Centre Emile Bernheim
Research Institute in Management Sciences

SolvayBrusselsSchool
of Economics and Management

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B. Lorent

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Université Libre de Bruxelles - Solvay Brussels School of Economics and Management
Centre Emile Bernheim
ULB CP145/01 50, avenue F.D. Roosevelt 1050 Brussels BELGIUM
e-mail: ceb@admin.ulb.ac.be Tel. : +32 (0)2/650.48.64 Fax : +32 (0)2/650.41.88

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Insurance Solvency Regulation: Regulatory Approaches Compared[1]

Benjamin Lorent[2]

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Abstract

In this paper we compare the main regulatory frameworks: American (US RBC, Risk-Based-Capital), Swiss (SST, Swiss Solvency Test) and European (Solvency II). We improve on the existing literature by focusing on technical aspects of regulation schemes, particularly the capital requirements' calculation and by including latest quantitative and qualitative improvements of the Solvency II project. The comparison concludes that Swiss and European systems are advanced regulatory processes in comparison with American regulation although the latter system was perceived as a revolution some years ago. Even if the Swiss regime and the future European directive are quite similar, there are also some key differences to highlight. European approach to determine regulatory capital is mainly risk-sensitive, based on risk measures, whereas US RBC is mainly based on static factors and accounting data reported in the audited statutory annual statement. The three systems also differ with regards to the use of different risk measures, the consideration of operational and catastrophe risks, the use of internal models, the treatment of diversification effect, the limits imposed to investments, and the consideration of qualitative aspects.

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Keywords: Solvency II, Swiss Solvency Test, US RBC, Insurance Regulation

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[2] Research Center E. Bernheim, Solvay Brussels School of Economics and Management, Université Libre de Bruxelles, avenue F.D. Roosevelt 21, CP 145/01, B-1050 Brussels, Belgium. Corresponding author's email, phone and fax: blorent@ulb.ac.be, +3226506551, +3226504188.

1. Introduction

The insurance sector dramatically evolved during the past twenty years. The emergence of global groups such as AIG or AXA, the increased complexity of risk management and investment strategies, including derivatives, the development of credit risk transfer and the increased competition between financial institutions are certainty good news for the efficiency of the insurance sector. But it implies that prompt corrective action of prudential authorities becomes more crucial than ever as an insurance company becomes financially distressed. The recent financial crisis shows the rationale for regulators to reinforce solvency surveillance systems. Because economic conditions are more volatile now than previously, a company should hold more capital today to provide the same level of safety as then. It is also true that variations in individual company risk characteristics are wider now than in previous decades.

Several countries acknowledged these evolutions, and therefore undertook in-depth reform of their supervisory systems. Most major economies around the globe have changed their regulatory solvency framework to a system of risk-based capital standards. Cummins *et al.* (1994), among others, reviewed major criteria affecting an insurer's insolvency risk and discussed the rationales and objectives of solvency regulation in the form of risk-based capital (RBC). Canada and United States were among the first countries to introduce a RBC system in 1992 and in 1994 respectively. Japan, in 1996, and Australia, in 2001, moved their regulatory systems toward a RBC approach. In the US the adoption of a RBC system has been motivated by the wave of insurer insolvencies in the late 1980s and early 1990s. Europe undertook reforms more recently. European Commission launched in 2001 the Solvency II project. Solvency II fundamentally reforms the regulatory framework for insurance supervision in Europe (see Eling *et al*, 2007 or Doff, 2008, for an overview). The European system comes into force in October 2012. In Switzerland, the Federal Office of Private Insurance developed the Swiss Solvency Test (SST) in 2003. The SST was field tested in 2004 and 2005 and became applicable in 2008 for all insurers (see Keller, 2007).

This article contributes to the literature by providing an overview and comparison of three main insurance regulation systems around the world: the coming European framework, Solvency II, the Swiss system, Swiss Solvency Test (SST) and the American insurance regulatory scheme, risk-based capital (RBC). Other systems, such as in Australia, in Germany, in Japan, in the Netherlands and in the United Kingdom, are briefly described as well. Main literature contributions are Eling and Holzmüller (2008), Holzmüller (2009), Cummins and Philips (2009) and Vaughan (2009). We improve on the existing literature in several ways. Firstly we focus on technical aspects of regulatory schemes, particularly the capital requirement calculation. Secondly we integrate latest quantitative improvements of the Solvency II project, in particular the latest CEIOPS' Advice for Level 2 Implementing Measures on Solvency II[3] and the Quantitative Impact Study V (QIS V, CEIOPS 2010). Finally we aim to draw lessons learned from the current financial crisis.

The remainder of the paper is structured as follows. The next section describes the current European solvency regulation (Solvency I). Section 3 presents and compares the Solvency II project with the SST and the American RBC. It addresses main drawbacks and advantages of each regulation system. Section 4 summarizes main other insurance regulation systems. The final section concludes.

2. The Solvency I Regime

The current directives covering the solvency regulation of insurance date back to 1973 for the non-life sector and 1979 for the life sector. These two directives required insurers to hold a capital buffer to deal with the uncertainty of the insurance environment. They were subsequently amended in 1992 and in 1998. The need to review the legislation increased when markets were opened up under the third-generation directives in the mid 1990s which abolished price and product control. In 1994, the European supervisory authorities established a working group to look into solvency issues in a broad sense. Based on these discussions, the Müller[4] report appeared under the heading "Solvency of Insurance Undertakings" in 1997. This led to a review of the solvency rules and initiated the Solvency I project, which was completed in 2002 and came into force in 2004. Unfortunately, this new legislation brought only few amendments on the former directives.

