		
Facultative Proportional	15%	22.5%
Treaty Proportional	16%	24%
Facultative Excess of Loss	17%	25.5%
Treaty Excess of Loss	18%	27%

Table 6: Outstanding claims risk capital factor and premiums liability risk capital factor, inwards reinsurance.

3.1.4.2 INVESTMENT RISK

The Investment Risk Capital Charge is in response to the risk of an adverse movement in the value of an insurer’s assets and/or off-balance sheet exposures.

Investment risk can be derived from a number of sources, including market risk and credit risk. The Investment Risk Capital Charge is determined as the sum, across all assets and certain off-balance sheet exposures, of the value of each investment multiplied by the relevant Investment Capital Factor for that investment. For the purposes of this Prudential Standard, assets and exposures should be valued according to Australian Accounting Standards.

The capital charge may be adjusted to recognize any reduction in investment risk arising from the availability of risk mitigants.

In certain circumstances, an insurer may choose to hold assets in a special purpose vehicle, rather than on its own balance sheet. APRA may allow the insurer to “look through” the legal structures involved, and determine its Investment Risk Capital Charge (and any Investment Concentration Capital Charge) based on the individual assets of the special purpose vehicle, rather than simply on its direct exposure to the entity.

An insurer may securitize assets to reduce the Investment Risk Capital Charge.

The insurer must consult APRA prior to entering into the securitization transaction in order to be able to realize any reduction in the MCR. To achieve a reduction in the Investment Risk Capital Charge an insurer must be able to demonstrate at a minimum:

- that it has effectively transferred the risks arising from holding the assets to a third party;
- that there is an appropriate on-going separation of the third party from the insurer; and
- that any risks transferred back to the insurer via facility agreements are subject to specified limits and are provided on an arms length basis.

3.1.4.3 CONCENTRATION RISK

At a minimum, the Concentration Risk Capital Charge is in response to the risk associated with an accumulation of exposures to a single catastrophic event. APRA will require a more sophisticated whole of portfolio approach to be implemented by some insurers where APRA assesses that the single event approach is inadequate in evaluating those insurers' reinsurance needs. If this is required of an insurer and it does not comply with the requirement, the insurer's MCR may be increased. The Concentration Risk Capital Charge is set equal to the insurer's Maximum Event Retention (MER). APRA intends to monitor an insurer's calculation of its MER and may require adjustments to be made to the calculation where APRA is not satisfied with the methodologies and/or assumptions used.

In calculating the MER, an insurer may not take into account potential recoveries from a reinsurance arrangement if it has failed the reinsurance documentation test.

3.1.5 DISCLOSURE

Disclosure and transparency are important allies of the supervisor. To improve policyholder and market understanding of its capital adequacy position, an insurer should disclose, in its published annual report, the following items:

1. the amount of eligible Tier 1 capital, with separate disclosure of each of the items;

2. the aggregate amount of any deductions from Tier 1 capital;
3. the amount of eligible Tier 2 capital, with separate disclosure of each of the items;
4. the aggregate amount of any deductions from Tier 2 capital;
5. the total capital base of the insurer derived from the items 1 to 4;
6. the MCR of the insurer; and
7. the capital adequacy multiple of the insurer (item 5 divided by 6).

CHAPTER 4

ENHANCED CAPITAL REQUIREMENT IN UNITED KINGDOM

United Kingdom has a long insurance history: general insurance contracts began to be underwritten very early in London. There is evidence of marine insurance by 1426 and probably only Genoa and Venice had insurance contracts before this.

The Privy Council argued there was a need to co-ordinate and control the writing of insurance, for this reason the Office of Assurances was established, in 1575, in the Royal Exchange.

Legislation governing the conduct of Marine Insurance business can be traced back to the first half of the 18th century. Modern solvency regulation of general insurance business was first introduced in 1909.

There was very little pro-active supervision at that time, and the principle was of "freedom with publicity". This meant insurance companies could charge whatever they liked, and manage their financial affairs as they wished, but should publish their annual financial statements. This "publicity" was viewed as an important control on their economic well-being and an incentive to develop a strong balance sheet.

During the 20th century there were important changes in the market, in particular many of the larger companies worked together to some extent and industry-negotiated "tariffs" meant that there was no premium rate differentiation within these groupings in major classes.

The scandal of the Fire, Auto and Marine Insurance Company, which defrauded policyholders, gave a wake-up call to UK general insurance industry in the mid-1960s.

In addition, a new entrant to the motor market, Vehicle & General, ignored the tariff and adopted an entirely new rating system, swept to a dominant position in the market and then collapsed into insolvency. These events, an increasing level of international co-operation and discussion through the OECD, and then through the established European Community, led to an increased acceptance of the role of government in developing regulation and supervising compliance by insurers. For many years insurance regulation in

the UK was the responsibility of the Insurance Division of the Department of Trade and Industry (DTI), under the framework of the Insurance Companies Act 1982 and subsequent regulations. In January 1998 responsibility passed to H M Treasury (HMT) and in January 1999 the supervisory activity was delegated by Treasury to the Financial Services Authority (FSA).

By joining the European Economic Community, the First Non-Life Insurance Directive became a requirement for the UK insurances. Under this directive each insurance company was to be supervised in respect of its entire business by the supervisory authority in the member state where the head office was situated. The continuation of the insurance activity was subordinated to the maintenance of the solvency margin. The required solvency margin was the highest between:

- 18% of net premium up to 10 million euros of premium income, and 16% of premium income above that level;
- 26% of net incurred claims up to 7 million euros, and 23% of claims above that level.

If the excess of assets over liabilities fell below the required minimum margin of solvency, the supervisor would ask the company to prepare and implement a "plan for the restoration of a sound financial position".

In addition there was a "guarantee fund" set at one-third of the required minimum margin, subject to a minimum in absolute money term. If the excess of assets over liabilities fell below this level the supervisor could require the company to prepare a "short-term financial scheme". Failure to put in place such an arrangement provided grounds for the supervisor to withdraw the company's license to underwrite new business. The FSA thought that the improvements of "Solvency I"²⁵ were modest, and designed as a temporary measure while "Solvency II"²⁶ is carried out but temporally too far.

This situation led regulators in the UK to adopt alternative approaches to prudent insurance regulation.

Current capital requirements are here analyzed.

²⁵ See Chapter 5.

²⁶ See Chapter 5.

4.1 DEFINITION OF CAPITAL

The FSA has divided its definition of capital into three tiers, and generally prefers a firm to hold higher quality capital that meets the characteristics of permanency and loss absorbency that are features of tier one capital.

Tier one capital typically has the following characteristics:

- it is able to absorb losses;
- it is permanent;
- it ranks for repayment upon winding up, administration or similar procedure after all other debts and liabilities; and
- it has no fixed costs, that is, there is no inescapable obligation to pay dividends or interest.

Tier one include, for example, share capital, reserves, partnership and sole trader capital, verified interim net profits and, for a mutual, the initial fund plus permanent members' accounts. Tier one capital is divided into core tier one capital, perpetual non-cumulative preference shares, permanent interest bearing shares (PIBS) and innovative tier one capital.

Tier two capital includes forms of capital that do not meet the requirements for permanency and absence of fixed servicing costs that apply to tier one capital. Tier two capital includes, for example:

- capital which is perpetual but cumulative only perpetual capital instruments may be included in upper tier two capital; and
- capital which is not perpetual or which may have fixed servicing costs that cannot generally be either waived or deferred (for example, most subordinated debt); such capital should normally be of a medium to long-term maturity ;dated capital instruments are included in lower tier two capital;

Tier three capital consists of forms of capital conforming least well to the characteristics of the tier one capital: either subordinated debt of short maturity (upper tier three capital) or net trading book profits that have not been externally verified (lower tier three capital).

Deductions should be made at the relevant stage of the calculation of capital resources to reflect capital that may not be available to the firm or assets of uncertain value.

As the various components of capital differ in the degree of protection that they offer the firm and its customers and consumers, restrictions are placed on the extent to which certain types of capital are eligible for inclusion in a firm's capital resources. These rules are called the capital resources gearing rules.

Capital resources can be calculated either as the total of eligible assets less foreseeable liabilities (which is the approach taken in the Insurance Directives) or by identifying the components of capital. Both calculations give the same result for the total amount of capital resources.

4.2 CAPITAL REQUIREMENTS

To ensure that there is no significant risk that insurance liabilities cannot be met as they fall due, FSA requires that firm maintain at all times overall financial resources, including capital resources and liquidity resources, which are adequate, both as to amount and quality. The adequacy of a firm's capital resources must be evaluated in relation to all the activities of the firm and the risks dealt with them.

To minimize the risk of insolvency, an insurer must maintain at all times capital resources equal to or in excess of its capital resources requirement (CRR).

The CRR for any insurer is the higher of:

- the Minimum Capital Requirement (MCR);
- the Enhanced Capital Requirement (ECR).

4.2.1 CALCULATION OF MCR

For an insurer carrying on general insurance business the MCR is the higher of:

- the base capital resources requirement for general insurance business applicable to that firm; and
- the general insurance capital requirement.

The MCR gives effect to the EU Directive minimum requirements. For general insurance business, the EU Directive minimum is the higher of the general insurance capital requirement and the relevant base capital resources requirement.

The amount of an insurer's base capital resources requirement is set out in the table below. If an insurer falls within one or more of the descriptions of type of firm set out in the table, its base capital resources requirement is the highest amount set out against the different types of firm within whose description it falls.

Firm category	Amount: Currency equivalent of	
General insurance business		
Liability insurer (classes 10-15)	Directive mutual	€ 2.625 mln
	Non-directive insurer	€ 350 000
	Other (excluding pure reinsurer but including mixed insurer)	€ 3.5 mln
Other insurer	Directive mutual	€ 1.725 mln
	Non-directive insurer (1 to 8, 16 or 18)	€ 260 000
	Non-directive insurer (9 or 17)	€ 175 000
	Mixed insurer	€ 3.5 mln
	Other(excluding pure reinsurer)	€ 2.3 mln

Table 7: Amount of an insurer's base capital resources requirement.

The general insurance capital requirement is the highest of:

- the premiums amount;
- the claims amount; and
- the brought forward amount.

The premiums amount is:

- 18% of the gross adjusted premiums amount; less 2% of the amount, if any, by which the gross adjusted premiums amount exceeds €57.5 million; multiplied by
- the reinsurance ratio.

The claims amount is:

- 26% of the gross adjusted claims amount; less 3% of the amount, if any, by which the gross adjusted claims amount exceeds €40.3 million; multiplied by
- the reinsurance ratio.

The brought forward amount is the general insurance capital requirement (GICR) for the prior financial year, multiplied, if the ratio is less than one, by the ratio (expressed as a percentage) of:

- the (calculated net of) for outstanding at the end of the prior; to
 - the technical provisions (calculated net of reinsurance) for claims outstanding at the beginning of the prior financial year.
1. If the amount of the technical provisions is in both cases zero, the brought forward amount is the general insurance capital requirement (GICR) for the prior financial year, multiplied, if the ratio is less than one, by the ratio (expressed as a percentage) of:
 - the technical provisions (calculated gross of reinsurance) for claims outstanding at the end of the prior financial year; to
 - the technical provisions (calculated gross of reinsurance) for claims outstanding at the beginning of the prior financial year.
 2. If the amount of the technical provisions (calculated gross of reinsurance) is in both cases zero, the brought forward amount is the general insurance capital requirement (GICR) for the prior financial year.

The reinsurance ratio is:

1. if the ratio lies between 50% and 100%, the ratio (expressed as a percentage) of:
 - the claims incurred (net of reinsurance) in the financial year in question and the two previous financial years; to
 - the gross claims incurred in that three-year period.
2. 50%, if the ratio calculated (1) is 50% or less; and
3. 100%, if the ratio calculated in (1) is 100% or more.

4.2.2 CALCULATION OF ECR

The ECR for firms carrying on general insurance business is an indicative measure of the capital resources that a firm may need to hold based on risk sensitive calculations applied to its business profile.

For firms carrying on general insurance business, the FSA will use the ECR as a benchmark for its consideration of the appropriateness of the firm's own capital assessment. For firms where an ECR is not calculated, the MCR will provide a benchmark for the firm's own capital assessment.

ECR is the sum of:

- the asset-related capital requirement; and
- the insurance-related capital requirement; less
- the firm's equalisation provisions.

We analyze below the insurance related capital requirement which is a measure of the capital that a firm should hold against the risk of:

- an adverse movement in the value of a firm's liabilities, to recognize that there may be substantial volatility in claims and other technical provisions made by the firm; and
- the premiums a firm charges in respect of particular business not being adequate to fund future liabilities arising from that business.

The insurance-related capital requirement is calculated by applying capital charge factors to the value of the net written premiums and the technical provisions in respect of different classes of business.

1. If any amount which is to be multiplied by a capital charge factor is a negative amount, that amount shall be treated as zero.
2. The amounts resulting from multiplying the net written premiums in respect of each such class of business by the corresponding capital charge factor must be aggregated.

3. The amounts resulting from multiplying the technical provisions in respect of each such class of business by the corresponding capital charge factor must be aggregated.
4. The insurance-related capital requirement is the sum of the amounts calculated in accordance with (3) and (4).

Class of Business	Net Written Premium capital charge factor	Technical provision capital charge factor
Direct and facultative accident and health	5%	7.5%
Direct and facultative personal lines motor business	10%	9%
Direct and facultative household and domestic all risks	10%	10%
Direct and facultative personal lines financial loss	25%	14%
Direct and facultative commercial motor business	10%	9%
Direct and facultative commercial lines property	19%	10%
Direct and facultative commercial lines liability	14%	14%
Direct and facultative commercial lines financial loss	25%	14%
Direct and facultative aviation	32%	14%
Direct and facultative marine	22%	17%
Direct and facultative goods in transit	12%	14%
Direct and facultative miscellaneous	25%	14%
Non-proportional accident & health	35%	16%
Non-proportional motor	10%	14%
Non-proportional transport	16%	15%
Non-proportional aviation	61%	16%
Non-proportional marine	38%	17%
Non-proportional property	53%	12%
Non-proportional liability (non motor)	14%	14%
Non-proportional financial lines	39%	14%
Non-proportional aggregate cove	53%	12%
Proportional accident & health	12%	16%
Proportional motor	10%	12%
Proportional transport	12%	15%
Proportional aviation	33%	16%
Proportional marine	22%	17%
Proportional property	23%	12%
Proportional liability (non motor)	14%	14%
Proportional financial lines	25%	14%
Proportional aggregate cove	23%	12%
Miscellaneous reinsurance accepted business	39%	14%

Table 8: Net written premium and technical provision capital charge factors.

4.3 INDIVIDUAL CAPITAL ASSESSMENT

Under ICAS, FSA requires firms to undertake regular assessments of the amount and quality of capital which is adequate for the size and nature of its business.

We can summarize the objectives of the ICAS regime as follow:

- to ensure that senior management focus on risk management;
- that there is a link between risk and capital-setting; and
- that this is demonstrated through clear documentation of all prudential risks, processes and controls.

In making an assessment of capital adequacy, insurers should first identify the significant risks facing their business and subsequently quantify how much capital is required clearly demonstrating the link between their risk framework and the ICA calculation. Central to this process should be the insurers' risk management framework.

In the ICA's calculation, insurers can use two broad approaches, namely:

- stress and scenario tests;
- economic capital models (also known as stochastic models or Dynamic Financial Analysis (DFA)).

Although these are significantly different in application, they are not in principle different as a stochastic model is based on stress and scenarios weighted by probabilities. In a DFA model, stress tests are generated automatically and often cannot be "seen". Both methods are acceptable for the 2010 ICAs.

It takes time to develop a stochastic model that is sufficiently robust. It is also important that management understands and "buys in" to the model. Even where a stochastic model has been used, stress tests are needed to validate the model output for reasonableness and to help with calibrating assumptions. Agents must ensure that the stress and scenario tests which they undertake are relevant to their business and sufficiently extreme to represent the 1:200 level.

One of the weaknesses in adopting a solely stress and scenario testing approach is in the aggregation of risks to arrive at an overall capital figure.

Two common approaches to reflect aggregation of risk are:

- specification of a correlation matrix between each scenario; and
- 'ripple effects'.

Under the first approach, a range of stress tests is considered and quantified in isolation. A correlation matrix is then specified between risk categories/stress tests (judgementally: high/medium/low correlation) and then aggregated to derive an overall capital figure.

Under the second approach a range of scenarios is chosen, and for each one the associated 'ripple effects' resulting from that scenario are also quantified. An extension of this approach is a 'cause and effect' table, where for each defined scenario, the knock-on effect of losses from other pre-defined events is also derived. However, because dependency does not require cause and effect, a cause and effect approach is unlikely to be sufficient without adjustment.

Aggregation of scenarios will depend on the complexity of the stress tests. In some cases, using the maximum value of the scenarios may be appropriate, or alternatively aggregation may be achieved through a correlation matrix approach.

In addition robust stress and scenario test approach should:

- ensure that stress tests cover all risk aspects;
- ensure that stress tests used are sufficiently severe at the 1:200 level otherwise combination of less severe impacts must be aggregated; and
- allow for dependencies.

We now analyze ICA as presented in INSPRU 7.1, starting from the main requirements set out by FSA.

This section is structured around the main requirements set out by the FSA under three 'sub-principles for ICAS', which may be summarized as:

1. the firm's assessment of the adequacy of its capital resources;
2. comparability to a 99.5% / 1 year probability that the value of the firm's assets will exceed the value of their liabilities; and
3. model methodology: documenting the firm's reasoning and judgment underlying the ICA assessment.

PRINCIPLE 1: The assessment of the adequacy of the firm's capital resources must:

- reflect the firm's assets, liabilities, intra-group arrangements and future plans;
- be consistent with the firm's management practice, systems and controls;
- consider all material risks that may have an impact on the firm's ability to meet its liabilities to policyholders; and
- use a valuation basis that is consistent throughout the assessment.

PRINCIPLE 2: Where the FSA requests a firm to submit to it a written record of the firm's assessments of the adequacy of its capital resources those assessments must include an assessment comparable to a 99.5% confidence level over a one year timeframe that the value of assets exceeds the value of liabilities, whether or not this is the confidence level otherwise used in the firm's own assessments.

PRINCIPLE 3: The written record of a firm's individual capital assessments carried out must:

- in relation to the assessment comparable to a 99.5% confidence level over a one year timeframe that the value of assets exceeds the value of liabilities, document the reasoning and judgements underlying that assessment and, in particular, justify:
 - a. the assumptions used;
 - b. the appropriateness of the methodology used; and
 - c. the results of the assessment.
- Identify the major differences between that assessment and any other assessments carried out by the firm using a different confidence level.

4.3.1 SUB PRINCIPLE 1.1

The assessment of the adequacy of the firm's capital resources must reflect the firm's assets, liabilities, intra-group arrangements and future plans.

The ICA should reflect both the firm's desire to fulfill its business objectives and its responsibility to meet liabilities to policyholders. This means that the ICA should demonstrate that the firm holds sufficient capital to be able to make planned investments and take on new business (within an appropriate planning horizon). It should also ensure that if the firm had to close to new business (if it has not already done so), it would be able to meet its existing commitments.

4.3.2 SUB PRINCIPLE 1.2

The assessment of the adequacy of the firm's capital resources must be consistent with the firm's management practice, systems and controls.

The ICA should reflect the firm's ability to react to events as they occur. When relying on prospective management actions, firms should understand the implications of taking such actions, including the financial effect, and taking into consideration any preconditions that might affect the value of management actions as risk mitigants. Firms should also consider whether their systems and controls provide sufficient information to permit senior management to identify the crystallization of risks in a timely manner so as to provide them with the opportunity to respond and allow the firm to obtain the full value of the modeled management action. Firms should also analyze the wider implications of the management actions, particularly where they represent significant divergence from the business plan and use this information to consider the appropriateness of taking this action.

4.3.3 SUB PRINCIPLE 1.3

The assessment of the adequacy of the firm's capital resources must consider all material risks that may have an impact on the firm's ability to meet its liabilities to policyholders.

The ICA should consider all material risks which may arise before the policyholder liabilities are paid, including risks relate to events that occur with an expected likelihood beyond the confidence level. The major risks pertinent to ICA are:

- Insurance Risk: typically refers to fluctuations in the timing, frequency and severity of insured events, relative to the expectations of the firm at the time of

underwriting. Insurance risk may also refer to fluctuations in the timing and amount of claim settlements. For general insurance business, examples of insurance risk include variations in the amount or frequency of claims or the unexpected occurrence of multiple claims arising from a single cause. Insurance risk may be divided in:

- underwriting Risk, which includes:
 - the adequacy of the firm's pricing, taking the insurance premium cycle into account and the high level of uncertainty in pricing in new or emerging markets;
 - the uncertainty of claims experience;
 - the dependence on intermediaries for a disproportionate share of the premium income;
 - geographical or jurisdictional concentrations;
 - the appropriateness of policy wordings;
 - the risk of mis-selling, for example, the number of complaints or disputed claims;
 - the tolerance for expense reserve variations or variations in expenses
 - the length of tail of the claims development and latent claims; and
 - the effects of rapid growth or decline in the volume of the underwriting portfolio.

- Reserving and Claims Risks, which includes:
 - the frequency and size of large claims;
 - possible outcomes relating to any disputed claims, particularly where the outcome is subject to legal proceedings;
 - the ability of the firm to withstand catastrophic events, increases in unexpected exposures, latent claims or aggregation of claims;
 - the possible exhaustion of reinsurance arrangements, both on a per risk and per event basis;
 - social and societal factors driving an increase in the propensity to claim and to sue;
 - other social, economic and technological changes;

- the adequacy and uncertainty of the technical claims provisions, such as outstanding claims, IBNR and claims handling expense reserves;
 - the adequacy of other underwriting provisions, such as the provisions for unearned premium and unexpired risk reserves;
 - the appropriateness of catastrophe models and underlying assumptions used, such as possible maximum loss (PML) factors used;
 - unanticipated legal judgements and legal change with retrospective effect specifically with regard to the claims reserves; and
 - the effects of inflation.
- Credit Risk: typically refers to any risk in an insurer's ability to recover money owed by third parties. This includes all counterparties, including reinsurance firms, intermediaries, policyholders, banks and issuers of investments.
- Market Risk: typically refers to the risk that arises from fluctuations in the values of or income from assets, from interest rates or exchange rates.
- Liquidity Risk: typically refers to the risk that a firm reaches a position where, although total assets exceed the value of liabilities, the firm does not have sufficient financial resources available in cash to enable it to meet its obligations as they fall due, or can secure such resources only at prohibitive cost.
- Operational Risk: can be defined as the risk of an incident occurring which leads to or could lead to the actual outcome of a business process to differ from the expected outcome due to inadequate or failed processes, people, systems, or external factors.
- Group Risk: typically refers to the risks a firm is exposed to as a member of a group. In many cases, being a member of a group can provide significant advantages in terms of financial strength, technical expertise and management experience. However, there may be group risks external to the individual entity that may deplete or divert financial resources held by the individual firm to meet liabilities arising from the parent or another entity in the group.

4.3.4 SUB PRINCIPLE 1.4

The assessment of the adequacy of the firm's capital resources must use a valuation basis that is consistent throughout the assessment.

The valuation of the assets and of the liabilities should reflect their economic substance. A realistic valuation basis should be used for assets and liabilities taking into account the actual amounts and timings of cash flows under any projections used in the assessment. In carrying out the ICA, wherever possible the value of assets should be marked to market. Where marking to market is not possible, the ICA should use a method suitable for assessing the underlying economic benefit of holding each asset.

4.3.5 SUB PRINCIPLE 2

Where the FSA requests a firm to submit to it a written record of the firm's assessments of the adequacy of its capital resources, those assessments must include an assessment comparable to a 99.5% probability over a one-year timeframe that the value of assets exceeds the value of liabilities, whether or not this is the confidence level otherwise used in the firm's own assessments.

If a firm selects a longer time horizon than one year it may choose to use a lower confidence level than 99.5%. In such a case, the firm should be prepared to justify its choice and explain why this confidence interval is appropriate and how it is comparable to a 99.5% confidence level over a one year timeframe. An assessment based on a longer timeframe should also demonstrate that there are sufficient assets to cover liabilities at all future dates. This may be illustrated by future annual balance sheets.

4.3.6 SUB PRINCIPLE 3.1

The written record of a firm's individual capital assessments submitted by the firm to the FSA must in relation to the assessment comparable to a 99.5% confidence level over a one year timeframe that the value of assets exceeds the value of liabilities, document the reasoning and judgments underlying that assessment and, in particular, justify the assumptions used.

FSA requires a firm to document the reasoning and judgements underlying its ICA, justifying the assumptions and methodology used, and to explain any major differences between its ICA and the firm's own assessment, where this is different from the ICA.

FSA set out a number of requirements covering:

- the choice of assumptions;
- the evidence required to support these assumptions; and
- the regular review of assumptions.

Where the choice of assumptions is supported by data, the firm should consider the relevance of that data to the firm's current and future circumstances and the robustness of any estimates derived. Where the choice of assumptions is supported by expert judgment, the firm should consider the nature and value of the expertise being used to support this judgment and any biases that may exist. Where possible, the firm should use data to test and support these expert judgements.

4.3.7 SUB PRINCIPLE 3.2

The written record of a firm's individual capital assessment submitted by the firm to the FSA must in relation to the assessment comparable to a 99.5% confidence level over a one year timeframe that the value of assets exceeds the value of liabilities, document the reasoning and judgments underlying that assessment and, in particular, justify the appropriateness of the methodology used.

The methodology used within the ICA should allow the firm to quantify the financial effect of material risks at the required confidence level. The methodology used should also reflect the nature of the firm's business and be consistent with the way in which the firm identifies and manages risk. Firms should be able to explain their rationale for choosing their approach to risk and assessment of capital required. There are no simple classifications of approach to risk and capital assessment, so the rationale should be considered in the context of a number of defining characteristics in the structure of the capital model.

Generally, larger firms would be expected to take a more sophisticated approach to capital modeling than smaller ones.

4.3.8 SUB PRINCIPLE 3.3

The written record of a firm's individual capital assessment submitted by the firm to the FSA must in relation to the assessment comparable to a 99.5% confidence level over a one year timeframe that the value of assets exceeds the value of liabilities, document the reasoning and judgments underlying that assessment and, in particular, justify the results of the assessment.

FSA guidance indicates that firms should consider the full range of possible outcomes (not only those below the 99.5%/1yr confidence level), however unlikely any one single outcome might be, to ensure capital is set to provide appropriate protection against all but the most extreme losses. FSA also suggest that checks should be made as to the reasonableness of the outcomes, with consideration given to a range of scenarios that could give rise to the scale of loss envisaged in the capital assessment.

4.3.9 SUB PRINCIPLE 3.4

The written record of a firm's individual capital assessments submitted by the firm to the FSA must identify the major differences between that assessment and any other assessments carried out by the firm using a different confidence level.

FSA guidance indicates that whilst a firm is required to submit an assessment comparable to a 99.5% probability over a one-year time horizon that the value of assets exceeds liabilities, it may be the case that for its own assessment the firm will use a different confidence level. For example, this may be because the firm:

- has a different view of its capital adequacy;
- is seeking to meet the demands of ratings agencies to secure a given rating; and
- seeks to distinguish itself from competitors when describing its financial strength to policyholders.

Where the firm does use a different confidence level, the FSA require the submission of a comparison between the firm's own assessment and the prescribed 99.5% confidence

level. This would include any major differences in the definition of assets or liabilities, the management actions used, the risks considered or the valuation methodology.

4.4 INDIVIDUAL CAPITAL GUIDANCE

In assessing the adequacy of a firm's capital resources, the FSA draws on more than just a review of the submitted ICA.

When forming a view of any individual capital guidance to be given to a firm, the review of the firm's ICA along with the ARROW risk assessment²⁷ and any other issues arising from day-to-day supervision will be considered.

The FSA will take a risk-based and proportionate approach to the review of a firm's ICA, focusing on the firm's approach to dealing with the key risks it faces. Any individual capital guidance given will reflect the judgments reached through the ARROW review process as well as the review of the firm's ICA.

A firm should not expect the FSA to accept as adequate any particular model that the firm develops or that the results from the model are automatically reflected in any individual capital guidance given to the firm for the purpose of determining adequate capital resources.

Where the FSA considers that a firm will not comply with (adequate financial resources, including capital resources) by holding the capital resources required the FSA may give the firm individual capital guidance advising it of the amount and quality of capital resources which the FSA considers it needs to hold in order to meet that rule.

In giving individual capital guidance, the FSA seeks a balance between delivering consistent outcomes across the individual capital guidance it gives to all firms and recognizing that such guidance should reflect the individual features of the firm.

The FSA also takes account of the quality of the wider risk management around the development of the numbers used in the ICA. The aim is to deliver individual capital guidance that comes closest to ensuring that there is no significant risk that a firm is unable to pay its liabilities as they fall due.

Following an internal validation process, the FSA will write to the Board of the firm being assessed providing both quantitative and qualitative feedback on the results of the FSA's

²⁷See FSA, "The FSA's risk assessment", <http://www.fsa.gov.uk/>, 2006.

assessment. This letter will notify the firm of the individual capital guidance considered appropriate. The letter will include reasons for any capital add-ons identified, where applicable.

If a firm considers that the individual capital guidance is inappropriate to its circumstances, then the firm should inform the FSA that it does not intend to follow that guidance.

If the FSA and the firm still do not agree on an adequate level of capital, then the FSA may consider using its powers to require it to hold capital in accordance with the FSA's view of the capital necessary.

CHAPTER 5

THE NEW CAPITAL REQUIREMENTS IN EUROPEAN UNION: FROM SOLVENCY I TO SOLVENCY II

The starting point of a formal set of solvency requirements that insurance companies were required to fulfill in a free market can be considered the Life insurance directives (EEC 1979) and the non-life insurance directives (EEC 1973)²⁸. The approaches adopted were simple and straight forward to operate. Solvency assessment was based on simple factors and formulae that were applied on accounting results after adjustment for reinsurance. For example, in case of life insurance, simple factors were used on the mathematical reserve or the capital at risk depending upon who bore the investment risk.

The calculation of the Minimum Solvency Margin (often referred to as the Required Solvency Margin) consisted of a sum of two results:

- the first related to the mathematical provisions (represented by Investment Risk);
- the second related to policies where the policyholder bears the investment risk (represented by Technical Risk).

In addition, there was a Guarantee fund that was an amount in absolute terms.

One third of the Minimum Solvency Margin was compared with the guarantee fund to arrive at the minimum guarantee fund. In essence, the calculation involved:

A. *Minimum Solvency Margin* =
4% *mathematical reserves (gross of reinsurance)* +
0.3% *capital sum at risk*.

B. *Guarantee fund* = 800 000 ECU in 1979

²⁸ <http://ec.europa.eu/>.

C. Minimum Guarantee Fund = max (1/3 A, B)

The base formula for Minimum Solvency Margin was applicable for life insurance and annuity business. The 4% was based on the assumption that the loss ratio (losses/technical provisions) follows a Pearson Type IV²⁹ distribution and 4% corresponds to 95% confidence interval. Insurers were required to meet the Required Solvency margin (RSM) and any fall in capital below this level would trigger a 'warning signal'. If the capital falls to the level of the Minimum Guaranteed Fund, 'wind up' would be triggered. So, the "wind up" was based on fixed ratios.

Though the factors were simple to apply, easy to administer and understand, they were simple formula based and did not consider risks explicitly. However, they lacked the capability to cope with the increase in market complexity and rising customer protection needs.

The assets could be valued at historical/amortized costs as well as market value. Hence, asset valuation was not completely harmonized. In life insurance, since simple factors were being applied, a strengthening of the reserving basis led to an increase in mathematical reserve and hence a direct increase in the required solvency margin. So, in effect prudence did not really work towards the advantage of the insurance company in terms of availability of free capital.

5.1 SOLVENCY I

The findings of Müller report³⁰ and the work done by a few other committees which looked into solvency regulations, paved the way for the introduction of Solvency I in EU in the year 2002 which introduced some additional parameters in solvency evaluation.

Solvency I provided a simple, but robust mechanism to regulate insurer solvency. It has improvements over the early day regulations, but still maintained its simplicity. A positive consequence of this was that it made the administration and compliance management easy and inexpensive.

²⁹ <http://en.wikipedia.org/>.

³⁰ H. Müller et al. (1997) Solvency of Insurance Undertakings, Conference of the Insurance Supervisory Services of the Member States of the European Union.

In spite of its relative simplicity, Solvency I did significantly increase the protection of the policyholders. That explains the reason why the system performed well over the years.

Though Müller report found the existing structure of solvency margin satisfactory, some suggestions were made for further improvement. The key suggestions were:

- the minimum guarantee fund should be reviewed and updated at regular 5 year intervals;
 - in Solvency I, Minimum requirement was increased to 3 million euro - to be updated in the future in line with EU consumer price inflation.
- the regulations should not only look at the solvency margin, but also at the composition of the margin and the guarantee fund; and
- the risks identified to be classified as:
 - technical (insufficient premiums, mortality, morbidity, interest rate – that would perhaps affect discontinuance rates, reinsurance etc.);
 - investment (depreciation, liquidity, matching, interest rate including reinvestment, derivatives etc.); and
 - nontechnical (management, 3rd party credit risk, regulations etc.).

The introduction of Solvency I norms helped provide higher protection to policyholders.

A few of the significant differences which came up were:

- unlike the 'point in time' approach in the previous regime, Solvency I stipulated that solvency requirements should be met at all times and not just on the date of the latest balance sheet;
- permanent health insurance required additional capital over and above what was specified in the earlier regime; and
- insurance companies were required to have an additional solvency margin for unit-linked contracts (firm bears no investment risk) where the allocation to management expenses was not fixed beyond 5 years.

Another significant difference was that the member states were free to set more stringent requirements than those specified in the Directive, if they so desired.

However, since the creation of these rules, significant changes had taken place in the insurance industry, creating the need to adapt the rules appropriately.

The equity markets were strong in the later nineties helping insurance companies but this changed in early part of this decade – 2001/02, the interest rates fall makes difficult to meet the guaranteed returns, the Life expectancy increased as the frequency of high impact events more often than ever.

The working document for Solvency I had already indicated the need for a better system which recognizes the various risks that an insurance company is exposed to in a more holistic manner. Another factor which prompted reforming of the solvency regulation was the fact that some other countries like the US had already started the move towards a risk based capital system.

In 1999, at a meeting of the Insurance Committee (IC) it was agreed that a more fundamental review of the overall financial position of an insurance company should be done. This review was to include previously neglected risk classes (e.g. ALM risk, Operations Risk etc)

Solvency II committee came into existence as a result of this decision.

5.2 SOLVENCY II

Solvency II is a new, risk-sensitive system for measuring the financial stability of insurance companies in the EU. It is intended to provide greater security for policyholders and stability for financial markets by providing insurance supervisors with better information and tools to assess the financial strength and the overall solvency of insurance companies. Solvency II will be based on economic principles for the measurement of assets and liabilities. It will also be a risk-based system as risk will be measured on consistent principles and capital requirements based directly on this measurement.

A set of simple factors, as used for Solvency I, cannot cope well with the diversity of risks in typical insurance portfolios. The more advanced companies have developed sophisticated internal models to measure the effects of adverse events on their portfolios. Provided they can be validated to an adequate standard, these models will form the basis of the capital assessment under Solvency II.

Companies that do not have an internal model of the required standard will still be able to use a factor-based system (the 'Standard Approach'), although it is likely to be more complex than the current system.

The aim of Solvency II is not to increase overall levels of capital but rather to ensure a high standard of risk assessment and efficient capital allocation. It should also contribute to increased transparency and help in the development of a level playing field across Europe.

Solvency II is an opportunity to improve insurance regulation by introducing:

- a risk-based system;
- an integrated approach for insurance provisions and capital requirements;
- a comprehensive framework for risk management;
- capital requirements defined by a standard approach or internal model; and
- recognition of diversification and risk mitigation.

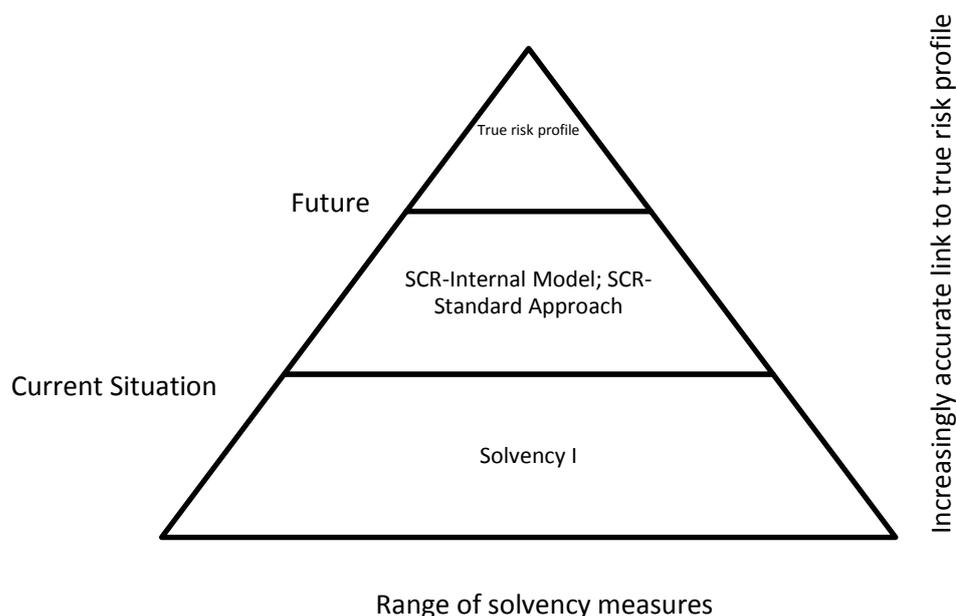


Figure 2: The journey of European Union Solvency Standard.

The Solvency II has been developed in accordance with the EU's "Lamfalussy process", this means it's divided in four levels. The first level sets out key principles and relates the adoption of provisions under the existing framework procedure of "co-decision" based on

the proposals that the Commission submit to the Council and the European Parliament for adoption.

The second level relates to the implementing measures, defining detailed requirements that are tested through Quantitative Impact Studies (QIS).

The third level relates to the transposition and application of legislation of the first and second level in the Member States by the CEIOPS³¹ to ensure harmonized outcome.

Finally the fourth level is a review by the Commission of the proper implementation of legislation across the European Union.

5.2.1 THE STRUCTURE

The structure adopted in Solvency II has embraced a 3 pillar approach:

- Pillar I, which focuses on quantitative requirements: valuing assets, liabilities and capital;
- Pillar II, which focuses on supervisory activities: which provides qualitative review through the supervisory process including a focus upon the company's internal risk management processes; and
- Pillar III, which addresses supervisory reporting and public disclosure of financial and other information by insurance companies.

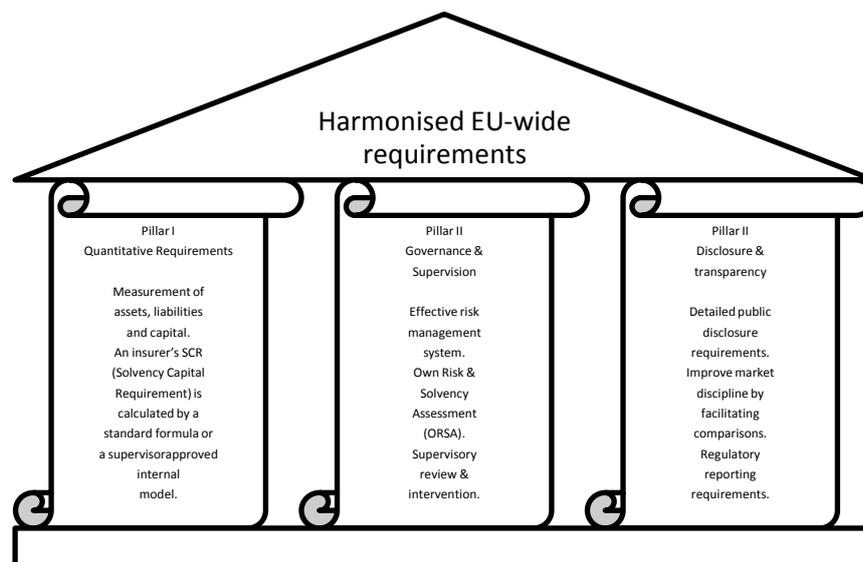


Figure 3: Solvency II structure.

³¹ The Committee of European Insurance and Occupational Pensions Supervisors.

Pillar I requires demonstration of adequate financial resources and there will be dual-level requirements: the Solvency Capital Requirement (SCR) and Minimum Capital Requirement (MCR).

Below the MCR, which is calculated with a simple method, policyholders are exposed to unacceptable risk and breaching the MCR leads to serious supervisory action.

The Solvency Capital should be determined in order to consider all quantifiable risks faced by a company and be based on the amount of economic capital corresponding to a default probability of ruin and a specific time horizon.

With regard to the calibration parameters, the European Commission suggests a probability of ruin of 0.5%, in particular a VaR risk measure with a confidence level equal to 99.5%, and a time horizon of one year.

For what concerns the risks to be considered in determining the requirements, the European Commission refers to the classification adopted by the International Actuarial Association (IAA), includes:

- underwriting risk;
- credit risk
- market risk; and
- operational risk.

The SCR may be calculated in different ways, using:

- Standard Model: this is default formula currently being constructed and will be available for all companies to use;
- Internal Models: are firm specific calculations designed to maximise capital efficiency. They will encompass all the risks present in the standard model, however will be structured to capitalise on the entity's' unique composition and inherent risk diversification. As these internal models are produced by the firms themselves, they require regulatory sign-off before they can be used. This ensures they capture all the risks within the standard model to an adequate degree; and
- Partial Model: due to the potentially prohibitive costs of constructing an entity specific internal model (particularly for smaller companies), the partial model is an amalgamation of the above. A firm can choose to use the standard model, but on

certain risk modules it can provide its own calculations. As in the internal model these specific areas will require local regulatory permission.

Pillar II comprises two aspects. First, an insurance firm must have in place sound and effective strategies and processes to assess and manage the risks to which it is subject and to assess and maintain its capital needs. Second, those strategies and processes should be subject to review by the supervisory authority.

The starting point should be for all firms to undertake their own individual risk and capital assessment. Where under Pillar I a firm is using either an internal model or is using a stress or scenario approach under standard formula, the firm's Pillar I calculation and its Pillar II assessment will overlap significantly. However, there are important differences between these two pillars. The Pillar II assessment should represent the firm's view of its capital needs, based on an analysis of all the risks that it is exposed to – and factoring in any reasonable mitigation management action. Requiring all firms to conduct an individual risk and capital assessment in Pillar II will act as powerful tools to foster, encourage and reward, as well as to help embed better and more comprehensive risk management practices in firms. This in turn will lead to a much better assessment and alignment of actual capital needed by a firm to meet its risk profile. For those firms using the standard formula, the assessment should also consider the extent to which it adequately captures the capital required for the risks of that particular firm, including internal controls, risk management systems and governance of the firm. For firms using an internal model the assessment should also take account of control and model risks and demonstrate the extent to which the quantitative models appropriately reflects the actual capital required.

The supervisory review under Pillar II has two aims: to ensure that a firm is well run and meets adequate risk management standards; and to ensure that the firm is adequately capitalised. If, as a result of the supervisory review, the supervisor concludes that the firm should hold more or higher quality of capital, an "add-on" of capital could be applied and this would be the adjusted SCR. Extra capital is of course not the always the best response or even always an appropriate response to problems identified in the supervisory review. In particular, inadequate risk management standards at an insurance firm identified in the supervisory review, quite simply needs to be remedied by the firm.

The purpose of Pillar III is to enhance market discipline on regulated firms by requiring them to disclose publicly key information that is relevant to market participants. It follows from this that in choosing which information should be selected for disclosure under Pillar III, supervisors should be guided by the actual needs of market participants rather than by their own information needs. Pillar III public disclosure serves a different purpose from private regulatory reporting of information to supervisors.

In the following section we analyze the journey of the capital requirements for underwriting premium and reserve risks under the different quantitative impact studies.

5.2.2 THE STANDARD FORMULA UNDER QIS2

The second quantitative impact study introduced a first structure for the determination of the SCR, defining the risks to be considered and must be evaluated by appropriate methods.

The QIS 2 structure is the following:

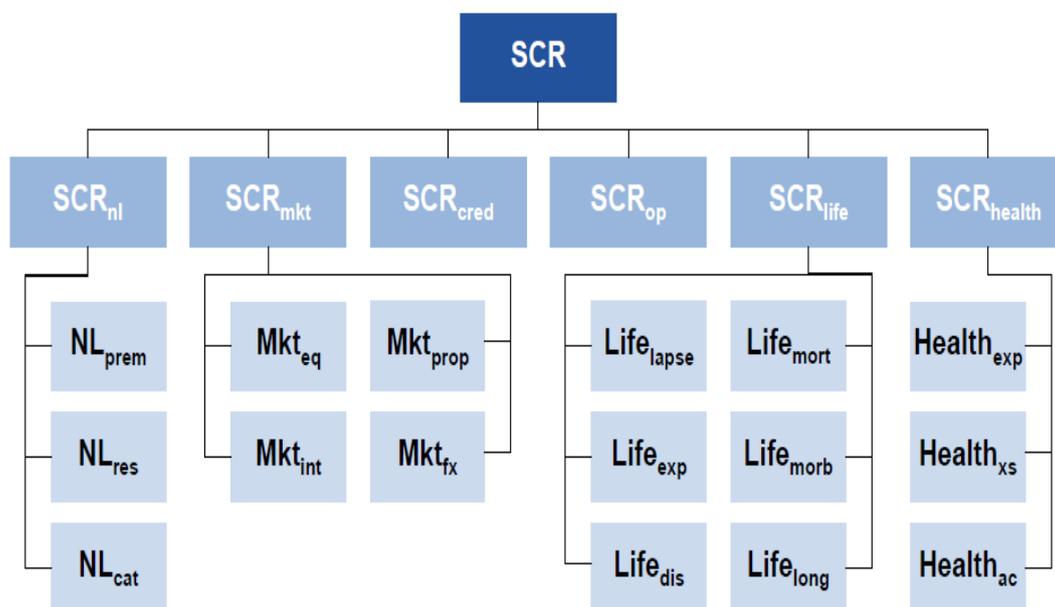


Figure 4: QIS 2 structure.

It's clear that QIS 2 defines six categories of risk:

1. life underwriting risk;
2. non-life underwriting risk;
3. health underwriting risk;
4. market risk;
5. credit risk; and
6. operational risk;

The total capital requirement derived by the aggregation of the Line of Business it's called Basic SCR (BSCR) and it is:

2

$$BSCR^{(QIS2)} = \sqrt{\sum_{rxc} CorrSCR^{rxc} SCR_r SCR_c}$$

Where $CorrSCR^{rxc}$ is:

CorrSCR	SCR _{mkt}	SCR _{cred}	SCR _{life}	SCR _{health}	SCR _{nl}	SCR _{op}
SCR _{mkt}	1					
SCR _{cred}	MH	1				
SCR _{life}	ML	ML	1			
SCR _{health}	ML	ML	ML	1		
SCR _{nl}	ML	ML	L	L	1	
SCR _{op}	M	ML	ML	ML	M	1

Table 9: QIS2 CorrSCR matrix.

In the technical specification are not defined numerical values for the correlations, but only generic correlations level:

- L: low;
- ML: medium-low;
- M: medium; and

- MH: medium-high.

The QIS 2 capital requirement is obtained considering the BSCR, an allowance for the risk absorption ability of future profit sharing (RPS), and – for non-life insurance – the expected profit or loss from next year’s business (NL_PL), so that:

3

$$SCR^{(QIS2)} = BSCR^{(QIS2)} - RPS - NL_PL$$

In the next section we analyze the QIS2 capital requirement for a non-life insurer.

5.2.2.1 SCR NON-LIFE UNDERWRITING RISK MODULE³²

Non-life underwriting risk is split into three components: reserve risk, premium risk and cat risk.

The capital charges for the sub-risks should be combined using a correlation matrix as follows:

4

$$SCR_{nl}^{(QIS2)} = \sqrt{\sum_{rxc} CorrNL^{rxc} NL_r NL_c} = \sqrt{NL_{pr}^2 + NL_{res}^2 + NL_{CAT}^2 + 2 * 0,5 * NL_{pre} NL_{res}}$$

Where $SCR_{nl}^{(QIS2)}$ is the placeholder capital charge for non-life underwriting risk, NL_r, NL_c are capital charges for the individual non-life underwriting sub-risks according to the rows and columns of correlation matrix $CorrNL$ which is defined as follows:

CorrNL	NL _{res}	NL _{prem}	NL _{CAT}
NL _{res}	1		
NL _{prem}	0.5	1	
NL _{CAT}	0	0	1

Table 10: QIS2 CorrNL matrix.

³² In this section is not analyzed the CAT risk, for more informations refer to “QIS 2 technical specifications”.

The QIS2 LoB classification is:

Line of Business	
1	Accident and health
2	Motor, third-party liability
3	Motor, other classes
4	Marine, aviation, transport (MAT)
5	Fire and other property damage
6	Third-party liability
7	Credit and suretyship
8	Legal expenses
9	Assistance
10	Miscellaneous
11	Reinsurance

Table 11: QIS 2 LoB classification.

5.2.2.1.1 NL PREMIUM RISK

To define the capital requirement for premium risk a factor based approach is used, and it's:

5

$$NL_{prem} = \rho(\sigma)P$$

Where P is the estimate of net earned premium of the overall business in forthcoming year, σ is the estimate of the standard deviation of the overall combined ratio and ρ is a function of the standard deviation specified as follows:

6

$$\rho(x) = \frac{0.99 - \Phi(N_{0.99} - \sqrt{\log(x^2 + 1)})}{0.01}$$

Where Φ is the cumulative distribution function of the standard normal distribution and $N_{0.99}$ equal to the 99% quantile of the standard normal distribution.

In addition the estimate P of the volume of net earned premium for the overall non-life business in the forthcoming year is defined as follows:

7

$$P = \sum_{lob} P_{lob}$$

And σ of the total business is:

8

$$\sigma = \sqrt{\frac{1}{P^2} \sum_{r,c} CorrLob_Prem^{rxc} * P_r * P_c * \sigma_r \sigma_c}$$

With $CorrLob_Prem^{rxc}$ defined as follows:

CorrLob_Prem	1	2	3	4	5	6	7	8	9	10	11
1	1										
2	0.25	1									
3	0	0.5	1								
4	0	0	0.5	1							
5	0	0	0.5	0.25	1						
6	0.25	0	0	0	0	1					
7	0	0	0	0	0	0.75	1				
8	0.5	0.25	0	0	0	0.5	0.75	1			
9	0	0	0.5	0.5	0.5	0	0	0	1		
10	0	0	0	0	0	0	0	0	0	1	
11	0	0	0.5	0.5	0.5	0.5	0	0	0	0	1

Table 12: QIS2 CorrLoB_Prem matrix.

And σ_r, σ_c respectively the σ of LoB r and LoB c

To estimate σ are available two different approaches:

- “Market-wide approach”; and
- “Undertaking-specific approach”.

The market wide approach estimates the standard deviation of the combined ratio in the individual LoBs as follows:

9

$$\sigma_{M,lob} = sf_{lob} * f_{lob}$$

Where sf_{lob} is the size factor defined as follows:

10

$$sf_{lob} = \begin{cases} 1 & \text{if } P_{lob,gross} \geq 100\text{mln of euro} \\ \frac{10}{\sqrt{P_{lob,gross} * 10^{-6}}} & \text{if } 100\text{mln of euro} > P_{lob,gross} \geq 20\text{mln of euro} \\ \frac{10}{\sqrt{20}} & \text{otherwise} \end{cases}$$

And f_{lob} is the volatility factor specific for each Line of Business and equal to:

LoB	1	2	3	4	5	6	7	8	9	10	11
f_{lob}	0.05	0.125	0.075	0.15	0.10	0.25	0.10	0.15	0.10	0.15	0.15

Table 13: QIS2 premium risk volatility factors.

The undertaking specific approach estimates the standard deviation of the combined ratio in the individual LoBs as follows:

11

$$\sigma_{U,lob} = \sqrt{c_{lob} * \sigma_{CR,lob}^2 + (1 - c_{lob}) * \sigma_{M,lob}^2}$$

Where $\sigma_{CR,lob}^2$ is the estimate of the standard deviation of the combined ratio in the individual LoB on the basis of historic combined ratios of the undertaking and c_{lob} is the credibility factor for LoB defined as:

12

$$c_{lob} = 0.2 * \max \left\{ \begin{matrix} 0 \\ J_{lob} - 10 \end{matrix} \right\}$$

With J_{lob} equal to the number of historic combined ratios for each LoB (to the extent available, not more than 15 years).

In case of $J_{lob} > 10$, the estimate $\sigma_{CR,lob}$ of the standard deviation of the combined ratio in the individual LoB on the basis of historic combined ratios of the undertaking and is defined as:

13

$$\sigma_{CR,lob} = \sqrt{\frac{1}{(J_{lob} - 1) * P_{lob}} * \sum_y P_{lob,y} * (CR_{lob,y} - \mu_{lob})^2}$$

Where μ_{lob} is the company specific estimate of the expected value of the combined ratio in the individual LoB and equal to:

14

$$\mu_{lob} = \frac{\sum_y P_{lob,y} * CR_{lob,y}}{\sum_y P_{lob,y}}$$

5.2.2.1.2 NL RESERVE RISK

To define the capital requirement for reserve risk a factor based approach is used which is very similar to the premium risk, and it's:

15

$$NL_{res} = \rho(\sigma)PCO$$

With:

16

$$PCO = \sum_{lob} PCO_{lob}$$

ρ the same of premium risk, and σ of the total business is

17

$$\sigma = \sqrt{\frac{1}{PCO^2} \sum_{r,c} CorrLob_Res^{rxc} * PCO_r * PCO_c * \sigma_r \sigma_c}$$

With $CorrLob_Res^{rxc}$ equals to $CorrLob_Prem^{rxc}$.

To estimate the total standard deviation for reserve risk, only the market wide approach is available:

18

$$\sigma_{lob} = sf_{lob} * f_{lob}$$

Where sf_{lob} is the size factor defined as follows:

19

$$\left\{ \begin{array}{ll} 1 & \text{if } PCO_{lob,gross} \geq 100\text{mln of euro} \\ \frac{10}{\sqrt{P_{lob,gross} * 10^{-6}}} & \text{if } 100\text{mln of euro} > PCO_{lob,gross} \geq 20\text{mln of euro} \\ \frac{10}{\sqrt{20}} & \text{otherwise} \end{array} \right.$$

And f_{lob} is the volatility factor specific for each Line of Business and equal to:

LoB	1	2	3	4	5	6	7	8	9	10	11
f_{lob}	0.15	0.15	0.075	0.15	0.10	0.20	0.10	0.10	0.20	0.20	0.20

Table 14: QIS2 reserve risk volatility factors.

5.2.3 THE STANDARD FORMULA UNDER QIS3

The QIS 3 structure is the following:

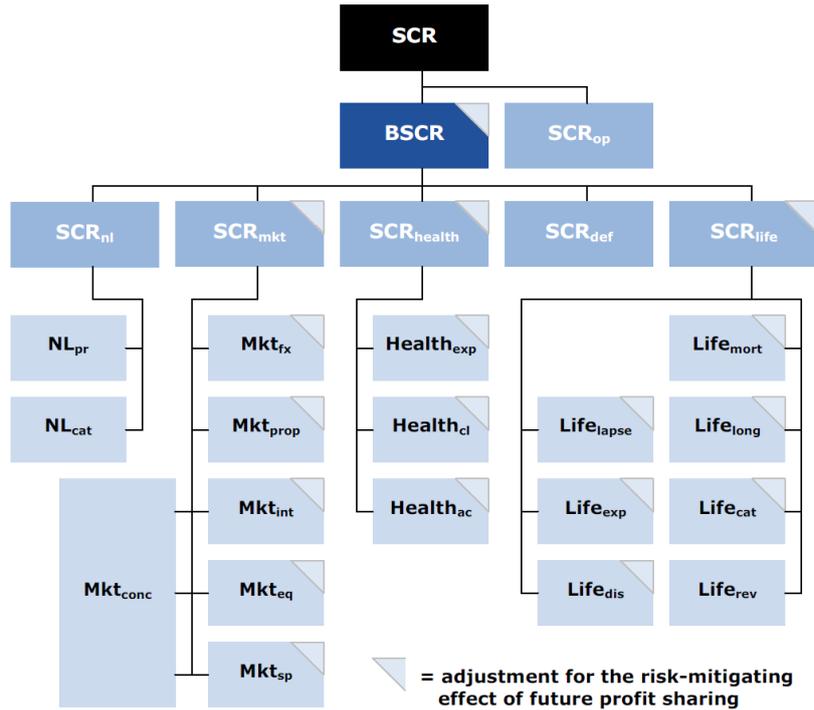


Figure 5: QIS3 structure.

QIS3 defines the same risk categories of QIS2 but reviews the structure.

Particularly the total capital requirement is determined adding to *BSCR* the operational risk capital requirement, assuming full correlation with all the other risks:

20

$$SCR^{(QIS3)} = BSCR^{(QIS3)} + SCR_{op}$$

Where *BSCR* is obtained aggregating all the other risks using the following formula:

21

$$BSCR^{(QIS3)} = \sqrt{\sum_{rxc} CorrSCR^{rxc} * SCR_r * SCR_c} - \min\left(\sum_{rxc} CorrSCR^{rxc} * KC_r * KC_c, FDB\right)$$

The *BSCR* considers the new correlation matrix

CorrSCR	SCR _{mkt}	SCR _{def}	SCR _{life}	SCR _{health}	SCR _{nl}
SCR _{mkt}	1				
SCR _{def}	0.25	1			
SCR _{life}	0.25	0.25	1		
SCR _{health}	0.25	0.25	0.25	1	
SCR _{nl}	0.25	0.5	0	0	1

Table 15: QIS3 CorrSCR matrix.

And the mitigating effect of the single SCR through the KC_r factors and the amount of the technical reserve linked to future discretionary benefits (FDB).

In addition it is eliminated NL_PL.

5.2.3.1 SCR NON-LIFE UNDERWRITING RISK MODULE³³

The third quantitative impact study reviewed the non-life underwriting risk module. First of all has been reviewed the aggregation structure unifying the premium and the reserve module and then aggregating the result obtained with the CAT risk capital requirement supposing incorrelation.

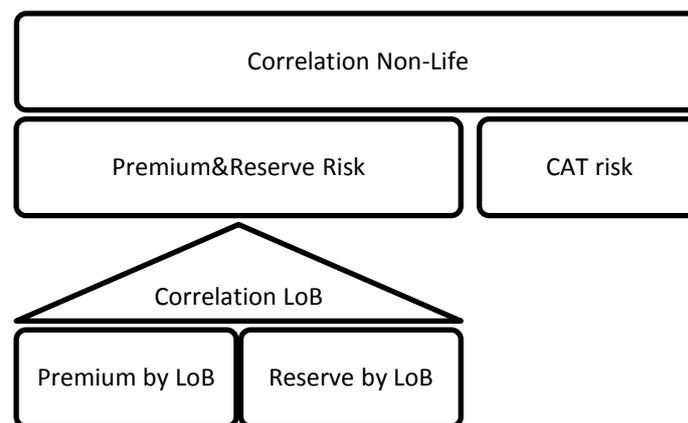


Figure 6: QIS3 aggregation structure.

Even the LoB classification has been reviewed:

³³ In this section is not analyzed the CAT risk, for more information refer to “QIS 3 technical specifications”.

Line of Business	
1	Accident and health-workers compensation
2	Accident and health-health insurance
3	Accident and health-others/default
4	Motor, third-party liability
5	Motor, other classes
6	Marine, aviation, transport (MAT)
7	Fire and other property damage
8	Third-party liability
9	Credit and suretyship
10	Legal expenses
11	Assistance
12	Miscellaneous non-life insurance
13	Non-proportional reinsurance – property
14	Non-proportional reinsurance – casualty
15	Non-proportional reinsurance – MAT

Table 16: QIS3 LoB classification.

5.2.3.1.1 NL PREMIUM AND RESERVE RISK

The capital requirements for Premium & Reserve Risk are determined multiplying a transformation ρ for the total volume, net of reinsurance, of the reserve amount (only Best Estimate) and the premiums of the following year maintaining an annual growth at least 5%.

22

$$NL_{pr} = \rho(\sigma)V \text{ with } V = \sum_{lob} V_{prem,lob} + V_{res,lob}$$

The function $\rho(\sigma)$ is defined as follows:

23

$$\rho(\sigma) = \exp\left(-\frac{\sigma^2}{2} + N_{0.995} * \sqrt{\log(\sigma^2 + 1)}\right) - 1$$

With $N_{0.995}$ equal to the 99.5% quantile of the standard normal distribution.

The standard deviation σ of the combined ratio for the overall non-life insurance portfolio are determined in two steps:

- in a first step, for each individual line of business standard deviations and volume measures for both premium risk and reserve risk are determined;
- in a second step, the standard deviations and volume measures for the premium risk and the reserve risk in the individual LoB are aggregated to derive an overall volume measure V and an overall standard deviation σ .

The standard deviation for premium risk in the individual LoB is derived as a credibility mix of an undertaking-specific estimate and a market-wide estimate as follows:

24

$$\sigma_{prem,lob} = \sqrt{c_{lob} * \sigma_{U,prem,lob}^2 + (1 - c_{lob}) * \sigma_{M,prem,lob}^2}$$

Where c_{lob} is the credibility factor for LoB, $\sigma_{U,prem,lob}$ is the undertaking-specific estimate of the standard deviation for premium risk and $\sigma_{M,prem,lob}$ is the market-wide estimate of the standard deviation for premium risk.

The market-wide estimate of the standard deviation for premium risk in the individual LoB is determined as follows:

LoB	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
$\sigma_{M,prem,lob}$	7.5%	3%	5%	10%	10%	12.5%	10%	10%	12.5%	5%	7.5%	12.5%	15%	15%	15%

Table 17: QIS3 premium risk volatility factors.

And the credibility factor is:

25

$$c_{lob} = \begin{cases} \frac{n_{lob}}{n_{lob} + 4} & \text{if } n_{lob} \geq 7 \\ 0 & \text{otherwise} \end{cases}$$

The undertaking-specific estimate $\sigma_{U,prem,lob}$ of the standard deviation for premium risk is determined on the basis of the volatility of historic loss ratios as follows:

26

$$\sigma_{U,prem,lob} = \sqrt{\frac{1}{(n_{lob} - 1) * V_{prem,lob}} * \sum_y P_{lob,y} * (LR_{lob,y} - \mu_{lob})^2}$$

Where μ_{lob} is the company-specific estimate of the expected value of the loss ratio in the individual LoBs and μ_{lob} is defined as the premium-weighted average of historic loss ratios:

27

$$\mu_{lob} = \frac{\sum_y P_{lob,y} * LR_{lob,y}}{\sum_y P_{lob,y}}$$

The standard deviation for reserve risk in the individual LoB is determined as follows:

LoB	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
$\sigma_{res,lob}$	15%	7.5%	15%	12.5%	7.5%	15%	10%	15%	10%	10%	10%	15%	15%	20%	20%

Table 18: QIS3 reserve risk volatility factors.

The overall volume measure V is determined as follows:

28

$$V = \sum_{lob} (V_{prem,lob} + V_{res,lob})$$

The overall standard deviation σ is determined as follows:

29

$$\sigma = \sqrt{\frac{1}{V^2} \sum_{r,c} CorrLob^{rxc} * V_r * V_c * a_r * a_c}$$

Where r, c are indices of the form (prem,lob) or (res,lob), V_r, V_c are volume measures for the individual line of business, the factors a_r are defined as follows:

30

$$a_r = \begin{cases} \sigma_{prem,lob} & \text{if } r = (prem,lob) \\ \sigma_{res,lob} & \text{if } r = (res,lob) \end{cases}$$

And $CorrLob^{rxc}$ is the correlation matrix defined as:

31

$$CorrLob^{rxc} = \begin{cases} CorrLob_{pr} & 50\%CorrLob_{pr} \\ 50\%CorrLob_{pr} & CorrLob_{pr} \end{cases}$$

With $CorrLob_{pr}$:

$CorrLob_{pr}$	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	1														
2	0.5	0.5													
3	0.5	0.5	1												
4	0.25	0.25	0.25	1											
5	0.25	0.25	0.25	0.5	1										
6	0.25	0.25	0.25	0.5	0.25	1									
7	0.25	0.25	0.25	0.25	0.25	0.25	1								
8	0.5	0.25	0.25	0.5	0.25	0.25	0.25	1							
9	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.5	1						
10	0.5	0.25	0.5	0.5	0.5	0.25	0.25	0.5	0.5	1					
11	0.25	0.25	0.25	0.25	0.5	0.5	0.5	0.25	0.25	0.25	1				
12	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	1			
13	0.25	0.25	0.25	0.25	0.25	0.25	0.5	0.25	0.25	0.25	0.5	0.25	1		
14	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.5	0.5	0.5	0.25	0.25	0.25	1	
15	0.25	0.25	0.25	0.25	0.25	0.5	0.5	0.25	0.25	0.25	0.25	0.5	0.25	0.25	1

Table 19: QIS3 CorrLoB premium risk.

5.2.4 THE STANDARD FORMULA UNDER QIS4

The QIS3 structure is utilized even in QIS4. The total capital requirement is determined adding to BSCR the operational risk capital requirement, assuming full correlation with all the other risks but, differently from QIS3, are subtracted two adjustments for future discretionary benefit and for the deferred taxes:

32

$$SCR^{(QIS4)} = BSCR^{(QIS4)} - ADJ_{FDB} - ADJ_{DT} + SCR_{op}$$

The *BSCR* is derived as follows

33

$$BSCR^{(QIS4)} = \sqrt{\sum_{rxc} CorrSCR^{rxc} * SCR_r * SCR_c}$$

Where the correlation matrix is:

CorrSCR	SCR _{mkt}	SCR _{def}	SCR _{life}	SCR _{health}	SCR _{nl}
SCR _{mkt}	1				
SCR _{def}	0.25	1			
SCR _{life}	0.25	0.25	1		
SCR _{health}	0.25	0.25	0.25	1	
SCR _{nl}	0.25	0.5	0	0.25	1

Table 20: QIS4 CorrSCR matrix.

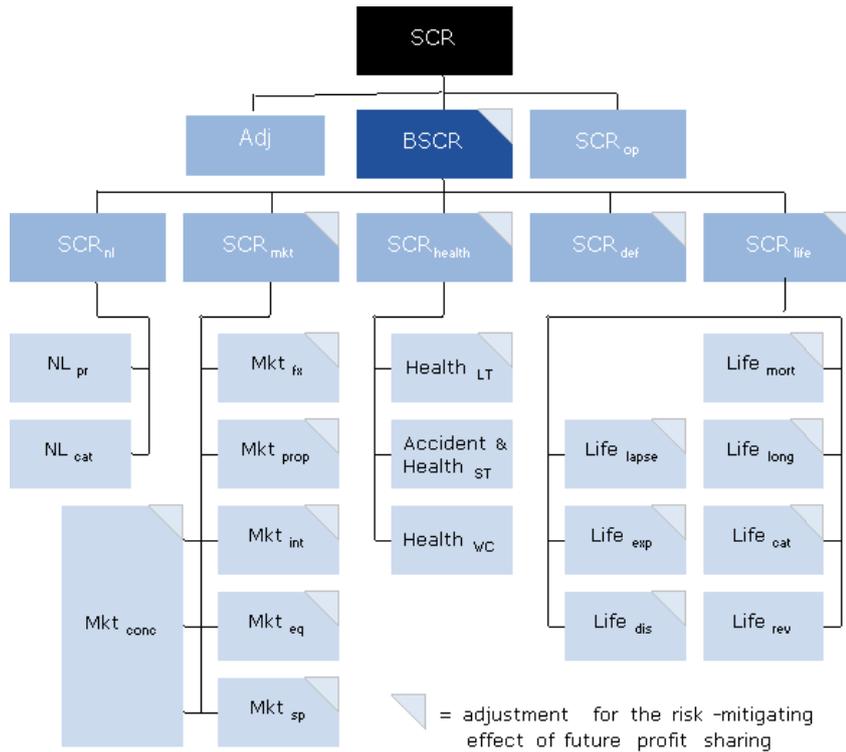


Figure 7: QIS4 structure.

5.2.4.1 SCR NON-LIFE UNDERWRITING RISK MODULE³⁴

The LoB classification has been reviewed in QIS4:

	Line of Business
1	Motor, third-party liability
2	Motor, other classes
3	Marine, aviation, transport (MAT)
4	Fire and other property damage
5	Third-party liability
6	Credit and suretyship
7	Legal expenses
8	Assistance
9	Miscellaneous

³⁴ In this section is not analyzed the CAT risk, for more information refer to “QIS 4 technical specifications”.

Line of Business	
10	Non-proportional reinsurance – property
11	Non-proportional reinsurance – casualty
12	Non-proportional reinsurance – MAT

Table 21: QIS4 LoB classification.

5.2.4.1.1 NL PREMIUM AND RESERVE RISK

The QIS 4 maintains the same standard of QIS3 with some modifications:

1. In

34

$$NL_{pr} = \rho(\sigma)V, V = \sum V_{lob}$$

35

$$V_{lob} = (V_{prem,lob} + V_{res,lob}) * (0.75 + 0.25 * DIV_{pr,lob})$$

36

$$DIV_{pr,lob} = \frac{\sum_j (V_{(prem,j,lob)} + V_{(res,j,lob)})^2}{(\sum_j (V_{(prem,j,lob)} + V_{(res,j,lob)}))^2}$$

That meant it's introduced a geographical diversification.

2. The new market-wide estimate of the standard deviation for premium risk in the individual LoB are:

LoB	1	2	3	4	5	6	7	8	9	10	11	12
$\sigma_{M,prem,lob}$	9%	9%	12.5%	10%	12.5%	15%	5%	7.5%	11%	15%	15%	15%

Table 22: QIS4 premium risk volatility factors.

3. The maximum value of n_{lob} for the determination of $\sigma_{U,prem,lob}$ is fixed according to the line of business in the following table:

LoB	Maximum n_{lob}
2, 4, 7, 8, 10	5
3, 9, 12	10
1, 5, 6, 11	15

Table 23: QIS4 maximum number of Loss Ratios usable in the undertaking specific approach.

4. The new values of the standard deviation for reserve risk in the individual LoB are:

LoB	1	2	3	4	5	6	7	8	9	10	11	12
$\sigma_{M,res,lob}$	9%	9%	12.5%	10%	12.5%	15%	5%	7.5%	11%	15%	15%	15%

Table 24: QIS4 reserve risk volatility factors.

5. In QIS4 after having derived $\sigma_{(res,lob)}$ and $\sigma_{(prem,lob)}$ the standard deviation for premium and reserve risk in the individual LoB is defined by aggregating the standard deviations for both subrisks under the assumption of a correlation coefficient of $\alpha=0.5$:

37

$$\sigma_{lob} = \frac{\sqrt{(\sigma_{(prem,lob)}V_{(prem,lob)})^2 + (\sigma_{(res,lob)}V_{(res,lob)})^2 + 2\alpha\sigma_{(prem,lob)}\sigma_{(res,lob)}V_{(prem,lob)}V_{(res,lob)}}}{V_{(prem,lob)} + V_{(res,lob)}}$$

6. The credibility factor c_{lob} is defined in the following table.

C_{lob}	Number of historical years of data available (excluding the first 3 years after the line of business was first written)														
Maximum value of n_{lob}	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
15	0	0	0	0	0	0	0.64	0.67	0.69	0.71	0.73	0.75	0.76	0.78	0.79
10	0	0	0	0	0.64	0.69	0.72	0.74	0.76	0.79	-	-	-	-	-
5	0	0	0.64	0.72	0.79	-	-	-	-	-	-	-	-	-	-

Table 25: QIS4 credibility factors.

7. The QIS4 correlation matrix is:

CorrLob	1	2	3	4	5	6	7	8	9	10	11	12
1	1											
2	0.5	1										
3	0.5	0.25	1									
4	0.25	0.25	0.25	1								
5	0.5	0.25	0.25	0.25	1							
6	0.25	0.25	0.25	0.25	0.5	1						
7	0.5	0.5	0.25	0.25	0.5	0.5	1					
8	0.25	0.5	0.5	0.5	0.25	0.25	0.25	1				
9	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	1			
10	0.25	0.25	0.25	0.5	0.25	0.25	0.25	0.5	0.25	1		
11	0.25	0.25	0.25	0.25	0.5	0.5	0.5	0.25	0.25	0.25	1	
12	0.25	0.25	0.5	0.5	0.25	0.25	0.25	0.25	0.5	0.25	0.25	1

Table 26: QIS4 CorrLoB matrix.

5.2.5 THE STANDARD FORMULA UNDER QIS5

The QIS5 structure is:

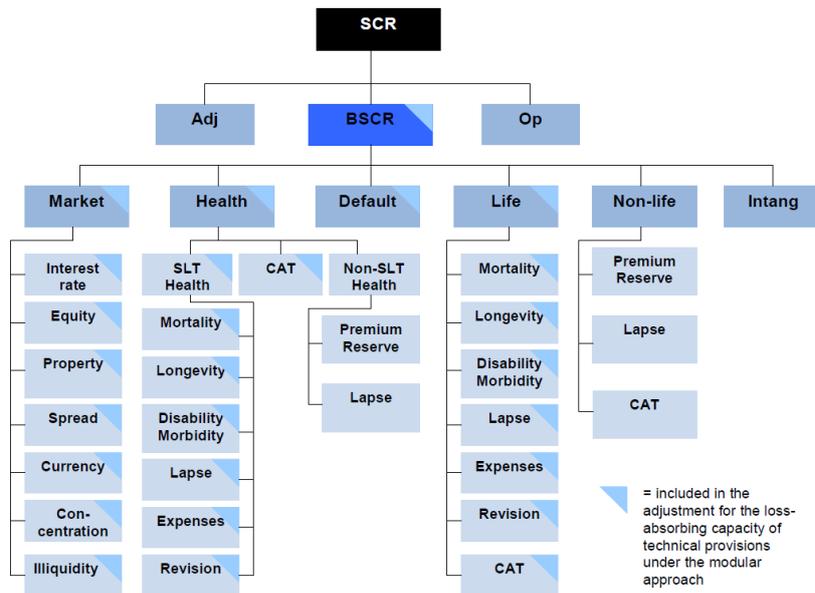


Figure 8: QIS5 structure.

The SCR is calculated as:

38

$$SCR^{(QIS5)} = BSCR^{(QIS5)} + ADJ + SCR_{op}$$

Where the BSCR is

39

$$BSCR^{(QIS5)} = \sqrt{\sum_{rxc} CorrSCR^{rxc} * SCR_r * SCR_c}$$

The *BSCR* considers the new correlation matrix

CorrSCR	SCR _{mkt}	SCR _{def}	SCR _{life}	SCR _{health}	SCR _{nl}
SCR _{mkt}	1				
SCR _{def}	0.25	1			
SCR _{life}	0.25	0.25	1		
SCR _{health}	0.25	0.25	0.25	1	
SCR _{nl}	0.25	0.5	0	0	1

Table 27: QIS5 CorrSCR matrix.

5.2.5.1 SCR NON-LIFE UNDERWRITING RISK MODULE³⁵

The capital requirement for non-life underwriting risk is derived by combining the capital requirements for the non-life sub-risks using a correlation matrix as follows:

40

$$SCR_{nl} = \sqrt{\sum CorrNL^{rxc} * NL_r * NL_c}$$

Where $CorrNL^{rxc}$ is set equal to:

CorrNL	NL _{res}	NL _{prem}	NL _{CAT}
NL _{res}	1		
NL _{prem}	0	1	
NL _{CAT}	0	0.25	1

Table 28: QIS5 CorrNL matrix.

The LoB classifications is not reviewed in QIS5:

³⁵ In this section is not analyzed the CAT risk and the undertaking specific approach, for more information refer to “QIS 5 technical specifications”.

Line of Business	
1	Motor, third-party liability
2	Motor, other classes
3	Marine, aviation, transport (MAT)
4	Fire and other property damage
5	Third-party liability
6	Credit and suretyship
7	Legal expenses
8	Assistance
9	Miscellaneous
10	Non-proportional reinsurance – property
11	Non-proportional reinsurance – casualty
12	Non-proportional reinsurance – MAT

Table 29: QIS5 LoB classification.

5.2.5.1.1 NL PREMIUM AND RESERVE RISK

The QIS5 standard formula is the same of QIS4 but introduces some modification:

- The market-wide estimates of the net standard deviation for premium risk for each line of business are:

Line of Business	$\sigma_{M,prem,lob}$
1	10% NP _{lob}
2	7% NP _{lob}
3	17% NP _{lob}
4	10% NP _{lob}
5	15% NP _{lob}
6	21.5% NP _{lob}
7	6.5% NP _{lob}
8	5% NP _{lob}
9	13% NP _{lob}
10	17.5%
11	17%
12	16%

Table 30: QIS5 premium risk volatility factors

Where the adjustment factor for non-proportional reinsurance NP_{lob} of a line of business allows undertakings to take into account the risk-mitigating effect of particular per risk excess of loss reinsurance.

- The volatility factors for the reserve risk are:

LoB	1	2	3	4	5	6	7	8	9	10	11	12
$\sigma_{M,res,lob}$	9.5%	10%	14%	11%	11%	19%	9%	11%	15%	20%	20%	20%

Table 31: QIS5 reserve risk volatility factors.

CHAPTER 6

THE SWISS SOLVENCY TEST

The insurance regulator in Switzerland (Federal Office of Private Insurance – “FOPI”) was assigned the goal to ensure that the receivables of policyholders are protected. Historically this goal has been achieved with a combination of measures. These include prudent reserving and pricing requirements as well as prescriptions over what assets are allowed to be held by insurance companies. On top of this, there is a requirement to meet a minimum solvency margin based on a simple standard formula.

The financial stability of several insurers has been shaken in the past few years by events like the crash in the equity markets in 2001 and 2002, the steady fall in bond yields as well as the impact of increased longevity which have had significant adverse effects. These events have significantly reduced market values of equity investments, and at the same time have increased the value of some embedded options and guarantees which have been sold by insurers in the past, leading to required reserve increases. For some insurers, the effects of the fall in the equity markets have been compounded by deteriorating technical results and large catastrophe claims.

This has led to a number of changes in the way insurance companies are being regulated, monitored and valued around the world.

Herbert Lüthy, director of the FOPI, embarked on an analysis project for the reorientation of insurance supervision in autumn 2002 with the support of a task force. At the same time, a draft Insurance Supervision Act (ISA) was elaborated, submitted to the Federal Council and subsequently tabled in Parliament. In reference to solvency, the bill states that the solvency requirement should take account of the risks to which an insurance company is exposed.

In spring 2003 the director of the FOPI initiated the Swiss Solvency Test (SST) project with the aim of defining basic principles of a future system for determining solvency. This was done in cooperation with the insurance industry, consulting companies and academia.

This is a “risk-based” solvency standard, which is based on the actual risks run by the companies. It puts the responsibility on the companies to investigate their own risk situation and to take this into account in the target capital calculation. In this way, transparency and competition will be enhanced, as companies are rewarded for better managing their risks.

6.1 PRINCIPLES OF THE SST

The principles of the SST can be summarized as follows:

- all assets and liabilities must be valued on a market-consistent basis. The difference between the market-consistent value of the liabilities and the discounted best estimates of their associated payment flows is called market value margin (MVM);
- the risks to be examined are market, credit, and insurance risks;
- the available capital is given by the risk-bearing capital (RBC). It is defined as the difference between the market-consistent values of the assets and the discounted best estimates of the liabilities;
- the required capital is given by the target capital (TC). It is defined as the sum of the market value margin and the expected shortfall of the difference between the discounted RBC in one year and the current RBC;
- the market value margin is approximated by the cost-of-capital approach. This is the sum of discounted costs of capital for future required regulatory capital for the run-off of the portfolio arising from liabilities and assets replicated to the extent possible;
- the risk-bearing capital must be greater than or equal to the target capital;
- the SST applies to individual legal entities and to groups and conglomerates with head offices in Switzerland;
- the insurance undertakings must evaluate a series of scenarios. These consist of (i) scenarios predetermined by the supervisory authority, and (ii) scenarios specific to the undertaking. If risks described by the scenarios are not taken into account in the risk model, then the results from the evaluation of the scenario must be

incorporated into the target capital. Uncertain values must be treated stochastically;

- risk models developed by the undertakings ("internal models") may and should be used. Such models may partially or entirely replace the standard model. An internal model must be used for risks that are not adequately described by the standard model;
- the internal model must be integrated into the risk management processes of the undertaking;
- the structure and the assumptions of the internal model must be published. The scope of the publication must be such that an external person with specialized knowledge can form a qualified opinion about the model and its quality;
- the insurance undertaking must draft an SST report. This report must permit an external person with specialized knowledge to understand the results of the SST. The report must be signed by the general management; and
- the general management of an insurance undertaking is responsible that the undertaking complies with the aforementioned principles of the SST.

6.2 CONSISTENT VALUATION OF ASSETS AND LIABILITIES

Companies, investors and regulators have long struggled with interpreting accounting information where assets and liabilities are valued on different bases. The inconsistency can cause artificial volatility in free capital.

This has led to companies building internal models that focus more on the "economic" value of their businesses. The theme has been followed on in discussions at the IASB³⁶, and proposals for a "Fair Value" accounting system, and also by various regulatory bodies around the world.

The SST is based on "market-consistent valuation" of both assets and liabilities. This means that assets are valued at their price in the market, while guaranteed liabilities are valued based on the price that financial markets would place on these liabilities, taking into account all embedded options and financial guarantees.

³⁶ International Accounting Standards Board.

The market-consistent valuation has a number of advantages:

- completeness: the valuation takes into account all options and guarantees within the liabilities;
- Best Estimate Principle: the valuation contains no implicit or explicit loadings, but is based on the best estimate assumptions for insurance risks (e.g. mortality, disability);
- up-to-date: the valuation is always based on the most recent information;
- objectivity: the valuation is based on observable market parameters and is less prone to manipulation; and
- consistency; assets and liabilities are measured consistently.

6.2.1 ASSETS

In the SST, all the assets on the balance sheet should be valued at their market value. For traded assets, these are easily observed in the market.

Wherever possible, market-consistent valuation is based on observable market prices (marking to market). If such values are not available, a market-consistent value is determined by examining comparable market values, taking account of liquidity and other product-specific features, or on a model basis (marking to model). In particular, market-consistent means that up to date values are used for all parameters.

6.2.2 LIABILITIES

For liabilities, the market consistent value is defined as the sum of the best-estimate of the liabilities and the risk margin (section 6.2.2.2).

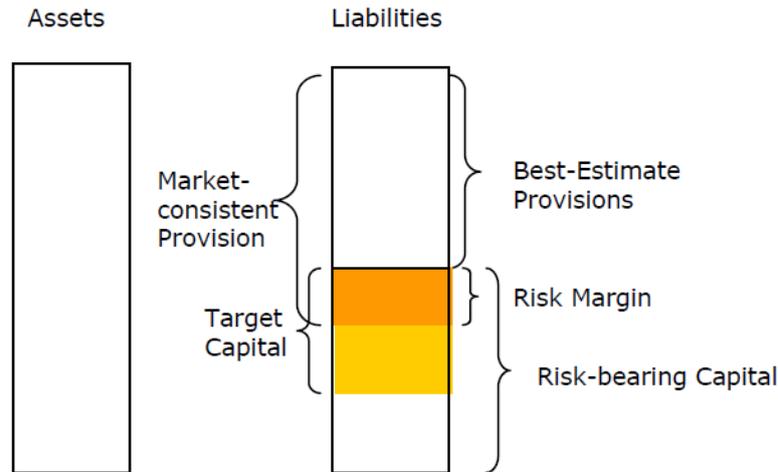


Figure 9: Market consistent assets and liabilities.

6.2.2.1 BEST ESTIMATE

No specific method for valuing the liabilities on a market consistent basis has been prescribed by the regulator. Valid approaches include valuing a replicating portfolio, modeling all policyholder liabilities and interactions with the financial markets on a stochastic basis and using discounting methods (deflators) and/or scenarios (risk-neutral) which ensure market-consistency.

This definition directly implies that all embedded options in a portfolio of liabilities have to be valued.

All generally accepted approaches value guaranteed liabilities with cash-flows by discounting the expected cash-flows using the risk-free yield curve. The risk-free yield curve will be given by the regulator.

However, policyholders usually do not always act in a fully rational manner. This should be taken into account when valuing insurer liabilities, provided the modeling of policyholder behavior can be justified empirically.

For some lines of business, notably group pensions business (BVG business) in Switzerland, it is not possible to determine the future liabilities with the required degree of accuracy. This is due to the fact that the liabilities are partially defined by external factors, e.g. the Federal Council or the Parliament, that are hard to predict.

In such cases reasonable assumptions concerning the behavior of those institutions need to be made and algorithms created which model their behavior as well as that of the insurer's management.

Only liabilities which are contractually agreed or required by law have to be considered for SST purposes. This includes mandatory policyholder participation schemes such as the legal quote for BVG business.

All assumptions concerning insurance risks (e.g. mortality, disability rate, etc) are to be made on a best-estimate basis without implicit or explicit safety margins.

The assumptions and the methodology to determine market consistent values for liabilities have to be disclosed to the regulator within the SST-Report.

6.2.2.2 MARKET VALUE MARGIN

The market value margin (MvM) of an item is defined as the difference between the market-consistent value and the expected value of the payment flow of the item. For many financial items such as shares and bonds, the market knows the market value because these items are traded. In such cases, the MvM is implicitly contained in the price and is no longer of interest for purposes of the SST.

Technical liabilities, however, have the characteristic that their market value is generally not observable and that the expected value of the payment flow can only be estimated. For this reason, a model value for the market value margin must be determined when calculating the market value of a technical position.

If a portfolio is in run-off, then the policyholder does not bear any loss if someone else assumes the run-off risk (settlement risk). First, this is the case if the insurer bears the risk with sufficient available risk-bearing capital, or second, if an external entity (another insurer, an investor, a capital provider) assumes the portfolio or, equivalently, adds more capital. In this second case, the external entity must make risk capital available for the run-off. It will be willing to do so if it receives compensation.

The price for a technical liability is therefore composed of an amount for the expected settlement and a compensation for the associated risk. According to the definition above, this is precisely the market value margin.

The model value used for the market value margin for a portfolio containing technical liabilities is based on the assumption that the MvM is composed of capital costs or dividends. Purely mathematically speaking, these contain a risk-free share $r_1^{(0)}$ and a risk-carrying share i_{spread} on top of this, the amount of which has been fixed at 6%.

The concept of the market value margin is valid at all times. In general, we are interested in the market value and therefore the MvM at the current time t_0 . In the SST, however, the value at the end of the year t_1 is of primary significance. For this reason, we will discuss the MvM here from this perspective.

According to the reasoning above, the risk-capital provider will make risk capital K_{t_1} available at time t_1 if the provider receives a dividend $(r_1^{(0)} + i_{spread}) * K_{t_1}$. The risk capital can be invested risk-free for one year, i.e. it already generates the share $r_1^{(0)} * K_{t_1}$. Accordingly, it is sufficient if an additional amount $i_{spread} * K_{t_1}$ is made available. This amount is taken from the basket of the market value margin. The same applies for the additional subsequent years.

It is important for the MvM to compensate the risk-assuming party for technical risks, but not for all risks assumed. For this purpose, imagine a portfolio consisting, first, of the technical liabilities, and second, of the existing instruments (assets) that replicate the liabilities to the extent possible. For a non-life portfolio, these could be government bonds that produce the expected payment flow of the liabilities.

The MvM need only compensate the risks of this portfolio. The market risks in the currently existing portfolio, in which the assets are in general composed differently than in an optimally replicating portfolio, the MvM does not need to cover, however.

Based on the spread interest rate and the one-year risk capital to be provided in the individual years after t_1 , the definition of the market value margin is:

41

$$\frac{MvM}{1 + r_1^{(0)}} := i_{spread} \left(\frac{K_{t_1}}{1 + r_1^{(0)}} + \frac{K_{t_1+1yr}}{(1 + r_2^{(0)})^2} + \frac{K_{t_1+2yr}}{(1 + r_3^{(0)})^2} \right)$$

6.3 RISKS CONSIDERED

Financial and insurance risks give rise to target capital requirements, while some other risks are treated qualitatively.

The split is shown in the following diagram:

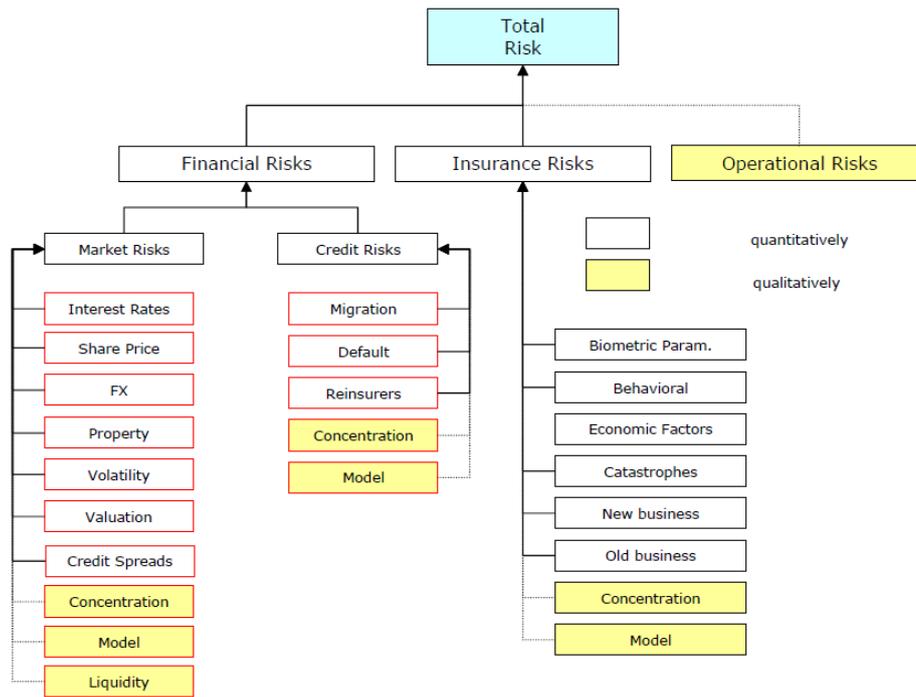


Figure 10: Quantitative and qualitative risks considered by in the SST.

6.3.1 QUANTITATIVE

The risks to be measured are technical risks, market risks, and credit risks. Operational risks are currently not considered by the SST with respect to capital requirements. They may be included in the future, however.

The market risk is the risk that the RBC may change due to changes of external economic factors or influences. These influences are called risk factors. In the standard model of the SST, nearly 100 risk factors in the areas of interest rates, shares, real estate, and alternative investments are examined.

The technical risk is the risk that the RBC may change due to the randomness of the insured risks and the uncertainties in estimating technical parameters.

The credit risk is the risk that the RBC may change due to defaults and rating changes of the counterparties. In particular, credit risk is contained in bonds, loans, guarantees, mortgages, and reinsurance policies and balances.

6.3.2 QUALITATIVE

A number of risks inherent to insurance companies are difficult to measure reliably, and treated more appropriately qualitatively than quantitatively until generally accepted methods have been developed.

Examples of risks which are treated qualitatively include:

- operational Risk: for example employee fraud, errors in systems, political risk etc.

6.3.2.1 OPERATIONAL RISKS

Operational risks are difficult to quantify so a qualitative assessment approach will initially be used. Capital requirements for these risks would be too arbitrary.

Sufficient empirical data are not yet available. However, banks are now compiling such data to comply with Basel II. It is therefore conceivable that operational risks could be quantified in the future if insurance companies were to compile relevant data.

Operational risks can be controlled, e.g. through appropriate corporate governance measures. For the supervisory authority, it is therefore important that insurance companies should have efficient internal risk management systems.

Risk management is monitored via a structured self-assessment questionnaire that every insurance company is required to complete.

The supervisory authority will discuss the self-assessment with the insurance company at least every three years.

6.3.2.1.1 SELF-ASSESSMENT

The self-assessment comprises a structured report in the form of a questionnaire that every insurance company has to fill out. Its purpose is to provide an insight into how well the company manages operational risks. The supervisory authority sets the questions and the assessment benchmark.

The completed forms have to be signed by the Board of Directors and the management. The self-assessment form must be submitted to the supervisory authority annually. If necessary, the supervisory authority will discuss the report with the insurance company. In any case, it should be discussed every three years even without specific cause.

The self-assessment should be contained in the audit report. In other words, the auditors must check that the questionnaire has been completed correctly.

Three types of sanctions/incentives can be applied in the case of poor management of operational risks:

a) Graduated supervisory control

This means stepping up supervision of an insurance company if the result of the self-assessment is poor. Increased control may take the form of more frequent contact with the supervisory authority, specific reporting requirements or an increase in local checks. Alternatively, specific risk management requirements may be imposed.

b) Addition of a loading to target capital

If a target capital were to be defined to cover operational risks, this would not be expected to absorb all operational risks. On the contrary, it should be regarded as an incentive/sanction system for inadequate risk management. This option should be left open in the regulations, even though it is not used at present.

c) Public disclosure

Public disclosure requirements would be an additional incentive to ensure good risk management.

At present, use is mainly made of option a). However, the regulations should include the possibility of using the other two options.

In addition to the self-assessment, claims data has to be compiled to facilitate assessment of operational risks. Both aspects act as incentives for good risk management. Moreover, compiling data ensures equality of treatment for banks and insurance companies and can be used as a basis for quantifying operational risks in a few years' time.