2.1 General Principles

For each sector, the rules included in the Solvency I regime are divided in 4 pillars (liabilities, assets, solvency margin and minimum guarantee fund):

[3] Former Consultation Papers 47, 69 and 70, available at http://www.ceiops.eu.

[4] From the name of the working group's chairman, Dr. Helmut Müller.

2.1.1 Non-life Sector[5]

Non-life liabilities are valued as the future estimated outgoing cash-flows. The amount of the technical reserves is determined according to the rules fixed by each State. Technical reserves are required to be covered by equivalent and matching assets localized in each country where business is carried on. Assets are valued either at historic cost or market value if lower.

The required solvency margin is defined as the greater of the premium and the claims index:

- Premium index: (18% of the first 50 million € gross premiums + 16% of the remaining gross premiums) * retention ratio[6]
- Claims index: (26% of the first 35 million € gross claims, being averaged over 3 or 7 years + 23% of the remaining gross claims)* retention ratio

A minimum guarantee fund which is irrespective of the size of the insurer is set as one third of the required solvency margin with a minimum floor of 2 to 3 million €, depending on the line of business. The amount of the minimum guaranteed fund has been increased considerably since previous directives, at least to an amount compensating for the inflation since 1973.

2.1.2 Life Sector[7]

Life liabilities are valued as the future cash-flows discounted either at 60% of the current bond yields or at rate not higher than the yield being earned on assets. The amount of the technical provisions is calculated by a sufficiently prudent prospective actuarial valuation, taking account of all future liabilities including all guaranteed benefits, bonuses, options available and expenses. The assets covering the technical provisions take account of the type of business carried on by insurers in such a way as to secure the safety, yield and marketability of its investments, which the company will ensure are diversified and adequately spread. Assets are valued either at historic cost or market value if lower.

The required solvency margin is calculated as follows:
Required solvency margin = 4% of gross mathematical provisions (1% for unit-linked products) * retention rate mathematical provisions[8] + 0.3%* capital at risk[9] * retention rate capital at risk[10].

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[5] Based on the 73/239/EEC and 2002/13/EC directives.

[6] Retention ratio = net claims (after reinsurance)/ gross claims, three-year average (not less than 50%).

[7] Based on the 2002/83/EC directive.

[8] Net provisions (after reinsurance)/gross provisions (not less than 85%).

The minimum guarantee fund is set as one third of the required solvency margin with a minimum floor of 3 million €.

2.1.3 Strengths and Drawbacks of the Solvency I Legislation

Solvency I is simple, easily implemented at a lower cost and comparable across European companies. However, a range of weaknesses have to be highlighted.

Valuation of assets and liabilities is not based on a market-consistent approach. Valuation based on historic data offers little insights into the future viability of a business in a changing environment.

Solvency margins depend only on fixed ratios and factors for the underlying risks (e.g. 4% for life insurance). The major advantage of a factor-based approach is its simplicity, which makes it easy to apply for a wide range of companies, but this comes at the cost of decreased risk-sensitivity. Moreover the simple factors used are intended to arrive at one overall solvency margin that covers all underlying risks. Therefore, no further differentiation of risk classes is applied in the methodology. The factor-based components are less risk-sensitive, because a reduction in capital requirements is achieved by reducing the size rather than the risk profile. Therefore the approach does not take into account the level of prudence of the insurer. A prudent insurer may prefer to over-provisioning, increasing the level of solvency margin as capital requirements are partly based on provisions. It may create distortions and gives incentives for under-provisioning as Solvency I rewards insurers holding lower reserves, i.e. a higher risk of insolvency. There is no credit for insurers who have already allowed for uncertainty by establishing higher provisions.
Only liabilities elements such as premiums, claims or reserves are using for the determination of solvency capital. The asset side of insurance companies is ignored. Although for with-profit life insurance the 4% factor takes also account of investment risk, there is no reasonable allowance for asset risk, a weakness that has become more important as insurers have increased the riskiness of their investment portfolios.

Furthermore no allowance is made for diversification (risk transfer instruments, asset-liability management, correlation between assets and liabilities, correlation among risk categories…).

[9] Amount equal to the difference between the promised payments under the policies underwritten and the mathematical provisions.

[10] Net capital at risk (after reinsurance)/gross capital at risk (not less than 50%).

Although the effect of reinsurance is taken into account via the retention ratios, allowance for reinsurance is inadequate, especially the credit quality. There are insufficient controls on the credit risk.

Apart from quantitative elements, there are no incentives to implement a sound risk management system. In particular, there is no possibility to use an internal model. Finally member states continue to hold the autonomy to regulate or deregulate many financial, technical, and commercial aspects of insurance business, leading to a lack of harmonization throughout European countries. For instance, national authorities have discretion about the form and method in calculating technical reserves. As the solvency margin is based on reserves, it might lead to levels of solvency capital that are substantially different from a country to the next, for an identical risk.

All these drawbacks show the rationale for a revising insurance regulation. Solvency I has to be considered only as an interim solution. The system was however conceived in a period when the general economic features as well as insurance practices were different. Insurance companies are today faced with a different business situation with increasing competition, convergence between financial sectors as well as international dependence. At the same time insurance, asset, and risk management methods and techniques have been significantly refined.

3. Comparison between Solvency II, Swiss Solvency Test and US Risk-Based Capital

This section describes and compares the Solvency II project with the Swiss framework (Swiss Solvency Test, SST) and the American regulation (risk-based capital, RBC) system. The study shows clear differences between European systems and the American approach. We observe numerous key areas of convergence and a high level of consistency between Solvency II and the Swiss framework. However we also note that while the key principles underpinning these two regimes are converging, there is still a variety of approaches chosen in applying those principles.

3.1 History

3.1.1 Solvency II

As discussed in the section 2.1.3, a general recasting of the European regulatory scheme was most welcome. Therefore in 2001, the European Commission launched the Solvency II project, a revision of the solvency regulation aiming to fully reflect the latest developments of the sector. Solvency II is not merely a solution brought to the drawbacks of Solvency I. Solvency II also recognized the evolving environment and the improving capacity of insurers to manage theirs risks, especially the use of internal models to evaluate their risk profile. The aim of the future system is to increase the level of harmonisation of quantitative and qualitative supervisory methods and thereby contribute to the creation of a level playing field within the insurance industry, as well as between financial sectors. For the time being, the European insurance market is subject to a mix of European legislation and regulation and national laws. Harmonisation throughout European companies should be increased by providing specific principles for the valuation of assets and liabilities, including technical provisions. The development of financial conglomerates geographically more globalized confirms this need of a single insurance market.

The Solvency II directive has been adopted in July 2007 by the European Commission and in April 2009 by the European Parliament. Member States have to bring into force the laws, regulations and administrative provisions necessary to comply with the directive by October 2012 at the latest (EC, 2009). The Solvency II project is based on the four-level Lamfalussy approach. After the adoption of the directive by the Commission and Parliament, detailed implementing measures will be developed in consultation with market participants and regulation committees. Implementing measures will be used to further define the principles set out in the directive so as to enhance harmonisation and supervisory convergence. They will be developed on the basis of mandates given by the European Commission to CEIOPS[11] and will be subject to consultation with stakeholders and to an impact assessment trough the use of Quantitative Impact Studies (QIS). Four QIS were already performed and a fifth one is planned for autumn 2010.

3.1.2 Swiss Solvency Test

In 2003, the director of FOPI (Federal Office of Private Insurance) initiated the Swiss Solvency Test (SST) with the aim of defining the main principles of a future solvency system with close collaboration of insurance sector, consultants and universities (see FOPI, 2004). The SST is encompassed into the new Insurance Supervision act (as of 1 January 2006). As of 2008, all companies (direct insurers, reinsurers and insurance groups) have to perform the SST. In 2011, target capital requirement will be in force. The SST applies to individual legal entities and to groups and conglomerates with head offices in Switzerland. In order for Swiss companies not to

[11] Committee of European Insurance and Occupational Pensions Supervisors.

be at a competitive disadvantage to insurers domiciled in EU member countries, it is an aim of the SST to be compatible with Solvency II.

3.1.3 US Risk-Based Capital

The foundations of the American regulation scheme go back to the mid 1970s[12]. At that time, there was an auto insurance crisis due to escalating auto insurance rates. In response to this insolvency crisis, the American regulator (NAIC[13]) created the Insurance Regulatory Information System (IRIS) to help monitor and identify firms in trouble. The IRIS system is based on a series of simple financial ratios that feature a range of "normal" values, with no further distinction to determine what is actually normal for a particular insurer. The individual company' results are public. At the end of the 1980's, the United-States faced a new wave of insurer's failures. The NAIC decided to launch a work group in order to review the solvency system. This led to a more complex solvency regulation system, the adoption of Financial Analysis and Solvency Tracking System (FAST), and risk-based capital (RBC) standards in the early 1990s. The FAST system is used by the NAIC to calculate 20 financial ratios and an overall score. These ratios do not impose capital requirement, contrary to RBC standards, but aimed at early detection of companies experiencing financial distress. FAST is also designed to prioritize insurance companies for more in-depth financial analysis. Unlike the IRIS ratio results, the FAST ratios results are kept secret. By design these three systems have different areas of emphasis but they are meant to work together, as part of a coordinated solvency monitoring approach, rather than as stand-alone systems (Barth, 2003).

Insurance regulatory authority in the US ultimately rests with the federal government[14], although most operational control of insurance regulation has been ceded to the office of the commissioner of insurance for the state of domicile. Insurers must then comply with the relevant laws for each state in which they write policies. In particular, an inter-state insurer must be licensed in each state in which it does business, there is no "single passport" system in the US. This can lead to a fractured system where a large national insurance company must respond to regulatory requirements from 50 different state insurance commissioners. On the other it provides a higher number of checks and balances involved in the regulation process that might

[12] See Cummins and Venard (2007).

[13] National Association of Insurance Commissioners is the association of state insurance commissioners.

[14] The federal government has ultimate authority by the powers vested in Congress to regulate interstate commerce and to levy taxes.

reduce the possibility of regulatory errors. Insurers must also comply with applicable federal laws regardless of the state or states in which they operate.

State insurance commissioners are charged with protecting the interests of consumers and typically respond with laws that regulate financial issues (e.g. capital requirements, investments, accounting procedures…) and market practices (e.g. rates, policy forms…). Financial regulations are fairly uniform among the states whereas market regulations can vary to a much greater degree. Non-domiciliary states have also the possibility to perform some control, e.g. financial monitoring. This can lead to externality problems as non-domiciliary states actions might have financial impacts on the insurers.

3.2 General Principles

Solvency II is based on the three-pillar approach that is also existent in Basel II. The starting point is to include quantitative rules in the first pillar, primarily qualitative elements in the second, and disclosure in the third. Pillar I focuses on financial requirements, as valuation of assets and liabilities, investments and capital requirements. The capital requirements are based on a two-level approach: a Solvency Capital Requirement (SCR) and a Minimum Capital Requirement (MCR). The SCR can be calculated using a prescribed standard model or internal models. The Swiss Solvency Test is made up of two parts: determination of the capital requirements and a qualitative assessment. The capital requirements follow also a two-level approach: a required Target Capital (TC) and a Minimum Solvency (TS). As Solvency II, the SST prescribes a standard model but allows also the use of internal risk models to calculate the TC. The US RBC standards have two main components. The first is a RBC formula that establishes a minimum capital level, which is compared to the actual level of capital. The second is a RBC model law that grants automatic authority to the state insurance regulator to take certain actions based on the company's level of impairment (see NAIC, 2009).