6.4 RISK BEARING CAPITAL

The risk-bearing capital (RBC) is the capital that can be used to equalize fluctuations over the course of business. The values taken into account for the risk-bearing capital may not be used for other purposes. The RBC is defined as the difference between the market-consistent value of the assets and the discounted best estimate of the liabilities.

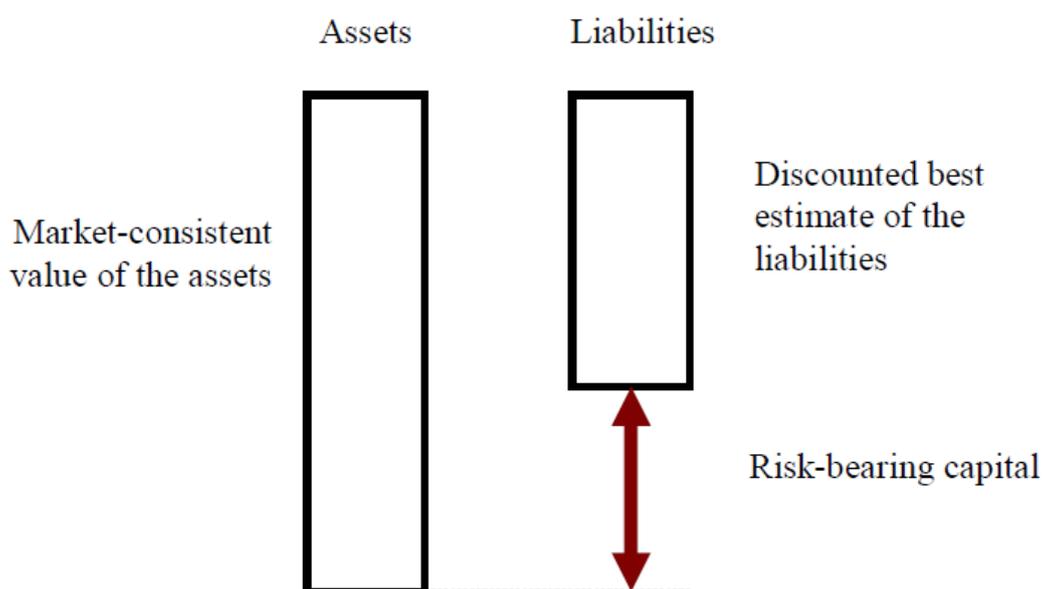


Figure 11: Definition of risk-bearing capital (RBC) as the difference of values between assets and liabilities at time t .

Figure 11 represents the risk-bearing capital at the beginning t_0 and at the end t_1 of the year. The risk-bearing capital at time t_0 can be derived from the enumeration of assets and liabilities, i.e., from the market-consistent balance sheet, and is therefore known (RBC (0)). The future risk-bearing capital (RBC (1)), however, is an unknown, i.e. stochastic, quantity, since the environment in which the undertaking is situated will change in an unknown way.

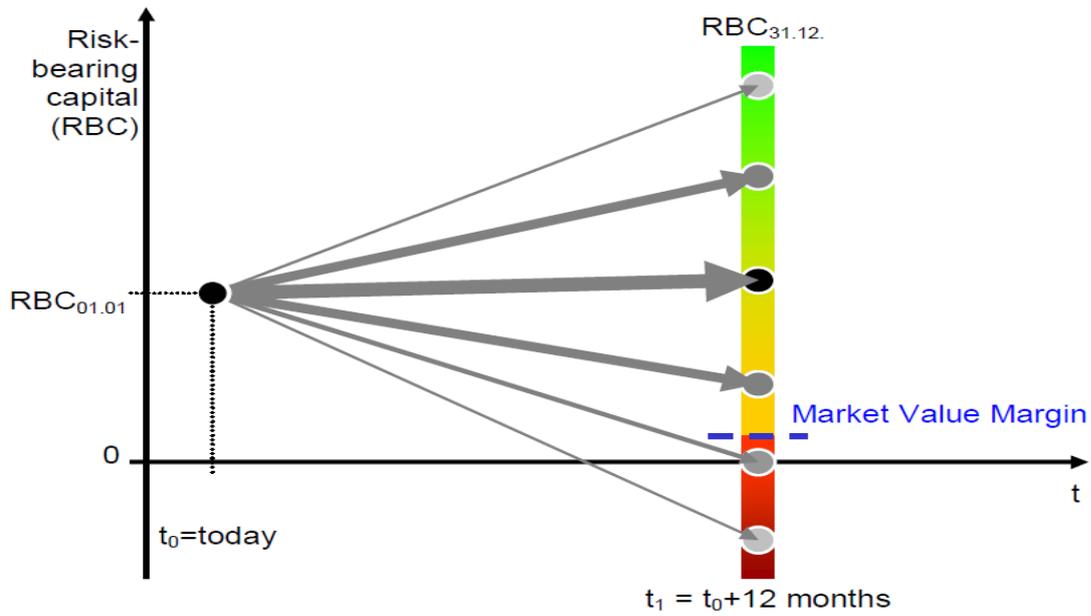


Figure 12: Risk-bearing capital at times t_0 (known quantity) and t_1 (unknown, stochastic quantity).

Depending on the magnitude of the RBC at the end of the year, the relationship between the market value of the assets and the value of liabilities will be different:

$RBC < 0$	Assets < Best estimate of liabilities
$0 < RBC < MVM$	Best estimate of liabilities < Assets < Market value of liabilities
$MVM < RBC$	Market value of liabilities < Assets

Table 32: Relationship between the market value of assets and the value of liabilities at the end of the year.

If the RBC at the end of the year is greater than the market value margin, then the value of the assets is greater than the market value of the liabilities.

Figure 13 examines the different areas of the RBC in more detail.

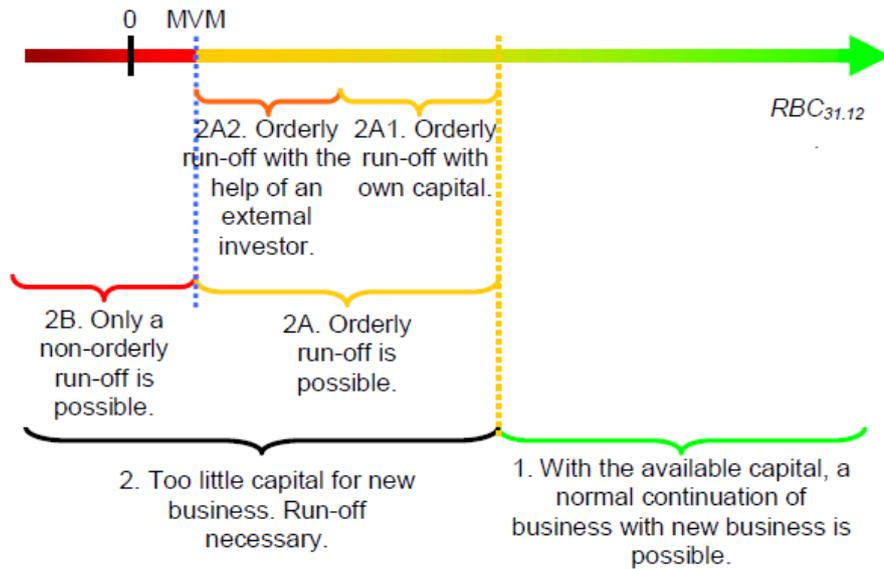


Figure 13: Different magnitudes of the RBC and their effect on the further course of the insurance undertaking.

- d) Area 1: If the RBC exceeds a certain amount, sufficient RBC is available to bear existing risks and to underwrite new business.
- e) Area 2: If the RBC does not reach the amount mentioned for Area 1, too little capital is available to take on new business. This means that existing contracts and claims are settled. Depending on whether the RBC is greater or smaller than the market value margin, the run-off risk must be borne by the insurance undertaking, or it is borne by the still existing capital or even by an external capital provider:
 - o Area 2A: The portfolio is in run-off, but the policyholders will most probably receive their guaranteed benefits. In the case of 2A1, the still existing RBC bears the run-off risk. In the case of 2A2, it is possible to transfer the risk to an external capital provider. The reason is that the RBC is greater than the market value margin, the market value of the assets is greater than the market value of the liabilities. This means that an investor or another insurance is willing to assume the assets and liabilities.
 - o Area 2B: The portfolio being settled does not have sufficient capital ($RBC < MVM$) for the settlement risks to be borne by the RBC or for an external capital provider to assume the risk. Accordingly, the processing risk remains with the policyholders. If the RBC is positive, the expected value of the liabilities is smaller than the value of the assets, but the risk

that the liability payments could exceed this value is high. If the RBC is negative, then not even the expected value of the liabilities is covered by the assets.

Area 2B mentioned above contains the circumstances in which a very high probability exists that the insurance company will not or cannot meet its obligations relating to existing policyholders. If the policyholder is to be protected, these circumstances must be avoided.

The capital requirement, called Target Capital (section 6.6), of the SST is therefore chosen so that a situation falling within Area 2B is highly unlikely to arise.

The following section introduces the expected shortfall. The expected shortfall serves to capture the possible low values of the RBC at the end of the year in a single value. This value is the average of the lowest possible RBCs and can therefore be regarded as a representative of these low values. The demands on the current RBC are fixed so that the expected shortfall is no lower than the market value margin.

6.5 RISK MEASURE

Before we look at the definition of target capital, we will introduce the two risk measures "value at risk" (VaR) and "expected shortfall" (ES). The term "expected shortfall" is synonymous with "tail value at risk" (TailVaR).

A risk measure is a mapping from the random variables representing the risks to the real line. A risk measure gives a single number that quantifies the risk exposure in a way that is meaningful for the problem at hand. The standard deviation of a distribution is such a measure of risk. One of the other most commonly used risk measures in the fields of finance and statistics is the quantile or Value-at-Risk. This risk measure is the size of loss for which there is a small (e.g. 1%) probability of exceedence. For some time, it has been recognized that this measure suffers from serious deficiencies if losses are not Normally distributed.

Following Artzner et al. (1999), a coherent risk measure is defined as one that has the following four properties for any two bounded loss random variables X and Y . the risk measure is denoted by the function $\rho(\cdot)$.

- Subadditivity:

42

$$\rho(X + Y) \leq \rho(X) + \rho(Y)$$

This means that the capital requirement for two risks combined will not be greater than for the risks treated separately. This is necessary, since otherwise companies would have an advantage to disaggregate into smaller companies.

- Monotonicity:

43

$$\text{if } X \leq Y \text{ for all possible outcomes, then } \rho(X) \leq \rho(Y)$$

This means that if one risk always has greater losses than another risk, requirement should be greater.

- Positive Homogeneity:

For any positive constant λ

44

$$\rho(\lambda X) = \lambda \rho(X)$$

This means that the capital requirement is independent of the currency in which the risk is measured.

- Translation invariance

For any positive constant α

45

$$\rho(X + \alpha) = \rho(X) + \alpha$$

This means that there is no additional capital requirement for an additional risk for which there is no uncertainty. In particular, by making X identically zero, the total capital required for a certain outcome is exactly the value of that outcome.

Risk measures satisfying these criteria are deemed to be coherent. There are many such risk measures. The classical VaR does not satisfy these criteria.

The q -quantile, x_q , is the smallest value satisfying

46

$$\Pr\{X > x_q\} = 1 - q$$

As a risk measure, x_q is the Value-at-Risk and is used extensively in financial risk management of trading risk over a fixed (usually relatively short) time period. It is not a coherent risk measure.

The Tail Value at Risk (TailVaR) is defined as

47

$$E(X|X > x_q)$$

It can be seen that this will be larger than the VaR measure for the same value of q described above since it is the VaR x_q plus the expected excess loss; i.e.,

48

$$E(X|X > x_q) = x_q + E(X - x_q|X > x_q)$$

TailVaR is a coherent measure in the sense of Artzner et al (1997).

Overbeck (2000) also discusses VaR and TailVaR as risk measures. He argues that VaR is an "all or nothing" risk measure, in that if the extreme event causing ruin occurs, there is no capital to cushion losses. He also argues that TailVaR provides a definition of "bad times" which are those where losses exceed some threshold, not using up all available capital. TailVaR provides the expected excess loss over that threshold, when the threshold

has been exceeded. One can define the threshold x_q as we have done above in the definition

49

$$\rho(X) = E(X|X > x_q)$$

Alternatively, one can define the threshold by first establishing the quantity $\rho(X)$ by any method, and then solve to determine the threshold x_q which defines the “bad times” of Overbeck (2000).

The goal of risk measurement in general is to use an appropriate risk measure to assign a real number to an uncertainty or a quantity with an unknown value, so that the risk exposure of this quantity can be represented. The risk measure used in the SST is the expected shortfall or the TailVaR at 99%.

The risk measure "expected shortfall" is more conservative than VaR at the same certainty level.

Since it can be assumed that a real claims distribution will show several extremely high losses with very low probabilities, the expected shortfall is a more appropriate risk measure, since – in contrast to the VaR – it takes the magnitude of these extreme losses into account.

In contrast to the value at risk, expected shortfall quantifies what the average cost of one of the $(100 \cdot \alpha)\%$ worst events is. In practice, expected shortfall turns out to be more stable than value at risk.

6.6 TARGET CAPITAL

It was mentioned above that the circumstances 2B of figure 13 are undesirable. They should be avoided where possible. The target capital is the answer to the question of how large the risk-bearing capital at time t_0 must be for RBC at time t_1 to be greater than or equal to the market value margin with a high degree of probability. Using the expected shortfall, the answer is:

$$ES_{\alpha}(RBC(t_1)|RBC(t_0) = TC) = MVM$$

This is an implicit equation for the target capital TC . It states that if the current $RBC(t_0)$ is sufficiently large for purposes of the SST (i.e. equal to the target capital), then the expected shortfall of the RBC is guaranteed to be equal to the market value margin at the end of the year. Accordingly, due to the construction of the expected shortfall, the probability is low that $RBC(t_1)$ would fall below the market value margin.

The following simpler but essentially equivalent definition of target capital is used instead of the equation above:

$$TC = -ES_{\alpha}\left(\frac{RBC(t_1)}{1 + r_1^{(0)}} - RBC(t_0)\right) + \frac{MVM}{1 + r_1^{(0)}}$$

$r_1^{(0)}$ stands for the current one-year risk-free interest rate.

The target capital is therefore composed of the expected shortfall of the change of the risk-bearing capital for the one-year risk and the market value margin.

To cover all the receivables at the end of the year, the RBC at the end of the year is required to be greater than or equal to the market value margin in the average of the α worst cases. This market value margin is set as the price for the risk capital to be held in the future that would have to be paid to another insurance undertaking or investor if they should assume the portfolio. Accordingly, the market value margin essentially covers the costs that a company assuming the portfolio would have to pay to provide the future target capital and can therefore also be considered a risk premium for the run-off of the liabilities.

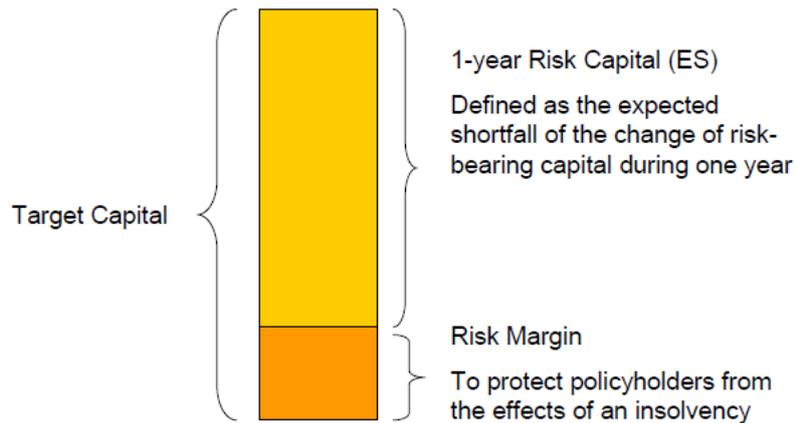


Figure 14: Target capital as the sum of 1-year risk capital and the risk margin.

In other words, the TC at a certainty level of 99% is the expected value of the 1% largest possible value reductions plus the abovementioned market value margin for future risk capital. If one of the (unlikely) 1% largest value reductions in the RBC then occurs within one year, then on average there is still sufficient RBC to take over the future risk capital.

6.7 STANDARD MODELS

The SST consists of a set of standard models (e.g. for asset, liability and credit risks) and a set of scenarios. Except for the credit risk model the results of the standard models are probability distributions which describe the stochastic nature of the change of risk-bearing capital due to the modeled risk factors.

The appointed actuary also has to evaluate the scenarios and has to supplement the set with company specific scenarios which better capture the specific risk of the company.

The results of the standard models are combined with the evaluations of the scenarios using an aggregation method. The aggregation consists of calculating the weighted mean of probability distribution given the normal situation (captured by the standard models) and special situations (described by the scenarios).

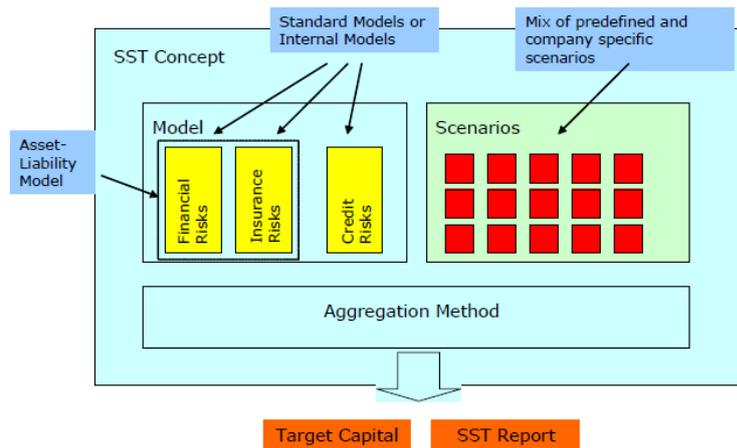


Figure 15: The general structure of the SST.

The SST contains standard models for

- market risks;
- life insurance risks;
- nonlife insurance risks;
- health insurance risks; and
- credit risks.

With the exception of the credit risk model, all standard models result in a probability distribution. The modular setup provides for consistent and transparent integration of different standard models as well as the possibility for the integration of internal models.

For credit risk, the standard model is the Basel II standardized approach. The life insurance model takes into account the biometric risks as well as the risk of policyholder behavior. The nonlife model covers the technical risks both in future claims of the current year and in reserve results. It is less a fixed algorithm than a method to derive a loss distribution. The health insurance model consists of normal distributions for health insurance risks. The asset model will be used for life, nonlife and health insurers; it covers interest rate, foreign exchange, equity and credit spread risks. It is based on a covariance approach and assumes that the individual market risk factor changes follow a multivariate normal law.

All of these standard models depend on three types of parameters:

- Type 1: Parameters which are set by the regulator and which cannot be changed. For instance, these include the risk-free interest rate, the safety level and the probabilities of some of the prescribed scenarios as well as some other macro-economic parameters. Other examples would include parameters specifying the frequency and severity of natural catastrophes.
- Type 2: Parameters which have to be set by companies, for example the volatility of the hedge fund exposure, where the exposures of different companies are so different that prescribing any fixed parameter would be pointless.
- Type 3: Parameters which are set by the regulator and which can be changed by the companies. Most of the parameters are elements of this class. The parameter estimation by the company has to follow the guidelines of the regulator. The company has to show the estimation procedure to the regulator.

It is a general rule that if a parameter of type 3 does not reflect the company specific situation, the company has to adapt the parameter to a more appropriate value.

6.7.1 ASSET MODEL

The asset model quantifies the market risks, which stem from possible changes on both the assets and the liability side due to changes in market risk factors. The asset model considers both assets and liabilities simultaneously.

The asset model is conceptually similar to the well-know RiskMetrics approach.

The model consists at the moment of 23 risk factors. While it is tempting to introduce more risk factors in order to model with greater detail the market risk, it is important that a regulatory model remains reasonably simple. Introducing many more risk factors would make the model too unwieldy.

The risk factors are described below³⁷:

- discretized term structure of interest rate using time buckets of 0-2 years, 2-3 years, 3-4 years, 5-7 years, 7-10 years, 10-15 years, 15-20 years, 20-30 years, 30 and more years;

³⁷ For more information see FOPI, "Technical document of the Swiss Solvency Test", <http://www.finma.ch/>, 2006.

- implied volatility of interest rates;
- exchange rates (FX): EUR/CHF, GBP/CHF, USD/CHF, JPY/CHF;
- implied volatility of FX rates;
- share price index (including dividends, modeled by one global index);
- private Equity (modeled by one global index);
- hedge Funds (modeled by one global index);
- participations;
- other equity;
- implied volatility of share price index;
- property (residential and commercial); and
- credit spread (Investments and sub-investment grade).

All the risk factor changes are assumed to be normally distributed (with mean 0). The joint behavior of the risk factors is described by their covariance matrix.

Changes in risk factors lead to changes in the risk bearing capital. For reasons of simplicity, it is assumed that the change in risk-bearing capital is a linear function of the risk factor changes. The coefficients are defined as the difference quotient (the sensitivities) for each risk factor. This means that if the share prices drop by 20%, the change in risk-bearing capital is twice the change that occurs when the share prices drops by 10%.

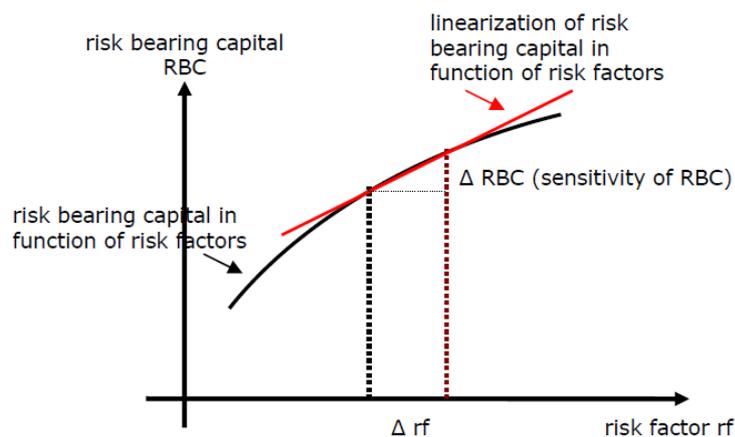


Figure 16: Linearization of change of risk bearing capital.

For an insurer it is sufficient to determine the sensitivities of the risk-bearing capital with respect to the risk factors. Given the assumptions outlined above, the change of risk-bearing capital with respect to all the risk factors together is univariate normally distributed. The volatility can be directly calculated from the sensitivities and the covariance matrix of the risk factor changes.

As an example, the sensitivity to interest rates has an impact on both the asset side (an increase will for instance reduce the value of the bonds) and also on the liability side (an increase will reduce the value of the liabilities). The change in risk bearing capital is then the difference between the change in assets and liabilities.

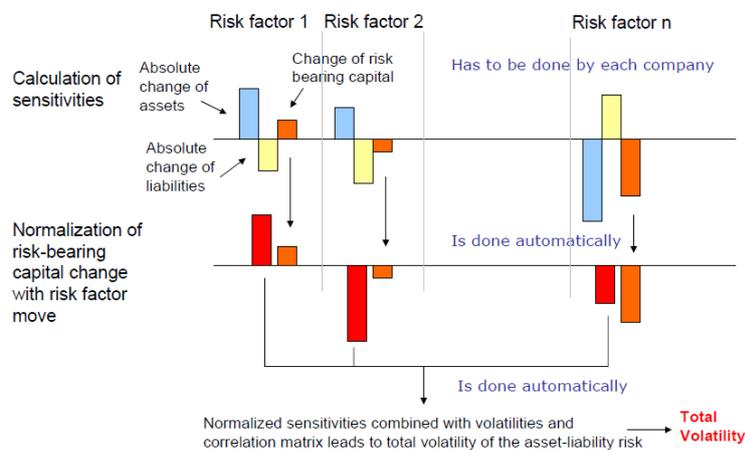


Figure 17: Calculation of total volatility due to market risk factors.

This asset model is a simplification of reality. Many risks are not considered, amongst them:

- specific risks (country, industry, counterparty ...);
- concentration risks; and
- Liquidity risks.

Furthermore, nonlinearities are not captured by the standard asset model. Relevant nonlinear effects – for instance due to derivatives – have to be modeled outside the standard model.

If these nonlinear effects are relevant, then the appointed actuary needs to model them appropriately, for instance by adjusting the sensitivities, by defining scenarios or by some other method.

To calibrate the volatilities and correlation matrix, monthly data is used, if possible. In cases where the market is sufficiently liquid, the volatilities can be estimated directly using observable data. In cases where the market is illiquid, observed data has to be supplemented or adjusted to take into account illiquidity or intransparency.

Some volatilities will be prescribed by the regulator (for example the interest rate volatilities or foreign exchange volatilities) whereas some parameters will have to be estimated by the company (for instance the volatility of the equity portfolio).

The asset model is supplemented with scenarios to take into account non-normality.

6.7.2 LIFE INSURANCE MODEL

The standard model for life insurance risks is also defined by a number of risk factors. The risk factor changes are assumed to be normally distributed, analogously to the asset model. The company calculates the sensitivity of the risk-bearing capital with respect to the separate risk factors. These sensitivities are then aggregated, taking into account the volatilities of the risk factors and the correlation between the risk factors.

The risk factors are:

	Volatilities	Correlations							
mortality	20%	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
longevity	10%	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
disability (BVG)	10%	0.00	0.00	1.00	1.00	0.00	0.00	0.00	0.00
disability (non-BVG)	20%	0.00	0.00	1.00	1.00	0.00	0.00	0.00	0.00
recovery rate (BVG)	20%	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00
lapse rate	25%	0.00	0.00	0.00	0.00	0.00	1.00	0.75	0.75
capital option	25%	0.00	0.00	0.00	0.00	0.00	0.75	1.00	1.00

Table 33: Life risk factors and their correlation –values used for the Field Test 2004-

For the standard model the change of the risk factors within one year is relevant. Again, it is assumed that the change of risk-bearing capital is linear.

The risk factors can change due to two reasons:

- due to random fluctuations (stochastic risk);
- due to the risk that the risk factors was incorrectly estimated or may change (parameter and trend risk).

Depending on the size of a portfolio, the underlying insurance cover and the risk factor, the influence of the stochastic risk and parameter risk can differ. For a small portfolio consisting of YRT (yearly renewable term) policies, the stochastic mortality risk will be relatively large compared to the parameter risk. For a large annuity portfolio, the parameter longevity risk will dominate the stochastic risk. Since the risk factor changes are assumed to be normally distributed, they are defined by the standard deviation (volatility). In the standard model, the regulator has defined the volatilities as well as the correlations between the risk factors. For the life insurance risk factors, there is little adequate data available to estimate the correlations or volatilities properly. Hence, the parameters were set in discussion with experienced actuaries and constitute the best estimate of a number of professionals.

6.7.3 NON LIFE MODEL

This model will be discuss in the next chapter.

6.7.4 HEALTH INSURANCE MODEL

Unlike for life and non-life insurers, the simplifying assumption is made for health insurers that the claims provisions of the health insurers do not span more than one year, but rather are used up within a year. This entails that the value of the claims provisions in the market-consistent balance sheet of the SST is not discounted. Accordingly, the claims provisions do not depend on the interest-rate curve and do not bear any interest rate risk (unlike the provisions of life and non-life insurers). The model for the market risks is therefore not an asset-liability model, but rather a pure asset model. Because of the one-year span of the provisions, the calculation of the market value margin is also omitted. Since the provisions are independent of the interest rates, the market risks and the technical risks can be easily separated.

The standard model of the SST for health insurers distinguishes three lines of business (LoB). These are:

- E: ICA costs of care and daily allowance in individual insurance;
- K: Collective daily allowance; and
- O: Other business operated by the health insurer.

First, we will consider the lines of business E and K. In both lines of business, the sum of the benefits S_E and S_K in one year is to be modelled. It's made the simplifying assumption that they have a normal distribution. The goal is therefore to estimate the first two moments of the normal distribution for the annual benefits in both lines of business.

The risk in both lines of business has two causes:

- random fluctuations of the number of cases and the variability of the amount of the individual cases. The associated risk is called random risk; and
- uncertainty in estimating the parameters, such as the expected inflation, the expected value of the number of claims, the average claims amount, etc. The associated risk is called parameter risk.

Both the random risk and the parameter risk result in a variance contribution. The total variance is the sum of these contributions.

Based on the loss history of their own portfolio, companies determine the expected value and the standard deviation of the result both of these lines. The results are then aggregated, taking into account a (specified) correlation between the two lines.

The line of business "Other business" includes transactions that are not related to health insurance, but are nevertheless operated by a health insurer. These include accident insurance or household contents insurance.

By nature, these business areas harbour a technical risk. These risks are like those assumed by a typical non-life insurer, so that the treatment of the risks in the SST is analogous to non-life insurance.

Accordingly, the risks of the LoB O must be quantified as in the SST for non-life insurers. Instead of this approach, a simplified approach may be chosen, if the premium volume (after any reinsurance) of the LoB O is smaller than 10% of the total premium volume of the legal entity under consideration.

The simplified approach consists in representing the distribution of the claims expense with a normal distribution, the variance and expected value of which must be estimated by the health insurer.

6.7.5 CREDIT RISK MODEL

In order to limit the possibility for arbitrage of credit risk from the banking to the insurance sector (and the reverse), credit risk quantification follows as closely as possible the one used by the banking regulator. Therefore, a credit risk charge is calculated using an approach compatible to Basel II. This charge is then added to the target capital for insurance and market risks.

The standard model for credit risk is the Basel II standardized approach, with operational risk excluded. This approach can be implemented quite easily and without much extra effort.

Internal models for credit risk have to be calibrated to the same risk measure as used by Basel II, namely the Value at Risk on the 99% quantile. Possibilities for internal models are for instance:

- Basel 2 Internal Ratings-based approach (Foundation);
- Basel 2 Internal Ratings-based approach (Advanced); and
- Credit risk portfolio model.

If a company intends to use a portfolio model, it is prerequisite that all the credit risks within the scope of Basel II are captured. This means in particular that all the requirements of Basel II to use the internal ratings-based approaches need to be satisfied.

6.8 SCENARIOS

One requirement of the SST is to evaluate scenarios. These are events

- that have a very small probability of occurring; and
- that have a negative effect on the RBC.

The supervisory authority predetermines several scenarios. Insurance undertakings should supplement these with their own scenarios that reflect their own specific risk situation. If a risk described by a scenario has not already been modeled elsewhere, the evaluation of the scenarios must be incorporated in the calculation of the target capital. The SST therefore uses two types of scenarios:

- Type 1: Scenarios that must be evaluated and whose effect is aggregated with the distribution of a distribution-based model ("aggregation method"). Scenarios of this type concern risks that are not covered in the distribution-based model.
- Type 2: Scenarios that must be evaluated, but whose effect is not aggregated with the distribution-based model. Scenarios of this type concern risks that are already covered by the distribution-based model. The evaluation of the scenario can serve to support or adjust the assumptions in the distribution-based model.

For these scenarios, effects must also be taken into account that not only concern the insured claims amount. If a scenario has effects that concern the insurance business in other ways, these effects must be included in the calculation. A scenario "dirty bomb in a European city", for instance, has the consequence of direct insurance benefits, but it also has an impact upon the financial markets and the national economy. These effects must also be taken into account. For every scenario i , the insurance undertaking must estimate the expected effect c_i on the risk-bearing capital. The evaluation of a scenario enables verification of whether the risk-bearing capital at the beginning of the year is sufficient under such a scenario. The scenarios of type 1, however, are not only to be used as a stress test; they also directly affect the target capital. The method to be used for the standard model is described below. To a reasonable extent, the method can be adjusted from the standard model in the direction of an internal model. The part of the standard model described so far is based on a distribution function for changes to the RBC. By including them, it is easier to capture the tail of the distribution. Attention should be paid to the fact that claims from scenarios are not already reflected by the claims in the distribution-based model.

This approach is based on the idea that the analytically modeled distribution does not adequately take into account certain extreme situations.

In the case of some of the predefined scenarios, it is possible that the effects for an insurer are positive, i.e. that they generate profit. In this event, it is permissible to include such scenarios as well. However, it would not be permissible for an insurer to formulate a scenario itself so that its evaluation would result in a profit for the insurer. The following table is a list of the scenarios for life, health, and non-life insurers. The formulation of the scenarios relates to the standard model.

Scenario	Probability	Life	Non-life	Health
Industrial	0.5%		x	
Pandemic	1%	x	x	x
Accident on a works outing	0.5%		x	x
Accident: Panic in a football stadium	Type 2		x	x
Hail scenario	type 2		x	
Disability	0.5%	x		
Daily allowance for sickness	0.5%			x
Default of the reinsurers	Depends	x	x	x
Financial distress scenario	0.5%	x	x	x
Deflation	0.1%	x	x	x
Under-provisioning	0.5%		x	x
Anti-selection for health insurers	0.5%			x
Historical market scenario	0.1% each	x	x	x
Terrorism	0.5%	x	x	x
Longevity	0.5%	x		

Table 34: List of the scenarios for life, health, and non-life insurers with their probability of occurrence.

The distribution-based model and the scenarios each take one part of all risks into account. The goal is to combine these two parts and consider the risks in a total distribution. For purposes of simplicity, it's assumed that at most one scenario can occur in the year, and that this scenario will only occur once at most. This approximation is acceptable, since it's assumed that the scenarios are rare and that the number of scenarios is low.

We define the following events:

- S_k scenario no. k with $1 \leq k \leq m$ occurs
- S_0 none of the scenarios S_1 to S_m occur.

Furthermore, we define the following probabilities:

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$$p_0 := P(S_0) = \text{probability that no scenario occurs}$$

$$p_k := P(S_k) = \text{probability that scenario } S_k \text{ occurs } (1 \leq k \leq m)$$

The approximation above states that the scenarios are mutually exclusive. This entails that

53

$$p_0 = 1 - (p_1 + p_2 + \dots + p_m)$$

where $p_1 + p_2 + \dots + p_m$ is the probability that any one of the m scenarios occurs. For each scenario S_j , the evaluation of the scenarios shows how great the effect c_j on the risk-bearing capital is:

54

$$c_i := E(RBC_{31.12}(\text{scenario occurs}) - RBC_{31.12}(\text{scenario doesn't occur})) \quad i = 1, 2, \dots, m$$

As a rule, the scenarios reduce the risk-bearing capital, so that c_i are negative quantities. A year in which no scenario occurs is called a "normal year" here. In a normal year, let the distribution function of the change to the risk-bearing capital be:

55

$$F_0(x) := P\left(\frac{RBC_{31.12}}{1 + r_1^{(0)}} - RBC_{1.1} \leq x | S_0\right)$$

This function is the result from the distribution-based model. We postulate that the distribution function under scenario S_i is

56

$$F_i(x) := P\left(\frac{RBC_{31.12}}{1 + r_1^{(0)}} - RBC_{1.1} \leq x | S_i\right) = F_0(x - c_i) \quad i = 1, \dots, m$$

This approach is based on the assumption that, if a scenario occurs (e.g. industrial explosion with CHF 100 million claims expenses), all possible changes to the risk-bearing

capital (Δ_{RBC}) will be CHF 100 million smaller than the possible Δ_{RBC} in a normal year. This assumption is not always valid: if a scenario affects other risk factors, this would not only entail a shift, but also a deformation of the distribution function. For purposes of simplicity, we will ignore such effects.

If scenario S_i occurs, the distribution of Δ_{RBC} is therefore given by the distribution Δ_{RBC} without a scenario, but shifted by the value c_i .

The aggregation of the scenarios and the normal year is accomplished by determining the total distribution function of the Δ_{RBC} from the distribution functions of the scenarios and the normal year.

This function is

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$$F(x) = \sum_{i=0}^m p_i F_i(x) = \sum_{i=0}^m p_i F_0(x - c_i)$$

and can be determined for a set of bases, since the distribution function $F_0(x)$ and therefore also the distribution function $F_i(x)$ are given numerically. Subsequently, the VaR and the expected shortfall can be determined for $F(x)$ at certainty level α .

It can be shown that this approach generates the same distribution as the distribution of the sum of:

- the continuous random variables from the distribution-based model; and
- the independent discrete random variables S with $P(S=c_i)=p_i$ for $i=0,\dots,m$.

The intuition behind this approach is to imagine that the total distribution of the Δ_{RBC} can also be derived using a Monte Carlo simulation. For this purpose, a sample is drawn from the basket of the Δ_{RBC} without scenarios, and independently a second sample is drawn from the basket of the scenarios S_0 to S_m with the values c_0, \dots, c_m . The total change of the RBC is the sum of the two sample values. This consideration also shows that $F(x)$ can also be calculated easily by folding the two random variables Δ_{RBC} and S .

Risks that occur both in the distribution-based model and in the scenarios are counted double with the aggregation method, which leads to a risk assessment result that is too high.

To avoid the double counting of risks, only scenarios should be considered in the aggregation whose risks are not reflected in the distribution-based model.

Nevertheless, it still makes sense on other grounds to evaluate scenarios that result in double counting.

Scenarios are very instructive, they can be used to show other offices or entities the dimension of a risk and to better justify the representation of the risk in the distribution-based model, since it provides additional information.

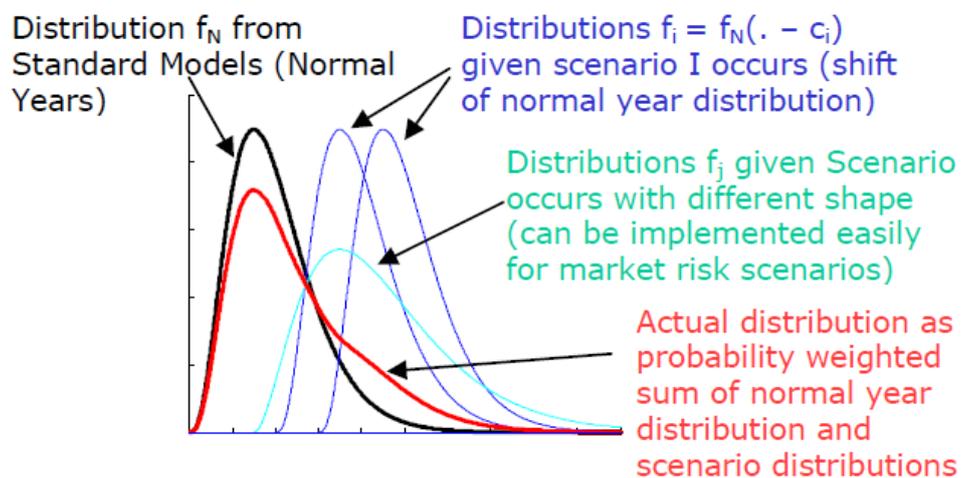


Figure 18: Aggregation of normal results with scenarios.

6.9 INTERNAL MODEL

The supervisory authority encourages the use of internal model for target capital calculation. Using a wide range of models reduces the danger of a systematic risk caused by the standard model imposed by the supervisory authority.

Internal models are permitted provided they meet certain requirements prescribed by the supervisory authority. The internal models need to satisfy quantitative, qualitative and organizational requirements. In particular, they must be integrated into the insurer's internal processes and may not be used exclusively to calculate target capital.

The internal model may itself lead to a distribution function of the discounted risk-bearing capital in one year, or it may be embedded within the standard models and partly modify the standard SST.

All relevant risk factors must be factored into the internal models. The dependency structure of the risk factors must be taken into account.

Data and parameters in internal models must be up-to-date and relevant for the insurance company. If these don't satisfy the requirements, they must be supplemented by external data, that has to be of relevance for the insurance company's specific exposure and their sources must be cited.

The appointed actuary has to assess the model risk and stability of the results by means of a sensitivity analysis, back-testing, or similar methods. The internal models must be reviewed regularly and adjusted if necessary.

The market consistent value must be calibrated to the same confidence level and risk measure as the SST.

Internal models need to be deeply embedded within an appropriate organizational framework. In particular, they need to be integrated into the company's daily risk management processes, regularly updated and tested. While it is relatively straightforward to formulate guidelines regarding quantitative and qualitative requirements, defining regulatory preconditions on the organizational framework is more difficult. The regulator does not intend to specify rigidly what type of corporate governance, and risk-management structure a company needs to possess in order to use internal models, however minimal requirements depending on the complexity and scope of the business will have to be met before an internal model can be used for target capital calculation.

It is an aim of the SST to give incentives for companies to develop and use internal models for target capital calculations. Since the regulator does not expect all companies to develop their own internal models, standard models can be used. If internal models are accepted by the regulator, they can be calibrated to 'best-estimate' assumptions, i.e. they do not need to contain implicit or explicit safety margins (note that this does not mean that for instance financial market parameters need not be adjusted for illiquidity or intransparency). To give an incentive for companies to switch from standard to internal models, the standard model is more conservative than 'best-estimate'. Conservativeness in the standard models is achieved – when possible – by the use of a conservative methodology. For instance the treatment of reinsurance risk within the standard model assumes that all reinsurers default at the same time. An insurer can use an internal model

describing more adequately the dependency structure of default between different reinsurers.

6.10 SST REPORT

The SST report summarizes the risk position of the company. It has a mandatory minimum content prescribed by the regulator. It is to be provided to the regulator on an annual basis and has to be signed-off by the CEO³⁸.

It is important that the SST-Report will be as concise as possible but as detailed as necessary such that the relevant information is contained in it. All relevant information to understand the target capital calculation has to be part of the SST-Report. The risk management and the risk governance have to be described within a separate report (risk management report), which also has to be sent to the regulator.

³⁸ Chief executive officer.

CHAPTER 7

THE UNDERWRITING RISK IN THE SWISS SOLVENCY TEST FOR NON LIFE INSURERS

In this part we analyze the SST standard model for non-life insurers, which is the base of Chapter 8.

The SST model for non-life insurers is based on the accident year principle. This means that claims are grouped according to the date when the claim occurred. Other principles to group the claims are the underwriting year basis and the reporting year basis.

The accident year principle leads naturally to the distinction of:

- claims which have occurred in previous years $PY = (-\infty, t_0)$ i.e. 2004, 2003, . . . ;
and
- claims which have not yet occurred but which will eventually occur in t_0 , the so called current year (CY) claims.

Both PY and CY claims are related to a specific risk. The risk of PY claims is that their best estimate provision $r_{PY}^{(0)}$ at the beginning of the year t_0 differs from the best estimate at the end of the year. The difference originates from the increase in information about the claims settlement process. The risk of CY claims consists of the uncertainties about the number of claims and about the amount of each single claim. The annual nominal incurred loss in t_0 is denoted with S_{CY} .

7.1 ASSUMPTIONS

The business model for a non-life insurer is based on the following assumptions.

On January 1 t_0 , the insurer has got assets of value $a(0)$ and claims provisions (discounted best estimate) $l(0)$. The provisions include IBNyR (incurred but not yet reported) and provisions for future claims handling expenses/costs. These costs are composed of “allocated loss adjustment expenses” (ALAE) and “unallocated loss adjustment expenses” (ULAE). It is suggested to use the “New Yorker”-method to estimate the ULAE’s value.

In addition the SST assumes that the earned premium p for t_0 have already flown in a first part in $t_0 - 1$ and will flow in a second part on January 2 t_0 . The first part is booked but not yet earned in $t_0 - 1$. Therefore it is called the “unearned premium”. Because of that, there is an “unearned premium reserve” (upr) on the liability side of the balance sheet 31.12. $t_0 - 1$. The remaining premium for t_0 is then $p - upr$. Immediately after the cash-in the value of the assets is $a(0) + p - upr$.

Beside the claims adjustment expenses mentioned above there are the ordinary costs k to run the business. Similar to the premium, the SST assumption is that the cash flow related to the costs takes place on January 2. Overall, the value of the assets after premium inflow and cost outflow is:

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$$a(0) + p - upr - k$$

This is the amount of assets which is available to invest at the beginning of t_0 . The investment leads to a (stochastic) performance over the year. We denote this by R_I in relative terms, or by

59

$$R_I(a(0) + p - upr - k)$$

in absolute terms.

The non-life portfolio is divided into 12 lines of business (LoB.) In some of these LoB, the settlement of claims takes more than one year. This is especially true for all types of liability and accident annuity business. Therefore, we define for each LoB the payout

pattern. Since there is a difference in the settlement of *CY* – and *PY* -claims, we also have to distinguish between *CY*

60

$$\alpha_1^{(l)}, \alpha_2^{(l)}, \alpha_3^{(l)}, \dots$$

and *PY* payout patterns:

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$$\beta_1^{(l)}, \beta_2^{(l)}, \beta_3^{(l)}, \dots$$

for LoB $l = 1, 2, \dots, 12$. The patterns are normalised, i.e.

62

$$\sum_{i=1}^{12} \alpha_i^{(l)} = 1, \sum_{i=1}^{12} \beta_i^{(l)} = 1 \quad \forall l \in 1, 2, \dots, 12$$

If the superscript l is omitted in the following, we mean the patterns for the sum of all lines of business. It is assumed that the claims payment flow at the end of the year. For instance, the cash flows for *CY* claims are

63

$$\alpha_0 S_{CY}, \alpha_1 S_{CY}, \alpha_2 S_{CY}, \dots$$

at the end of t_0, t_1, t_2 etc.

To describe the yield curve of risk-free zero coupon bonds, we use the notation

64

$$r_0^{(0)} \equiv 0, r_1^{(0)}, r_2^{(0)}, \dots$$

for the (observable) interest rates at time t_0 and

65

$$R_0^{(1)} \equiv 0, R_1^{(1)}, R_2^{(1)}, \dots$$

for the unknown, hence stochastic, interest rates at time t_1 . This immediately leads to the discount factors

66

$$v_i^{(0)} = \frac{1}{(1 + r_i^{(0)})^i}, \quad V_i^{(1)} = \frac{1}{(1 + R_i^{(1)})^i}, \quad i = 0, 1, \dots$$

at time t_0 and t_1 , respectively.

If we combine payout patterns for CY and PY with the discount factors, we get the discounted incurred loss for the CY claims

67

$$d_{CY}^{(0)} S_{CY} = v_1^{(0)} \alpha_0 S_{CY} + v_2^{(0)} \alpha_1 S_{CY} + v_3^{(0)} \alpha_2 S_{CY} + \dots = \left(\sum_{i=0} v_{i+1}^{(0)} \alpha_i \right) S_{CY}$$

and the discounted best estimate for the PY claims provisions

68

$$d_{PY}^{(0)} r_{PY}^{(0)} = v_1^{(0)} \beta_0 r_{PY}^{(0)} + v_2^{(0)} \beta_1 r_{PY}^{(0)} + v_3^{(0)} \beta_2 r_{PY}^{(0)} + \dots = \left(\sum_{i=0} v_{i+1}^{(0)} \beta_i \right) r_{PY}^{(0)}$$

$d_{CY}^{(0)}$ and $d_{PY}^{(0)}$ are discount factors at date t_0 for CY - and PY -claims. At the end of t_0 , just before the payment for t_0 flows, we obtain for the discounted values

69

$$D_{CY}^{(1)} S_{CY} = V_1^{(0)} \alpha_0 S_{CY} + V_2^{(0)} \alpha_1 S_{CY} + V_3^{(0)} \alpha_2 S_{CY} + \dots = \left(\sum_{i=0} V_i^{(0)} \alpha_i \right) S_{CY}$$

And

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$$D_{PY}^{(1)} Cr_{PY}^{(0)} = V_0^{(0)} \beta_0 Cr_{PY}^{(0)} + V_1^{(0)} \beta_1 Cr_{PY}^{(0)} + V_2^{(0)} \beta_2 Cr_{PY}^{(0)} + \dots = \left(\sum_{i=0} V_i^{(0)} \beta_i \right) Cr_{PY}^{(0)}$$

$Cr_{PY}^{(0)}$ is the best estimate at $t_1 = \text{December 31}$ of the future cash flows for PY claims.

Due to the increase in information during t_0 , C will deviate from its expected value $E(C) = 1$. If an insurer thinks at t_1 that the provisions can be reduced then chooses a $C < 1$ and obtains a profit on the loss reserves. Note that in $D_{CY}^{(1)}S_{CY}$ and $D_{PY}^{(1)}Cr_{PY}^{(0)}$ there is not only the insurance risk (S_{CY} and $Cr_{PY}^{(0)}$) but also an interest rate risk ($D_{CY}^{(1)}$ and $D_{PY}^{(1)}$).

7.2 CHANGE IN RISK BEARING CAPITAL

Putting the assumptions above into the term $\frac{RBC_{31.12.t_0}}{1+r_1^{(0)}} - rbc_{1.1.t_0}$ and applying two approximation yields

71

$$\begin{aligned} \frac{RBC_{31.12.t_0}}{1+r_1^{(0)}} - rbc_{1.1.t_0} &\approx \frac{E[R_I] - r_1^{(0)}}{1+r_1^{(0)}} (a(0) + (p - upr) - k) \\ &+ \frac{R_I - E[R_I]}{1+r_1^{(0)}} (a(0) + (p - upr) - k) - \frac{D_{CY}^{(1)} - E[D_{CY}^{(1)}]}{1+r_1^{(0)}} E[S_{CY}] - \frac{D_{PY}^{(1)} - E[D_{PY}^{(1)}]}{1+r_1^{(0)}} \cdot r_{PY}^{(0)} \\ &\quad + (p - k) - d_{CY}^{(0)} E[S_{CY}] \\ &\quad d_{CY}^{(0)} (S_{CY} - E[S_{CY}]) - d_{PY}^{(0)} (C - 1)r_{PY}^{(0)} \end{aligned}$$

The first line on the right hand side is the expected investment performance above the one year risk free rate. The second line refers to the financial and ALM risk. The first term is the difference between the stochastic investment performance R_I and its expectation. The second and the third terms are the interest rate risk contribution from the insurance liabilities.

On the next line we have the expected technical result on a discounted basis. The last line then refers to the insurance risk on the new claims ($S_{CY} - E[S_{CY}]$) and on the change in claims provisions $(C - 1)r_{PY}^{(0)}$. Note that the expected values of the risk terms for market risks and insurance risks are zero by construction. Above we mentioned two approximations. The first one refers to the fact that insurance liabilities are discounted. Therefore the risk in a liability consists of the interest rate risk in the discount factors $D_{PY}^{(1)}$,

$D_{CY}^{(1)}$ and the risk in the nominal value of the liability $S_{CY}, Cr_{PY}^{(0)}$. The assumption made is that the products of two random variables like $D_{CY}^{(1)} S_{CY}$ can be replaced by their first order Taylor approximations:

72

$$D_{CY}^{(1)} S_{CY} \approx E \left[D_{CY}^{(1)} \right] E[S_{CY}] + E \left[D_{CY}^{(1)} \right] (S_{CY} - E[S_{CY}]) + \left(D_{CY}^{(1)} - E \left[D_{CY}^{(1)} \right] \right) E[S_{CY}]$$

in case of the current year risk. Applying the same approximation for the reserving risk term yields

73

$$\begin{aligned} D_{PY}^{(1)} C &\approx E \left[D_{PY}^{(1)} \right] E[C] + E \left[D_{PY}^{(1)} \right] (C - E[C]) + \left(D_{PY}^{(1)} - E \left[D_{PY}^{(1)} \right] \right) E[C] = \\ &= D_{PY}^{(1)} + E \left[D_{PY}^{(1)} \right] (C - 1) \end{aligned}$$

where we have used that provisions are best estimate provisions $E[C] = 1$.

The second approximation applied in equation 71 is the assumption that

74

$$\frac{D_{PY/CY}^{(1)}}{1 + r_1^{(0)}} \approx d_{PY/CY}^{(0)}$$

This means that discounting to time t_1 with the yield curve at t_1 and then discounting to time t_0 using the discount factor at t_0 can be replaced by directly discounting to time t_0 with the yield curve at t_0 . Note that this assumption is only applied in the insurance risk terms.

The standard model of the SST provides the distribution of the change in the risk bearing capital. In what follows, we give an overview over the insurance risk model.

7.3 STOCHASTIC MODEL FOR INSURANCE RISKS

The insurance risk model provides a distribution for the incurred loss S_{CY} on the claims occurring in the interval $CY = [t_0, t_1)$ and the change in provisions $(C - 1)r_{PY}^{(0)}$ for the claims which have occurred in $PY = (-\infty, t_0)$.

7.3.1 DETERMINATION OF THE DISTRIBUTION FOR THE TECHNICAL RESULT ARISING FROM CY CLAIMS

In the following, we will provide a description of how the claims expense S_{CY} is modelled in the standard model. It should be noted that the difference between the variable and its expected value $E[S_{CY}]$ must be used for the aggregation in formula.

To model the annual claims expense S_{CY} , a distinction is made between normal claims and major claims. The reason is that no reasonable probability distribution exists that describes both normal and major claims. For purposes of the SST, the boundary between normal and major claims can be chosen to be CHF 1 million or CHF 5 million.

Major claims encompass both individual major claims (by line of business) and cumulated claims, for instance caused by natural phenomena such as hail or floods. Cumulated claims may extend across lines of business. For instance, a hailstorm affects property insurance, but especially also comprehensive motor vehicle insurance.

Accordingly, we are looking for the distribution of the total claims expense as a sum of normal claims and major claims:

75

$$S_{CY} = S_{CY}^{NC} + S_{CY}^{MC}$$

The two distributions for the claims expense for normal and major claims must be found. The SST assumes that the major claims are independent of the normal claims. This entails that the aggregation of the two claims types into S_{CY} results from folding the two distributions.

7.3.1.1 CY CLAIMS: DISTRIBUTION OF NORMAL CLAIMS

The annual claims expense for normal claims is composed of the individual claims of the lines of business. The SST does not make any explicit assumption about the distribution of the individual claims; instead, the annual claims expenses are only represented with their expected value and variance.

7.3.1.1.1 EXPECTED VALUE

The expected value for the entire normal claims expense S_{CY}^{NC} can be calculated as the sum of the expected value per line of business i :

76

$$E(S_{CY}^{NC}) = \sum_{i=1}^{12} E(S_{CY,i}^{NC})$$

The expected claims expenses $E(S_{CY,i}^{NC})$ per line of business can, for instance, be estimated as the product of the expected claims rate and the expected value of the earned premium:

77

$$E(S_{CY,i}^{NC}) = LR_i P_i \quad i = 1, 2, \dots, 12$$

7.3.1.1.2 VARIANCE

The variance of the total normal claims expense is calculated as the sum of the variances and covariances of all lines of business:

78

$$VAR(S_{CY}^{NC}) = \sum_{i=1}^{12} VAR(S_{CY,i}^{NC}) + \sum_{i \neq j}^{12} Cov(S_{CY,i}^{NC}, S_{CY,j}^{NC}) =$$

$$\sum_{i=1}^{12} (VK_i E(S_{CY,i}^{NC}))^2 + \sum_{i \neq j}^{12} \rho_{i,j} (VK_i E(S_{CY,i}^{NC})) (VK_j E(S_{CY,j}^{NC}))$$

with VK_i as the variation coefficient of line of business i , defined by:

79

$$VK_i = \frac{\sigma(S_{CY,i}^{NC})}{E(S_{CY,i}^{NC})}$$

With $\sigma(S_{CY,i}^{NC})$ as the standard deviation of the normal claims expense $E(S_{CY,i}^{NC})$ in line of business number i and $\rho_{i,j}$ as the correlation coefficient for lines of business i and j .

7.3.1.1.2.1 VARIATION COEFFICIENTS

The contributions to the variance of the annual claims expense come from two sources. First, statistical fluctuations of the number and magnitude of claims around the expected value occur. This contribution to the uncertainty is called random or process risk. Second, an uncertainty exists with respect to the parameter of the distribution, or in other words with respect to the expected value and the variance. These quantities are namely not known, but rather must be estimated on the basis of statistics and expert knowledge, which are associated with uncertainty. The associated risk is called parameter risk. Examples of parameter risk are: wrong inflation estimates for life insurance, wrong estimates of claims frequencies, external changes, etc. A more precise consideration is given by the expression

80

$$Var(S_{CY,i}^i) = Var([S_{CY,i}^{NC} | \theta_i]) + E[Var(S_{CY,i}^{NC} | \theta_i)]$$

for the total variance for the claims expense of line of business number i . The first term represents the parameter risk, i.e. the variability of the model parameters from one year to the other that is caused by external circumstances. The totality of these circumstances is characterized by the random variable (risk parameter) θ . θ can be viewed as the risk characteristic of a fixed claims year. It measures how precisely an actuary can estimate the

expected expenditure, or what external influences cannot be buffered by the risk equalization in the collective. (For this risk, the size of the company plays no role, which means that it cannot be diversified away.)

The second addend is the random risk that consists in the uncertainty of the annual claims amount given the risk parameter θ_i (i.e. given the expected value and the variance of the distribution).

Assuming that for a given θ_i , the number of claims in line of business i has a Poisson distribution with Poisson parameter λ_i (=expected number of claims), then the variation coefficient of $S_{CY,i}^{NC}$ is

81

$$VK_i^2 = \frac{\text{Var}(S_{CY,i}^{NC})}{(E(S_{CY,i}^{NC}))^2} = VK_{p,i}^2 + \frac{1}{\lambda_i} (VK^2(Y_{i,j}) + 1)$$

where $VK(Y_{i,j})$ denotes the variation coefficient of the individual claims amount in line of business i .

The first addend $VK_{p,i}$ represents the contribution of the parameter risk, and the second addend represents the contribution of the random risk.

7.3.1.1.2.1.1 PARAMETER RISK

The variation coefficient of the parameter risk $VK_{p,i}$ of line of business i is composed of a parameter uncertainty with respect to the expected value of the individual claims amount $E[Y_{i,j}]$ and a parameter uncertainty with respect to the expected value of the number of individual claims $E(N_i)$. These uncertainties in the parameters arise from external circumstances that affect many, if not all, companies. For this reason, standard values for the variation coefficients of the parameter risk have been determined for each line of business on the basis of common statistics of the insurers.

Line of business	Variation coefficient of the parameter risk
MVL	3.50%
MVC	3.50%
Property	5.00%
Liability	3.50%
UVG	3.50%
Accident w/o UVG	4.75%
Health Collective	5.75%
Health Individual	5.75%
Transport	5.00%
Aviation	5.00%
Finance and Surety	5.00%
Legal Expenses	5.00%
Others	4.50%

Table 35: Variation coefficients of the parameter risk.

7.3.1.1.2.1.2 RANDOM RISK

The variability of the j -th individual claims amount $Y_{i,j}$ in line of business i is represented by the variation coefficient $VK(Y_{i,j})$. The contribution in the parentheses results from the variability of the number of claims (for a given θ , this has a Poisson distribution with the expected value λ_i).

For the non-life SST, standard values for the variation coefficients of the individual claims amounts are made available for each line of business.

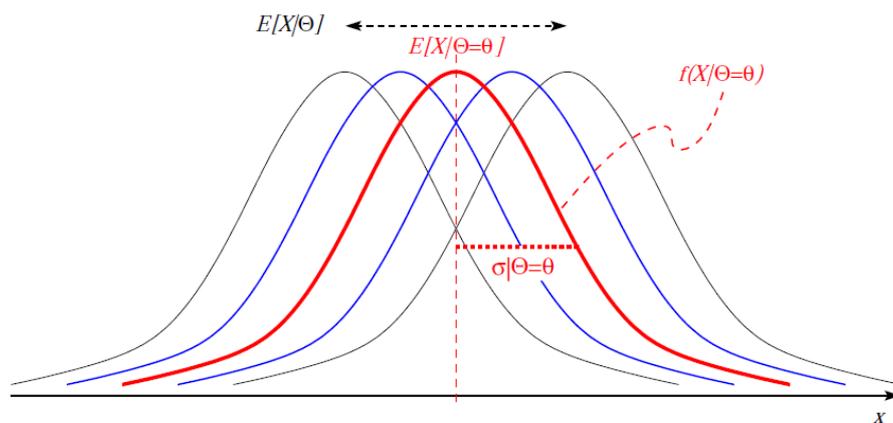


Figure 19: Uncertainty of X owing to stochastic variability around the expected value and due to uncertainty in the expected value. For a given risk characteristic $\Theta = \vartheta$, the density of X is given by the red curve (stochastic risk). However, the density itself is variable (parameter risk), shown here as the uncertainty of $E[X|\Theta]$ (black arrow).

Line of business	Variation coefficient	
	Major claims threshold 1 million	Major claims threshold 5 million
MVL	7,00	10
MVC	2,50	2,5
Property	5,00	8
Liability	8,00	11
UVG	7,50	9,5
Accident w/o UVG	4,50	5,5
Health Collective	2,50	2,5
Health Individual	2,25	2,25
Transport	6,50	7
Aviation	2,50	3
Finance and Surety	5,00	5
Others	5,00	5

Table 36: Variation coefficients for random risk depending on the major claims threshold.

7.3.1.2 CY CLAIMS: DISTRIBUTION OF MAJOR CLAIMS

Major claims encompass both individual major claims and cumulated claims:

- individual claims with a large claims amount. Such claims may for instance arise in the property (e.g. fire in a factory building) and liability lines of business (e.g. product liability or motor vehicle liability). As a first approximation, the amount of an individual claim does not depend on the insuring company; and
- cumulated claims: a group of claims triggered by the same event (e.g. hail or storm). The individual claims are generally not major claims, but the total claims expense may be high due to the large number of individual claims. Although the individual claims are not greater than the normal claims, they cannot be represented in the normal claims model due to their mutual dependency (cumulated event).

The SST major claims model considers the following event types and lines of business:

Line of business	Comments on modelling major events
MVL	Modelled as individual major claim
MVC	Encopasses hail claims,modelled as market share of market-wide claims
Property without natural hazards	Modelled as individual major claim
General liability	Modelled as individual major claim
Health, collective	Modelled as individual major claim
Health, individual	Modelled as individual major claim
Aviation	No modelling of major cliams
Transport	Modelled as individual major claim
Finance and surety	Modelled as individual major claim
Accident	Modelled as market share of market-wide cumulated claims
Natural hazard pool	Modelled as share of the market-wide claims
Other natural hazards	Modelled as share of business interruption or another appropriate quantity relative to the market-wide claims.

Table 37: Major claims modelling by line of business/type of event.

Frequently, insurance undertakings participate in a cumulated claim according to their market share in the line of business in question, so that it makes sense to determine common parameters.

The major claims are modelled separately for each line of business of type of event i with a compound Poisson distribution:

82

$$S_{CY,i}^{MC} = \sum_{j=1}^{N_i^{MC}} Y_{i,j}^{MC}$$

Here, the number of claims N_i^{MC} of line of business i has a Poisson distribution with the expected value λ_i^{MC} .

It is assumed that the individual gross claims $Y_{i,j}^{MC}$ are distributed independently of each other and identically within the line of business or type i . A Pareto distribution is used for each type i :

83

$$F_{Y_{i,j}^{MC}}(y) = Pr(Y_{i,j}^{MC} \leq y) = \begin{cases} 0 & y < \beta \\ 1 - \left(\frac{y}{\beta}\right)^{-\alpha} & y \geq \beta \end{cases}$$

β is the smallest claim considered in the major claim model, which is why β is often called the major claim "threshold". Another name is "observation point of the Pareto distribution". The standard values of the parameters in the SST are designed so that β is either CHF 1 or 5 million. One of these values must be chosen by each insurer. This choice can be made individually for each line of business, but the notation " β " in this document does not take this account.

Pareto distributions have the quality that they assign greater weight to high claims than many other distributions. The strength of the weighting is determined by the Pareto parameters α_i . The smaller the value of α_i , the more weight the higher major claims have. The standard values for the Pareto parameters are:

Line of business	Major claims threshold 1 million	Major claims threshold 5 million
MVL	2,50	2,80
MVC	1,85	1,85
Property	1,40	1,50
Liability	1,80	2,00
UVG incl. UVGZ	2,00	2,00
Health Collective	3,00	3,00
Health Individual	3,00	3,00
Transport	1,50	1,50
Finance and Surety	0,75	0,75
Others	1,50	1,50

Table 38: Parameters α_i of the Pareto distribution.

By using the Pareto distribution for modelling the individual claims amounts, arbitrarily high claims amounts are possible in the model. In reality, however, claims in certain lines of business cannot be arbitrarily high, e.g. due to contractually agreed maximum insurance amounts. It therefore makes sense to truncate the Pareto distribution at a certain value. For this purpose, standard truncation points are determined for some lines of business.

These guidelines are listed in the following table. They are not binding, but deviations must be explained.

Line of business	Truncation point
MVL	Unlimited
MVC	Market share x CHF 1.5 billion
Property without natural hazards	Individual estimate of the largest possible claim for each insurer
General liability	Individual estimate of the largest possible claim for each insurer
UVG incl. UVGZ	Unlimited
Accident without UVG	CHF 50 million
Health, collective	Individual estimate of the largest possible claim for each insurer
Health, individual	Individual estimate of the largest possible claim for each insurer
Transport	2 × largest possible insurance amount
Finance and surety	Individual estimate of the largest possible claim for each insurer
Others	Individual estimate of the largest possible claim for each insurer
Natural hazard pool	At the contractually agreed CHF 500 million per event for the market-wide claims
Natural hazards not in the natural hazard pool	Market share × CHF 1 billion

Table 39: Truncation points of the Pareto distribution.

7.3.1.2.1 MODELLING OF CUMULATED CLAIMS DUE TO HAIL EVENTS

In this section we analyzed the modeling of cumulated claims due to hail events which will be modeled in the next chapter.

The modeling of cumulated hail claims mainly concerns comprehensive motor vehicle insurance. As in other lines of business, major hail claims are also represented with a Poisson and Pareto distribution.

First, the threshold for the market-wide major hail claims is fixed at $\beta_{Hail}^{(Market;0)} = CHF\ 45\ million$.

The expected value of the number of claims $> CHF\ 45\ million$ is $\lambda_{Hail}^{(0)} = 0.9$.

The modeling also requires an individual major claims threshold per company, however. This threshold depends on the company's chosen individual major claims threshold β and the market share of the hail claims m_{hail} (this can be equal to the market share with respect to comprehensive motor vehicle insurance.).

7.3.1.2.2 CUMULATED EVENTS IN ACCIDENT INSURANCE

Like hail claims, the cumulated claims in accident insurance are modelled as the individual market share $m_{accident}$ in a market-wide cumulated claim. The market-wide claim distribution is a compound Poisson distribution with threshold $\beta_{accident}^{(Market;0)} = CHF\ 20\ million$. The probability that a cumulated claim greater than or equal to $\beta_{accident}$ occurs for private insurers in a given year has been estimated as $\lambda_{accident}^{(0)} = 0.1$. The Pareto parameter is $\alpha_{accident} = 2$.

As for the treatment of cumulated hail claims, an adjustment of the smallest observed market-wide claim $\beta_{accident}^{(Market)}$ and the expected frequency $\lambda_{accident}$ is necessary so that they are consistent with the company's own major claims threshold and the market share.

84

$$\beta_{accident}^{(Market)} = \frac{\beta}{m_{accident}}$$

85

$$\lambda_{accident} = \lambda_{accident}^{(0)} \left(\frac{\beta_{accident}^{(Market)}}{\beta_{accident}^{(Market;0)}} \right)^{-\alpha_{accident}}$$

It is suggested to measure the market share using the earned premium before reinsurance.

7.3.1.3 AGGREGATION OF THE MAJOR CLAIMS DISTRIBUTION

This section explains how the abovementioned major claims distributions (compound Poisson distributions by line of business) can be aggregated in a simple way. First, this relies on the fact that the sum of independent variables with a compound Poisson distribution again has a compound Poisson distribution. Second, a compound Poisson distribution can be numerically derived with the Panjer algorithm in a simple manner.

As a first step, we reiterate that the major claims distribution by line of business or type of event is given by the stochastic sum of individual gross claims $Y_{i,j}^{MC}$

86

$$S_{CY,i}^{MC,G} = \sum_{j=1}^{N_i^{MC}} Y_{i,j}^{MC}$$

The index i stands for one of the lines of business with individual major claims and for the events "cumulated hail claim" and "cumulated accident claim".

The distribution of the numbers of claims by line of business/type of event i has a Poisson distribution:

87

$$N_i^{MC} \sim \text{Poisson}(\lambda_i^{MC})$$

The gross claims amount distribution by line of business/type of event i is:

88

$$Y_{i,j}^{MC} \sim \text{Pareto}(\alpha_i, \beta_i)$$

The sum of the annual claims expenses across lines of business/types of event

89

$$S_{CY}^{MC} = \sum_{i=1}^{12} \sum_{j=1}^{N_i^{MC}} Y_{i,j}^{MC}$$

again has a compound Poisson distribution it can be written as

90

$$S_{CY}^{MC} = \sum_{k=1}^{N^{MC}} Y_k$$

Where

91

$$N^{MC} \sim \text{Poisson} \left(\sum_i \lambda_i^{MC} \right)$$

applies to the distribution of numbers of claims, while the distribution of the individual claims Y_k is constructed as follows as a weighted average of the distribution function of the individual claims of the individual lines of business/types of business:

92

$$F_Y(y) = \frac{1}{\sum_i \lambda_i^{MC}} \sum_i \left(\lambda_i^{MC} F_{Y_{CY,i}^{MC}}(y) \right)$$

This total major claims distribution S can now be calculated with the fast Fourier transformation or preferably with the Panjer algorithm.

7.3.2 DETERMINATION OF THE DISTRIBUTION FOR THE TECHNICAL RESULT ARISING FROM PY CLAIMS

The risk of the provisions consists in the uncertainty of the settlement result. The standard model assumes that the quantity $C_{PY} R_{PY}^{(0)}$ has a lognormal distribution, with a certain variance and the expected value $R_{PY}^{(0)}$. This implies that we assume best estimate provisions, $E[C_{PY}] = 1$. This section discusses how the variance should be estimated.

As in the case of new claims, a distinction is made between random risk and parameter risk. The random risk consists of randomness that arises from inaccurate estimates of the individual claims. It is determined according to individual companies by estimating the variances

93

$$\text{Var}_Z \left(C_{PY,i} R_{PY,i}^{(0)} \right) = \left(R_{PY,i}^{(0)} \text{Vko}_Z(C_{PY,i}) \right)^2 \quad i = 1, 2, \dots, 13$$

of the provisions of the 13 lines of business, using the time series of the historical settlement results. It is vital to determine the settlement results on the basis of best estimate provisions.

The parameter risk of the provisions arises when the estimates of parameters are uncertain that affect all provisions of a line of business at the same time, or if the level of the total claims provisions was chosen incorrectly.

The variance of $C_{PY}R_{PY}^{(0)}$ with respect to the parameter risk can be calculated easily using the predetermined variation coefficients of the different lines of business as:

94

$$Var_P \left(C_{PY,i}R_{PY,i}^{(0)} \right) = \left(R_{PY,i}^{(0)} Vko_P(C_{PY,i}) \right)^2 \quad i = 1,2, \dots, 13$$

Parameter risk and random risk are aggregated by line of business by adding the variances.

95

$$Var \left(C_{PY,i}R_{PY,i}^{(0)} \right) = Var_Z \left(C_{PY,i}R_{PY,i}^{(0)} \right) + Var_P \left(C_{PY,i}R_{PY,i}^{(0)} \right) \\ i = 1,2, \dots, 13$$

The standard parameter for random and parameter risks are:

Line of business	Vko _p	Vkoz ³⁹
MVL	3,50%	2,50%
MVC	3,50%	20,00%
Property	3,00%	15,00%
Liability	3,50%	4,00%
UVG	2,00%	4,00%
UVG accident	3,00%	5,00%
Health Collective	3,00%	7,00%
Health Individual	5,00%	0,00%
Marine	5,00%	25,00%
Aviation	5,00%	20,00%
Finance and Surety	5,00%	15,00%
Legal protection	5,00%	0,00%
Others	5,00%	50,00%

Table 40: Variation coefficients for the PY parameter and random risks.

³⁹ Values taken from: A. Gisler, "The Insurance Risk in the SST and in Solvency II: Modeling and Parameter Estimators", ASTIN Colloquium1-4 June 2009, Helsinki.

7.3.3 AGGREGATION OF TECHNICAL RISKS

The preceding sections explained how a distribution of the CY claims expense S_{CY} and of the settlement result $(C - 1)r_{PY}^{(0)}$ can be reached.

However, we need a total distribution of the technical risk in accordance with formula 71

96

$$(p - k) - d_{CY}^{(0)}E[S_{CY}] + d_{CY}^{(0)}(S_{CY} - E[S_{CY}]) - d_{PY}^{(0)}(C - 1)r_{PY}^{(0)}$$

When using this formula, centred around the expected value $E[S_{CY}]$, the following steps must therefore be performed:

- centring of S_{CY} around $E[S_{CY}]$. This gives us a distribution of $(S_{CY} - E[S_{CY}])$;
- discounting of $(S_{CY} - E[S_{CY}])$ with $d_{CY}^{(0)}$;
- discounting of the settlement result $(C - 1)r_{PY}^{(0)}$ with $d_{PY}^{(0)}$;
- aggregation of the discounted claim CY with the settlement result; and
- shifting of the resulting distribution by the deterministic value $(p - k) - d_{CY}^{(0)}E[S_{CY}]$.

As shown above, the term $d_{CY}^{(0)}(S_{CY} - E[S_{CY}])$ is composed of normal and major claims. Essentially, there are two options for the aggregation of the normal and major claims. It is possible to model the normal claims expense S_{CY}^{NC} with a lognormal distribution and to aggregate this distribution by folding it with the distribution of the major claims expense. This would result in the distribution of the CY claims. This approach is displayed in the following figure:

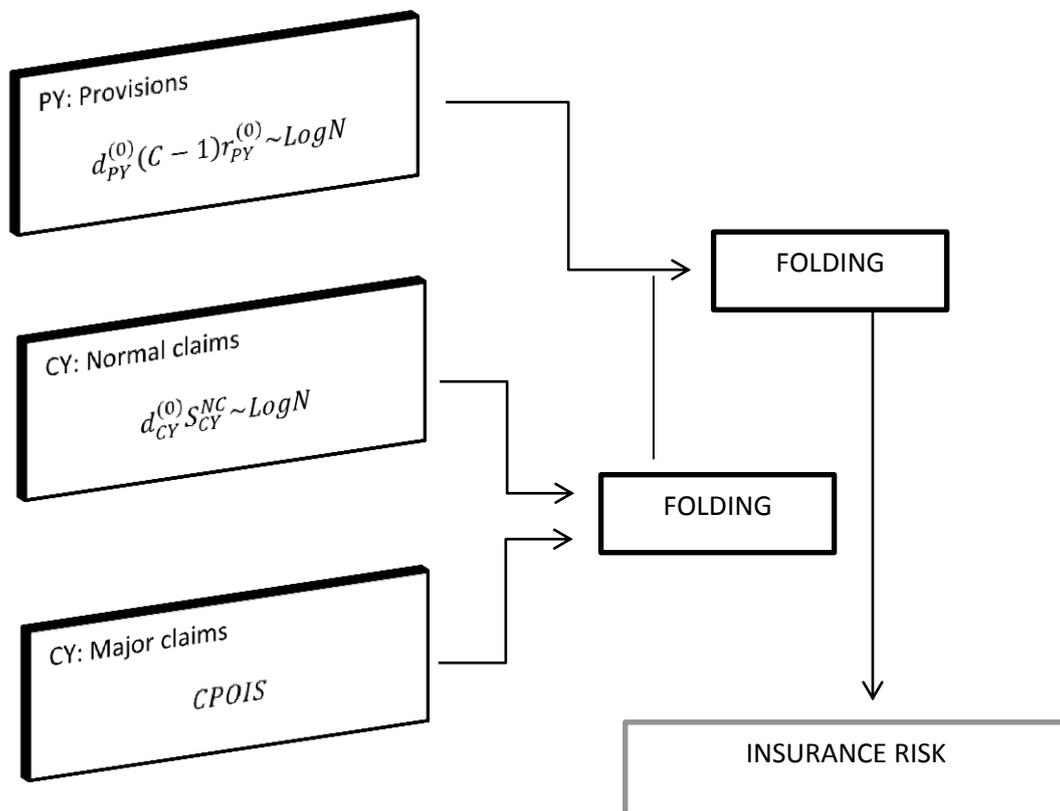


Figure 20: Aggregation of the major and normal claims, then aggregation with the provision risk.

Deviating from this, the standard model of the SST allows a folding operation to be omitted. This is accomplished by aggregating the normal claims expense with the uncertainty of the provisions

97

$$d_{CY}^{(0)}S_{CY}^{NC} + d_{PY}^{(0)}C_{PY}r_{PY}^{(0)}$$

This aggregation can be performed approximatively by adding expected values and variances. The SST assumes that the resulting variable has a lognormal distribution.

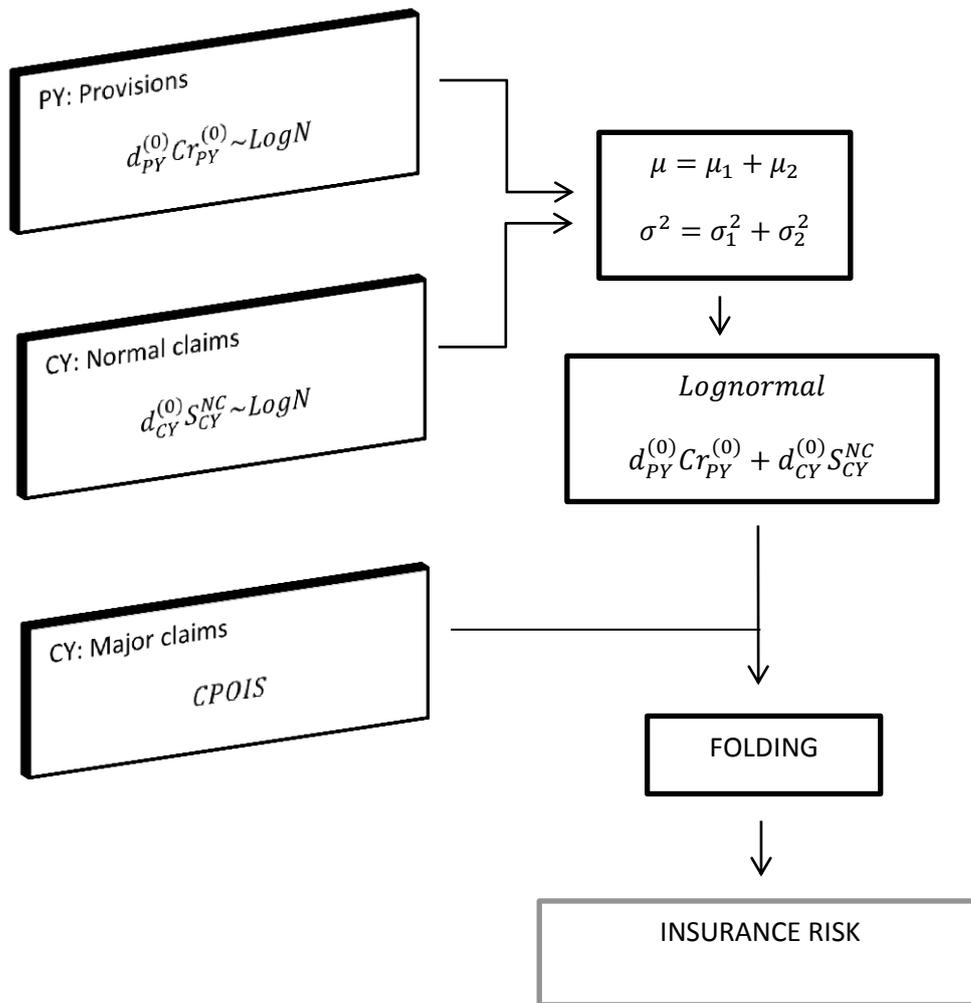


Figure 21: Aggregation of the provision risks and the normal claims through the addition of moments, then aggregation with the major claims.

CHAPTER 8

A COMPARISON BETWEEN SWISS SOLVENCY TEST AND SOLVENCY II

8.1 SWISS SOLVENCY TEST STANDARD MODEL

In this chapter we analyze the SST non-life standard model.

We consider an insurance company which is just entered in the market, so we focus only on premium risk.

This study considers a medium large insurance company (Company OMEGA), supposing that it's a multi-line non-life insurer which practices in the following lines of business:

- LoB1: MVL, motor vehicle liability;
- LoB2: MVC, comprehensive motor vehicle insurance, without claims arising from natural hazards;
- LoB3: Liability; and
- LoB4: Property.

Following the SST standard model, we must divide normal claims to major claims.

The distribution of normal claims S_{CY}^{NC} is modeled with a Log Normal distribution whose expected value can be calculated as the sum of the expected value per line of business i :

98

$$E(S_{CY}^{NC}) = \sum_{i=1}^4 E(S_{CY,i}^{NC})$$

The expected claims expenses $E(S_{CY,i}^{NC})$ per line of business can, for instance, be estimated as the product of the expected claims rate and the expected value of the earned premium:

99

$$E(S_{CY,i}^{NC}) = LR^{40}_i P_i \quad i = 1,2,3,4$$

The variance of the total normal claims expense is calculated as the sum of the variances and covariances of all lines of business:

100

$$\begin{aligned} VAR(S_{CY}^{NC}) &= \sum_{i=1}^4 VAR(S_{CY,i}^{NC}) + \sum_{i \neq j}^4 Cov(S_{CY,i}^{NC}, S_{CY,j}^{NC}) = \\ &= \sum_{i=1}^4 (VK_i E(S_{CY,i}^{NC}))^2 + \sum_{i \neq j}^4 \rho_{i,j} (VK_i E(S_{CY,i}^{NC})) (VK_j E(S_{CY,j}^{NC})) \end{aligned}$$

with VK_i as the variation coefficient of line of business i , defined by:

101

$$VK_i = \frac{\sigma(S_{CY,i}^{NC})}{E(S_{CY,i}^{NC})}$$

With $\sigma(S_{CY,i}^{NC})$ as the standard deviation of the normal claims expense $E(S_{CY,i}^{NC})$ in line of business number i and $\rho_{i,j}$ as the correlation coefficient for lines of business i and j .

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$$VK_i^2 = \frac{Var(S_{CY,i}^{NC})}{(E(S_{CY,i}^{NC}))^2} = VK_{p,i}^2 + \frac{1}{\lambda_i} (VK^2(Y_{i,j}) + 1)$$

where $VK(Y_{i,j})$ denotes the variation coefficient of the individual claims amount in line of business i .

⁴⁰ In this case we intend the loss ratio with regard only to normal claims.

The first addend $VK_{p,i}$ represents the contribution of the parameter risk, and the second addend represents the contribution of the random risk.

Line of business	$VK_{p,i}$
MVL	3.50%
MVC	3.50%
Liability	3.50%
Property	5%

Table 41: Variation coefficients for parameter risk in CY claims.

The table below provides an overview of the standard predefined variation coefficients for calculating the random risk, depending on the major claims threshold for individual companies and lines of business (CHF 1 or 5 million).

Line of business	$VK(Y_{i,j})$, threshold 1mln CHF	$VK(Y_{i,j})$, threshold 5mln CHF
MVL	7	10
MVC	2.5	2.5
Liability	8	11
Property	5	8

Table 42: Variations coefficient for random risk depending on the major threshold.

We define the threshold equal to 1mln CHF, and we need the loss ratio of the normal claims.

To derive it we must introduce the major claims model.

The major claims are modeled separately for each line of business of type of event i with a compound Poisson distribution:

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$$S_{CY,i}^{MC} = \sum_{j=1}^{N_i^{MC}} Y_{i,j}^{MC}$$

Here, the number of claims N_i^{MC} of line of business i has a Poisson distribution with expected value λ_i^{MC} . It is assumed that the individual gross claims $Y_{i,j}^{MC}$ are distributed

independently of each other and identically within the line of business or type i . A Pareto distribution is used for each type i :

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$$F_{Y_{i,j}^{MC}}(y) = Pr(Y_{i,j}^{MC} \leq y) = \begin{cases} 0 & y < \beta \\ 1 - \left(\frac{y}{\beta}\right)^{-\alpha} & y \geq \beta \end{cases}$$

β is the smallest claim considered in the major claim model, which is why β is often called the major claim "threshold". Another name is "observation point of the Pareto distribution". The standard values of the parameters in the SST are designed so that β is either CHF 1 or 5 million. One of these values must be chosen by each insurer. This choice can be made individually for each line of business.

In this paper β is equal to CHF 1 million.

Pareto distributions have the quality that they assign greater weight to high claims than many other distributions. The strength of the weighting is determined by the Pareto parameters α_i . The smaller the value of α_i , the more weight the higher major claims have. The standard values for the Pareto parameters are:

Line of business	$\beta = 1\text{mln CHF}$
MVL	2.5
MVC-hail	1.85
Liability	1.8
Property	1.4

Table 43: Parameters α_i of the Pareto distribution.

The modeling of cumulated hail claims mainly concerns comprehensive motor vehicle insurance. As in other lines of business, major hail claims are also represented with a Poisson and Pareto distribution.

First, the threshold for the market-wide major hail claims is fixed at $\beta_{Hail}^{(Market;0)} = \text{CHF } 45$ million.

The expected value of the number of claims $> \text{CHF } 45$ million is $\lambda_{Hail}^{(0)} = 0.9$.

The modeling also requires an individual major claims threshold per company, however. This threshold depends on the company's chosen individual major claims threshold β and

the market share of the hail claims m_{hail} (this can be equal to the market share with respect to comprehensive motor vehicle insurance.)

Market Premiums ⁴¹	MVC Insurance Premiums	Market share
3 011.73mln CHF	312.52mln CHF	10%

Table 44: MVC market share.

105

$$\beta_{\text{Hail}}^{(\text{Market};0)} = \frac{\beta}{m_{\text{hail}}} = \frac{1\text{mln CHF}}{10\%} = 10\text{mln CHF}$$

The expected number for the individual threshold is generated by the Pareto distribution as

106

$$\lambda_{\text{Hail}} = \lambda_{\text{Hail}}^{(0)} \left(\frac{\beta_{\text{Hail}}^{(\text{Market})}}{\beta_{\text{Hail}}^{(\text{Market};0)}} \right)^{-\alpha} = 0.9 \left(\frac{10}{45} \right)^{-1.85} = 14.5$$

The Pareto distribution for the event claims amount of the market-wide hail claims can be truncated at CHF 1.5 billion. Accordingly, it has the following form:

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$$F_{Y_{\text{hail},\text{MVC}}^{\text{MC}}} = \begin{cases} 0 & y < 10\text{mln CHF} \\ 1 - \left(\frac{y}{10\text{mln CHF}} \right)^{-1.85} & 10\text{mln CHF} \leq y \leq 1500\text{mln CHF} \\ 1 & y > 1500\text{mln CHF} \end{cases}$$

We are now able to derive the expected loss ratio of major claims simply calculating the expected value of the total amount of major claims for each line of business and dividing it by the premiums.

We know that the claim size is modeled with a Pareto distribution and the expected value of a random variable following a Pareto distribution with $\alpha > 1$ is

⁴¹ Value taken from: ISVAP, "Lettera circolare comparto auto 2009", <http://www.isvap.it/>, 2009.

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$$E(Z_{MC}^{lob}) = \frac{\alpha_{lob} \beta_m^{lob}}{\alpha_{lob} - 1}$$

And for a bounded Pareto distribution:

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$$E(Z_{hail}) = \frac{\beta^\alpha}{1 - \left(\frac{\beta}{H}\right)^\alpha} * \left(\frac{\alpha}{\alpha - 1}\right) * \left(\frac{1}{\beta^{\alpha-1}} - \frac{1}{H^{\alpha-1}}\right), \text{ for } \beta \leq z \leq H^{42}$$

Multiplying $E(Z_{MC}^{lob})$ for the expected number of claims (λ_{MC}^{lob}) we obtain the expected total amount of major claims for each LoB:

110

$$E(S_{MC}^{lob}) = E(Z_{MC}^{lob}) * \lambda_{MC}^{lob}$$

The loss ratio of major claims is easily derived:

111

$$LR_{MC}^{lob} = \frac{E(X_{MC}^{lob})}{Premium_{lob}}$$

And finally having the total loss ratio:

112

$$LR_{NC}^{lob} = LR_{TOT}^{lob} - LR_{MC}^{lob}$$

⁴² We must underline that our company will pay only the 10 percent of every sigle Z_{hail} .

λ_{MC}^{lob} are calculated as a percentage of the total λ_{lob} and are summarized in the following table:

Line of business	% ⁴³	λ_{lob}	λ_{MC}^{lob}
MVL	0.0011	58333.33	64.17
MVC-hail	-	166666.7	14.54
Liability	0.00025	6250	1.56
Property	0.0001	7500	0.75

Table 45: Expected number of total claims, percentage of major claims and expected number of major claims.

The results are:

	MVL	MVC	Liability	Property
β	1mln CHF	10mln CHF	1mln CHF	1mln CHF
α	2.5	1.85	1.8	1.4
H	-	1500mln CHF	-	-
Market Share	-	10%	-	-
$E(Z_{MC})$	1.67mln CHF	21.46mln CHF	2.25mln CHF	3.5mln CHF
λ_{MC}	64.17	14.54	1.56	0.75
$E(S_{MC})$	106.94mln CHF	31.21mln CHF	3.52mln CHF	2.63mln CHF
Premium	413.49 mln CHF	312.52mln CHF	125.01mln CHF	192.32mln CHF
LR_{MC}	25.86%	9.99%	2.81%	1.36%
LR_{TOT}^{44}	87.70%	68.60%	83.80%	77.80%
LR_{NC}	61.84%	58.61%	80.99%	76.44%

Table 46: Normal claims loss ratios, major claims loss ratios, total loss ratios, expected claim amount of major claims, expected claim size of major claims, expected number of major claims, Pareto parameters, threshold between normal and major claims for each line of business and MVC market share and major claims truncation point.

We are now able to calculate the expected value of the normal claims, and the results are:

Line of business	LR_i	P_i	$E(S_{CY,i}^{NC})$
MVL	61.84%	413.49 mln CHF	255.68mln CHF
MVC	58.61%	312.52mln CHF	183.18mln CHF
Liability	80.99%	125.01mln CHF	101.24mln CHF
Property	76.44%	192.32mln CHF	147mln CHF
Total Business		1 0433.34mln CHF	687.1mln CHF

Table 47: Expected normal claims claim amounts for each line of business and for total business.

⁴³ Values taken from: FOPI, "SST Template 2008", <http://www.fopi.ch/>, 2008.

⁴⁴ Values taken from: Ania, "Appendice statistica 2009", <http://www.ania.it/>, 2009.

Introducing the SST correlation matrix:

	MVL	MVC	Liability	Property
MVL	1	0.5	0.5	0.25
MVC	0.5	1	0.25	0.25
Liability	0.5	0.25	1	0.25
Property	0.25	0.25	0.25	1

Table 48: SST correlation matrix.

The values of $\sqrt{\text{Var}(S_{CY,TOT}^{NC})}$ and $\sqrt{\text{Var}(S_{CY,i}^{NC})}$ are derived:

Line of Business	$\sqrt{\text{Var}(S_{CY}^{NC})}$
MVL	11.67mln CHF
MVC	6.52mln CHF
Liability	10.92mln CHF
Property	11.36mln CHF
Total Business	28.83mln CHF

Table 49: Standard deviation of the normal claim amount for each line of business and for total business.

We must calculate the capital requirement for normal claims supposing they are distributed with a Lognormal.

The results are summarized below:

Line of Business	LogNormal parameters		P_i	VaR(99%)/P	$RBC_{NC}^{Premium}/P_i$
	μ	σ			
MVL	19.36	0.05	413.49 mln CHF	6.85%	7.93%
MVC	19.03	0.04	312.52mln CHF	5.02%	5.80%
Liability	18.43	0.11	125.01mln CHF	22.42%	26.31%
Property	18.80	0.07	192.32mln CHF	14.75%	17.19%
Total Business	20.35	0.04	1 0433.34mln CHF	6.69%	7.73%

Table 50: Parameters of the Log Normal distribution of normal claims, premiums and capital requirement divided by premiums for each line of business and for whole portfolio.

And graphically:

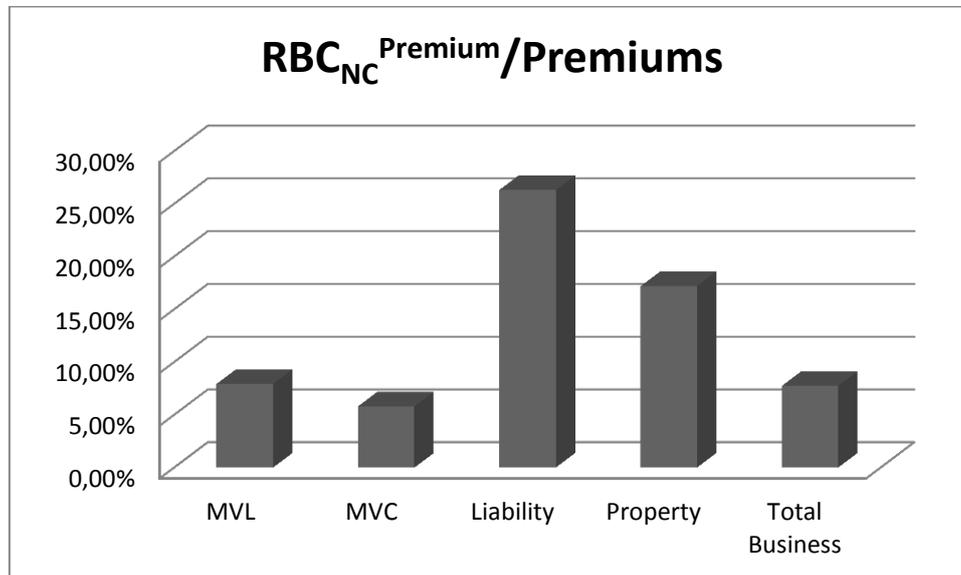


Figure 22: Comparison between normal claims capital requirements for each line of business and for the whole portfolio.