Following CEA (2005) and Eling *et al.* (2007) we classify solvency regimes into four groups. The first group of systems requires no specific level of capital and therefore has no model, e.g. in New-Zealand. The New-Zealand system is based on a self-regulatory framework. The requirement of being financially sound is ensured via the obligation to obtain a rating.

The second group requires use of static factor models. Static-based models are further broken down into simple factor-based models and risk-based models. Simple factor-based models apply only a small number of factors to static accounting in order to arrive at the capital requirements. The current Solvency I regime is an example. Therefore these models are not risk-based, as the rules are not oriented toward the insurer's risk structure. Risk-based models apply fixed ratios to select accounting positions but the ratios are calibrated to cover the underlying risk to a certain confidence level. The US RBC standards or the Japanese insurance regulation system belong to this models' category. As static-based models are quite descriptive, especially regarding capital requirements, they are also referred as rules-based approaches.

The third group requires the use of dynamic cash-flow-based models. These are further broken down into scenario-based models and purely principles-based models. The scenario-based models analyze the effects of various adverse scenarios, such as natural catastrophes or a stock market crash. The life Australian model is a classic example. Principles-based models are based on general guidelines and principles instead of precise rules (e.g. some parts of the SST or the UK regulation system).

Finally the fourth group requires a combination of static-based and dynamic cash-flow-based models. The SST or the UK system belong to this category. The Solvency II framework (as specified by the latest quantitative impact studies: QIS IV, CEIOPS 2008 and QIS V, CEIOPS 2010) belongs to the last category as well. Some risk measurements are based on static factor models (simple and risk-based) whereas some other risks (e.g. catastrophe or some market risks) require a scenario analysis. But technical aspects may be subject to future changes due to upcoming quantitative impact studies, especially QIS V planned for autumn 2010 and future Solvency II implementing measures.

A comparison between the American risk-based capital (RBC) standards and European systems is an area of concerns as the current US system is outmoded and lagging behind the evolution of the systems employed in Europe. The US RBC system is a rules-based regime as opposed to principles-based regimes in force in Europe[15]. In rules-based regimes, the required analyses are exactly defined. The computation of risk capital follows clear guidelines and voluminous and detailed set of rules. There is little discretion left to the insurance companies. There is no flexibility to handle individual situation and thus might not be very effective in assessing the wide range of insurance risk profiles. US insurance regulation is rooted in its historical legacy. The states have tended to apply a prescriptive approach to regulating insurers' financial condition and

[15] See Eling *et al.* (2007) for a valuable discussion on rules-based vs. principles-based approaches.

market practices that is heavily influenced by an accounting perspective. This is reflected in a voluminous set of laws, regulations, rules and other measures that govern insurers' actions (see Grace, 2009). As a result, regulators tend to focus on insurer's compliance with these prescriptions instead of the prudence of their management and actions and their overall financial risk.

The SST and the Solvency II system are mainly principles-based, e.g. the valuation of liabilities and assets. But a detailed methodology is often provided to the insurers. A principles-based model implies more discretion and flexibility left to the companies. For instance not all parameters included in the Swiss standard model are determined by the regulator. Several are estimated by the insurer itself based on its own portfolio. QIS V allows also companies to replace some parameters by parameters specific to the company when calculating the underwriting risk modules. But this is an option left to the discretion of the company when required in the SST. Another example are the internal models, encouraged and even required for Swiss reinsurers, which should be based on the principles laid down in the Solvency II directive or in the SST.

The increasing complexity of investment strategies and risks does not speak in favour of rules-based approach. Principles-based models are more flexible. As pointed by Holzmüller (2009), as long as the underlying principles are not affected, small changes and updates are easy to implement in a system like this as compared to a rules-based system, where small modifications can involve a lengthy process. Principles-based approach creates the right incentives for weak companies, that is, by improving their solvency positions by reducing their risk exposure or holding more capital. On the contrary, the rules-based models are less risk-based, because a reduction in capital requirements may be achieved by reducing the size rather than the risk profile. Finally principles-based approach might also trigger innovation when insurers need to develop their own risk models based on the principles. However, a rules-based system may be appropriate to address the potential for regulatory errors. Principles-based approach relies on supervisor's approval. This can pose a problem of regulatory forbearance. Relying upon principles might also increase the complexity and costs of regulation, both for the insurer, who need time and money to implement the principles into the models, and for the regulator, who needs sufficient resources to control all the individual models instead of one standard model (Eling *et al.*, 2008).

Another limitation of the US system is that it is based on a "snap-shot" of the firm at a given point in time, i.e. it is a static rather than a dynamic approach to solvency testing. Dynamic cash-flow systems, as in Europe, can provide information on a company's ability to withstand potentially adverse economic developments that cannot be captured by a static system. Cummins *et al.* (1999) examined a combination of US RBC standards and cash-flow simulation to measure predictability power of solvency models. They concluded that this framework gives better predictability power than the rules currently used in the United States. Solvency II and the SST may have the right incentives to predict insolvencies.

Another major difference between systems is that in Europe assets and liabilities will be market-consistently valued whereas US RBC is based mostly on statutory accounting rules, which in many instances do not reflect the market value of assets and liabilities. The RBC formulas typically pull an amount from the statutory financial statement and assess a factor to calculate an RBC risk charge. Therefore the approach applies calculate risks on the asset and liability sides of a conservative balance sheet. Next to the true company's value, a market-consistent approach requires the implementation of sound financial methods such as option pricing models leading to improvements of risk management processes.

Finally, the US RBC model allows limited internal modelling[16] and scenario tests[17] whereas European regulation schemes put internal models and scenarios forward. Internal model is likely to yield a variety of risk strategies, limiting the possibility of systemic risk inherent in using a single standard model for all or even most insurers. In Europe scenarios are an integral part of the solvency framework. A number of scenarios are prescribed, or sometimes left to the discretion of the company, e.g. the catastrophe risk.

3.3 Quantitative Aspects

For the sake of the comparison we follow the structure of the three Solvency II pillars. In this section we compare those pillar I aspects of the different regulation systems.

3.3.1 Capital Requirements[18]

In Europe, the capital requirements are based on a two-level approach: a target capital requirement, the amount of capital needed to meet future obligations and a minimum capital requirement, a safety level. The target capital, named Solvency Capital Requirement (SCR) under

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16 Only on market/interest rate risk for some categories of life insurance products.

17 Ibidem.

18 For technical specifications, see next section 3.3.1.2.

the Solvency II directive and Target Capital (TC) in the SST, is an early warning signal. If the insurer does not meet the necessary conditions, the company is not necessarily in an insolvency situation. But the regulator will take measures to help the company to retrieve its solvency situation. The minimum capital, Minimum Capital Requirement (MCR) under the Solvency II directive and Minimum Solvency (MS) in the SST, is a safety level. It is a trigger level under which a company should not go. The MCR corresponds to an amount of eligible basic own funds below which policyholders and beneficiaries are exposed to an unacceptable level of risk if insurance companies were allowed to continue their operations (EC, 2009). The calculation of the target capital requirement is based on proxies reflecting the risks encountered by companies. The SCR and the TC may be calculated using the prescribed standard model or an internal model. European systems differ in their definition of the minimum safety. The MS is based on the statutory balance sheet, and then this measure is not risk sensitive whereas the MCR is based on proxies reflecting the risk level of the company. It also exists in Solvency II an absolute floor (AMCR, Absolute Minimum Capital Requirement) of 2.2 million € for non-life and 3.2 million € for life companies.

The American states also impose two types of capital requirements on insurers. Each state has its own “fixed-minimum” requirement, equivalent to the Solvency II AMCR. This minimum is fairly crude and not adjusted for the size of an insurer or factors associated with its financial risk. It varies by state, line of business and stock vs. mutual companies. Insurers are also subject to a uniform and special solvency measure in order to determine whether intervention is needed and the extent of the need. For a given insurer, this measure is calculated as an amount of capital based on an assessment of risks that a company should hold to protect customers, the risk-based capital (RBC). A company’s RBC is calculated by applying factors to various asset, premium, claim, expense and reserve items. The factor is higher for those items with greater underlying risks and lower for less risky items. Contrary to European systems, RBC is designed as a minimum capital requirement and does not address any target or economic capital levels.

European systems have three level of intervention. Above the solvency level (SCR or TC) no intervention is required. If an insurance company falls below the solvency level, this can be interpreted as an early warning signal to regulators. Under the Solvency II directive the insurance company has six months to take the necessary measures to retrieve its solvency situation. The implementing measures are still vague regarding intervention rules of regulatory authorities. In the SST (see FINMA, 2008), the second level of intervention occurs if own funds fall below 80%

of the TC. The insurance company has two months to take the necessary measures to retrieve its solvency situation in collaboration with regulatory authorities. Under the Solvency II directive the third level is reached if own funds fall below the MCR. Then rigorous supervisory actions are taken, i.e. short-term realistic finance scheme to restore the solvency situation, restrict the free disposal of assets and as an ultimate measure the withdrawal of authorisation. In the SST, the third level corresponds to a ratio own funds/TC under 33%. In this case, the company must take measures to retrieve its solvency measure. The company can transfer a part of its insurance portfolio, reduce its risk level or increase the amount of own funds. As a last resort, the regulatory authorities shall withdraw the authorisation.

In United States, NAIC implemented a similar approach with different levels of regulatory actions (see NAIC, 2009). A model law grants automatic authority to the state insurance regulator to take specific actions based on the level of impairment, by comparing a company's Total Adjusted Capital (TAC), roughly equivalent to own funds, to its authorized control level RBC as computed by the RBC formulas. This model law exists because regulators previously had difficulty in closing down defaulting insurers because their actions could be challenged in court.
TAC is defined as the sum of statutory capital and surplus, adjusted for some other balance sheet items. The RBC represents the regulatory minimum amount of capital that a company is required to maintain to avoid regulatory actions. The system indicates specific actions to be taken based on the ratio of TAC to RBC:

1. If the ratio exceeds 200%, this is a no action level. Nothing needs to be done by the regulator.
2. If the ratio is situated between 150% and 200%, NAIC triggers a Company Action Level. The insurer must prepare a report to the regulator outlining the corrective actions the company intends to take. This plan must contain proposals to correct the company's financial problems and provide projections of the company's financial condition. If a company fails to file this comprehensive financial plan, this failure to respond triggers the next lower action level.
3. If the ratio is situated between 100% and 150%, NAIC triggers a Regulatory Action Level initiative. At this level, an insurance company is also required to file an action plan, and the state insurance commissioner is required to perform any examinations or analyses to the insurer's business and operations that the commissioner deems necessary.
4. If the ratio is situated between 70% and 100%, NAIC triggers an Authorized Control Level. At this stage, the regulator may take the control of the insurer even if the insurer is still technically solvent.