The capital requirements for normal claims go from 5.80% of the written premium for MVC to 26.31% for Liability. This large difference is due to two aspects: first of all the coefficient of variation of the claim size, that is equal to 8 (the highest for the LoBs examined), and to weight of normal claims, in fact if we look at the Loss Ratios in LoB “Liability” we see that 96.64% of total claims amount (normal claims + major claims) is caused by normal claims.

Even in LoB “Property” this weight is very high (98.25%) but the coefficient of variation of normal claims is lower than in “Liability” and this implies a minor capital requirement than “Liability”. The weights of normal claims are reported below:

Line of Business	LR _{TOT}	LR _{NC}	LR _{NC} /LR _{TOT}
MVL	87.70%	61.84%	70.51%
MVC	68.60%	58.61%	85.44%
Liability	83.80%	80.99%	96.64%
Property	77.80%	76.44%	98.25%

Table 51: Total loss ratio, normal claims loss ratio and percentage of the total loss ratio due to normal claims.

As said before the gross claims amount distribution by line of business/type of event i for major claims is:

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$$Y_{i,j}^{MC} \sim \text{Pareto}(\alpha_i, \beta_i)$$

The sum of the annual claims expenses across lines of business/types of event

114

$$S_{CY}^{MC} = \sum_{i=1}^4 \sum_{j=1}^{N_i^{MC}} Y_{i,j}^{MC}$$

again has a compound Poisson distribution and can be written as

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$$S_{CY}^{MC} = \sum_{k=1}^{N^{MC}} Y_k$$

Where

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$$N^{MC} \sim \text{Poisson} \left(\sum_i \lambda_i^{MC} \right)$$

applies to the distribution of numbers of claims, while the distribution of the individual claims Y_k is constructed as follows as a weighted average of the distribution function of the individual claims of the individual lines of business/types of business:

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$$F_Y(y) = \frac{1}{\sum_i \lambda_i^{MC}} \sum_i \left(\lambda_i^{MC} F_{Y_{CY,i}^{MC}}(y) \right)$$

This total major claims distribution S_{CY}^{MC} can now be calculated with the fast Fourier transformation or preferably with the Panjer algorithm.

We have that:

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$$N^{MC} \sim \text{Poisson}(81,02), \sum_i \lambda_i^{MC} = 64.17 + 14.54 + 1.56 + 0.75 = 81.02$$

While

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$$F_{Y_{CY,MVL}^{MC}}(y) = \begin{cases} 0 & y < 1 \text{mln CHF} \\ 1 - \left(\frac{y}{1 \text{mln CHF}}\right)^{-2,5} & y \geq 1 \text{mln CHF} \end{cases}$$

$$F_{Y_{CY,Liability}^{MC}}(y) = \begin{cases} 0 & y < 1 \text{mln CHF} \\ 1 - \left(\frac{y}{1 \text{mln CHF}}\right)^{-1,8} & y \geq 1 \text{mln CHF} \end{cases}$$

$$F_{Y_{\text{hair,MVC}}^{MC}} = \begin{cases} 0 & y < 10 \text{mln CHF} \\ 1 - \left(\frac{y}{10 \text{mln CHF}}\right)^{-1,85} & 10 \text{mln CHF} \leq y \leq 1500 \text{mln CHF} \\ 1 & y > 1500 \text{mln CHF} \end{cases}$$

$$F_{Y_{CY,Property}^{MC}}(y) = \begin{cases} 0 & y < 1 \text{mln CHF} \\ 1 - \left(\frac{y}{1 \text{mln CHF}}\right)^{-1,4} & y \geq 1 \text{mln CHF} \end{cases}$$

And the total major claims distribution S is:

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if $y < 1 \text{mln CHF}$

$$F_Y(y) = 0$$

if $1 \text{mln CHF} \leq y \leq 1500 \text{mln CHF}$

$$\frac{1}{81.02} \left(-64.17 * \left(1 - \left(\frac{y}{1 \text{mln CHF}} \right)^{-2.5} \right) - 1.56 * \left(1 - \left(\frac{y}{1 \text{mln CHF}} \right)^{-1.8} \right) - 0.75 * \left(1 - \left(\frac{y}{1 \text{mln CHF}} \right)^{-1.4} \right) - 14.54 * \left(1 - \left(\frac{y^{45}}{10 \text{mln CHF}} \right)^{-1.85} \right) \right)$$

if $y > 1500 \text{mln CHF}$

$$\frac{1}{81.02} \left(-64.17 * \left(1 - \left(\frac{y}{1 \text{mln CHF}} \right)^{-2.5} \right) - 1.56 * \left(1 - \left(\frac{y}{1 \text{mln CHF}} \right)^{-1.8} \right) - 0.75 * \left(1 - \left(\frac{y}{1 \text{mln CHF}} \right)^{-1.4} \right) - 14.54 \right)$$

Now the Panjer algorithm is:

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$$f_j = P(S_{CY}^{MC} = jc) = \begin{cases} f_0 \\ \frac{1}{1 - af_0} \sum_{i=1}^j \left(a + \frac{bi}{j} \right) s_i f_{n-i} \end{cases}$$

Where

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$$s_i = P(Y = ic)$$

Being compound mixed Poisson distributions follows that:

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$$a = 0, b = 81.02 \text{ and } f_0 = P(\text{Poisson}(81.02) = 0) = 6.487e - 36$$

Setting c equal to 10 000 CHF.

The last step before reaching the RBC is the convolution between the distribution of normal claims and major claims.

The convolution formula is:

⁴⁵ Our company will pay only the 10 percent of y (referred only to MVC).

$$(f * g)(Y) = \sum_{m=0}^{\infty} f(m) * g(Y - m)$$

The results are summarized below:

Line of Business	P_i	λ_i^{NC}	λ_i^{MC}	$RBC_{CY,i}^{NC}$	$RBC_{CY,i}^{MC}$	$RBC_{CY,i}^{NC+MC}$
MVL	413.49 mln CHF	58 269.16	64.17	7.93%	16.15%	17.58%
MVC	312.52mln CHF	166 652.13	14.54	5.80%	22.82%	24.77%
Liability	125.01mln CHF	6 248.44	1.56	26.31%	29.56%	38.11%
Property	192.32mln CHF	7 499.25	0.75	17.19%	34.02%	37.48%
Total Business	1 0433.34mln CHF	238 668.98	81.02	7.73%	12.00%	13.72%

Table 52: Premiums, expected number of normal claims, expected number of major claims, capital requirements for normal claims, capital requirements for major claims and capital requirements for normal and major claims.

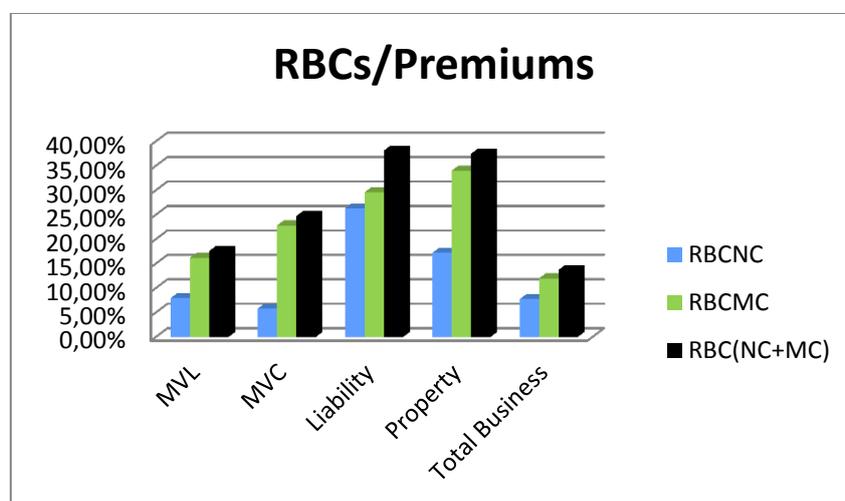


Figure 23: Comparisons between normal claims RBC, major claims RBC and normal plus major claims RBC.

The capital requirements with regard only to major claims go from 16.15% in MVL to 34.02% in Property. As we expected Property is the highest and MVL is the lowest in relative term. This is due to the parameter alpha of the Pareto distribution of major claims, in fact smaller the value of alpha, more weight the higher major claims have.

With regard to major and normal claims the capital requirements go from 17.58% in MVL to 38.11% in Liability.

These results contain an important parameter risk: the estimation of the step c .

Below are summarized the results of the capital required calculations (for Total Business only) under different values of c .

C	$RBC_{CY,i}^{NC+MC}$
5 000 CHF	13.718%
10 000 CHF	13.721%
100 000 CHF	13.755%

Table 53: RBC for CY claims under different values of c (Panjer algorithm step).

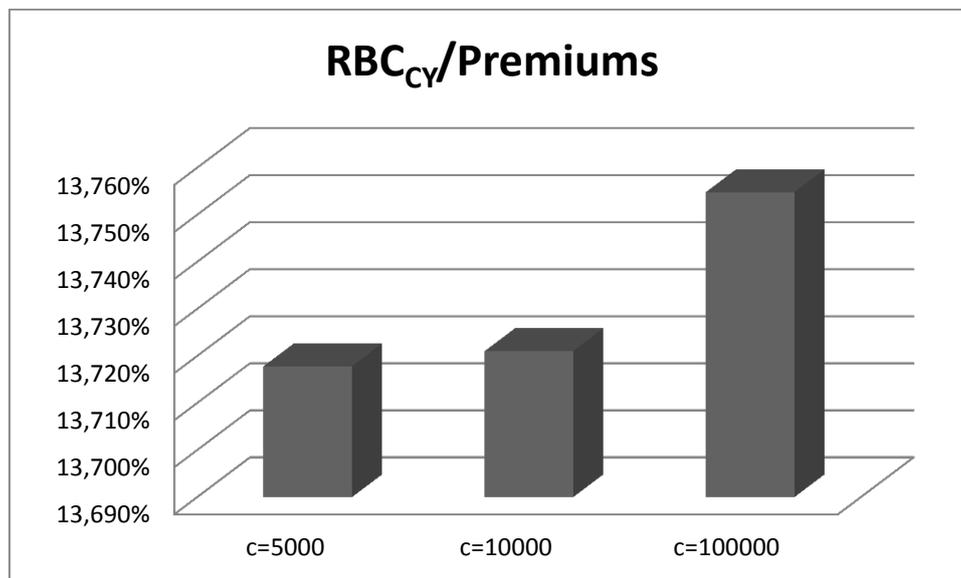


Figure 24: Comparisons between RBC CY claims depending on step c

We can say that decreasing step c the capital required decreases approaching to the real value. The differences between RBCs under three values of c are very small because we are on the distribution tail of major claims characterized by large values. It would be significantly different if we had to model the normal claims, characterized by small values, increasing c , the approximation would be much worse.

8.1.1 MARKET VALUE MARGIN

An important aspect of the SST is the presence of the risk margin (MVM).

As explain in Chapter 6 the MvM is defined as the cost of future regulatory capital for the whole run-off of a portfolio. Note that by run-off we mean that no new business is taken into account. The insurer is still considered to be a going-concern. The Market Value Margin is calculated on a legal entity level. For the purpose of the SST, it is sufficient to determine the “Cost of Capital” on a portfolio level, i.e. not on a line of business level.

For this reason we have to determine the payout-pattern of the whole portfolio.

Line of Business ⁴⁶	t=0	t=1	t=2	t=3	t=4	t=5	t=6	t=7	t=8	t=9
MVL	31.20%	34.20%	12.30%	6.20%	6.90%	9.20%				
MVC	66.30%	29.70%	2.00%	0.50%	0.30%	0.20%	1.00%			
Liability	11.90%	18.60%	11.30%	8.00%	7.40%	6.60%	10.00%	10.00%	10.00%	6.20%
Property	35.60%	44.10%	12.20%	2.40%	1.40%	1.10%	3.20%			
Total Business	38.61%	32.86%	9.50%	4.27%	4.27%	5.09%	2.09%	1.26%	1.26%	0.78%

Table 54: Payout-pattern.

In order to determine RBC of future years in the generic calculation, a full SST for the whole the run-off has to be performed for each of those years. It needs to be acknowledged that the further away the time horizon is, the more uncertain any such calculation becomes (the situation is often figuratively described as the “funnel of uncertainty”). For many companies, it is probably sufficient to approximate full SSTs for future year of the run-off, hence a number of simplifications can be tried.

The main idea of the simplifications is to make the future required regulatory capital $RBC(t)$ at time t dependent on an underlying proxy $p(t)$, which is simpler to determine than $RBC(t)$.

For instance, the underlying proxy could be the best estimate of the run-off portfolio of liabilities at time t , the sum insured at time t , or the number of expected claims at time t .

Here we suppose that $RBC_{reserve}$ is proportional to the Reserve Amount.

Remembering from Chapter 7:

⁴⁶ Values taken from: ISVAP, “Lettera circolare comparto auto 2009”, <http://www.isvap.it/>, 2009, & ISVAP, “Lettera circolare rami elementari 2004-2009”, <http://www.isvap.it/>, 2009.

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$$Var_Z \left(C_{PY,i} R_{PY,i}^{(0)} \right) = \left(R_{PY,i}^{(0)} Vko_Z(C_{PY,i}) \right)^2$$

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$$Var_P \left(C_{PY,i} R_{PY,i}^{(0)} \right) = \left(R_{PY,i}^{(0)} Vko_P(C_{PY,i}) \right)^2$$

127

$$Var \left(C_{PY,i} R_{PY,i}^{(0)} \right) = Var_Z \left(C_{PY,i} R_{PY,i}^{(0)} \right) + Var_P \left(C_{PY,i} R_{PY,i}^{(0)} \right)$$

Line of business	Vko _p	Vko _z ⁴⁷
MVL	3.50%	2.50%
MVC	3.50%	20.00%
Property	3.00%	15.00%
Liability	3.50%	4.00%

Table 55: Variation coefficients for the PY parameter and random risks.

Supposing that, during year 0, the total claims amount for each line of business is exactly its mean, using the payout-pattern of table 54 and assuming that

128

$$RBCreserve(t) = \frac{RBCreserve(1)}{BE(1)} * BE(t)$$

According to table 54, the Reserve Amount over the years should be:

⁴⁷ Values taken from: A. Gisler, "The Insurance Risk in the SST and in Solvency II: Modeling and Parameter Estimators", ASTIN Colloquium1-4 June 2009, Helsinki.

	RBC_{PY}	Best Estimate	$RBC_{PY}/\text{Best Estimate}$
t=1	64.25mln CHF	510.39mln CHF	12.59%
t=2		237.22mln CHF	
t=3		158.24mln CHF	
t=4		122.72mln CHF	
t=5		87.2mln CHF	
t=6		44.85mln CHF	
t=7		27.45mln CHF	
t=8		16.97mln CHF	
t=9		6.49mln CHF	

Table 56: RBC PY, Best Estimate of liabilities in t=1,....,9, and RBC PY/Best Estimate.

From which follows that the future RBC_{PY} should be equal to

Year	RBC_{PY}
t=1	64.25mln CHF
t=2	29.86mln CHF
t=3	19.92mln CHF
t=4	15.45mln CHF
t=5	10.98mln CHF
t=6	5.65mln CHF
t=7	3.46mln CHF
t=8	2.14mln CHF
t=9	817 609 CHF

Table 57: RBC PY for t=1,2,....,9.

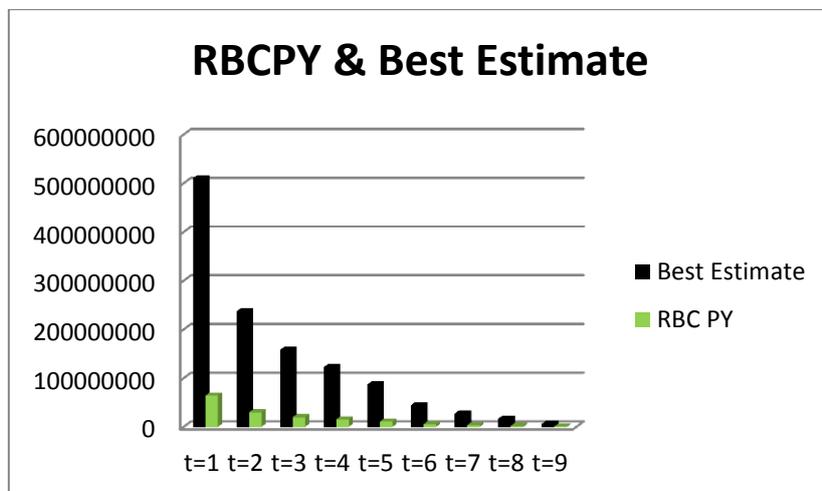


Figure 25: Comparison between Best Estimate and RBC PY for t=1,2,....,9.

We are now able to determine the MVM using the Cost of Capital approach, setting the discount factor equal to 3% and the cost of capital equal to 6%.

	t=1	t=2	t=3	t=4	t=5	t=6	t=7	t=8	t=9
Best Estimate of Liabilities	510.39mln CHF	237.22mln CHF	158.24mln CHF	122.72mln CHF	87.2mln CHF	44.85mln CHF	27.45mln CHF	16.97mln CHF	6.49mln CHF
RBCreserve	64.25mln CHF	29.86mln CHF	19.92mln CHF	15.45mln CHF	10.98mln CHF	5.65mln CHF	3.46mln CHF	2.14mln CHF	817 609 CHF
Discounting	0	1.03	1	0.970873786	0.942595909	0.915141659	0.888487048	0.862608784	0.837484257
Discounted RBC _{py}		30.76mln CHF	19.92mln CHF	15mln CHF	10.35mln CHF	5.17mln CHF	3.07mln CHF	1.84mln CHF	684 734 CHF
Present Value	86.79mln CHF								
Cost of Capital	5.21mln CHF								

Table 58: Summary of the MVM calculation

So at the beginning of year 1 the Target Capital⁴⁸ for our company is due to:

- Reserve risk;
- Risk margin (MVM); and
- Premium risk.

Till now we have calculated the capital requirement for reserve risk stands alone and the connected MVM.

To derive the capital requirement for premium risk we make two important assumptions:

- the insurance portfolio increases by 5% (g=real growth rate); and

⁴⁸ Defined as: $TC = -ES_{\alpha} \left(\frac{RBC(t_1)}{1+r_1^{(0)}} - RBC(t_0) \right) + \frac{MVM}{1+r_1^{(0)}}$, here we don't consider $r_1^{(0)}$.

- the claim inflation is 3% (i).

Under these assumptions our new parameters are:

Line of business	P_i	λ_i^{TOT}	λ_i^{MC}
MVL	434.16mln CHF	61 250.00	67.37
MVC	328.15mln CHF	175 000.00	14.54
Liability	131.26mln CHF	6 562.50	1.64
Property	201.94mln CHF	7 875.00	0.79

Table 59: Premiums, expected number of claims, and expected number of major claims in t=1.

While others don't change.

We must remember that the gross premium volume increases yearly by the claim inflation (i) and real growth (g):

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$$B_t = B_{t-1}(1 + g)(1 + i)$$

And:

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$$\lambda_t = \lambda_{t-1}(1 + g)$$

The SST standard model suggests the following aggregation method to derive the RBC for premium and reserve risk:

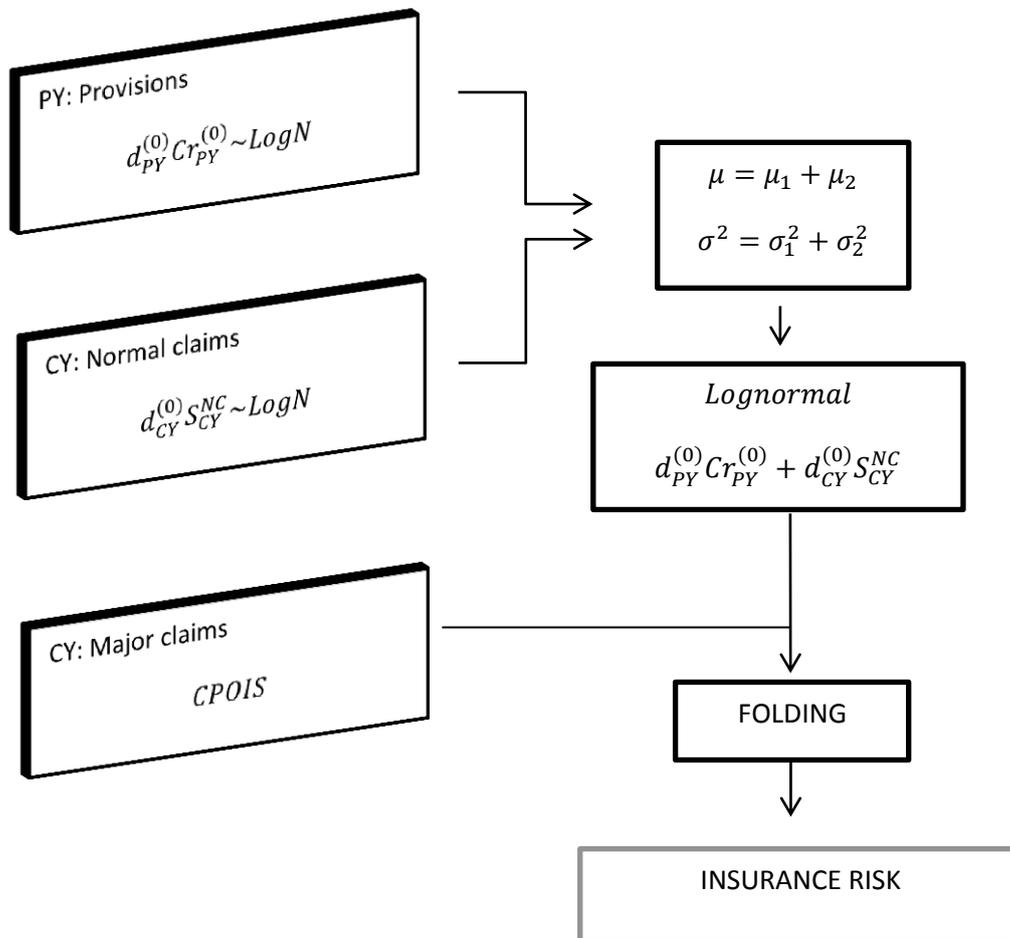


Figure 26: Aggregation structure adopted for CY major claims, CY normal claims and PY claims.

The results are summarized below:

Premium	1 128.37mln CHF
RBC _{PY}	6.00%
RBC _{CY(NC)}	7.67%
RBC _{CY(NC)&PY}	9.60%
RBC _{CY(NC & MC)}	13.12%
RBC _{CY & PY}	14.24%
MVM	0.46%
Target Capital	14.70%

Table 60: Different RBCs divided by premiums.

The Target Capital is simply the MVM plus the $RBC_{CY \& PY}$

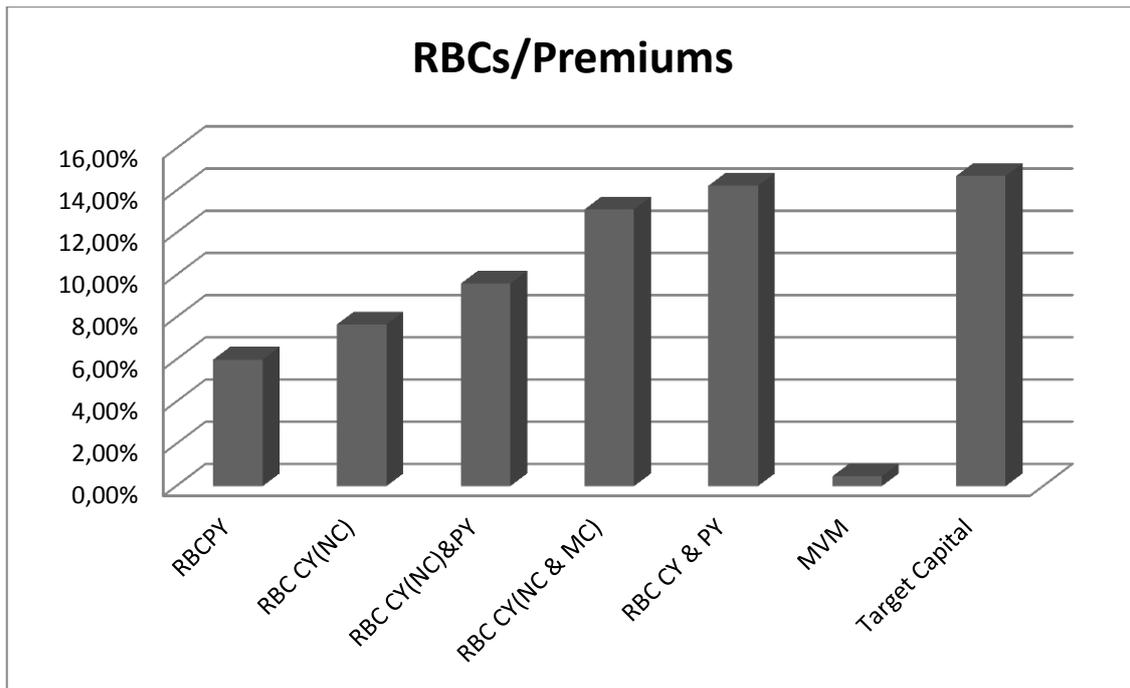


Figure 27: Comparison between different RBCs.

8.1.2 STANDARD MODEL FOR DIFFERENT INSURANCE COMPANIES

In this part of the analysis we try to understand how the capital requirements change varying the size of the company.

For this reason we introduce three companies which differ from company "OMEGA" only with regard to the expected number of claims and the premiums income.

- Company "ALFA" is an half of "OMEGA";
- Company "BETA" is a quarter of "OMEGA"; and
- Company "GAMMA" is one-eighth of "OMEGA".

The characteristics of the companies are summarized below:

COMPAGNIA ALFA		
Line of business	λ	Premi
MVL	29 166.665	206.74mln CHF
MVC	83 333.335	156.26mln CHF
Liability	3 125	62.5mln CHF
Property	3 750	96.16mln CHF

Table 61: Company ALFA characteristics.

COMPANIA BETA		
Line of business	λ	Premi
MVL	14 583.3325	103.37mln CHF
MVC	41 666.6675	78.13mln CHF
Liability	1 562.5	31.25mln CHF
Property	1 875	48.08mln CHF

Table 62: Company BETA characteristics.

COMPAGNIA GAMMA		
Line of business	λ	Premi
MVL	7 291.66625	51.69mln CHF
MVC	20 833.33375	39.07mln CHF
Liability	781.25	15.63mln CHF
Property	937.5	24.04mln CHF

Table 63: Company GAMMA characteristics.

As done before we define the threshold between normal and major claims equal to 1mln CHF, the parameters for all companies are:

Line of business	VK($Y_{i,j}$), threshold 1mln CHF
MVL	7
MVC	2.5
Liability	8
Property	5

Table 64: Variation coefficients of random risk.

Line of business	VK _{p,i}
MVL	3.50%
MVC	3.50%
Liability	3.50%
Property	5.00%

Table 65: Variation coefficients of parameter risk.

And following the procedure described in section 8.1 with regard only to normal claims we reach the following results:

COMPANY ALFA		
Line of business	P _i	$RBC_{pr}^{NC}/\text{Premiums}$
MVL	413.49 mIn CHF	9.51%
MVC	312.52mIn CHF	6.35%
Liability	125.01mIn CHF	37.87%
Property	192.32mIn CHF	22.11%
Total Business	1 0433.34mIn CHF	9.74%

Table 66: Company ALFA CY normal claims capital requirements.

COMPANY BETA		
Line of business	P _i	$RBC_{pr}^{NC}/\text{Premiums}$
MVL	103.37mIn CHF	12.16%
MVC	78.13mIn CHF	6.83%
Liability	31.25mIn CHF	56.19%
Property	48.08mIn CHF	30.13%
Total Business	260.83mIn CHF	12.83%

Table 67: Company BETA CY normal claims capital requirements.

COMPANY GAMMA		
Line of business	P_i	$RBC_{pr}^{NC}/\text{Premiums}$
MVL	51.69mln CHF	16.43%
MVC	39.07mln CHF	7.41%
Liability	15.63mln CHF	85.80%
Property	24.04mln CHF	43.03%
Total Business	130.42mln CHF	17.59%

Table 68: Company GAMMA CY normal claims capital requirements.

Graphically:

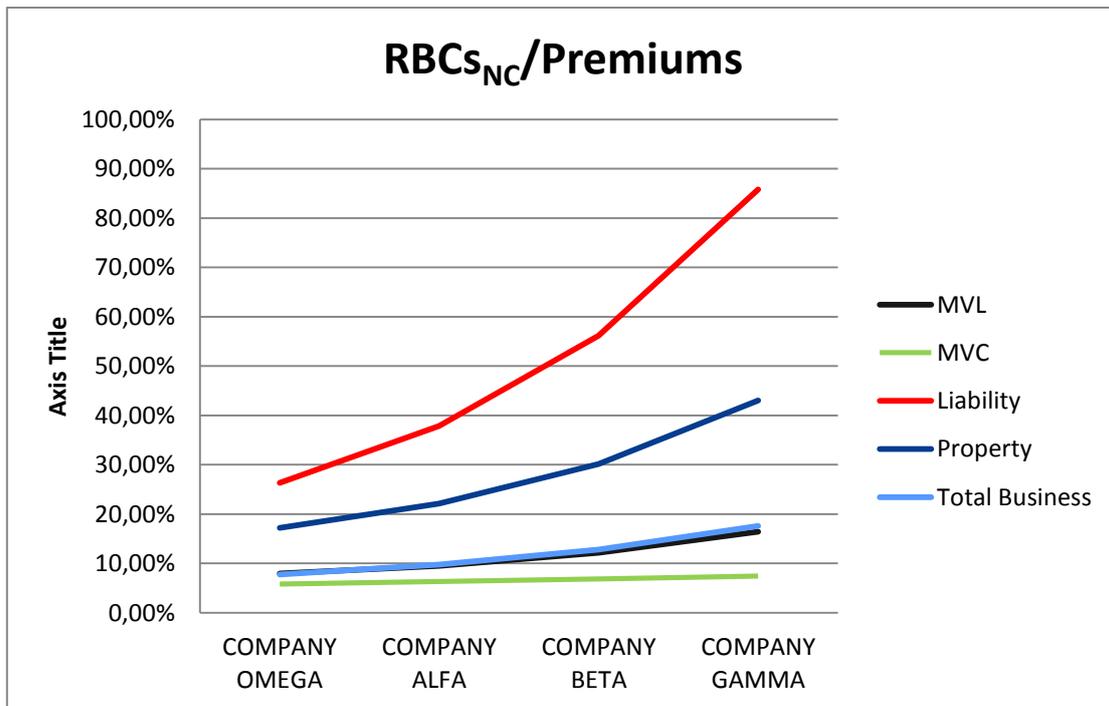


Figure 28: Capital requirements depending on company size.

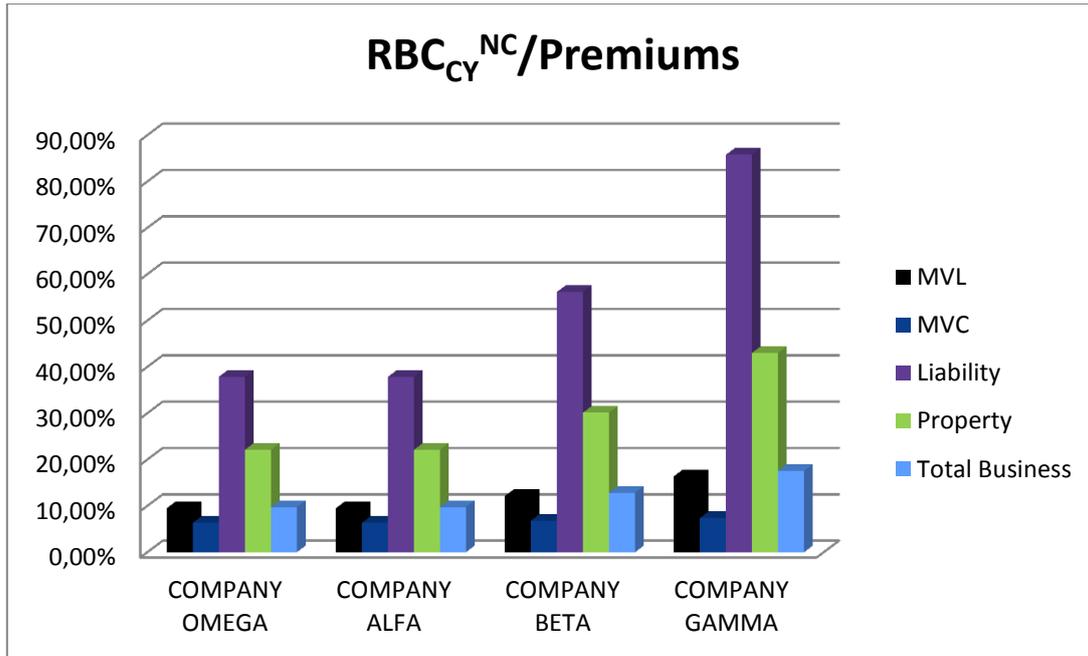


Figure 29: Capital requirements depending on company size.

As it's clear from the graph, there's an advantage in relative terms, for the biggest companies. This means that if you are a big company the capital requirement is less than the one for a smaller company. This is due to the diversification effect.

In particular, passing from company "OMEGA" (the biggest) to company "GAMMA" (the smallest), the difference is:

Line of business	Percentage Benefit
MVL	8.50%
MVC	1.62%
Liability	59.49%
Property	25.84%
Total Business	9.86%

Table 69: Percentage benefit passing from company OMEGA to company GAMMA.

With regard to the total capital requirement for CY claims (normal and major claims), the results are:

	P_i	$RBC_{pr}^{NC+MC}/\text{Premium}$
COMPANY OMEGA	1 0433.34mIn CHF	13.72%
COMPANY ALFA	521.69mIn CHF	17.38%
COMPANY BETA	260.83mIn CHF	23.06%
COMPANY GAMMA	130.42mIn CHF	31.63%

Table 70: RBC CY depending on company size.

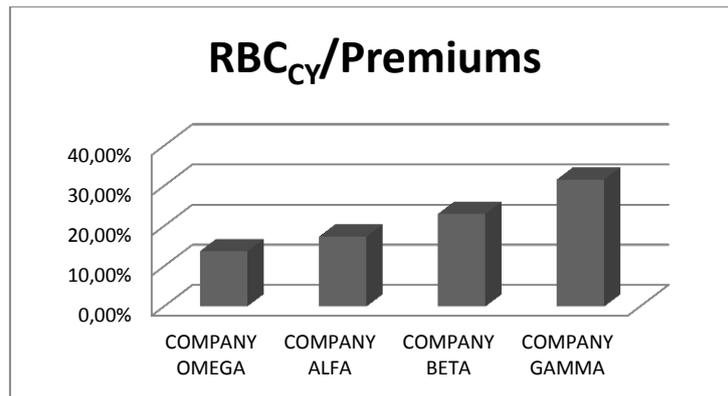


Figure 30: RBC CY depending on company size.

So the smallest company “GAMMA” has 31.63% of its premiums locked in capital requirement, while the largest “OMEGA” only 13.72%.

This implies two important aspects: first of all the SST standard model for non-life insurers includes a “size factor”, that is companies with different size have different capital requirements compared to premiums, secondly being a big company means a benefit in terms of capital required.

8.2 INTERNAL MODEL

We are now interested in developing an internal model using a simulation method.

The simulation consists in finding one possible probability distribution of the aggregate claim amount for each LoB analyzed. After that we will be able to calculate the capital requirement.

The Risk Theory provides two approaches to generate the aggregate claim size distribution.

The first approach is called “individual”, and suggests that the aggregate claim amount X , in one year, concerning an insurance portfolio or a single line of business, composed of a finite number of risks N , is given by the random variable:

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$$X_{ind} = \sum_{i=1}^n Z_i$$

where Z_i is the claim size of the i -th risk subsequently the occurrence of none, one or more claims during the year.

Defining Z_i -cumulative distribution function as:

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$$F_{Z_i} = Pr\{Z_i \leq Z\}$$

if the N portfolio risk are all mutually independent, then X_{ind} -cumulative distribution function will be given by the convolution of the N Z_i -cumulative distribution function, that is

133

$$F_{X_{ind}}(X) = Pr\{X_{ind} \leq X\} = Pr\{Z_1 + Z_2 + \dots + Z_N \leq X\} = \prod_{i=1}^N F_{Z_i}(X)$$

The independence hypothesis of the N random variables Z_i is often necessary to gain simpler mathematic formulations.

This approach is very useful in life insurance, where there’s only one claim (death), and the “quantum” for every claims is defined a priori. These two life insurance aspects are absent in non-life insurance: each person could have more than just one claim and, in addition, the amount of each claim is not known.

For all these reasons is more suitable, for the examinations of this chapter, the employment of the second approach: “the collective approach”.

Following this approach the aggregate claim amount is analyzed considering the entire portfolio, which must be composed of risks with a high homogeneity level.

The aggregate claim amount is given by a compound process:

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$$\tilde{X}_{coll} = \sum_{i=1}^{\tilde{N}} \tilde{Z}_i^{49}$$

Where \tilde{N} is the random variable of the number of claims occurred, and \tilde{Z}_i is the random claim size of the i -th claim occurred. \tilde{N} and \tilde{Z} are two random variables that must be independent each other and, in addition, the \tilde{Z}_i must be independent and identically distributed (iid).

Another important element is the disturb factor which plays a key role in the distribution of the number of claims. Is not always possible to use a simple Poisson distribution for modeling the number of claims. This is due to external factors, like climatic, epidemic, political and seasonal conditions, that can cause deviations of the number of claims from the expected value, which are not included in the pure random fluctuations of the variable. In general we can affirm that such factors act on the λ parameter of the simple Poisson causing its alteration.

There are different kinds of fluctuations:

- trends: when a slow moving change of the claim probabilities is occurring. They can produce an either increase or decrease of the expected value since a systematic change in the line environment conditions;
- short-period fluctuations: when fluctuations are affecting only in the short-term (usually less than a year) the assumed probability distribution, without any time-dependency; and
- long-period cycles: when changes are not mutually independent and they produce their effect on a long term and a cycle period of several years may be assumed. They are usually correlated to general economic conditions.

⁴⁹ In this case: $\tilde{X}_{coll} = \sum_{i=1}^{\tilde{N}_{NC}} \tilde{Z}_{i,NC} + \sum_{s=1}^{\tilde{N}_{MC}} \tilde{Z}_{s,MC}$, with \tilde{Z}_{NC} and \tilde{Z}_{MC} independent.

In the case under examination trends as well as long-term cycles are disregarded and only short-term fluctuations are taken into account. For this purpose a structure variable is introduced to represent short-term fluctuations in the number of claims. In practice the parameter of the simple Poisson distribution for the number of claims is turned to be a stochastic parameter $\lambda\tilde{q}$, where \tilde{q} is a random structure variable having its own probability distribution depending on the short-term fluctuations it is going to represent. If no trends are assumed, the only restriction for the probability distribution of \tilde{q} is that its expected value has to be equal to 1.

The presence of this second source of randomness will clearly increase the standard deviation in the number of claims \tilde{N} and very often the skewness will be greater, thus increasing the chance of excessive claim numbers.

In the following a Gamma distribution will be assumed as the probability distribution of the structure variable \tilde{q} . Then a negative binomial distribution is obtained for the random number of claims. Under these assumptions \tilde{X} is denoted to be a compound Polya Process, as a special case of the more general compound Mixed Poisson Process. In this particular case, the moments of the structure variable \tilde{q} are given by:

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$$E(\tilde{q}) = 1, \quad \sigma(\tilde{q}) = 1/\sqrt{h}, \quad \varphi(\tilde{q}) = 2/\sqrt{h}$$

Where h is the reciprocal value of the observed variance q.

The simulation can be summarized as follow:

- extraction of a random number q_i from a Gamma distribution with expected value 1 and coefficient of variation equal to $VK_{p,i}$
- extraction of a random number N_i from a Poisson distribution with expected value equal to $q_i * \text{Expected number of claims}$;
- extraction from a Log-Normal distribution for $n=1, 2, 3, \dots, N_i$ the single claim amount for normal claim $Z_{i,n}$. The parameters of the Log-Normal distribution are calculated with the "method of moments" as follow:

$$\sigma = \sqrt{\ln(\text{Coefficient of variation}^2 + 1)};$$

$$\mu = \ln(\text{Expected claim size}) - \frac{\sigma^2}{2};$$

- extraction from a Pareto distribution for $n_1=1,2,\dots,n$ the single claim amount for major claim; and
- doing the simple sum of the single claim amount we find one possible determination of the aggregate claim amount.

Before starting the simulation we need the moment of Z_{NC} which are derived from the SST standard model using the Theory of Risk formulas:

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$$E(S_{CY}^{NC}) = \lambda_{NC} * M_{NC},$$

$$\frac{\sigma(S_{CY}^{NC})}{E(S_{CY}^{NC})} = VK(Y_{i,j})$$

The following results are derived for normal claims:

Line of business	λ_i^{NC}	M_{NC}	$VK(Y_{i,j})$	$VK_{p,i}$
MVL	58269,16	4 388 CHF	7	3,50%
MVC	166652,13	1 099,17 CHF	2,5	3,50%
Liability	6248,44	16 202,62 CHF	8	3,50%
Property	7499,25	19 601,95 CHF	5	5%

Table 71: Internal model normal claims parameters.

While the parameters for major claims are:

Line of business	λ_i^{MC}	$VK_{p,i}$	α	β threshold
MVL	64.17	3.50%	2.5	1mln CHF
MVC	14.54	3.50%	1.85	9.5mln CHF
Liability	1.56	3.50%	1.8	1mln CHF
Property	0.75	5.00%	1.4	1mln CHF

Table 72: Internal model major claims parameters.

In addition, to simulate the major claims in LoB MVC it has been used a quite different approach being the Pareto distribution bounded:

1. extraction from a Uniform distribution of a value U which is supposed to be the value of the cumulative distribution function of our bounded Pareto;
2. calculation of the inverse of the bounded Pareto cumulative distribution function;
3. calculation of the claim size of our company multiplying the value found in step 2 by the market share.

The procedure has been repeated 400.000 times to obtain a large number of representative values of the aggregate claim amount.

The results of the simulations are:

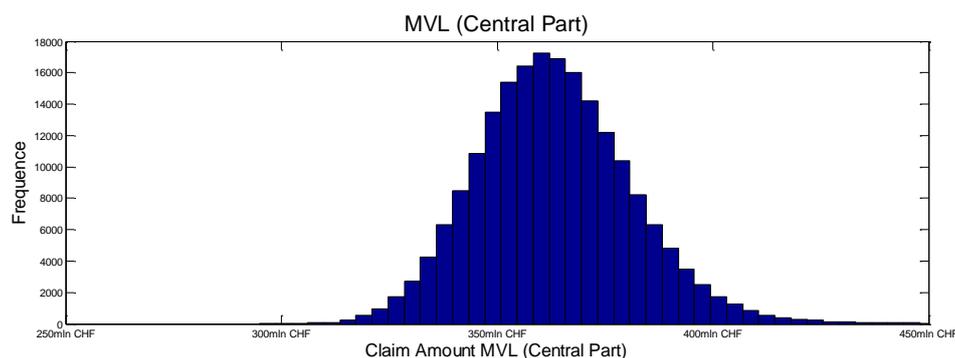


Figure 31: Distribution of the MVL claim Amount (central part).

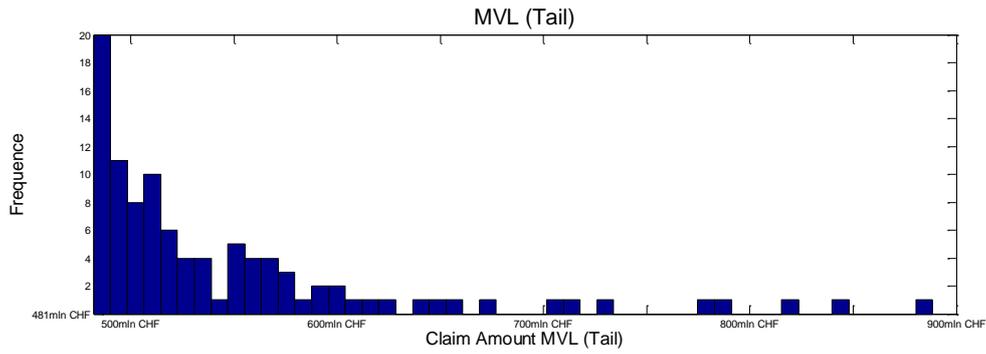


Figure 32: Distribution of the MVL claim Amount (tail).

MVL	
Mean	363.42mIn CHF
Standard Deviation	18.71mIn CHF
Coefficient of Variation	5.15%
Skewness	1.3
RBC/Premium	16.61%

Table 73: MVL simulations results.

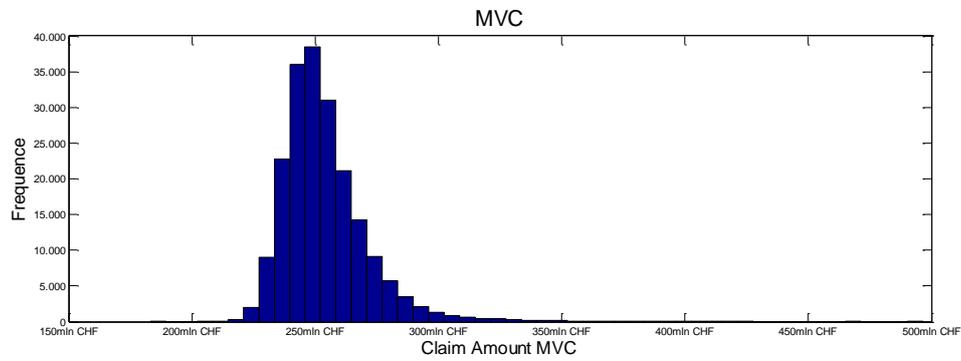


Figure 33: Distribution of the MVC claim amount.

MVC	
Mean	253.84mIn CHF
Standard Deviation	17.4mIn CHF
Coefficient of Variation	6.85%
Skewness	1.96
RBC/Premium	27.61%

Table 74: MVC simulations results.

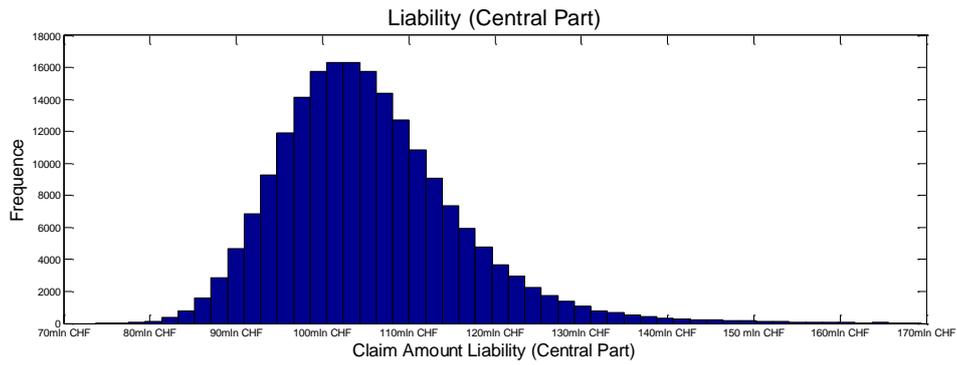


Figure 34: Distribution of the liability claim amount (central part).

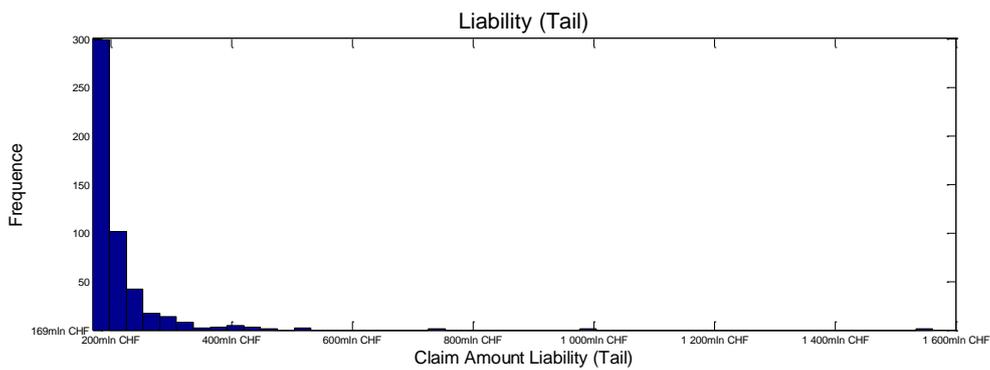


Figure 35: Distribution of the liability claim amount (tail).

Liability	
Mean	105.71mIn CHF
Standard Deviation	12.73mIn CHF
Coefficient of Variation	12.04%
Skewness	13.06
RBC/Premium	48.8%

Table 75: Liability simulations results.

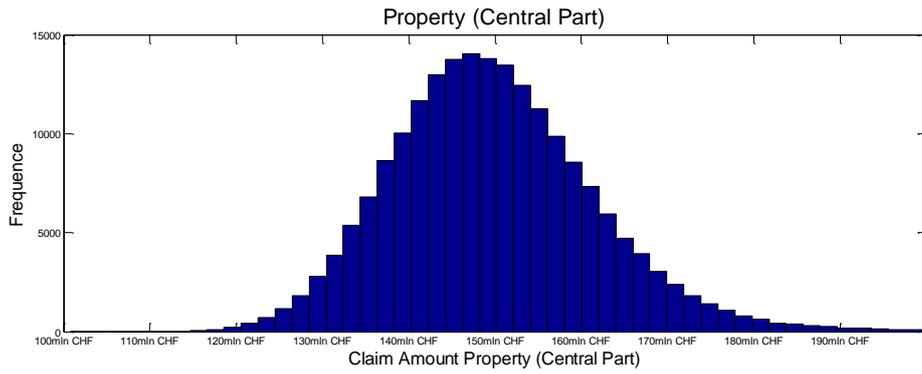


Figure 36: Distribution of the property claim amount (central part).

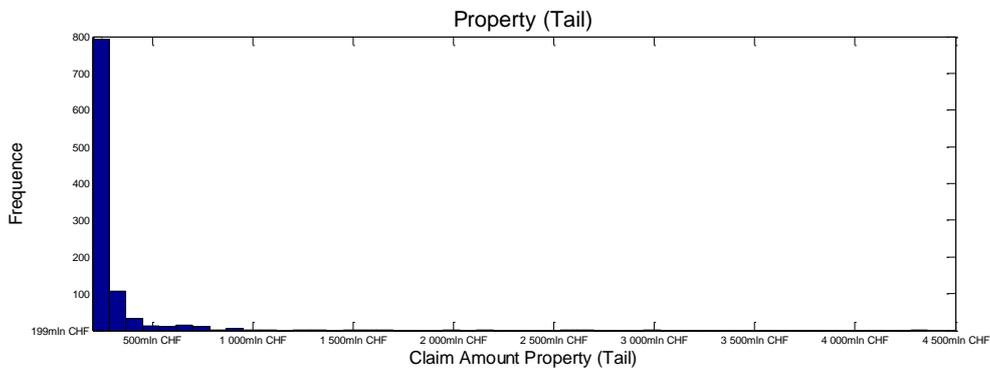


Figure 37: Distribution of the property claim amount (tail).

	Property
Mean	150.36mIn CHF
Standard Deviation	23.38mIn CHF
Coefficient of Variation	15.55%
Skewness	65439
RBC/Premium	46.35%

Table 76: Property simulations results.

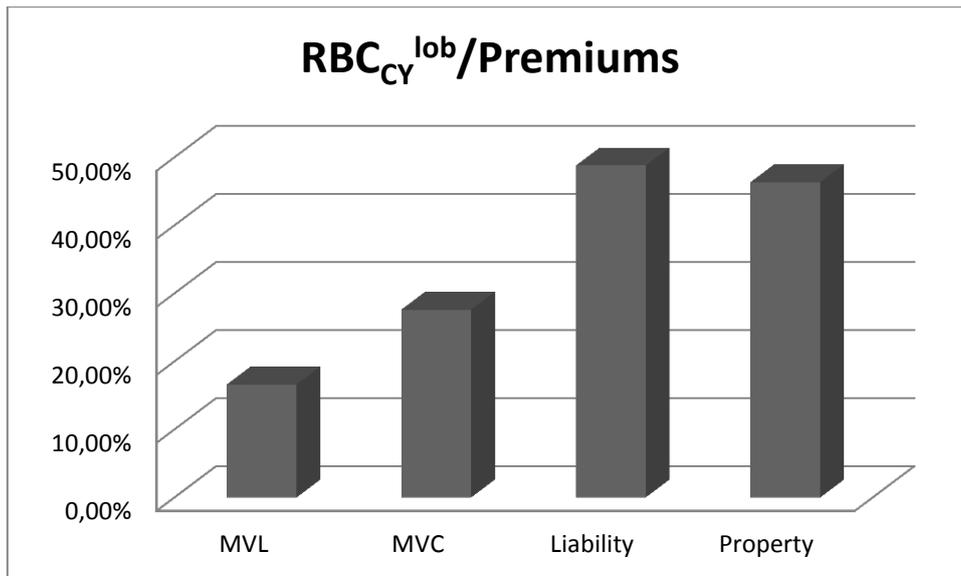


Figure 38: RBC CY divided by premiums.

We must aggregate the capital requirements, and this is done under three hypotheses:

Correlation	RBCCY/Premium
Independence	14.80%
Full correlation	29.25%
SST correlation	20.61%

Table 77: RBC CY divided by premiums depending on the correlation level.

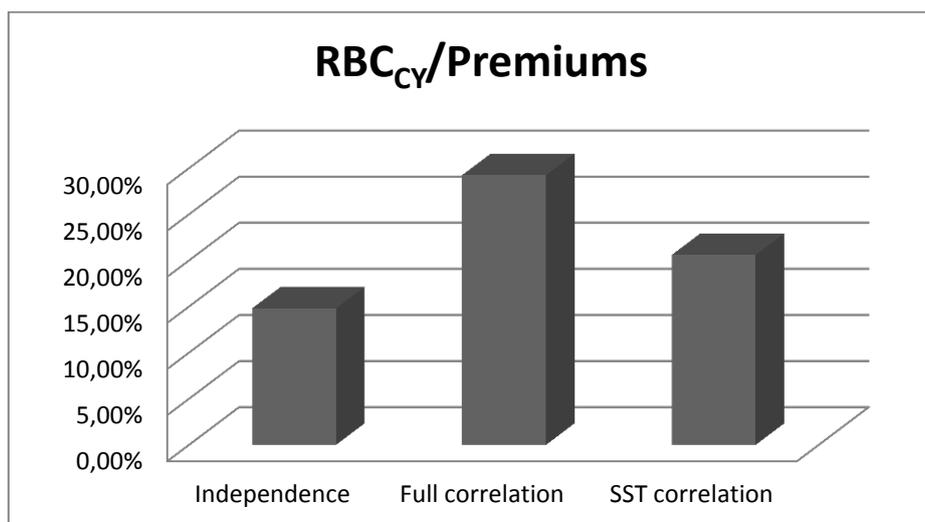


Figure 39: RBC CY divided by premiums depending on the correlation level.

This highlights another crucial aspect that the regulator has to solve: the correlation between LoBs. In fact passing from the hypotheses of independence to full correlation the difference is more or less 15% which is very high, while passing from independence to SST correlation is less than 6%.

8.3 PARTIAL INTERNAL MODEL I

We now try to develop a partial internal model in reference to major claims.

For this reason in this part we are going to model the normal claims as in the standard model while the major claims will be modeled with a compound Poisson process using a simulation method quite similar to the internal model developed in the section before.

The simulation can be summarized as follow:

- extraction of a random number q_i from a Gamma distribution with expected value 1 and coefficient of variation equal to $VK_{p,i}$;
- extraction of a random number N_i from a Poisson distribution with expected value equal to $q_i * \text{Expected number of major claims}$;
- extraction from a Pareto distribution⁵⁰ for $n=1, 2, 3, \dots, N_i$ the single claim amount for normal claim $Z_{i,n}$.

The severity of each claim is casually extracted from a Pareto distribution with parameter taken from the “SST technical document”.

Line of business	λ_i^{MC}	$VK_{p,i}$	α	β threshold
MVL	64.17	3.50%	2.5	1mIn CHF
MVC	14.54	3.50%	1.85	10mIn CHF
Liability	1.56	3.50%	1.8	1mIn CHF
Property	0.75	5%	1.4	1mIn CHF

Table 78: Simulations parameters.

⁵⁰ For LoB MVC the procedure is the one explained in section before.

The results of the 200.000 simulations are summarized below.

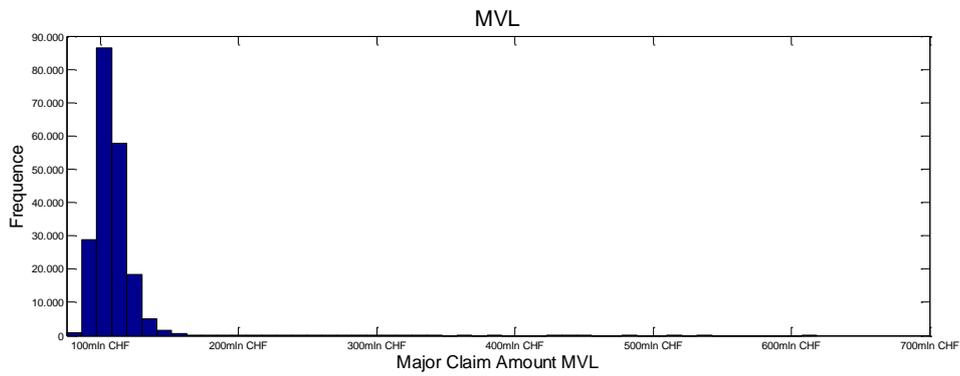


Figure 40: Distribution of MVL major claims.

MVL	
Mean	107.87mIn CHF
Standard Deviation	17.77mIn CHF
Coefficient of Variation	16.57%
Skewness	3.016
RBC/Premium	14.09%

Table 79: MVL simulations results.

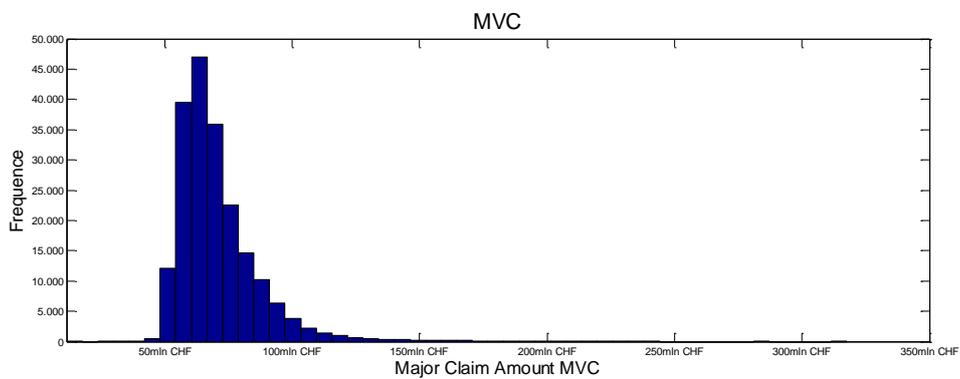


Figure 41: Distribution of MVC major claims.

MVC	
Mean	31.15mln CHF
Standard Deviation	13.64mln CHF
Coefficient of Variation	43.79%
Skewness	2.1168
RBC/Premium	22.82%

Table 80: MVC simulations results.

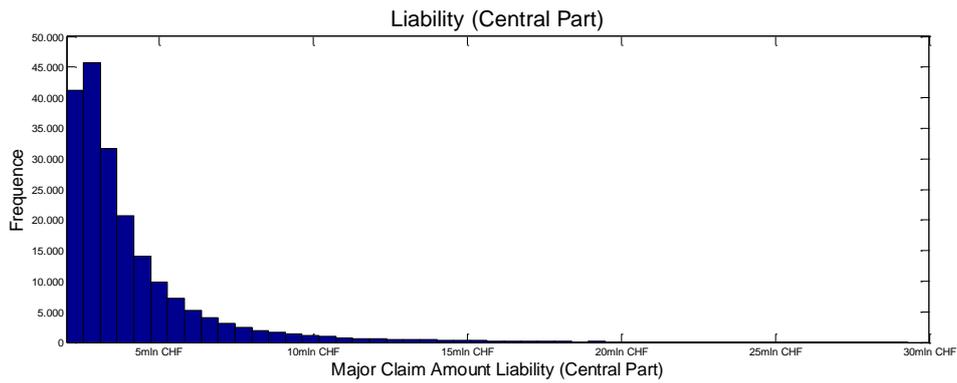


Figure 42: Distribution of liability major claims (central part).

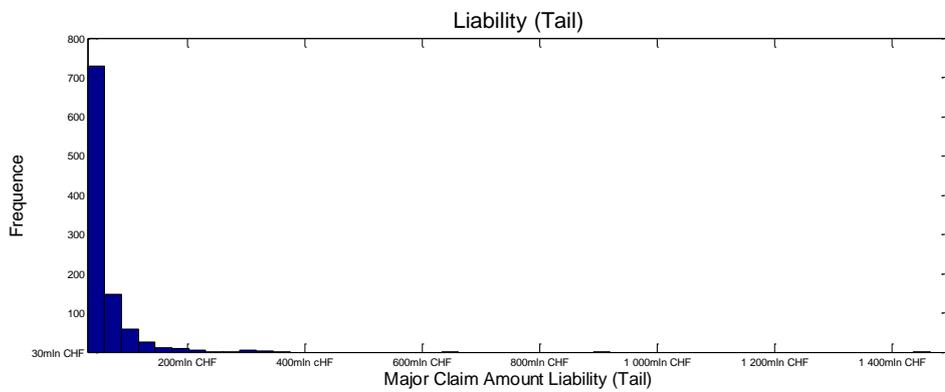


Figure 43: Distribution of liability major claims (tail).

Liability	
Mean	3.52mln CHF
Standard Deviation	7.46mln CHF
Coefficient of Variation	212.16%
Skewness	83.766
RBC/Premium	29.56%

Table 81: Liability simulations results.

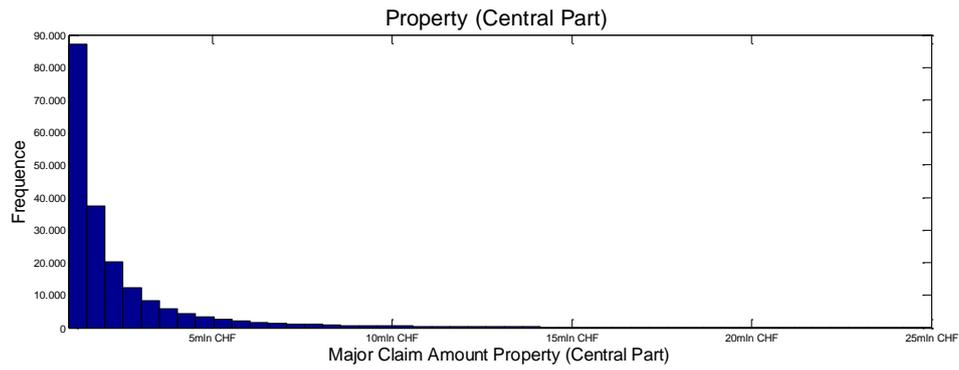


Figure 44: Distribution of property major claims (central part).

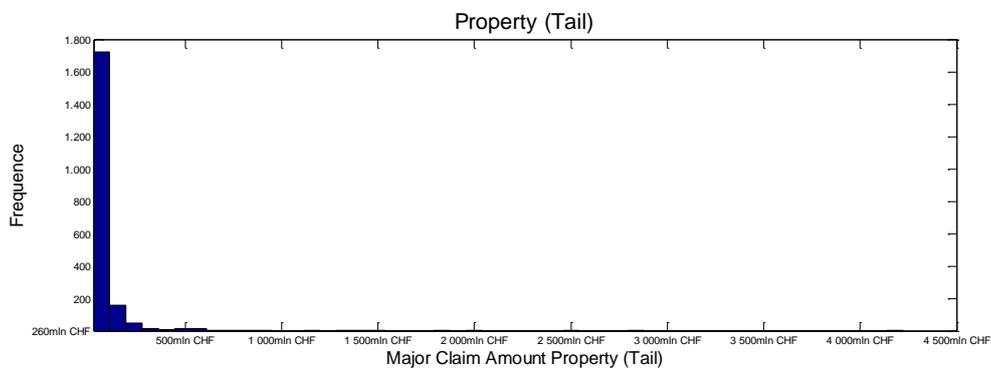


Figure 45: Distribution of property major claims (tail).

	Property
Mean	2.52mln CHF
Standard Deviation	14.55mln CHF
Coefficient of Variation	576.81%
Skewness	77.89
RBC/Premium	34.02%

Table 82: Property simulations results.

As said at the beginning, the capital requirement of normal claim is calculated following the standard model. The next table shows the $RBC_{NC}^{Standard Model}$ and $RBC_{MC}^{Internal Model}$:

Line of Business	$RBC_{NC}^{Standard Model}$	$RBC_{MC}^{Internal Model}$
MVL	7.93%	14.09%
MVC	5.80%	22.82%
Liability	26.31%	29.56%
Property	17.19%	34.02%

Table 83: RBC normal claims (standard model) & RBC major claims (internal model).

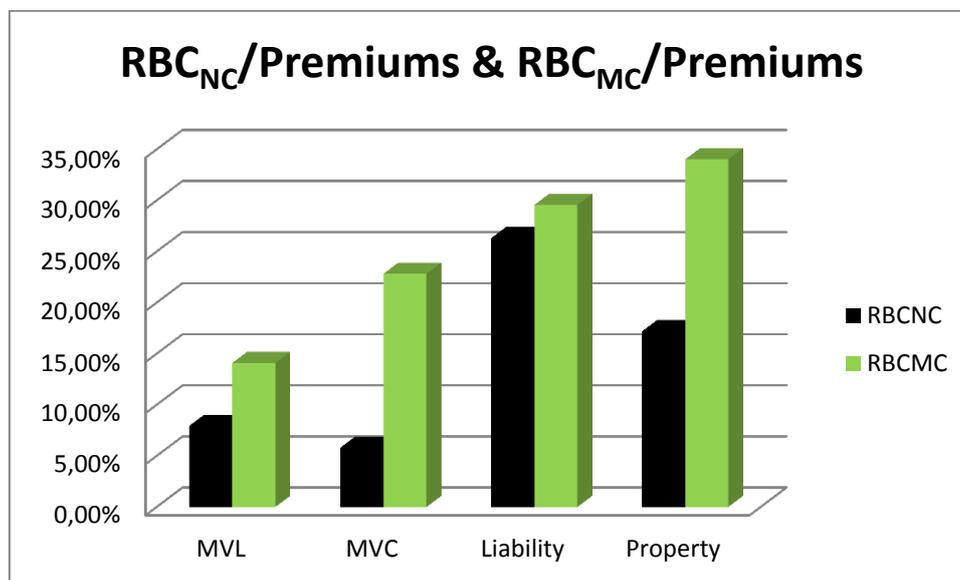


Figure 46: : RBC normal claims (standard model) & RBC major claims (internal model).

We now suppose different levels of correlations between normal claims and major claims. The results are shown in the following table:

Line of Business	Independence	Full Correlation	Correlation=0,5
MVL	16.17%	22.02%	19.32%
MVC	23.54%	28.62%	26.20%
Liability	39.58%	55.87%	48.42%
Property	38.12%	51.21%	45.14%

Table 84: RBC CY supposing different correlation levels between normal and major claims.

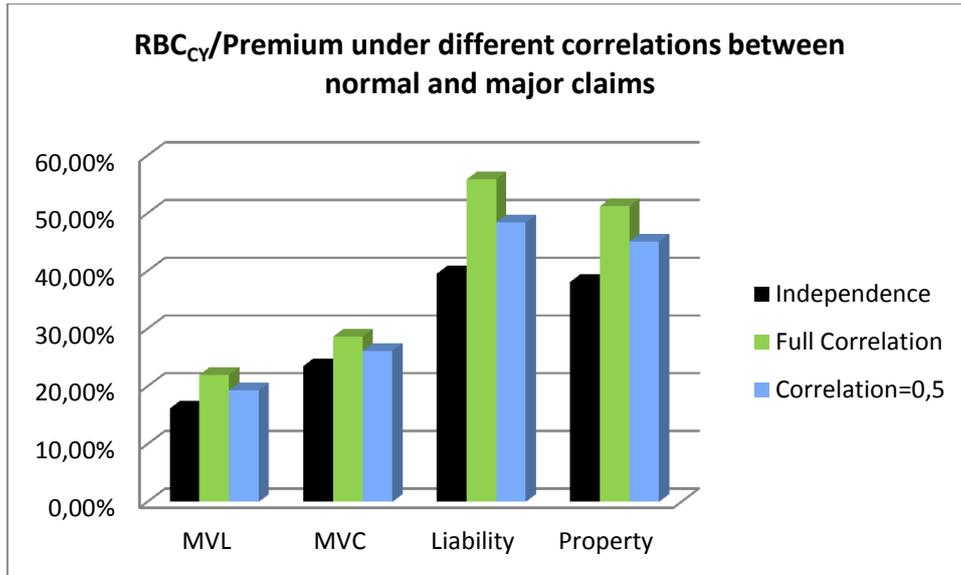


Figure 47: RBC CY supposing different correlation levels between normal and major claims.

We have just shown a second problem of aggregation: what is the correlation between normal and major claims?

We see that passing from independence to full correlation the RBCs change significantly:

- In MVL from 16.17% to 22.02%;
- In MVC from 23.54% to 28.62%;
- In Liability from 39.58% to 55.87%;and
- In Property from 38.12% to 51.21%.

In the following we will use independence between normal and major claim as suppose in the SST.

We must aggregate the capital requirement of each LoBs. In the following it will be suppose different levels of correlation and the results are compared.

Correlation	$RBC_{CY}^{Partial\ Internal\ Model} / Premium$
Independence	12.75%
Full Correlation	25.23%
SSTcorrelation	17.86%

Table 85: RBC CY total business supposing different correlation levels between LoBs.

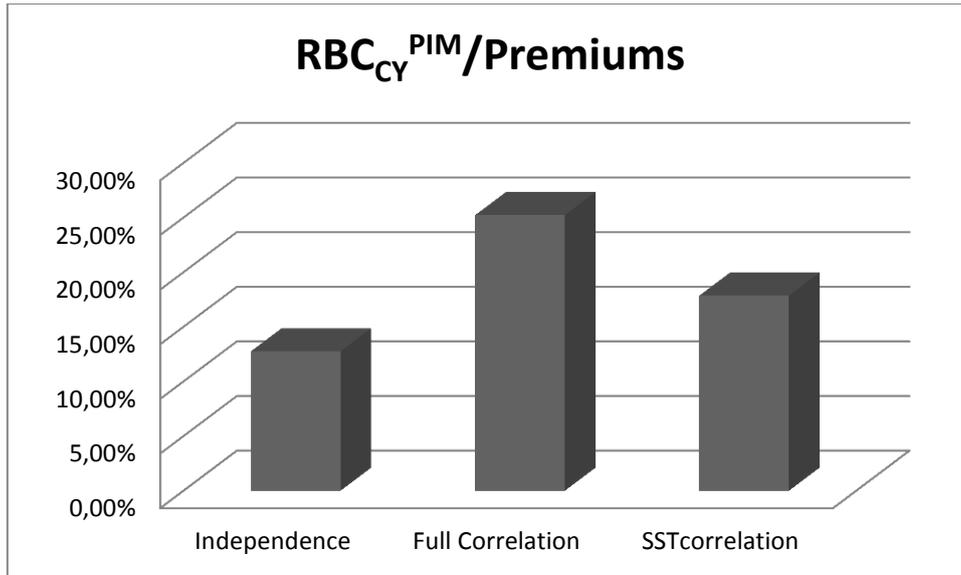


Figure 48: RBC CY total business supposing different correlation levels between LoBs.

8.4 PARTIAL INTERNAL MODEL II

We now try to develop a partial internal model in reference to normal claims.

For this reason in this part we are going to model the major claims as in the standard model while the normal claims will be modeled with a compound Poisson process using a simulation method.

The simulation can be summarized as follow:

- extraction of a random number q_i from a Gamma distribution with expected value 1 and coefficient of variation equal to $VK_{p,i}$;
- extraction of a random number N_i from a Poisson distribution with expected value equal to $q_i * \text{Expected number of normal claims}$;
- extraction from a Log Normal distribution for $n=1, 2, 3, \dots, N_i$ the single claim amount for normal claim $Z_{i,n}$.

Before starting the simulation we need the moment of Z_{NC} which are derived from the SST standard model using the Theory of Risk formulas:

$$E(S_{CY}^{NC}) = \lambda_{NC} * M_{NC},$$

$$\frac{\sigma(S_{CY}^{NC})}{E(S_{CY}^{NC})} = VK(Y_{i,j})$$

The following results are derived for normal claims:

Line of business	λ_i^{NC}	M_{NC}	$VK(Y_{i,j})$	$VK_{p,i}$
MVL	58 269.16	4 388 CHF	7	3.50%
MVC	16 6652.13	1 099.17 CHF	2.5	3.50%
Liability	6 248.44	16 202.62 CHF	8	3.50%
Property	7 499.25	19 601.95 CHF	5	5%

Table 86: Normal claims parameters.

The results of the 200 000 simulations are summarized below:

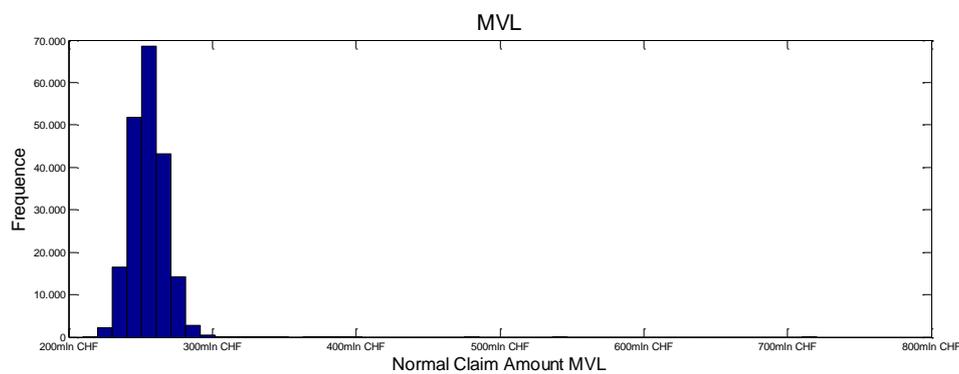


Figure 49: Distribution of MVL normal claims.

MVL		
	Simulated	Theoretical
Mean	255.66mIn CHF	255.68mIn CHF
Standard Deviation	11.74mIn CHF	11.67mIn CHF
Coefficient of Variation	4.59%	4.56%
Skewness	1.007	0.452
RBC/Premium	8.75%	

Table 87: MVL simulations results vs theoretical values.

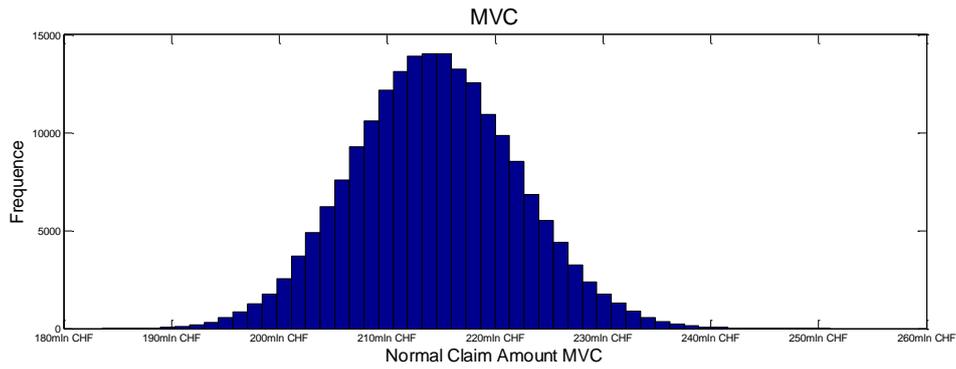


Figure 50: Distribution of MVC normal claims.

MVC		
	Simulated	Theoretical
Mean	214.4mIn CHF	183.18mIn CHF
Standard Deviation	7.64mIn CHF	6.52mIn CHF
Coefficient of Variation	3.57%	3.56%
Skewness	0.069	0.0702
RBC/Premium	6.67%	

Table 88: MVC simulations results vs theoretical values.

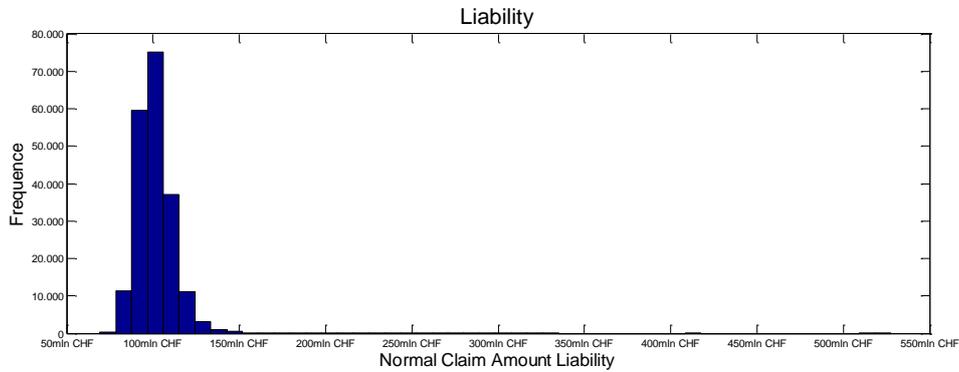


Figure 51: Distribution of liability normal claims.

Liability		
	Simulated	Theoretical
Mean	101.21mIn CHF	101.24mIn CHF
Standard Deviation	10.82mIn CHF	10.92mIn CHF
Coefficient of Variation	10.70%	10.78%
Skewness	2.823	5.643
RBC/Premium	39.46%	

Table 89: Liability simulations results vs theoretical values.

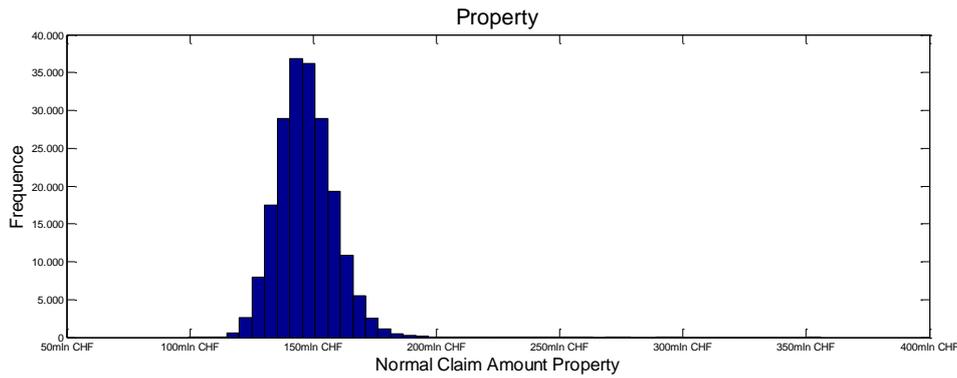


Figure 52: Distribution of property normal claims.

Property		
	Simulated	Theoretical
Mean	149.6mln CHF	147mln CHF
Standard Deviation	10.2mln CHF	11.36mln CHF
Coefficient of Variation	6.82%	7.72%
Skewness	0.750	0.762
RBC/Premium	18.91%	

Table 90: Property simulations results vs theoretical values.

Now, assuming independence between normal and major claims (as supposed in SST), and using the SST correlation matrix, we reach the following results:

Line of business	MC	NC	Total
MVL	16.15%	8.75%	18.37%
MVC	22.82%	5.71%	23.52%
Liability	29.56%	39.46%	49.30%
Property	34.02%	19.90%	39.41%
Total Business			19.47%

Table 91: RBC normal claims, RBC major claims and RBCs CY.

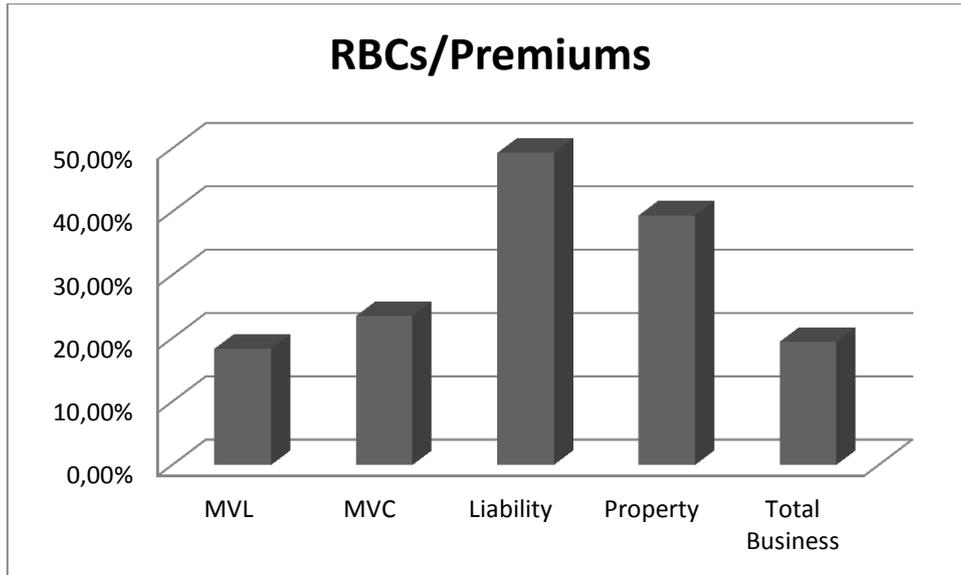


Figure 53: RBCs CY.

8.5 QIS2 STANDARD FORMULA FOR NON-LIFE PREMIUM RISK

As said in Chapter 5, the non-life underwriting risk is split into three components: reserve risk, premium risk and cat risk.

The capital charges for the sub-risks is combined using a correlation matrix as follows:

139

$$SCR_{nl} = \sqrt{\sum_{rxc} CorrNL^{xc} * NL_r * NL_c} = \sqrt{NL_{pr}^2 + NL_{res}^2 + NL_{CAT}^2 + 2 * 0,5 * NL_{pre}NL_{res}}$$

For our purpose, we consider only the part which regards the premium risk.

The QIS2 provides a factor-based approach, as follow⁵¹:

140

$$NL_{pr} = \rho(\sigma) * P,$$

Where

⁵¹ We must underline that it's not considered here the expected profit or loss from next year's business (NL_PL).

141

$$P = \sum_{lob} P_{lob} ,$$

142

$$\rho(x) = \frac{0,99 - \Phi(N_{0,99} - \sqrt{\log(x^2 + 1)})}{0.01} ,$$

Φ = cumulative distribution function of the standard normal distribution;

$N_{0,99}$ = 99% quantile of the standard normal distribution.

For the determination of σ , two methods are available:

- the market wide approach; and
- the undertaking-specific approach.

The estimate σ under this approach is set as:

143

$$\sigma = \sqrt{\frac{1}{P^2} \sum_{r,c} CorrLob_Prem^{rxc} * P_r * P_c * \sigma_r \sigma_c} ,$$

The market-wide estimates of the standard deviation of the combined ratio in the individual LoBs are defined as follows:

144

$$\sigma_{lob} = sf_{lob} * f_{lob} ,$$

sf_{lob} is the size factor and it's defined as follows:

$$\begin{array}{l}
 \frac{1}{\sqrt{P_{lob,gross} * 10^{-6}}} \\
 \frac{10}{\sqrt{20}}
 \end{array}
 \begin{array}{l}
 \text{if } P_{lob,gross} \geq 129.626 \text{mln CHF} \\
 \text{if } 129.626 \text{mln CHF} > P_{lob,gross} \geq 25.936 \text{mln CHF} \\
 \text{otherwise}
 \end{array}$$

f_{lob} is the volatility factor defined as follows⁵²:

LoB	MVL	MVC	Liability	Property
f_{lob}	12.50%	7.50%	25%	10%

Table 92: QIS2 premium risk volatility factors.

For each LoB the results are:

	MVL	MVC	Liability	Property
sf_{lob}	1	1	0.877058	1
f_{lob}	0.125	0.075	0.25	0.1
ϕ	0.986161	0.987822	0.982556	0.987013
$\rho(\sigma)$	0.383859	0.217843	0.744416	0.298713
NLpr/Premium	38.90%	21.78%	76.25%	29.87%

Table 93: QIS2 market wide approach results.

These are the QIS2 capital requirements for each LoB, but we are interested in the aggregate capital requirement.

We must introduce the QIS2 correlation matrix:

	MVL	MVC	Liability	Property
MVL	1	0.5	0	0
MVC	0.5	1	0	0.5
Liability	0	0	1	0
Property	0	0.5	0	1

Table 94: QIS2 CorrLoB matrix.

⁵² In "Solvency II" the Line of Business considered here are called: LoB1: Motor third party liability; LoB2: Motor, other classes; LoB3: Third-party liability; LoB4: Fire and other property damage.

The QIS2 capital requirement referred to the entire portfolio is the following:

Total Business	
Σ	0.074454
Φ	0.987839
$\rho(\sigma)$	0.216123
NLpr/Premium	21.61%

Table 95: QIS2 market wide approach results for the whole portfolio.

The undertaking specific estimates of the standard deviation of the combined ratio in the individual LoBs are defined as follows:

146

$$\sigma_{U,lob} = \sqrt{c_{lob} * \sigma_{CR,lob}^2 + (1 - c_{lob}) * \sigma_{M,lob}^2}$$

Where $\sigma_{CR,lob}^2$ is the estimate of the standard deviation of the combined ratio in the individual LoB on the basis of historic combined ratios of the undertaking and c_{lob} is the credibility factor for LoB defined as:

147

$$c_{lob} = 0.2 * \max \left\{ \begin{matrix} 0 \\ J_{lob} - 10 \end{matrix} \right\}$$

With J_{lob} equal to the number of historic combined ratios for each LoB (to the extent available, not more than 15 years).

In case of $J_{lob} > 10$, the estimate $\sigma_{CR,lob}$ of the standard deviation of the combined ratio in the individual LoB on the basis of historic combined ratios of the undertaking and is defined as:

148

$$\sigma_{CR,lob} = \sqrt{\frac{1}{(J_{lob} - 1) * P_{lob}} * \sum_y P_{lob,y} * (CR_{lob,y} - \mu_{lob})^2}$$

Where μ_{lob} is the company specific estimate of the expected value of the combined ratio in the individual LoB and equal to:

149

$$\mu_{lob} = \frac{\sum_y P_{lob,y} * CR_{lob,y}}{\sum_y P_{lob,y}}$$

The time series of the combined ratio is:

	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
MVL	124.10%	121.90%	116.84%	109.30%	101.70%	98.90%	97.40%	96.63%	97.28%	99.07%	100.98%	107.74%
MVC	72.71%	70.22%	70.00%	66.50%	65.70%	65.80%	64.80%	69.51%	71.10%	74.82%	85.71%	93.80%
Liability	145.10%	133.90%	130.96%	135.50%	132.88%	121.52%	123.49%	116.54%	119.21%	107.19%	110.31%	115.50%
Property	88.90%	82.50%	101.69%	84.07%	92.79%	91.70%	76.75%	81.06%	80.31%	87.39%	100.18%	107.40% ⁵³

Table 96: Combined ratios hystorical series.

And the following results are derived:

	sigmaUS	SCR/premium
MVL	0.11	32.37%
MVC	0.10	29.26%
Liability	0.21	70.46%
Property	0.1045	31.40%
Total Business	0.07	21.52%

Table 97: QIS2 undertaking specific approach results.

Graphically the QIS 2 capital requirements are:

⁵³ Values taken from: ANIA, "Appendice statistica 2009", <http://www.ania.it/>, 2009.

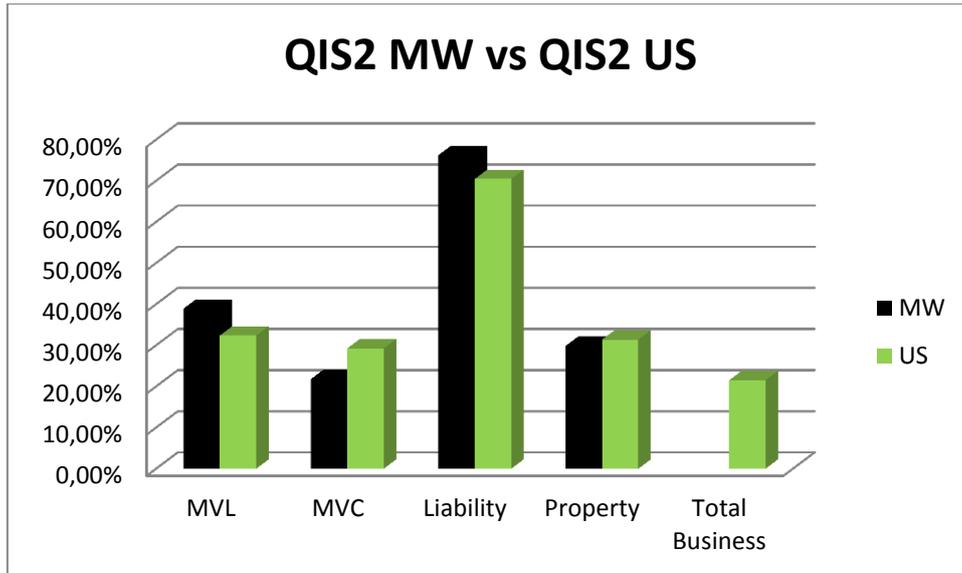


Figure 54: SCR QIS2 market wide vs SCR QIS2 undertaking specific.

As it's clear from the graph with regard to LoBs MVL and Liability the capital requirements using the Market-Wide approach are higher than the Undertaking specific approach.

For MVC and Property is the opposite.

8.6 QIS4 STANDARD FORMULA FOR NON-LIFE PREMIUM RISK

The QIS4 provides a factor-based approach, as follow:

150

$$NL_{pr} = \rho(\sigma)V \text{ with } V = \sum_{lob} V_{prem,lob} + V_{res,lob}$$

We must underline that we are only interested on premium risk, so the above equation becomes:

151

$$NL_{pr} = \rho(\sigma)V \text{ with } V = \sum_{lob} V_{prem,lob}$$

The function $\rho(\sigma)$ is defined as follows:

152

$$\rho(\sigma) = \exp\left(-\frac{\sigma^2}{2} + N_{0.995} * \sqrt{\log(\sigma^2 + 1)}\right) - 1$$

The standard deviation for premium risk in the individual LoBs is derived as a credibility mix of an undertaking-specific estimate and a market-wide estimate as follows:

153

$$\sigma_{prem,lob} = \sqrt{c_{lob} * \sigma_{U,prem,lob}^2 + (1 - c_{lob}) * \sigma_{M,prem,lob}^2}$$

Where c_{lob} is the credibility factor for LoB, $\sigma_{U,prem,lob}$ is the undertaking-specific estimate of the standard deviation for premium risk and $\sigma_{M,prem,lob}$ is the market-wide estimate of the standard deviation for premium risk.

The market-wide estimate of the standard deviation for premium risk in the individual LoB is set equal to:

	MVL	MVL	Liability	Property
Volatility factors	9.00%	9.00%	12.5%	10%

Table 98: QIS4 premium risk volatility factors.

And using the QIS4 correlation matrix

	MVL	MVC	Liability	Property
MVL	1	0.5	0.5	0.25
MVC	0.5	1	0.25	0.25
Liability	0.5	0.25	1	0.25
Property	0.25	0.25	0.25	1

Table 99: QIS4 CorrLoB matrix.

we obtain the following results:

Line of Business	SCR/Premium
MVL	25.52%
MVL	25.52%
Liability	36.75%
Property	28.66%
Total Business	19.60%

Table 100: QIS4 market wide approach results.

Using the undertaking-specific approach, the following loss ratios are needed:

	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
MVL	96.80%	96.40%	90.94%	86.89%	82.38%	80.51%	80.91%	81.45%	81.43%	81.07%	82.91%	87.77%
MVC	51.96%	50.26%	49.62%	46.12%	45.27%	45.22%	44.77%	48.95%	49.90%	52.36%	61.78%	68.20%
Liability	97.70%	87.90%	85.94%	84.51%	84.69%	79.10%	76.00%	76.68%	80.47%	74.70%	77.08%	83.50%
Property	67.60%	61.20%	75.84%	61.40%	68.91%	68.88%	53.60%	59.34%	57.60%	61.62%	76.03%	77.50% ⁵⁴

Table 101: Loss ratios hystorical series.

For “Property” and “MVC” we can only use 5 loss ratios, while for the other line of business we can use till 15 loss ratios.

In our case we have only 12 loss ratios, and so the following credibility factors are obtained:

LoB	Credibility factor
MVL	75.00%
MVC	79.00%
Liability	75.00%
Property	79.00%

Table 102: QIS4 credibility factors.

Using the formulas above mentioned, the capital requirements are:

⁵⁴ Values taken from ANIA, “Appendice statistica 2009”, <http://www.ania.it/>, 2009.

Line of Business	SCR/Premium
MVL	16.13%
MVL	22.98%
Liability	20.95%
Property	39.04%
Total Business	15.98%

Table 103: QIS4 undertaking specific approach results.