5. If the ratio is less than 70%, NAIC triggers a Mandatory Control Level. This requires the regulator to take steps to place the insurer under control.

Next to these action levels, RBC formula includes special requirements, i.e. trend test, for companies that have enough capital but are too close to the minimum limit for comfort. Trend tests place an otherwise adequately capitalized insurer into the Company Action Level under some circumstances. The rules depend on the insurance business and on the jurisdiction the company is domiciled or licensed.

3.3.1.1 Risk Measures

European solvency capital requirements are based on risk measures. Under the Solvency II standard formula, the parameters and assumptions used for the calculation of the SCR are intended to reflect a Value-at-Risk (VaR) risk measure. In the SST the Target Capital is based on an expected shortfall (ES) or Tail Value-at-Risk (TailVaR) approach.

The role of risk measurement[19] is to use an appropriate risk measure to assign a real number to an uncertainty or a quantity with an unknown value. So the risk can be represented and interpreted. In the context of solvency assessment, a risk measure is a function that assigns an amount of solvency capital to a certain probability distribution: the higher the underlying risk level is, the higher the resulting amount of capital is. The probability distribution to consider is the distribution of the company's economic wealth, i.e. its available capital (the excess of assets over liabilities). Solvency capital acts as a cushion against unforeseen losses and reduces the probability of insolvency. Risk measure assumes that the company determines its solvency capital corresponding to a ruin probability of a prespecified low level ($1-\alpha$). Ruin occurs when the amount of available capital falls under zero (liabilities higher than assets).

Under the Solvency II directive, SCR corresponds to the VaR of the basic own funds, i.e. roughly available capital, of an insurance undertaking subject to a prespecified confidence level of 99.5 % (α = 99.5%) over a one-year period (EC, 2009).

[19] Based on Artzner *et al.* (1999).

Box 1: Value-at-Risk Measure

Let examine a general random variable X, where the negative values of X are the bad values (values associated with losses). Given some confidence level α ∈ (0,1). The VaR at the confidence level α is given by the smallest number x such that the probability that the loss X is under x is larger than α.

$$VaR_{\alpha}(X) = \inf(x \in \Re : P(X \leq x) \geq \alpha)$$

In probabilistic terms, VaR is simply a quantile of the loss distribution (see figure 1). VaR is the maximum potential loss (i.e. decrease in available capital) under a certain probability of ruin (1-α %), over a certain time horizon (1 year). Assuming VaR equals 100, the probability for ruin to occur in the following year will amount to (1-α) %, provided the company holds 100 of capital.

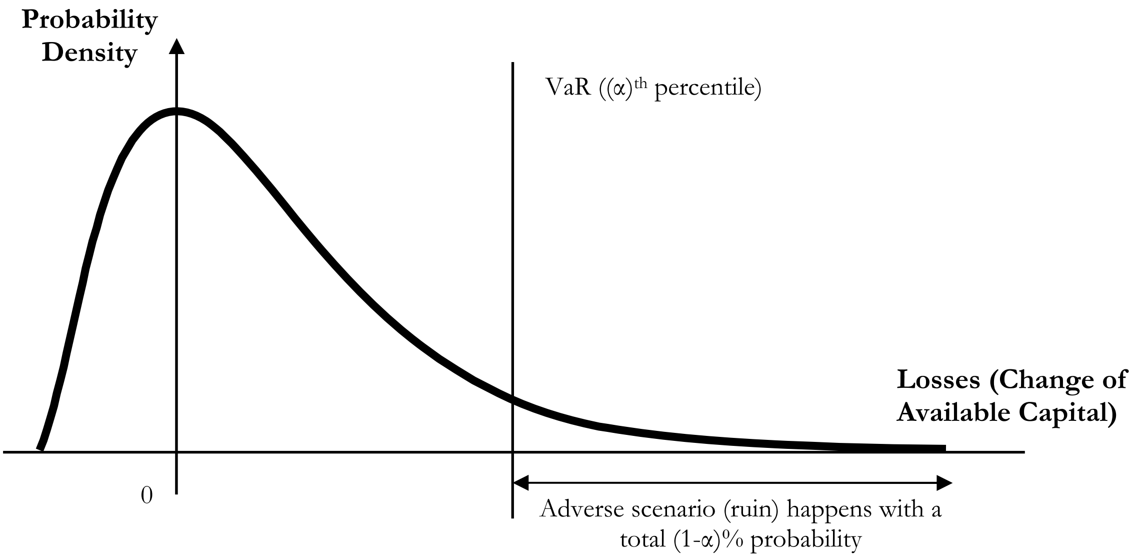

Figure 1: Value-at-Risk

Under the SST framework, the Target Capital is based on the expected shortfall (ES or Tail Value-at-Risk, TailVaR) approach. By definition, ES describes how large the loss is on average when it exceeds the VaR (see figure 2). In the SST, the prespecified probability α has been set to 99%. Therefore Target Capital is a 99% TailVaR approach on a one year horizon. In formal terms, ES is the minimum sum capable of compensating the 1% worst-case expected loss. It is the expected loss that will affect the company under ruin circumstances, given that ruin occurs with a certain probability (1-α %) and over certain time horizon (*x* years). Assuming TailVaR equals 100, it means that in the worst cases (the 1-α % situations in which ruin occurs in the following year), the company will lose 100 in the average.