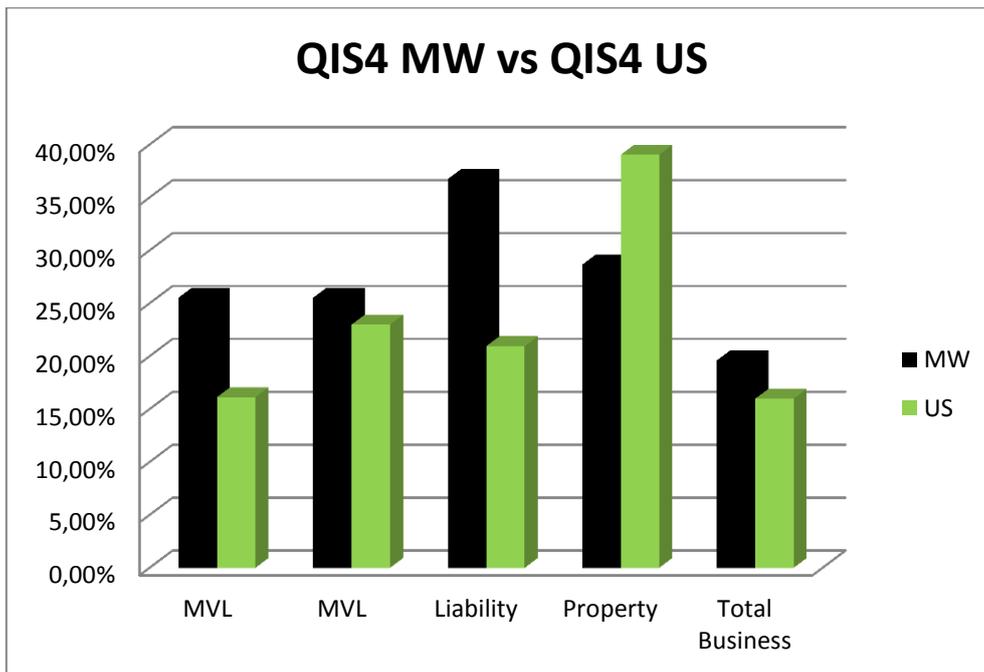


Figure 55: SCR QIS4 market wide approach vs SCR QIS4 undertaking specific approach.

The Undertaking specific approach lead to lower capital requirements in each LoBs unless for Property.

Now we try to understand what happen if in all LoBs we can use 15 loss ratios. This aspect changes our capital requirements with regard to LoBs:

- MVC; and
- Property.

The results are summarized below:

	MVC	Property	Total Business
Credibility factor	75.00%	75.00%	
sigma US 12 Loss Ratios	7.24%	12.56%	5.54%
sigma US 5 Loss Ratios	9.21%	16.49%	5.83%
SCR/Premium (12 Loss Ratios)	20.17%	36.95%	15.14%
SCR/Premium (5 Loss Ratios)	26.17%	50.46%	15.98%

Table 104: QIS4 undertaking specific approach results using 12 loss ratios instead of 5 for MVC and property.

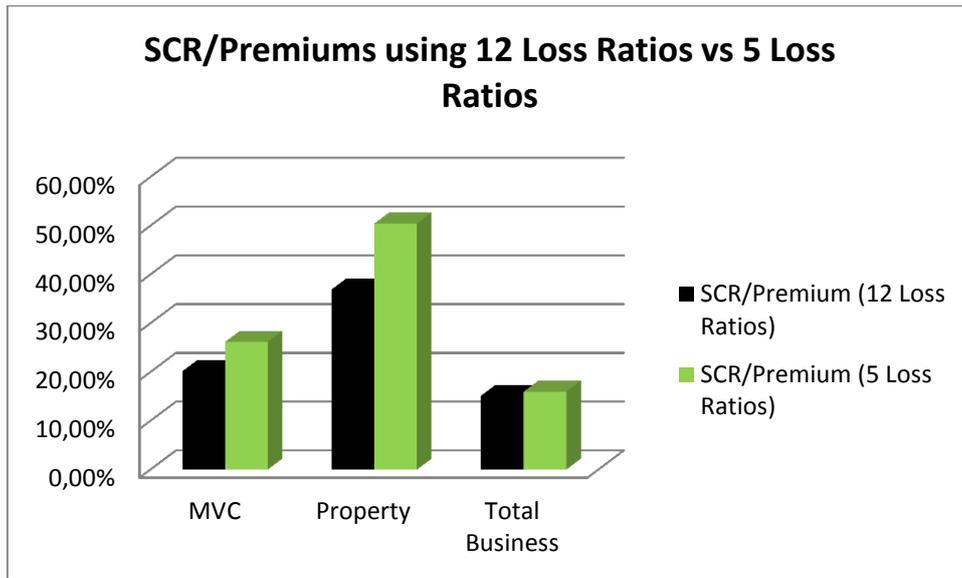


Figure 56: QIS4 undertaking specific approach results using 12 loss ratios instead of 5 for MVC and Property.

Using 12 Loss Ratios the capital requirements decrease. In particular in LoB MVC the capital requirement goes from 26.17% to 20.17%, in Property the change is higher passing from 50.46% to 36.95% and, with regard to Total Business, the requirement lowers from 15.98% to 15.14%. This is due to the volatility of the Loss Ratios in these two LoBs. The variance decreasing of the Loss Ratios implies a sigma (US) smaller and the associated capital requirement lower. If we analyze the Loss Ratios series, as expected, their variances are smaller considering 12 instead of 5:

Loss Ratios variance	MVC	Property
12 Loss Ratios	0.50%	0.62%
5 Loss Ratios	0.71%	0.91%

Table 105: Variance of 5 loss ratios vs variance of 12 loss ratios for MVC and Property.

8.7 QIS5 STANDARD FORMULA FOR NON-LIFE PREMIUM RISK

The capital requirement for the combined premium risk and reserve risk is determined as follows:

154

$$NL_{pr} = \rho(\sigma) * V,$$

Where:

V is a volume measure;

σ is the combined standard deviation;

155

$$\rho(\sigma) = \frac{\exp(N_{0.995} * \sqrt{\log(\sigma^2 + 1)})}{\sqrt{(\sigma^2 + 1)}} - 1,$$

Where $N_{0.995}$ is the 99.5% quantile of the standard normal distribution.

The market-wide estimates of the net standard deviation for premium risk for each line of business are:

LoB	MVL	MCV	Liability	Property
f _{lob}	10.00%	7.00%	15%	10%

Table 106: QIS5 premium risk volatility factors.

With regard only to premium risk σ is defined as follows:

156

$$\sigma = \sqrt{\frac{1}{V^2} \sum_{r,c} CorrLob^{rxc} * V_r * V_c * \sigma_r \sigma_c}$$

The matrix correlation is defined as follows:

	MVL	MVC	Liability	Property
MVL	1	0.5	0.5	0.25
MVC	0.5	1	0.25	0.25
Liability	0.5	0.25	1	0.25
Property	0.25	0.25	0.25	1

Table 107: QIS5 CorrLoB matrix.

For each LoB the results are:

	MVL	MVC	Liability	Property
σ	0.1	0.7	0.15	0.1
$\rho(\sigma)$	0.367493	0.209385	0.723834	0.286554
NLpr/Premium	36.75%	20.94%	72.38%	28.66%

Table 108: QIS5 market wide approach results.

These are the QIS5 capital requirements for each LoB, but we are interested in the aggregate capital requirement.

Using the correlation matrix defined above we reach the following results:

	Total Business
σ	0.087566834
$\rho(\sigma)$	0.247706747
NLpr/Premium	24.77%

Table 109: QIS 5 market wide approach results for the whole portfolio.

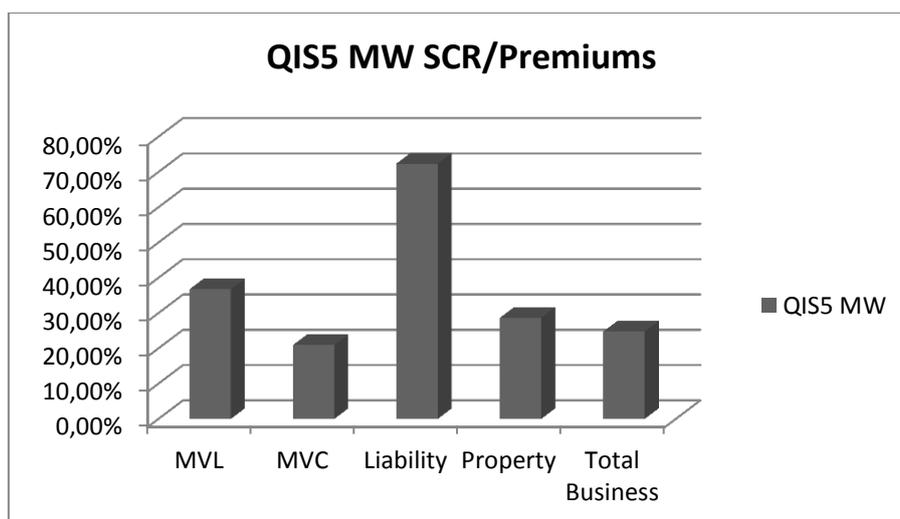


Figure 57: QIS5 market wide approach results.

Under QIS 5 the capital requirements go from 20.94% in MVC to 72.38% in Liability.

8.8 COMPARISONS

8.8.1 COMPARISONS BETWEEN THE SST MODELS

We are now able to make some comparisons between capital requirements found in the sections before.

First of all we compare the capital requirements of the models presented in sections 8.1, 8.2, 8.3 and 8.4 that follow the Swiss Solvency Test:

Line of Business	SST standard model	Partial Internal Model I	Partial Internal Model II	Internal Model
MVL	17.58%	16.71%	18.37%	16.61%
MVC	24.77%	23.54%	23.52%	27.61%
Liability	38.11%	39.58%	49.30%	48.8%
Property	37.48%	38.12%	39.41%	46.35%
Total Business	13.72%	17.86%	19.47%	20.61%

Table 110: Summary of the RBCs using SST standard model, Internal Model, Partial Internal Model I and Partial Internal Model II.

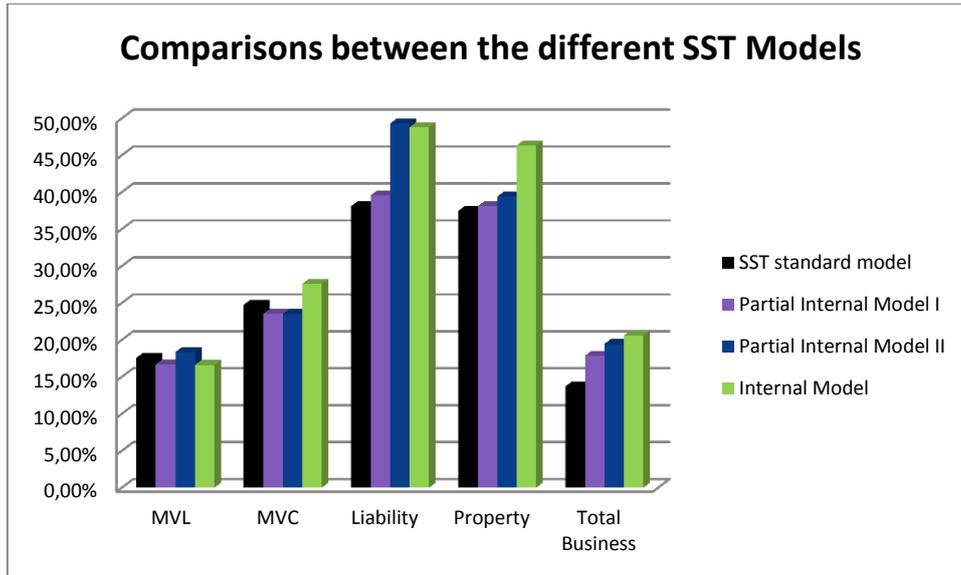


Figure 58: Comparisons between the RBCs of the different SST models.

For what concerns these different models, we see that for each line of business the results are very similar. What significantly differs is the capital required for the Total Business that goes from 13.72% with the standard model to 20.61% with the internal model passing through 17.82% (PIM I) and 19.47% (PIM II).

This large difference between the standard model and the other is due to the aggregation method of major claims. The standard model makes a weighted average of the distribution function of the individual major claims of the individual lines of business:

157

$$F_Y(y) = \frac{1}{\sum_i \lambda_i^{MC}} \sum_i (\lambda_i^{MC} F_{Y_{CY,i}^{MC}}(y))$$

And just then suppose independence between normal and major claims.

In "Partial Internal Model I", "Partial Internal Model II" and in "Internal Model" we have made something different, in fact we have aggregated major and normal claims supposing independence and then we have aggregate the capital required for each line of business using the correlation matrix. If we recalculate the capital required in "Partial Internal

Model I” and in “Partial Internal Model II”⁵⁵ using the aggregation method shown above we reach the results shown in table 113. The necessary data are summarized in the table below.

Line of Business	PIM I		PIM II	
	$RBC_{NC}^{Standard Model}$	$RBC_{MC}^{Partial Internal Model I}$	$RBC_{NC}^{Partial Internal Model II}$	$RBC_{MC}^{Standard Model}$
MVL	7.93%	14.09%	8.75%	16.15%
MVC	5.80%	22.82%	5.71%	22.82%
Liability	26.31%	29.56%	39.46%	29.56%
Property	17.19%	34.02%	19.90%	34.02%

Table 111: Summary of the RBC normal claims and RBC major claims in Partial Internal Model I and Partial Internal Model II.

In both PIM I and PIM II we aggregate the RBC_{NC}^{lob} using the SST correlation matrix and then we sum this result to the weighted average of the RBC_{MC}^{lob} .

Recalling that the weight of RBC_{MC}^{lob} are:

Line of business	λ_i^{MC}
MVL	64.166663
MVC-hail	14.54406
Liability	1.5625
Property	0.75

Table 112: Expected number of major claims.

⁵⁵ It’s not possible to do the same thing in “Internal Model” because the results of the simulations are “Total Claims Amount” and it’s not possible to divide normal from major claims.

The following results are obtained:

	PIM I	PIM II	Standad Model
$RBC_{NC}/Premiums$	7.73%	9.76%	
$RBC_{MC}/Premiums$	5.78%	6.42%	
$RBC_{NC+MC}/Premiums$	13.51%	16.19%	13.72%

Table 113: RBC CY in Partial Internal Model I, Partial Internal Model II and in Standard model using the correlation suggest in SST between major claims.

As expected the capitals required using this aggregation method are very close to the RBC found using the standard model.

8.8.2 COMPARISONS BETWEEN QISs

The results of the capital requirement calculations under the different QISs are summarized in the table and in the graph below:

Line of Business	QIS2 US	QIS2 MW ⁵⁶	QIS4 US	QIS4 MW	QIS5 MW
MVL	32.37%	38.90%	16.13%	25.52%	36.75%
MVC	29.26%	21.78%	22.98%	25.52%	20.94%
Liability	70.46%	76.25%	20.95%	36.75%	72.38%
Property	31.40%	29.87%	39.04%	28.66%	28.66%
Total Business	21.52%	21.61%	15.98%	19.60%	24.77%

Table 114: Summary of the SCRs under different QISs and different approaches.

⁵⁶ We must remember that it's not considered the expected profit or loss from next year's business (NL_PL) for QIS2 SCRs.

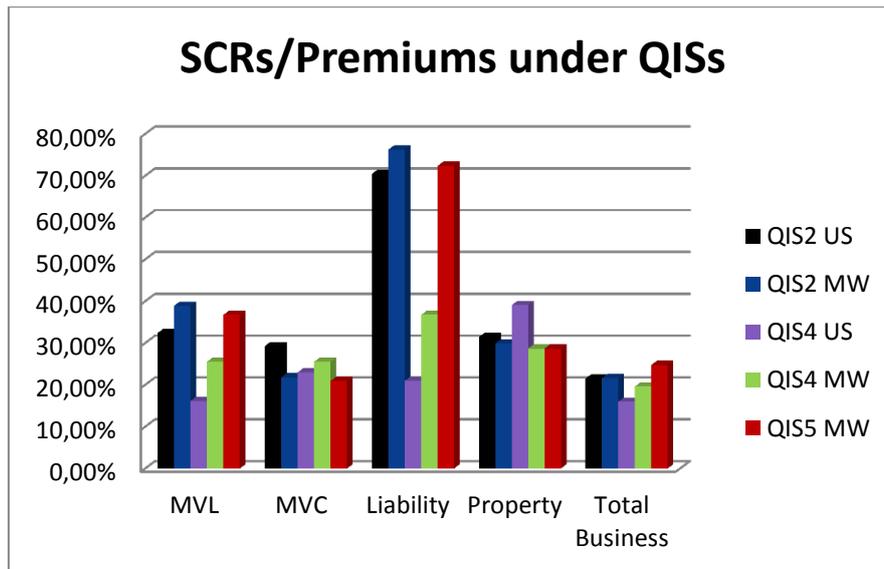


Figure 59: Comparisons between the SCRs under different QISs and different approaches.

We see that passing from QIS2 MW to QIS4 MW the capital requirements become smaller in each LoBs unless in MVC. This is due to changes in the volatility factors and in the risk measure.

With regard to changes in the volatility factors, they are reported below:

	MVL	MCV	Liability	Property
QIS2 MW	12.50%	7.50%	25.00%	10.00%
QIS4 MW	9.00%	9.00%	12.50%	10.00%

Table 115: QIS2 premium risk volatility factors vs QIS 4 premium risk volatility factors.

As it's clear from the table above the volatility factors, with the exception of the LoB MVC, have been lowered and this implies a reduction in the capital required.

Secondly QIS2 was calibrated to a TailVaR_{99%} risk measure, differently from other QISs whose risk measure is a VaR_{99.5%}.

As said before usually TailVaR_{99%} is larger than VaR_{99.5%}.

With regard to the Total Business another crucial element is the change of the correlation matrix which plays an important role in the determination of the capital requirement.

The QIS4 correlation matrix is worse, from the company point of view, than the one of QIS2. Notwithstanding this the capital required for the Total Business is less under QIS4,

this means that the correlation matrix effect is lower than the effect due to volatility factors' and risk measure changes.

With regard to the undertaking specific approach under QIS2 and QIS4, we see that the capital requirements are lower in each LoBs under QIS4:

Line of Business	QIS2 US ⁵⁷	QIS4 US
MVL	32.37%	16.13%
MVC	29.26%	22.98%
Liability	70.46%	20.95%
Property	31.40%	39.04%
Total Business	21.52%	15.98%

Table 116: SCRs under QIS2 undertaking specific approach vs SCRs under QIS4 undertaking specific approach.

So the effect due to increasing of MVC volatility factor is completely eliminated with the undertaking specific approach because the change in the risk measure and the volatility of Loss Ratios (used in QIS4) is less than the volatility of the Combined Ratios (used in QIS2) as shown below:

Variance	MVL	MVC	Liability	Property
$\sigma^2(CR_{lob})$	0.99%	0.77%	1.30%	0.91%
$\sigma^2(LR_{lob})$	0.36%	0.50%	0.42%	0.62%

Table 117: Combined ratios variance (QIS2) vs loss ratios variance (QIS4).

From table 117 we note that the variance of Loss Ratios is always less than the variance of Combined Ratios. This is due to the elimination of the uncertainty factor of the expenses.

We can now compare the results under QIS5 MW and QIS4MW disregarding QIS2. The results are shown in the table and in the graph below:

⁵⁷ We must remember that it's not considered the expected profit or loss from next year's business (NL_PL).

Line of Business	QIS4 MW	QIS5 MW
MVL	25.52%	36.75%
MVC	25.52%	20.94%
Liability	36.75%	72.38%
Property	28.66%	28.66%
Total Business	19.60%	24.77%

Table 118: SCRs under QIS4 market wide approach vs SCRs under QIS5 market wide approach.

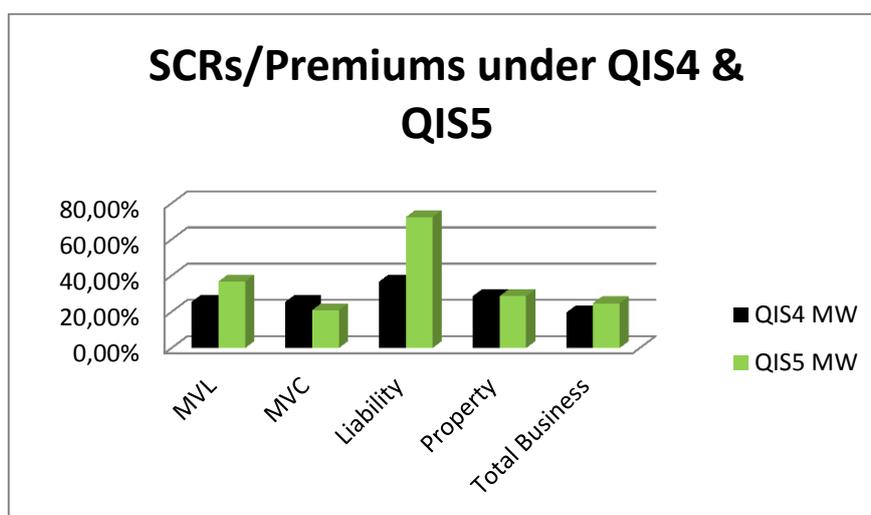


Figure 60: Comparisons between SCRs under QIS4 market wide approach and SCRs under QIS5 market wide approach.

We see that, under QIS5, the SCRs for LoBs MVL and Liability increase, for MVC decrease and remain constant for Property.

Comparing the volatility factors in table 119 it's clearly understandable that the changes in SCRs are completely due to the volatility factors.

We can notice that where the capital required is higher or lower the volatility factor is higher or lower too. For LoB Property, where the volatility factor is the same in QIS4 and QIS5, the SCR doesn't change.

	MVL	MCV	Liability	Property
QIS5 MW	10.00%	7.00%	15.00%	10.00%
QIS4 MW	9.00%	9.00%	12.50%	10.00%

Table 119: QIS4 premium risk volatility factors vs QIS5 premium risk volatility factors.

Even the $SCR_{\text{Total Business}}$ change is completely caused by the volatility factors, in fact the QIS4 and QIS5 correlation matrices between LoBs examined here are identical as shown above.

QIS4	MVL	MVC	Liability	Property	QIS5	MVL	MVC	Liability	Property
MVL	1	0.5	0.5	0.25	MVL	1	0.5	0.5	0.25
MVC	0.5	1	0.25	0.25	MVC	0.5	1	0.25	0.25
Liability	0.5	0.25	1	0.25	Liability	0.5	0.25	1	0.25
Property	0.25	0.25	0.25	1	Property	0.25	0.25	0.25	1

Table 120: QIS4 CorrLoB vs QIS5 CorrLoB.

8.8.3 COMPARISONS BETWEEN SST STANDARD MODEL AND QISs

Before doing comparisons between the Swiss Solvency Test standard model and the QISs, we must eliminate the hail risk.

This is necessary because of “Solvency II” takes into account the hail risk only in the CAT-risk module that here is not analyzed.

So the capital requirements are summarized in the next table:

Line of Business	SST	QIS2MW	QIS2US	QIS4MW	QIS4US	QIS5MW
MVL	17.58%	38.90%	32.37%	25.52%	16.13%	36.75%
MVC	5.80%	21.78%	29.26%	25.52%	22.98%	20.94%
Liability	38.11%	76.25%	70.46%	36.75%	20.95%	72.38%
Property	37.48%	29.87%	31.40%	28.66%	39.04%	28.66%
Total Business	12.45%	21.61%	21.52%	19.60%	15.98%	24.77%

Table 121: RBC SST Standard Model vs SCRs under different QISs and approaches.

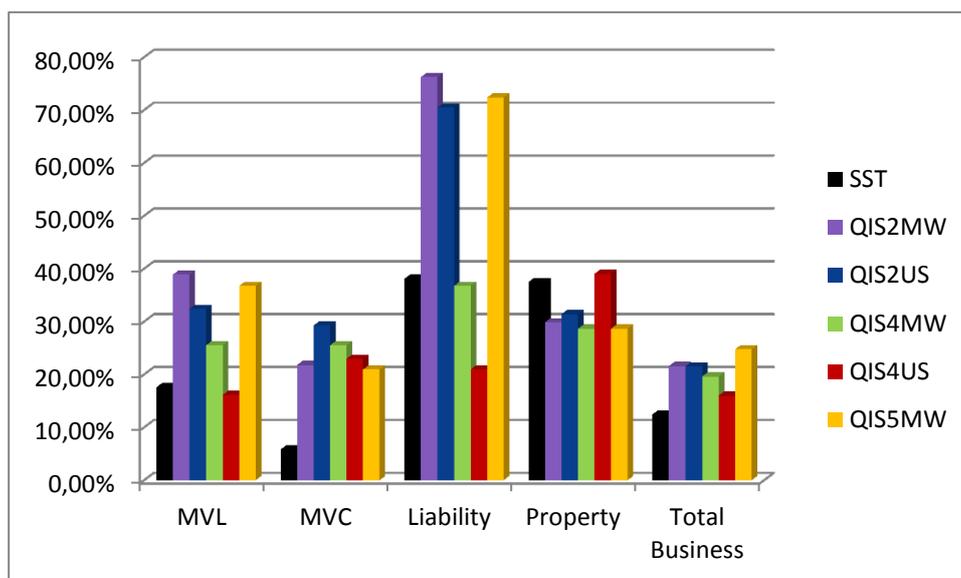


Figure 61: Comparisons between RBC in SST Standard Model and QIS' SCRs.

For what concerns the single line of business we can see that:

For MVL the capital requirement goes from 16.13% under QIS4 US to 38.90% under QIS2 MW;

For MVC the capital requirement goes from 5.8% under SST to 29.26% under QIS2 US;

For Liability the capital requirement goes from 20.95% under QIS4 US to 76.25% under QIS2 MW;

For Property the capital requirement goes from 28.66% under QIS4 MW to 39.04% under QIS4 US;

For the Total Business the capital requirement goes from 12.45% under SST to 24.77% under QIS5 MW.

It's important to underline that the capital requirements calculated under the market-wide approach in the different QISs are not very significant, because they don't take into account the size of the company, so, for example, following this approach, companies OMEGA, ALFA, BETA and GAMMA would have the same capital requirements.

This aspect is in contrast with the risk diversification which rises at increasing of the company size.

Not to put to a competitive disadvantage the company, the capital requirements under Solvency II and Swiss Solvency Test would be similar. From the table and the graph above

doesn't seem to be so. In fact the SST requires less capital than Solvency II, so companies operating in Switzerland would have an economic advantage having locked less capital. On the other hand the policy holders are more protected if they are insured with an European Union company. The critical problem is to find the better trade-off between policy-holders security and the capital allocation efficiency of the insurer.

Finally we must specify that, notwithstanding we have tried to make sensible comparisons, the results are only an approximation of the real capital requirements due to the simplifications made during calculations. In addition some risks are treated differently, for example the capital requirement concerning hail risk is comprised in the SST standard model of major claims while in Solvency II is computed using a scenario approach.

For this reason comparisons are quite dangerous and to make them more sensible would be more reasonable computing the total capital requirements for underwriting premium risk taking into account even the scenarios that are not treated.

CHAPTER 9

CAPITAL ADEQUACY OVER A MULTI-YEAR TIME HORIZON

In this section we try to calculate capital requirements over a time horizon different from one year. To succeed in this we must introduce the concept of “Risk Reserve”⁵⁸.

9.1 RISK RESERVE

A classical risk theoretical model is here used to analyze the risk reserve of the insurance company.

In classical Risk-Theory literature the stochastic Risk Reserve U_t at the end of year t is given by the relation:

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$$\tilde{U}_t = (1 + j)\tilde{U}_{t-1} + (1 + j)^{0.5}[B_t - E_t - \tilde{X}_t],$$

With gross premium volume (B_t), stochastic aggregate claim amount (\tilde{X}_t) and general and acquisition expenses (E_t) realized in the middle of the year, whereas j is the annual rate of investment return, assumed to be the risk-free rate. Neither dividends nor taxation are considered in the model.

The gross premium amount is defined as:

159

$$B_t = P_t + \pi P_t + cB_t$$

⁵⁸ See: N.Savelli, “Dispense di Teoria del Rischio II”, Università Cattolica Milano, 2010.

Where

160

$$P_t = E(\tilde{X}_t)$$

Is the risk premium, π is the safety loading applied as a constant quota of the risk premium and c is the expense loading applied as a constant coefficient of the gross premium.

Here we suppose that actual expenses are equal to expenses loading amount:

161

$$E_t = cB_t$$

And so we can write the risk reserve as:

162

$$\tilde{U}_t = (1 + j)\tilde{U}_{t-1} + (1 + j)^{0.5}[(1 + \pi)P_t - \tilde{X}_t]$$

The gross premium volume increases yearly by the claim inflation (i) and real growth (g):

163

$$B_t = B_{t-1}(1 + g)(1 + i)$$

assumed rates i and g to be constant in the regarded time horizon.

The aggregate claim amount, as said before, is given by a collective approach.

164

$$\tilde{X}_t = \sum_{s=0}^{\tilde{\lambda}_t^{NC}} \tilde{Z}_{s,t}^{NC} + \sum_{k=0}^{\tilde{\lambda}_t^{MC}} \tilde{Z}_{k,t}^{MC} \text{ for } lob = 1,2,3,4$$

Where $\tilde{\lambda}_t = \tilde{\lambda}_t^{NC} + \tilde{\lambda}_t^{MC}$ is the random variable of the number of claims occurred in year t , $\tilde{\lambda}_t^{MC}$ is the number of major claims occurred in year t calculated as a percentage of $\tilde{\lambda}_t$, $\tilde{Z}_{s,t}^{NC}$ the random amount of the s -th normal claim of year t and $\tilde{Z}_{k,t}^{MC}$ is the random amount of the k -th major claim.

The aggregate claims amount \tilde{X}_t it is assumed to be a compound Poisson process, where $\tilde{\lambda}_t$ is a simple Poisson random variable, with parameter $n_t = n_0(1+g)^t$ increasing by the annual real growth rate, $\tilde{Z}_{s,t}^{NC}$ are i.i.d. random variables with a continuous distribution - having d.f. $S(Z^{NC})$ - assumed each year to be scaled by the inflation rate only, and $\tilde{Z}_{k,t}^{MC}$ are i.i.d. random variables with a continuous distribution scaled each year by the inflation rate too. In addition we suppose that normal and major claims are independent.

Defining

165

$$\tilde{Z}_{i,t} = \tilde{Z}_{s,t}^{NC} + \tilde{Z}_{k,t}^{MC}$$

The following relations are fulfilled

166

$$E(\tilde{Z}_{i,t}^j) = (1+i)^{jt} E(\tilde{Z}_{i,0}^j) = (1+i)^{jt} a_{jZ,0}$$

and with $\tilde{\lambda}_t$ and $\tilde{Z}_{i,t}$ reciprocally independent for each year t .

Under the above mentioned assumptions, the main characteristics of \tilde{X}_t are in force:

167

$$E(\tilde{X}_t) = n_t a_{1Z,t} = n_t m_t = (1+g)^t (1+i)^t E(\tilde{X}_0)$$

168

$$\sigma^2(\tilde{X}_t) = n_t a_{2Z,t} = (n_t m_t)^2 \frac{r_{2Z,t}}{n_t} (1+g)^t (1+i)^{2t} \sigma^2(\tilde{X}_0)$$

169

$$\varphi(\tilde{X}_t) = \frac{1}{\sqrt{n_t}} \frac{a_{3Z,t}}{(a_{2Z,t})^{3/2}} = \frac{1}{\sqrt{n_t}} \frac{r_{3Z,t}}{(r_{2Z,t})^{3/2}} = \frac{1}{\sqrt{(1+g)^t}} \varphi(\tilde{X}_0)$$

where the expected claim size has been denoted by m and whereas $r_{2Z,t}$ and $r_{3Z,t}$ are risk indices of the claim size distribution.

The standard deviation of the aggregate claim amount \tilde{X}_t is rising up according the square root of the expected number of claims of the year.

The skewness of \tilde{X}_t is affected by a ratio depending on the second and third-order moments of the claim size distribution $\tilde{Z}_{i,t}$. In this case the skewness of the aggregate claim amount is always positive and the magnitude is reducing (increasing) time by time only accordingly the positive (negative) real growth rate g .

To be analyzed is usually preferred the risk reserve ratio (relative amount) to the absolute risk reserve amount and its equation is:

170

$$\tilde{u}_t = \frac{\tilde{U}_t}{B_t} = r\tilde{u}_{t-1} + p \left[(1 + \pi) - \frac{\tilde{X}_t}{P_t} \right]$$

With

171

$$r = \frac{1 + j}{(1 + i)(1 + g)} \text{ and } p = \frac{1 - c}{1 + \pi} (1 + j)^{0,5} = \frac{P}{B} (1 + j)^{0,5}$$

Factor p is depending on the incidence of the risk premium by gross premium (P/B), constant if expenses and safety loading coefficients (c and π) are maintained constant along the time, increased of the investment return for half a year.

After some manipulations we can write the ratio as:

172

$$\tilde{u}_t = r^t u_0 + p \left[(1 + \pi) \sum_{h=0}^{t-1} r^h - \sum_{h=1}^t \frac{\tilde{X}_h}{P_h} r^{t-h} \right]$$

where all the pure loss ratios $\frac{\tilde{X}_h}{P_h}$ are independent random variables.

We have to define the moment of the ratio which are easily derived and are equal to:

173

$$E(\tilde{u}_t) = r^t u_0 + \pi p \frac{1 - r^t}{1 - r}$$

174

$$\sigma^2(\tilde{u}_t) = \frac{1 + c_z^2}{n_0(1 + g)^t} p^2 \frac{1 - s^{2t}}{1 - s^2} = \sigma^2(\tilde{u}_0) \frac{1}{(1 + g)^t} \frac{1 - s^{2t}}{1 - s^2}$$

175

$$\begin{aligned} \varphi(\tilde{u}_t) &= - \frac{1}{\sqrt{n_0(1 + g)^t}} \frac{a_{3Z,0}}{(a_{2Z,0})^{\frac{3}{2}}} \frac{1 - w^{3t}/1 - w^3}{\left[1 - s^{2t}/1 - s^2\right]^{\frac{3}{2}}} \\ &= \varphi(\tilde{u}_0) \frac{1}{\sqrt{(1 + g)^t}} \frac{1 - w^{3t}/1 - w^3}{\left[1 - s^{2t}/1 - s^2\right]^{\frac{3}{2}}} \end{aligned}$$

Having denoted by s^2 and w^3 the synthetic factors:

176

$$s^2 = (1 + g)r^2 = \frac{(1 + j)^2}{(1 + g)(1 + i)^2}$$

$$w^3 = (1 + g)^2 r^3 = \frac{(1 + j)^3}{(1 + g)(1 + i)^3}$$

These formulas are right only if s, r and $w \neq 1$, otherwise they are quite different.

It is worth to emphasize $E(\tilde{u}_t)$ initially depends significantly on the initial ratio u_0 (by the factor r^t) but in case $r < 1$ its dominance is shortly decreasing in favour of the second addendum, where the safety loading coefficient π is playing a key role. Besides, the dimension n of the Insurer is not affecting the expected level of the capital ratio U/B ; actually n is affecting both risk reserve U and premiums volume B but according the same proportion and then the expected ratio is independent from the number of policies in force.

If $r < 1$, a finite convergence level of the expected ratio is obtained, and it is known as “equilibrium level”:

$$\bar{u} = \lim_{t \rightarrow \infty} E(\tilde{u}_t) = \frac{\pi p}{1 - r}$$

It's clear that the dimension n and the initial value u_0 do not contribute to the equilibrium level \bar{u} . Whether that equilibrium level is either improving or not over the initial value u_0 is depending on the input parameters π , c and r , whereas higher safety loading and investment return clearly drive up the equilibrium level while higher expenses, real growth and inflation depress it.

The standard deviation of the capital ratio U/B is initially increasing until a maximum point and then decreasing to zero and its value is affected also by the ratio p so that higher premium loadings will slightly reduce the variability of ratio U/B .

The reason relies on the fact that deviations of the total claim amount X have a minor impact on the gross premium volume if the magnitude of risk premiums – expected value of X - is less meaningful. It is worth to note that the coefficient of variation c_z is a key figure on the measure of the deviation of U/B , whereas the expected claim size m is not present at all. Clearly, a larger portfolio is increasing the standard deviation of the risk reserve amount U but, on the other hand, it is reducing the variability of the ratio U/B

The skewness is split in three factors: the first one related to number of policies and its rate of growth, the second to the claim size distribution and the third one to the combination of real growth, inflation and investment return.

As the time horizon is extended, the skewness of U/B is decreasing from a negative initial value to zero, representing a trend to a symmetric behavior of the U/B for the Central Limit Theorem.

9.2 CAPITAL REQUIREMENTS OVER DIFFERENT TIME HORIZONS

As in Chapter 7, normal claim is modeled with a Log Normal distribution while major claim with a Pareto.

It's important to say that the relations showed in the previous section are not completely useful here, with the exception of the mean, due to the lack of moments major of first of the Pareto distributions.

We start the analysis reminding the data of the company in the following table.

Data	MVL	MVC	Liability	Property	Total Business
Expected number of claims	58 333.33	166 666.70	6 250.00	7 500.00	
Expected number of normal claims	58 269.16	166 652.13	6 248.44	7 499.25	
Expected number of major claims	64.17	14.54	1.56	0.75	
$VK_{p,i}$	3.50%	3.50%	3.50%	5%	
Variation coefficient of normal claims	7	2.5	8	5	
Expected claim size of normal claims	4 388 CHF	1 099.17 CHF	16 202.62 CHF	19 601.95 CHF	
β threshold between normal and major claims	1mln CHF	10mln CHF	1mln CHF	1mln CHF	
Parameter α of Pareto distribution	2.5	1.85	1.8	1.4	
Truncation point of the Pareto distribution		1500mln CHF			
Market Share		10%			
Expected claim size of major claims	1.67mln CHF	21.46mln CHF	2.25mln CHF	3.5mln CHF	
Initial Gross Premium	413.49 mln CHF	312.52mln CHF	125.01mln CHF	192.32mln CHF	1 043.34mln CHF
safety loading coefficient	1.14%	1.09%	3.3%	4.35%	2.32%
c expenses coefficient	10.84%	17.22%	12.59%	18.41%	14.36%
Initial Risk Premium	368.65mln CHF	258.71mln CHF	109.27mln CHF	156.91mln CHF	893.54mln CHF

Table 122: Company's data used in the analysis.

The risk loading coefficient is kept constant over the full time horizon and it is initially computed according to the standard deviation premium principle for the initial portfolio structure as follows:

$$\pi E(\tilde{X}) = \beta \sigma(\tilde{X})$$

By placing β equal to 0.28.

After that it's derived c , the expenses loading coefficient:

$$\beta = \pi P + P + c\beta$$

$$c = \frac{\beta - \pi P - P}{\beta}$$

In addition are defined:

g, Real growth rate	i, Claim inflation	j, Investment return rate
5.00%	3.00%	4.00%

Table 123: Real growth rate, claim inflation and investment return rate.

Company OMEGA is multi-line , because we are interested in in the Total Business we must introduce the correlation between LoBs, to succeed in this a “Gaussian Copula” is here used.

A copula is used as a general way of formulating a multivariate distribution in such a way that various general types of dependence can be represented. The approach to formulating a multivariate distribution using a copula is based on the idea that a simple transformation can be made of each marginal variable in such a way that each transformed marginal variable has a uniform distribution. Once this is done, the dependence structure can be expressed as a multivariate distribution on the obtained uniforms, and a copula is precisely a multivariate distribution on marginally uniform random variables. When applied in a practical context, the above transformations might be fitted as an initial step for each marginal distribution, or the parameters of the transformations might be fitted jointly with those of the copula. There are many families of copulas which differ in the detail of the dependence they represent. A family will

typically have several parameters which relate to the strength and form of the dependence.

One example of a copula often used is the Gaussian copula which is constructed from the bivariate normal distribution via Sklar's theorem⁵⁹ with Φ_ρ being the standard bivariate normal cumulative distribution function with correlation ρ , the Gaussian copula function is:

182

$$C_\rho(u, v) = \Phi_\rho(\Phi^{-1}(u), \Phi^{-1}(v))$$

Where $u, v \in [0,1]$ and Φ denotes the standard normal cumulative distribution function.

Differentiating C yields the copula density function:

183

$$c_\rho(u, v) = \frac{\varphi_{X,Y,\rho}(\Phi^{-1}(u), \Phi^{-1}(v))}{\varphi(\Phi^{-1}(u))\varphi(\Phi^{-1}(v))}$$

Where:

184

$$\varphi_{X,Y,\rho}(x, y) = \frac{1}{2\pi\sqrt{1-\rho^2}} \exp\left(-\frac{1}{2(1-\rho^2)}[x^2 + y^2 - 2\rho xy]\right)$$

is the density function for the standard bivariate Gaussian with Pearson's product moment correlation coefficient ρ and ϕ is the standard normal density.

Having introduced the "Gaussian Copula" and defining ρ equal to the correlation matrix of the Swiss Solvency Test are below summarized the simulations results of the risk reserve ratio. The analysis of the risk reserve is very useful to calculate the capital requirement over different time horizons.

⁵⁹ Ludger Rüschendorf, "On the distributional transform, Sklar's Theorem, and the empirical copula process", <http://www.stochastik.uni-freiburg.de/>.

In the following we will suppose to be in $t=0$ with a risk reserve ratio equal to zero and we will calculate the capital requirements for 1, 2, 3, 4 and 5 years.

To do this we must introduce the concept of U_{req} which is the minimum risk-based capital (possibly required by either regulators and/or legislation) in order to be still in a solvency state after t years since the valuation date $U_t > 0$ within a given $1-\epsilon$ confidence level. In practice this measure should fulfill the following equation:

185

$$(1 + j)^t * U_{Req}(0, t) = -U_\epsilon(t)$$

where U_ϵ is always the ϵ -th order quantile of the risk reserve distribution in year t .

The amount $U_{Req}(0, t)$ is then the minimum capital to be required as a buffer to ensure that maximum losses accumulated by the insurer until year t (within a $1-\epsilon$ confidence level) can be offset and a solvency state still maintained. For supervisory purposes the time horizon t is mostly included between 1 and 2 years.

The result of 200 000 simulations are reported below:

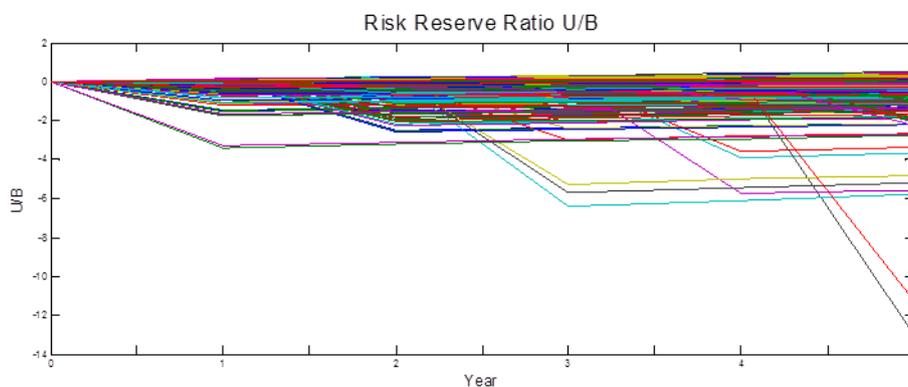


Figure 62: Results of 200 000 simulations of U/B.

A possible shortfall in this approach is that a simple quantile of the U/B probability distribution at year t (partly) disregards the state of the simulation paths in the previous years ($1, 2, \dots, t-1$). For instance, it occurs when the simulation paths of ratio U/B are partly negative at time $t-1$ and afterwards all of them are positive at the next time point t , from which a favourable quantile U_ϵ (positive and rather large) is drawn up for year t ; and

consequently no minimum capital might be required if the time horizon is fixed at year t , notwithstanding the probability to be in state of ruin at year $t-1$ is not zero. In the next table are reported the value of $U_{Req}/B(0)$ using a $TVaR_{99\%}$ risk measure.

Year	$U_{Req}/B(0)$
1	19.02% ⁶⁰
2	27.69%
3	33.68%
4	38.78%
5	43.91%

Table 124: $U_{req}/B(0)$ over different time horizons.

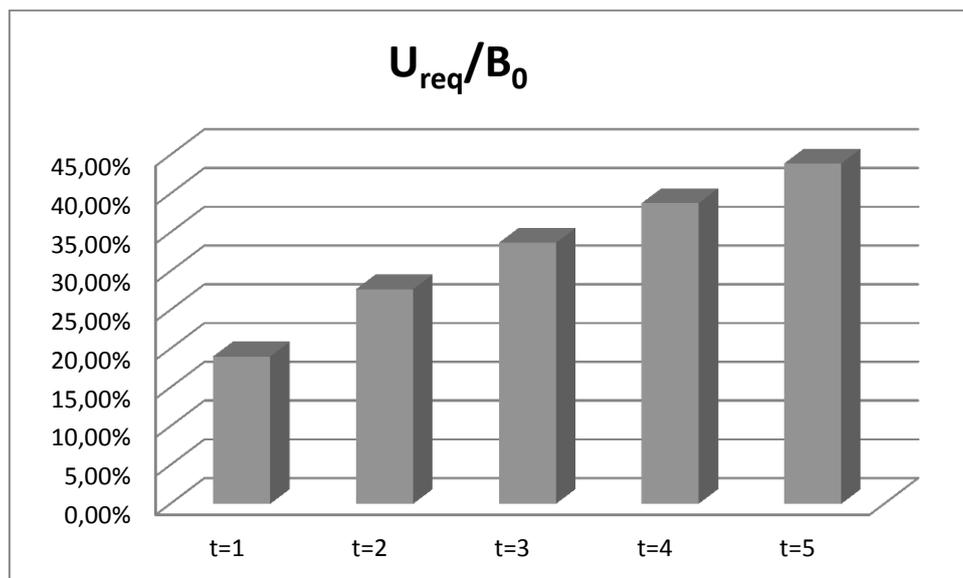


Figure 63: Comparison between u_{req} over different time horizons.

it means that no to be in ruin state during year 1 the company must have a U_0 equal to 19.02% of the premiums income, not to be in ruin state during year 2 it must have U_0 equal to 27.69% of the written premiums and so on. Focusing our attention to the amount of capital needed to be still in a solvency state at year t (within a given confidence

⁶⁰ This value differs from the internal model's RBC ratio found in Chapter 7. This difference is only due to the calculation method. In Chapter 7 we have aggregated, using the SST correlation matrix, the capital requirements calculated for each line of business stands alone while here we have derived the total business claims amount, using "Gaussian Copula", and then we have calculated the RBC.

interval, denoted by $U_{\text{Req}}(0,t)$ and by the ratio $u_{\text{Req}}(0,t)$ if that required amount is divided by the initial gross premiums volume.

The results for our insurer (see table 124 and figure 63) show how this measure is high sensitive to time horizon.