Box 1: Tail Value-at-Risk Measure

Let examine a general random variable X, where the negative values of X are the bad values (values associated with losses). Given some confidence level $\alpha \in (0,1)$. TailVaR is the conditional expectation of loss given that the loss is beyond the VaR level

$$ES_{\alpha}(X) = E\left[X \middle| X \geq VaR_{\alpha}(X)\right].$$

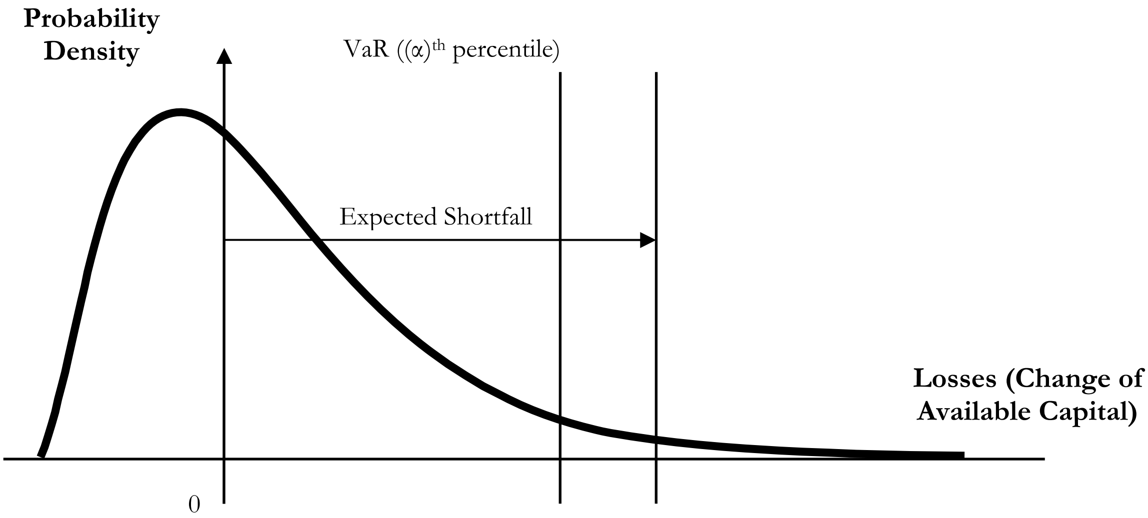

Figure 2: Tail Value-at-Risk

In practice TailVaR turns out to be more stable than VaR. Moreover, TailVaR is a better coherent risk measure[20] (see Artzner *et al.*, 1999) as it matches all the criteria. Value-at-risk is not, in general, a coherent risk measure as it does not respect the subadditivity property[21]. This might discourage the diversification. VaR is, however, coherent under the assumption of normally distributed losses. On the other, VaR is traditional, well-known and widely implemented in the financial sector, especially banking sector and rating agencies, and is easy to explain to managers and

[20] A coherent risk measure satisfies properties of monotonicity, subadditivity, homogeneity and translational invariance.

[21] Subadditivity is a property of a function that states that evaluating the function for the sum of two elements always returns something less than or equal to the sum of the function's values at each element. A measure of risk ϱ is subadditive, if $\varrho(R_a + R_b) \leq \varrho(R_a) + \varrho(R_b)$ for all random variables R_a, R_b.

stakeholders. It is therefore easy to implement throughout the company and to embed in the company's culture. For instance, VaR does not require data to estimate the tail of the distribution. TailVaR requires more mathematical background to be understood and implemented.
The debate in the literature (see e.g. Artzner *et al.*, 1999, Barth, 2000 or Butsic, 1994) about the adequacy of risk measures for solvency measurements especially stresses the fact that the VaR only takes into account the number of shortfalls. Expected shortfall quantifies the average cost of the (1-α)% worst event. The skewness of distributions and tail-behaviour requires careful consideration. For claims distribution showing extremely high losses with very low probabilities, i.e. catastrophe and large risks, the TailVaR is more appropriate. Such risks often trigger bankruptcy: studying them should improve extreme events management and limit the probability of insolvency. But extreme events mean often lack of necessary data to simulate their occurrence. This is why TailVaR is widely widespread in the reinsurance sector, therefore in the Swiss market.

As VaR does not provide information about the severity of the default, even if difficult to obtain in practice, it may be more adequate from the shareholder's perspective in the case of limited liability where losses are restricted to the initial payment (Eling *et al.*, 2008). However, as the cost of insolvency is significant for policyholders and then regulators, the TailVaR approach may be more appropriate. One practical option would have been a combination: make a distinction between the lines of business (TailVaR could be used for skew lines and VaR otherwise). Although TailVaR is more adequate from an insolvency perspective, Barth (2000) remarks that TailVaR only addresses the direct insolvency costs. Indirect solvency costs, such as the costs of market disruptions in the wake of insolvency are not taken into account. Finally the confidence level is quite similar between Europeans systems. The Swiss Federal Office of Private Insurance identified the VaR for Swiss life and non-life insurers that would be equivalent to a 99% TailVaR. At the minimum it corresponded to 99.5%, at maximum to 99.7%, and for the median to a 99.63% VaR (FOPI, 2005). The TailVaR approach might be then more conservative than a VaR, but depending upon the shape of the probability distribution of the change of available capital.

3.3.1.2 The Models

3.3.1.2.1 Solvency II

The general structure of the standard model is laid down in the Solvency II directive (EC, 2009). Technical aspects of the directive will be provided by future implementing measures. Technical analyses, Quantitative Impact Study (QIS), are carried out by the CEIOPS for the calibration of key parameters of the Solvency Capital Requirement standard formula and the calculation of technical provisions. Four QIS were already performed and a fifth one is planned for autumn 2010. This section describes the standard model for calculating the SCR as it currently stands in the QIS IV (CEIOPS, 2008) and in the QIS V[22] (CEIOPS, 2010). A first draft of the QIS V has been published in April 2010. Compared to QIS IV, a number of changes have been made, especially to the eligibility of own funds and to the calibration of the SCR standard formula.