We will introduce, in the next section, some risk measures in order to make sensible comparisons.

9.2.1 MEASURES OF RISK IN INSURANCE SOLVENCY ANALYSIS

First of all we define the “probability to be in ruin state at year t ” irrespective of the (ruin or not ruin) state at previous years.

Given the initial capital $U_0=U$ and defining the state of ruin when the Risk Reserve is negative, the probability mentioned above is:

186

$$\varphi(U; t) = Pr\{(U_t < 0 \mid U_0 = U)\}$$

The “finite time ruin probability” in the time span $(0,T)$ is the probability to be in ruin state at least in one of the time points $0,1,2,\dots,T-1,T$:

187

$$\psi(U; T) = Pr\{\tilde{U}_t < 0 \text{ for at least one } t = 1,2, \dots, T \mid U_0 = U\}$$

And consequently the survival probability is:

188

$$\phi(U; T) = 1 - \psi(U; T) = Pr\{\tilde{U}_t \geq 0 \text{ for each } t = 1,2, \dots, T \mid U_0 = U\}$$

Finally, the “one-year ruin probability” $\psi(U; T - 1, T)$ is the probability to fail in a ruin state for the first time at the time point t , having been in a no-ruin state for all the previous years:

189

$$\psi(U; T - 1, T) = Pr\{\tilde{U}_T < 0 \text{ and } U_h \geq 0 \text{ for } h = 1, 2, \dots, T - 1\}$$

It can also be derived from the “finite time ruin probabilities” by the relation:

190

$$1 - \psi(U; T) = [1 - \psi(U; T - 1)] = [1 - \psi(U; T - 1, T)]$$

From which the “one year ruin probability” is easily obtained:

191

$$\psi(U; T - 1, T) = 1 - \frac{1 - \psi(U; T)}{1 - \psi(U; T - 1)}$$

In case that the ruin barrier is otherwise defined, the mentioned ruin probabilities will be consequently modified.

In the following table different ruin probabilities are reported considering as ruin barrier $U_{\text{ruin}}=0$.

$U_0=U_{\text{req}}(0,1)$			
Year	One-Year Ruin Prob.	Annual Ruin Prob.	Finite Time Ruin Prob.
1	0.16%	0.16%	0.16%
2	0.28%	0.40%	0.44%
3	0.21%	0.48%	0.65%
4	0.18%	0.52%	0.82%
5	0.14%	0.51%	0.96%

Table 125: Different risk measures under $U_0=U_{\text{req}}(0,1)$.

$U_0=U_{req}(0,2)$			
Year	One-Year Ruin Prob.	Annual Ruin Prob	Finite Time Ruin Prob.
1	0.06%	0.06%	0.06%
2	0.08%	0.14%	0.14%
3	0.08%	0.19%	0.22%
4	0.07%	0.23%	0.29%
5	0.05%	0.24%	0.34%

Table 126: Different risk measures under $U_0=U_{req}(0,2)$.

$U_0=U_{req}(0,3)$			
Year	One-Year Ruin Prob.	Annual Ruin Prob	Finite Time Ruin Prob.
1	0.05%	0.05%	0.05%
2	0.05%	0.09%	0.10%
3	0.05%	0.13%	0.15%
4	0.04%	0.15%	0.18%
5	0.03%	0.16%	0.22%

Table 127: Different risk measures under $U_0=U_{req}(0,3)$.

$U_0=U_{req}(0,4)$			
Year	One-Year Ruin Prob.	Annual Ruin Prob	Finite Time Ruin Prob.
1	0.04%	0.04%	0.04%
2	0.04%	0.08%	0.08%
3	0.03%	0.11%	0.12%
4	0.03%	0.12%	0.15%
5	0.03%	0.14%	0.17%

Table 128: Different risk measures under $U_0=U_{req}(0,4)$.

$U_0=U_{req}(0,5)$			
Year	One-Year Ruin Prob.	Annual Ruin Prob	Finite Time Ruin Prob.
1	0.03%	0.03%	0.03%
2	0.03%	0.07%	0.07%
3	0.03%	0.09%	0.10%
4	0.02%	0.10%	0.12%
5	0.02%	0.11%	0.14%

Table 129 Different risk measures under $U_0=U_{req}(0,5)$.

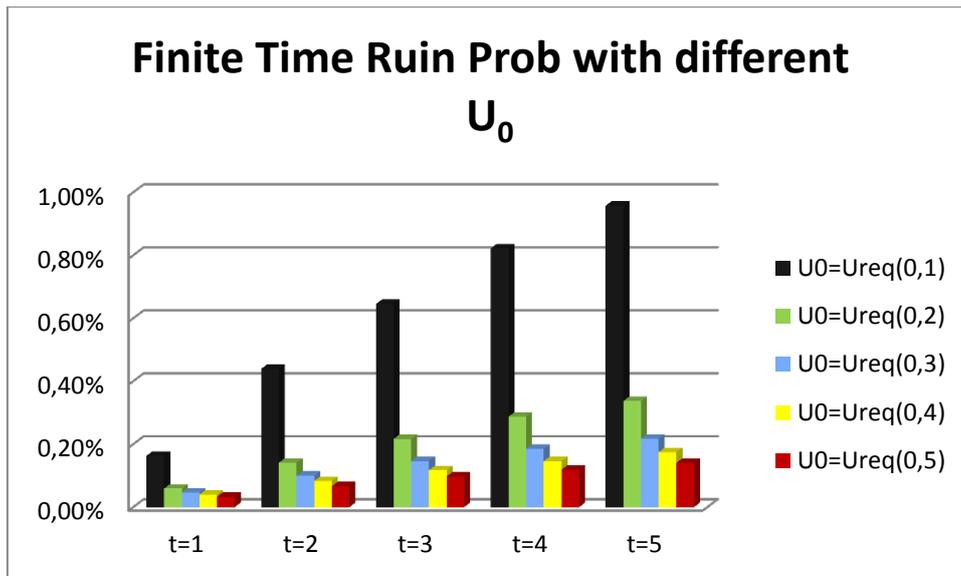


Figure 64: Comparison between Finite Time Ruin Probabilities under different level of U_0 .

Observing the four tables and the graph above it's clear that the policy holders would be more protected if $U_0 = U_{Req}(0,5)$ in fact the different risk measures are lower than under the other hypotheses.

If $U_0 = U_{Req}(0,5)$ the finite time ruin probability goes from 0.03% in $t=1$ to 0.14% in $t=5$, the annual ruin probability from 0.03% in $t=1$ to 0.11% in $t=5$ and the one year ruin probability from 0.02% in $t=4,5$ to 0.03% in $t=1,2,3$.

In the following table are compared the finite time ruin probabilities starting from a risk reserve equal to $U_0 = U_{req}(0, t)$ in year t .

Finite Time Ruin Probability					
Year	$U_0=U_{req}(0,1)$	$U_0=U_{req}(0,2)$	$U_0=U_{req}(0,3)$	$U_0=U_{req}(0,4)$	$U_0=U_{req}(0,5)$
1	0.16%				
2		0.14%			
3			0.15%		
4				0.15%	
5					0.14%

Table 130: Comparison between Finite Time Ruin Probabilities under different level of U_0 .

As expected the probabilities shown above are very close, but might seem strange that they are so low, because we expect their values near to 0.5%

In reality this is completely due to the long tails of the major claim Pareto distributions. Their great variability pushes the $\text{TVaR}_{99\%}$ far beyond $\text{VaR}_{99.5\%}$. If we recalculate the U_{Req} using a $\text{VaR}_{99.5\%}$ risk measure we obtain the following results:

Year	$U_{Req}/B(0)$
1	14.96%
2	21.01%
3	24.94%
4	28.65%
5	31.91%

Table 131: $U_{Req}/B(0)$ over different time horizons using a $\text{VaR}_{99.5\%}$ risk measure.

Year	Finite Time Ruin Probability				
	$U_0=U_{req}(0,1)$	$U_0=U_{req}(0,2)$	$U_0=U_{req}(0,3)$	$U_0=U_{req}(0,4)$	$U_0=U_{req}(0,5)$
1	0.34%				
2		0.33%			
3			0.33%		
4				0.32%	
5					0.31%

Table 132: Comparison between Finite Time Ruin Probabilities under different level of U_0 using a $\text{VaR}_{99.5\%}$ risk measure.

These finite time ruin probabilities are consistent with the risk measure used.

In the following we will introduce some measures of performance.

9.2.2 MEASURES OF PERFORMANCE

One of the most famous measures of performance is the expected Return on Equity (RoE).

Let denote with $\bar{R}(0, T)$ the expected RoE all over the full time horizon $(0, T)$. Here we assumed that no dividends are present, and so it will be equal to:

192

$$\bar{R}(0, T) = E \left(\frac{\tilde{U}_T - U_0}{U_0} \right) = (1 + g)^T (1 + i)^T \frac{E(\tilde{u}_t)}{u_0} - 1$$

In case the joint factor r is less than 1 another relevant expression that may be used is:

193

$$\bar{R}(0, T) = (1 + g)^T (1 + i)^T \left[r^T + (1 - r^T) \frac{\bar{u}}{u_0} \right] - 1$$

Once the finite-time expected RoE is computed we can also derive the expected forward rate $Rfw(T-1, T)$ from the recursive equation:

194

$$[1 + \bar{R}(0, T - 1)][1 + \bar{R}fw(T - 1, T)] = 1 + \bar{R}(0, T)$$

from which (being no dividends assumed), the following rate (gross of taxation) is obtained:

195

$$\begin{aligned} \bar{R}fw(T - 1, T) &= \frac{1 + \bar{R}(0, T)}{1 + \bar{R}(0, T - 1)} - 1 = (1 + g)(1 + i) \frac{E(\tilde{u}_t)}{E(\tilde{u}_{t-1})} - 1 \\ &= j + \pi p \frac{(1 + g)(1 + i)}{E(\tilde{u}_{t-1})} \end{aligned}$$

the expected forward return will be monotonically decreasing if, as usual, the expected value of the ratio U/B is constantly rising up (here dividends to shareholders or fresh new capital are disregarded).

Another useful way is to present $Rfw(T-1, T)$ as function of either the initial capital ratio and the equilibrium level, as in the next formula:

196

$$\bar{R}fw(T - 1, T) = j + \pi p \frac{(1 + g)(1 + i)}{E(\tilde{u}_{t-1})} =$$

$$= j + \left(\frac{(1 + g)(1 + i) - (1 + j)}{1 + r^{T-1} \left(\frac{u_0}{\bar{u}} - 1 \right)} \right)$$

It shows clearly as the expected forward RoE is only depending on the next six market and insurer no-dimensional parameters:

- initial capital (by u_0);
- safety loading (by π);
- expenses loading (by the presence of c in the parameter p);
- real growth (by g);
- claim inflation (by i);
- investment return (by j).

Furthermore, a strong relationship between return and capital for a general insurer is included.

If $r < 1$ the expected forward annual return has a limit for the time going to infinity only depending on the real growth and the claim inflation:

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$$\bar{R} = \lim_{t \rightarrow \infty} \bar{R}fw(T-1, T) = (1 + g)(1 + i) - 1$$

In case the monotony of expected value of the capital ratio U/B is fulfilled then the monotony of the expected annual return is assured too.

In practice, if the starting value of the capital ratio is higher (lower) than the equilibrium level then the expected annual forward RoE will be monotonically increasing (decreasing) until its limit value:

$$\text{if } u_0 > \bar{u}$$

$$\bar{R}fw(T-1, T) \text{ monotonically increasing to } (1 + g)(1 + i) - 1$$

$$\text{if } u_0 < \bar{u}$$

$$\bar{R}fw(T-1, T) \text{ monotonically decreasing to } (1 + g)(1 + i) - 1$$

This relation displays the strong relation between capital and return and the key role of the capital ratio available at the valuation time:

1. if $u_0 > \bar{u}$ the insurer would expect an increasing annual forward RoE for the next years until the upper limit \bar{R} . Meanwhile, a depressed capital ratio u_t will be expected along the time, towards the bottom limit \bar{u} (represented by the equilibrium level), and consequently a larger risk of ruin will be likely in force year by year reminding also the rising variability of the time process;
2. if the insurer has available only an initial capital ratio $u_0 < \bar{u}$, the annual forward RoE will be expected to be decreasing in the time horizon until the lower limit \bar{R} . On the other hand, the capital ratio u_t will be expected to increase until the upper limit \bar{u} and consequently it might reduce its risk of ruin year by year in case this increase were sufficient to offset the rising variability of the process over the time.

In the next tables are contained the $\bar{R}(0, T)$ and $\bar{R}fw(T - 1, T)$ depending on the initial risk reserve.

U ₀ =U _{req} (0,1)		
Year	R(0,T)	Rfw
1	14.39%	14.39%
2	30.21%	13.83%
3	47.58%	13.34%
4	66.63%	12.91%
5	87.51%	12.53%

Table 133: Expected return on equity and expected forward return with U₀=U_{req}(0,1).

U ₀ =U _{req} (0,2)		
Year	R(0,T)	Rfw
1	11.14%	11.14%
2	23.31%	10.95%
3	36.59%	10.77%
4	51.08%	10.61%
5	66.89%	10.46%

Table 134: Expected return on equity and expected forward return with U₀=U_{req}(0,2).

U ₀ =U _{req} (0,3)		
Year	R(0,T)	Rfw
1	9.87%	9.87%
2	20.61%	9.78%
3	32.30%	9.69%
4	45.02%	9.61%
5	58.85%	9.54%

Table 135: Expected return on equity and expected forward return with U₀=U_{req}(0,3).

U ₀ =U _{req} (0,4)		
Year	R(0,T)	Rfw
1	9.10%	9.10%
2	18.97%	9.05%
3	29.69%	9.01%
4	41.33%	8.97%
5	53.95%	8.93%

Table 136: Expected return on equity and expected forward return with U₀=U_{req}(0,4).

U ₀ =U _{req} (0,5)		
Year	R(0,T)	Rfw
1	8.50%	8.50%
2	17.71%	8.49%
3	27.68%	8.47%
4	38.49%	8.46%
5	50.18%	8.45%

Table 137: Expected return on equity and expected forward return with U₀=U_{req}(0,5).

First of all in each case analyzed $u_0 < \bar{u} = \lim_{t \rightarrow \infty} E(\tilde{u}_t) = \frac{\pi p}{1-r} = 51.51\%$, this implies that $\bar{R}fw(T-1, T)$ is monotonically decreasing to $(1+g)(1+i) - 1 = 8.15\%$. that condition is always verified in the tables above.

Secondly increasing the initial risk reserve the expected Return on Equity and the expected forward rate decrease. This is a crucial aspect for the company point of view and for the shareholders which are interested in the profitability of the insurance.

The following graphs are helpful in the comparison between the profitability of the company (shareholders and company) and the risk measures (company, shareholders and policyholders).

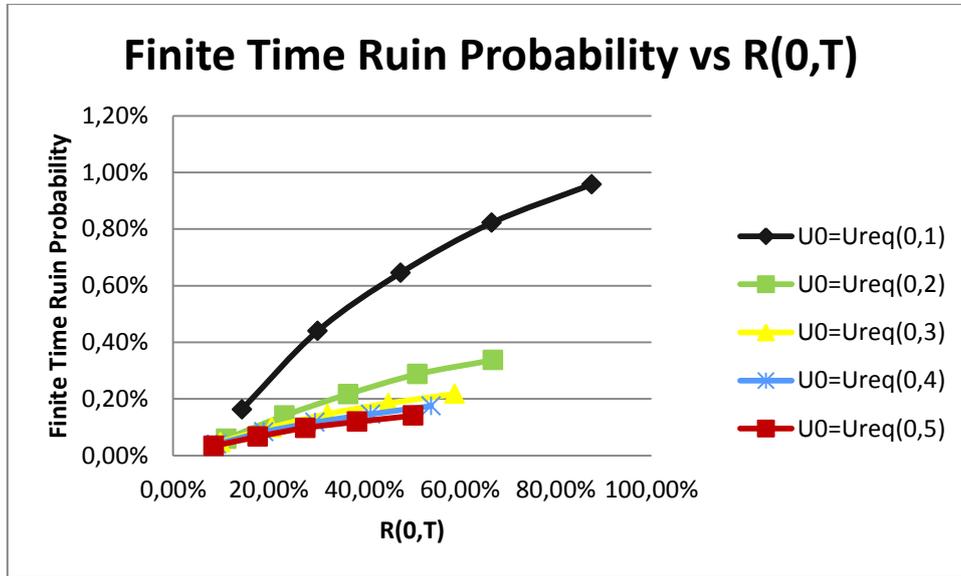


Figure 65: Comparison between Finite Time Ruin probability and expected return on equity.

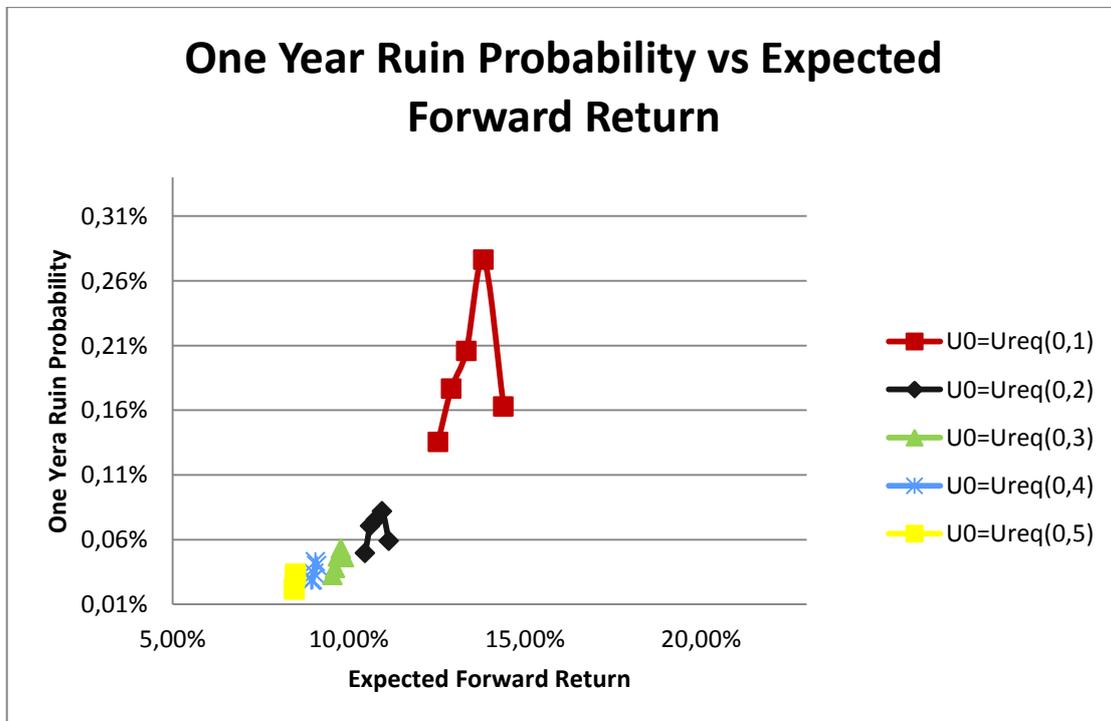


Figure 66: Comparison between One Year Ruin probability and expected forward return.

It's clear that there's a straight relationship, as obvious, between risk and return: increasing the risk the return becomes higher.

This is another problem that insurance regulators must face to find the right risk-return trade-off. This crucial aspect is very important, because the "solvency requirements" should protect policyholders who are risk averse and under this point of view the regulators would chose a time horizon of 5 years, where the ruin probabilities are lower.

On the other hand it's not possible to oblige insurance companies to hold to much capital, the returns would be crashed and the attractiveness of the company on the market share would be reduced.

As said before, for supervisory purposes the time horizon t is mostly included between 1 and 2 years. Just start a more accurate analysis under $U_0 = U_{req}(0,2)$, so with a time horizon of 2 years.

9.3 CAPITAL REQUIREMENT OVER A TWO YEARS TIME HORIZON

The following data are useful:

Data	MVL	MVC	Liability	Property	Total Business
Expected number of claims	58 333.33	166 666.70	6 250.00	7 500.00	
Expected number of normal claims	58 269.16	166 652.13	6 248.44	7 499.25	
Expected number of major claims	64.17	14.54	1.56	0.75	
$VK_{p,i}$	3.50%	3.50%	3.50%	5%	
Variation coefficient of normal claims	7	2.5	8	5	
Expected claim size of normal claims	4 388 CHF	1 099.17 CHF	16 202.62 CHF	19 601.95 CHF	
β threshold between normal and major claims	1mln CHF	10mln CHF	1mln CHF	1mln CHF	
Parameter α of Pareto distribution	2.5	1.85	1.8	1.4	
Truncation point of the Pareto distribution		1500mln CHF			
Market Share		10%			
Expected claim size of major claims	1.67mln CHF	21.46mln CHF	2.25mln CHF	3.5mln CHF	
Initial Gross Premium	413.49 mln CHF	312.52mln CHF	125.01mln CHF	192.32mln CHF	1 043.34mln CHF
safety loading coefficient	1.14%	1.09%	3.3%	4.35%	2.32%
c expenses coefficient	10.84%	17.22%	12.59%	18.41%	14.36%
Initial Risk Premium	368.65mln CHF	258.71mln CHF	109.27mln CHF	156.91mln CHF	893.54mln CHF
Initial Risk Reserve Ratio					27.69%

Table 138: Company's data used in the analysis.

The result of 200 000 simulations are reported below:

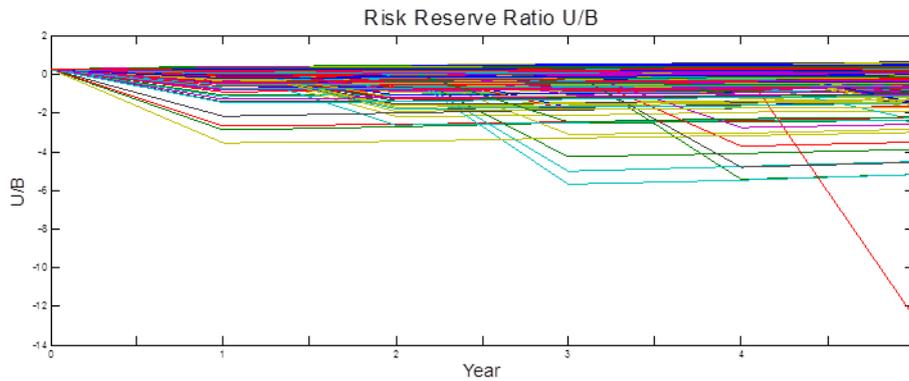


Figure 67: Results of 200 000 simulations of U/B.

Year	U/B		X/P	
	Mean	Standard deviation	Mean	Standard deviation
1	28.22%	4.42%	98.02%	5.48%
2	28.90%	6.20%	97.81%	5.62%
3	30.12%	7.48%	97.10%	5.62%
4	31.59%	8.43%	96.73%	5.45%
5	33.22%	9.48%	96.48%	6.11%

Table 139: Mean and standard deviation of U/B and X/P.

Using the formulas presented in the chapter's beginning and 0.0023 as variance of U_0 ⁶¹, the following graph explains the standard deviation and mean trends of U/B.

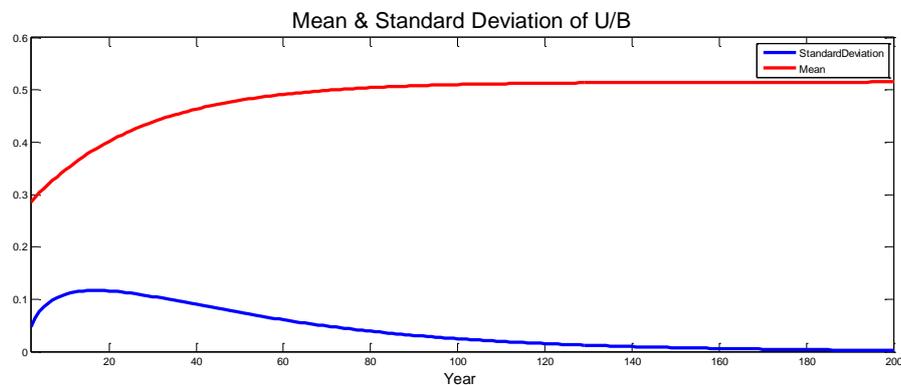


Figure 68: Mean and standard deviation of U/B over a 200 years time horizon.

⁶¹ Due to the lack of Pareto's moment is put equal to the simulation value of the Claims Amount in $t=0$.

As it's clear from the graph below the mean of U/B is monotonically increasing to the equilibrium level (51.51%) while the standard deviation of U/B increases and reaches its maximum value in T=16 and then decreases toward 0.

Percentiles of U/B						
Year	Mean	1.00%	5.00%	Median	95%	99.00%
0	27.69%					
1	28.22%	16.49%	21.50%	28.63%	33.81%	35.72%
2	28.90%	12.64%	19.34%	29.44%	36.99%	39.78%
3	30.12%	11.66%	18.99%	30.67%	39.83%	43.34%
4	31.59%	11.35%	19.10%	32.17%	42.62%	46.61%
5	33.22%	11.44%	19.67%	33.81%	45.34%	49.80%

Table 140: Mean and percentiles of U/B.

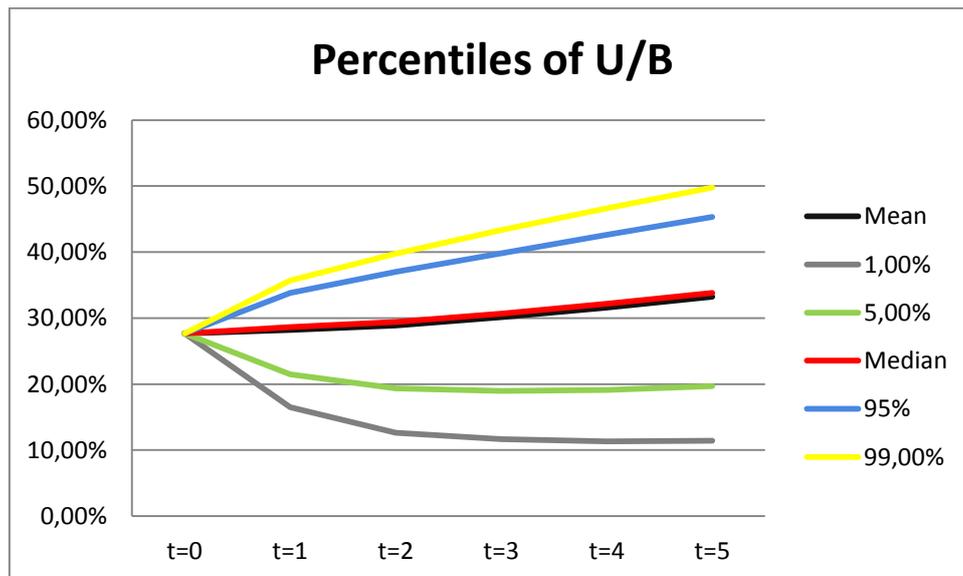


Figure 69: Mean and percentiles of U/B.

In practice, the mean value of the solvency ratio U/B is increasing from an initial level of 27.69% to 33.22% at year t=5 and accordingly the standard deviation of the ratio is more than doubled, increasing from 4.42% of year 1 to 9.48% of year 5. The combined effect of a rising mean value and a larger variability makes the annual ruin probability at year t monotonically increasing from 0.06% of year 1 to 0.24% of year 5.

As illustrated in Figure 67, the worst case among the 200.000 simulation paths is given by the catastrophic event of a risk reserve amount equals to -3.74 times the premiums volume at year 1 and to approximately -13.56 times in year 5.

Percentiles of X/P						
Year	Mean	1.00%	5.00%	Median	95%	99.00%
1	98.02%	88.70%	91.08%	98%	106.36%	112.59%
2	97.81%	88.39%	90.82%	97.23%	106.52%	113.42%
3	97.10%	88.15%	90.46%	96.67%	104.95%	110.64%
4	96.73%	87.70%	90.09%	96.30%	104.59%	110.45%
5	96.48%	87.58%	89.90%	96.06%	104.15%	109.77%

Table 141: Mean and percentiles of X/P.

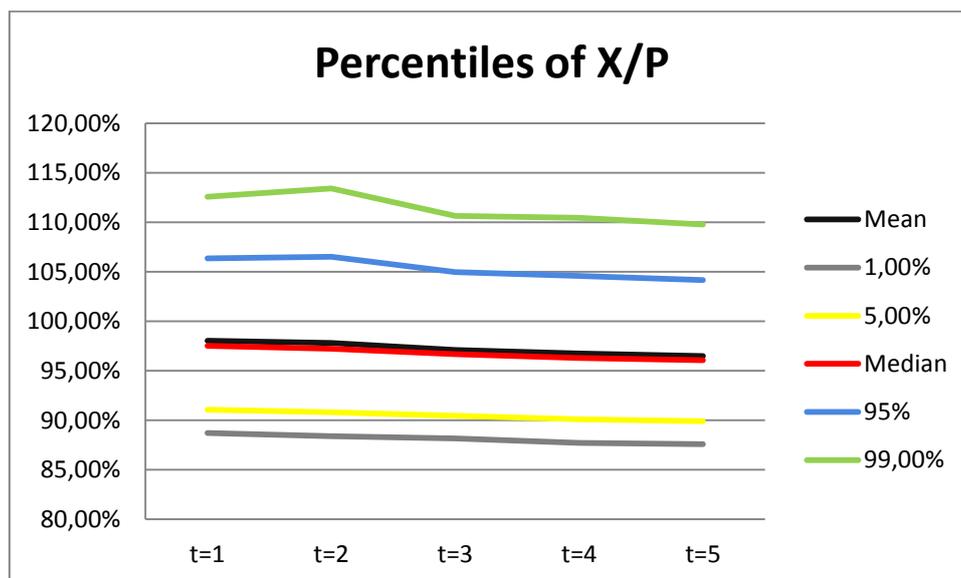


Figure 70: Mean and percentiles of X/P.

$U_0=U_{req}(0,2)$			
Year	One-Year Ruin Prob.	Annual Ruin Prob	Finite Time Ruin Prob.
1	0.06%	0.06%	0.06%
2	0.08%	0.14%	0.14%
3	0.08%	0.19%	0.22%
4	0.07%	0.23%	0.29%
5	0.05%	0.24%	0.34%

Table 142: One year ruin probabilities, annual ruin probabilities and finite time ruin probabilities.

Table 141 shows the percentiles of the loss ratio X/P : there's a 50% probability to obtain loss ratios major than 98% in $t=1$, 97.23% in $t=2$, 96.67% in $t=3$, 96.30% in $t=4$ and 96.06% in $t=5$ or a 98% probability to get loss ratios between 88.7% and 112.59% approximately in $t=1$ and so on.. It is worth noting that in figure 70 each percentile line is rather stable (slightly declining) because the structure of the insurer's portfolio is not modified along the years (e.g. the claim distribution is only rescaled every year).

Year	$U_0=U_{req}(0,2)$	
	R(0,T)	Rfw
1	11.14%	11.14%
2	23.31%	10.95%
3	36.59%	10.77%
4	51.08%	10.61%
5	66.89%	10.46%

Table 143: Expected return on equity and expected forward rate.

Table 143 summarizes $R(0,T)$ and $\bar{R}fw(T-1, T)$, our initial capital ratio u_0 is lower than the equilibrium level \bar{u} , for this reason we expect that $\bar{R}fw(T-1, T)$ is decreasing, as it is, while u_t is increasing.

On a 1-year time horizon the simulated scenario for our Insurer is rather promising as regards solvency (table 142), with a rather small probability at 0.06% (equivalent to a survival probability of 99,94%) to become ruined ($U < 0$).

On an extended time horizon $(0,T)$ the survival probability is clearly slightly decreasing as the required time horizon is larger: 99.86% during the second year, 99.78% during the third, 99.71% during the fourth and 99.66% during the fifth.

All these survival probabilities are affected by the variability of the stochastic process defined by the risk reserve amount U depending by the variance of the aggregate amount of claims (X) or equivalently by the variance of the loss ratio (X/B). With regards to profitability we can only observe that the expected value of the ratio U/B is rising from 27.69% in $T=0$ to 33.22% in $T=5$ and the expected forward rate of RoE is decreasing from 11.14% in $T=1$ to 10.46% in $T=5$.

The risk theoretical model described, is simpler than the model which reflects the real insurance world. This kind of approach is useful in order to understand better the implications of capital requirements over different time horizons.

CONCLUSIONS

In this paper we have reviewed the principal solvency standards around the world. First of all we have introduced the US “Risk-Based Capital” (Chapter 1) with its FAST system, then the Canadian “Minimum Capital Test” and the “Dynamic Solvency Testing” (Chapter 2), in Chapter 3 we have explained the APRA “Prudential Standards” and in Chapter 4 we have analyzed the solvency in United Kingdom characterized by the ECR, Individual capital assessment and Individual capital guidance.

In Chapter 5 the new European solvency is explained, starting from the first directives, passing through “Solvency I” till the “Quantitative Impact Studies” of “Solvency II”.

Chapters 6, 7, 8 and 9 are the paper’s core.

The “Swiss Solvency Test” is illustrated in Chapter 6 and Chapter 7 focuses on the “Non-Life Swiss Solvency Test” emphasizing the crucial aspects.

In Chapter 8 we have calculated different capital requirements. In the first part we have applied the SST standard model to different Insurances (from the biggest to the smallest: OMEGA, ALFA, BETA, GAMMA) in order to understand the effect of the size company on the RBC:

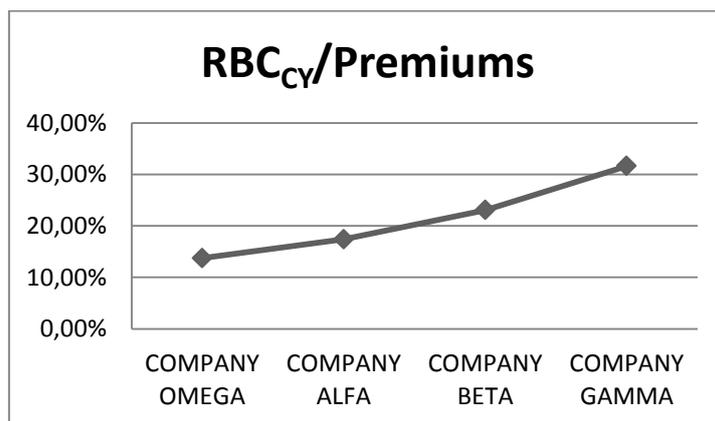


Figure 71: Capital requirements depending on company size.

The figure above underlines that the SST standard model comprises a size factor: increasing the size of the company the percentage of premiums locked in capital requirements decreases.

Then we have tried to underline one of the most important aspects of the SST: the Market Value Margin.

To do this, considering only company OMEGA, we have moved from $t=0$ in $t=1$ making some assumptions concerning the growth of the portfolio, the claim inflation, the payout-pattern of the claims and the future required regulatory capitals $RBC(t)$ at time t . In particular we have assumed that the future required regulatory capitals at time t ($RBC_{reserve}(t)$) are proportional to the Reserve Amount, which is a simplification of the reality.

The results are:

Premium	1 128.37mln CHF
RBC _{py}	6.00%
RBC _{CY(NC)}	7.67%
RBC _{CY(NC)&PY}	9.60%
RBC _{CY(NC & MC)}	13.12%
RBC _{CY & PY}	14.24%
MVM	0.46%
Target Capital	14.70%

Table 144: Different RBCs divided by premiums.

The MVM represents more or less 3% of the Target Capital.

We have then developed, concerning company OMEGA, an “Inter Internal Model” and two “Partial Internal Models” using a simulation method. In “Internal Model” we have supposed that the number of claims has a Poisson distribution, the normal claim size has a Log Normal distribution while the major claim size has a Pareto distribution. In “Partial Internal Model I” we have used the SST standard model for normal claims and an “Internal Model” for major claims supposing the number of major claims has a Poisson distribution and the major claim size has a Pareto distribution. In “Partial Internal Model II” we have used the SST standard model to model the major claims and an “Internal model” for normal claims supposing the number of normal claims has a Poisson distribution and the normal claim size has a Log Normal distribution. The results of these four approaches are:

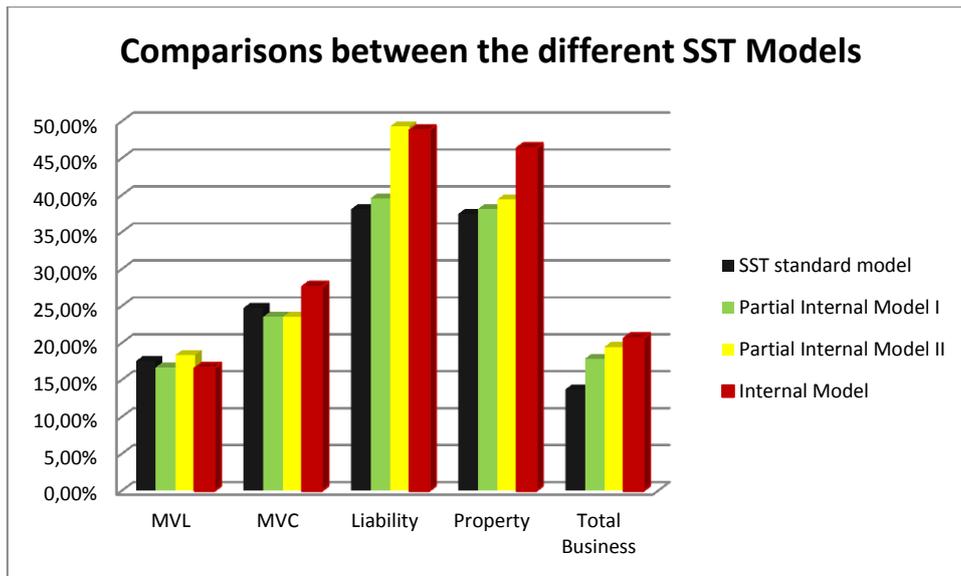


Figure 72: Comparisons between the RBCs of the different SST models.

For each line of business the results are very similar, what significantly differs is the capital required for the Total Business that goes from 13.72% with the standard model to 20.61% with the internal model while passing through 17.82% (PIM I) and 19.47% (PIM II).

In section 8.8.1 we have analyzed the reasons of this difference finding them in the different methods of major claims aggregation supposed.

In the second part of Chapter 8 we have calculated the capital requirements for company OMEGA under different QISs:

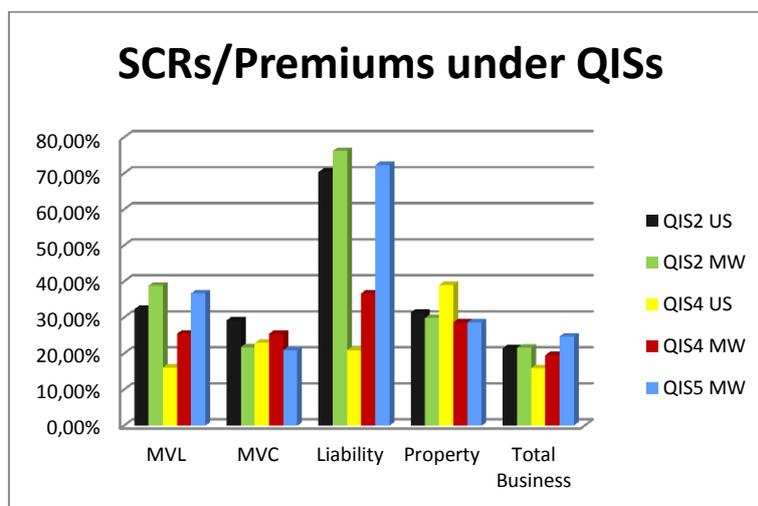


Figure 73: Comparisons between the SCR/Premiums under different QISs and different approaches.

and in section 8.8.2 we have analyzed the elements of difference that carry to different capital requirements.

These elements can be summarized in changes in the volatility factors, in the correlation matrices, in the methods used to derive the volatility of the portfolio and in changes of the risk measures (QIS2 was calibrated to a TailVaR_{99%} while the other QISs to a VaR_{99.5%}).

In the end of Chapter 8 we have tried to make comparisons between SST standard model and QISs:

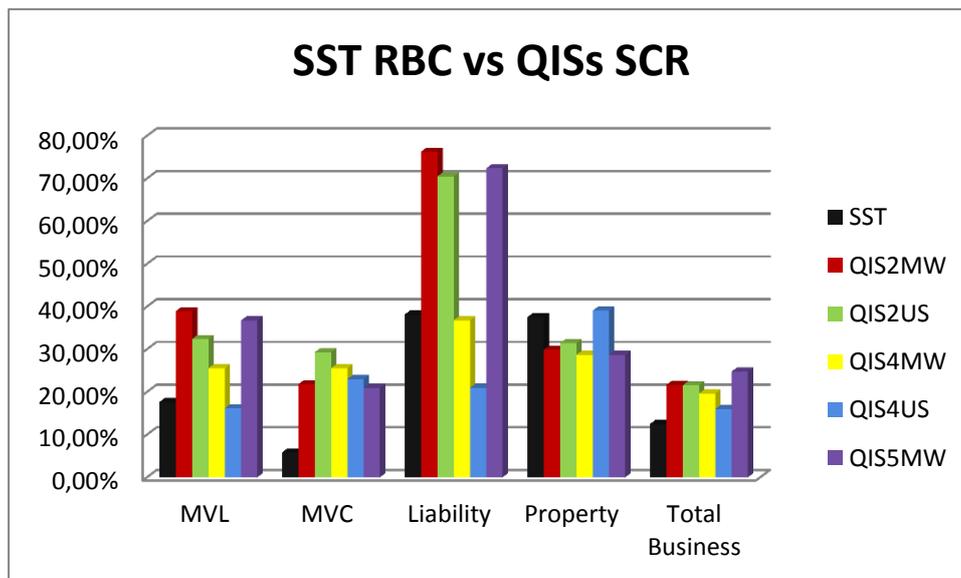


Figure 74: Comparisons between RBC in SST Standard Model and QISs' SCRs.

We have specified that, notwithstanding we have tried to make sensible comparisons, the results are only an approximation of the real capital requirements due to the simplifications made during calculations. In addition some risks are treated differently, for example the capital requirement concerning hail risk is comprised in the SST standard model (eliminated for comparisons) of major claims while in Solvency II is computed using a scenario approach.

For this reason comparisons are quite dangerous and to make them more sensible would be more reasonable computing the total capital requirements for underwriting premium risk taking into account even the scenarios that are not treated here.

Finally, in Chapter 9 we have extended the time horizon (supposed equals to one year in Chapter 8) to understand what are the implications, strengths and weakness in requiring a

capital that should protect the policy-holders for more than one year. To do this we have used the risk reserve, some measures of risk and of performance:

Year	$U_{Req}/B(0)$
1	19.02%
2	27.69%
3	33.68%
4	38.78%
5	43.91%

Table 145: $U_{req}/B(0)$ over different time horizons.

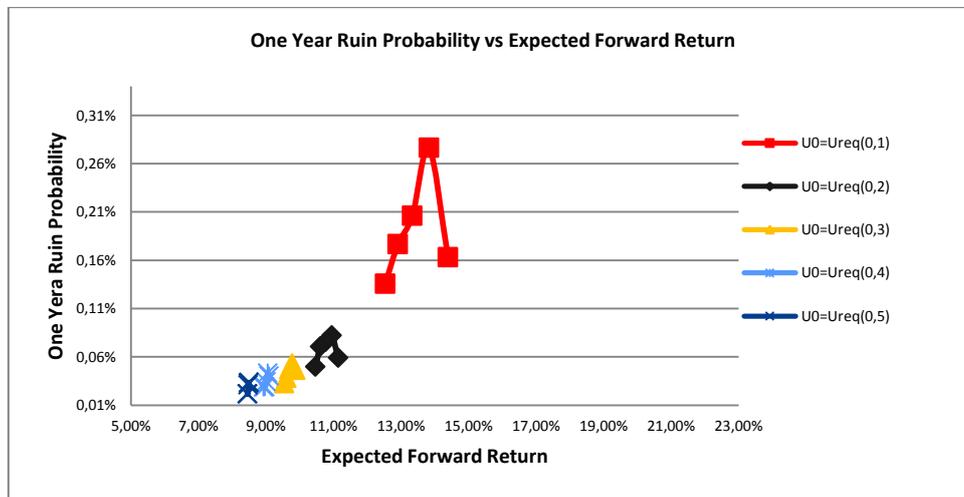


Figure 75: Comparison between One Year Ruin probability and expected forward return.

It's clear that there's a straight relationship, as obvious, between risk and return: increasing the risk the return becomes higher.

This is another problem that insurance regulators must face and find the right risk-return trade-off.

Comparing SST and Solvency II we should note that both, the SST and Solvency II are parameter-based models.

Whereas Solvency II is essentially a factor model, the SST is distribution based and the parameters enter in the calculation of the resulting distribution. From a mathematical point of view, the distribution based procedure is not a big complication and does not need more than techniques which are nowadays well known.

A first difference is the risk measure. In the SST the 99% expected shortfall is used, whereas in Solvency II it is the 99.5% value at risk. The difference is rather small in the case of a lognormal distribution within the relevant parameter range⁶².

A major difference is the modeling of the variance of the CY (premium) and the PY (reserve) risk. In the SST it is assumed, that the variance is the sum of a parameter risk and a random fluctuation risk, where the first is independent of the size of the company and the latter becomes smaller the bigger the company is. In Solvency II this variance is assumed to be independent of the size of the company using the market-wide approach (although in QIS5 the factor “ NP_{lob} ” introduces a kind of size factor) while a size factor is included in the undertaking specific approach based on the historical series of the Loss Ratios (Combined Ratios in QIS 2).

A further difference between the SST and Solvency II is that for the CY risks the SST models the claims load caused by the bulk of normal claims and the one caused by the big claims separately, whereas Solvency II does not make such a distinction.

Major differences also exist in the assumptions about the correlation matrices. The current SST assumptions are such that there are no correlations for the reserve risks between lines of business and that there is also no correlation between CY- and PY-risks, whereas Solvency II assumes a correlation of 50% between the premium and reserve risk of the same line of business and that the correlations between lob are the same for the premium risk and the reserve risk.

In the end we can say we have touched what are the problematic that the regulators must face.

First of all we have seen the importance of the correlation between LoBs, but even the correlation between normal and major claims: small changes of these values bring to large differences of capitals required.

Another problem is the comparability with “Solvency II”, and thirdly the time horizon covers an important role: expanding it the policy-holders are more protected but, on the other hand, the profitability of the company decreases.

We must underline that a standard model can't catch the true risk profile of an insurance company, being based on market assumptions that not include the own

⁶² At this regard see : “ON THE NON-LIFE SOLVENCY II MODEL”, Hürlimann W. (2008), <http://www.actuaries.org/>.

caracteristics of an insurer, for this reason internal models are encouraged to be used, in order to reach the true risk profile and get the solvency stronger.

All this aspect must be faced, consciously that a risk based system can only improve the stability of insurance companies and consequently to ensure more protection to policy-holders.

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