Solvency II adopts an economic risk-based approach which reflects the true risk profile of insurance companies. This approach relies on an appraisal of the whole balance-sheet (then not on the profit and loss accounts) of insurance companies, on an integrated basis, where assets and liabilities are evaluated on a market-consistent basis. This view can be summarized in the figure 3.

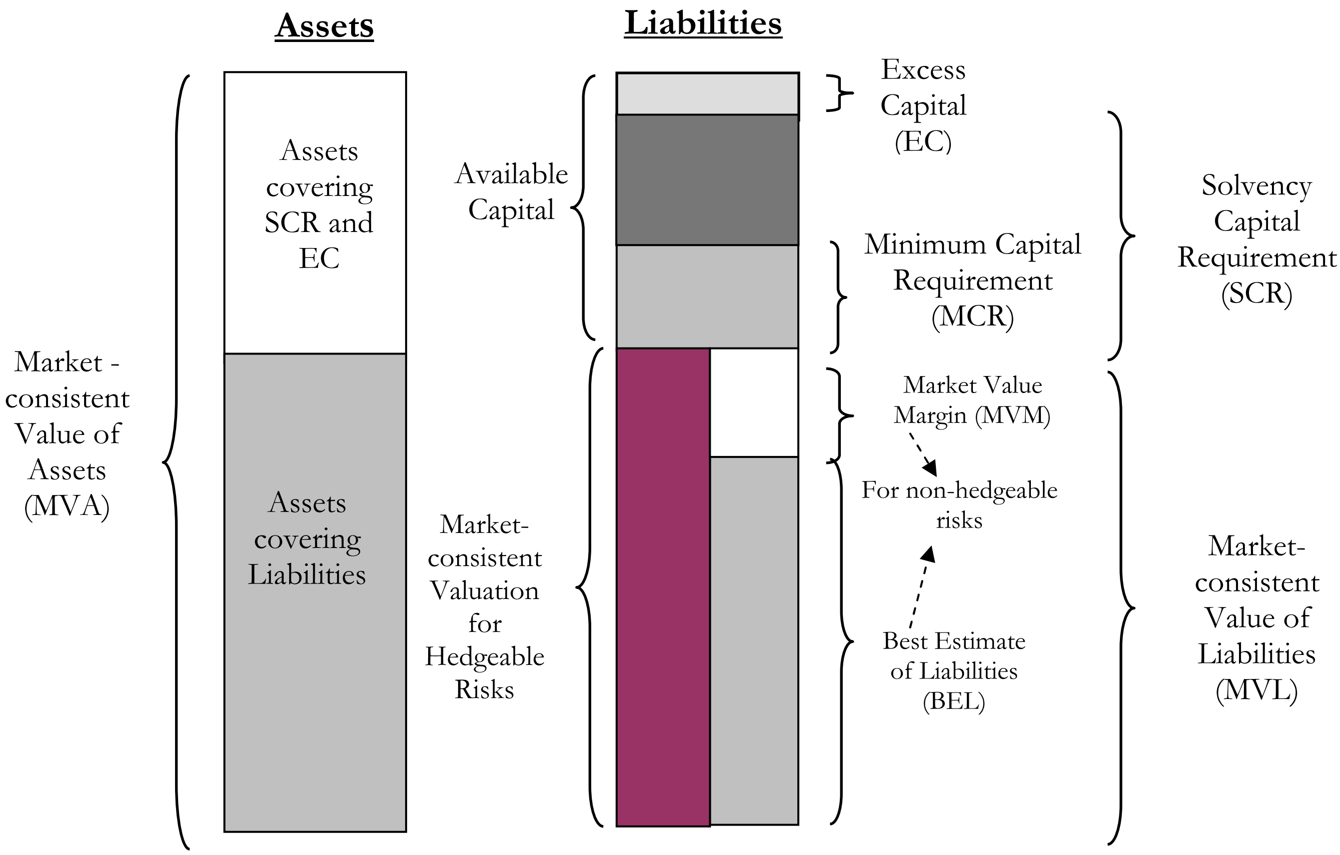

Figure 3: Solvency II: an Economic Total Balance-Sheet Approach.

The architecture of the standard model is modular. The Solvency Capital Requirement (SCR) is the sum of the following items (see figure 4): (1) the Basic Solvency Capital Requirement (*BSCR*);

[22] Technical aspects may be subject to future changes due to upcoming quantitative impact studies, including modifications of the QIS V and future Solvency II directive implementing measures.

(2) the capital requirement for operational risk (SCR_{op}) and; (3) the adjustment for the loss-absorbing capacity of technical provisions and deferred taxes (Adj).

The Basic Solvency Capital Requirement comprises individual risk modules, which are aggregated using a correlation matrix (inter-modular aggregation). It consists at least of the following risk modules: (1) non-life underwriting risks (SCR_{nl}); (2) life underwriting risks (SCR_{life}); (3) health underwriting risks (SCR_{health}); (4) market risks (SCR_{mkt}); (5) counterparty default risk (SCR_{def}); and (6) intangible asset risk ($SCR_{intangibles}$).

BSCR is calculated as follows:

$$BSCR = \sqrt{\sum_{rxc} CorrSCR_{r,c} \cdot SCR_r \cdot SCR_c} + SCR_{\text{intangibles}}$$

where $CorrSCR_{r,c}$ is the inter-modular correlation matrix.

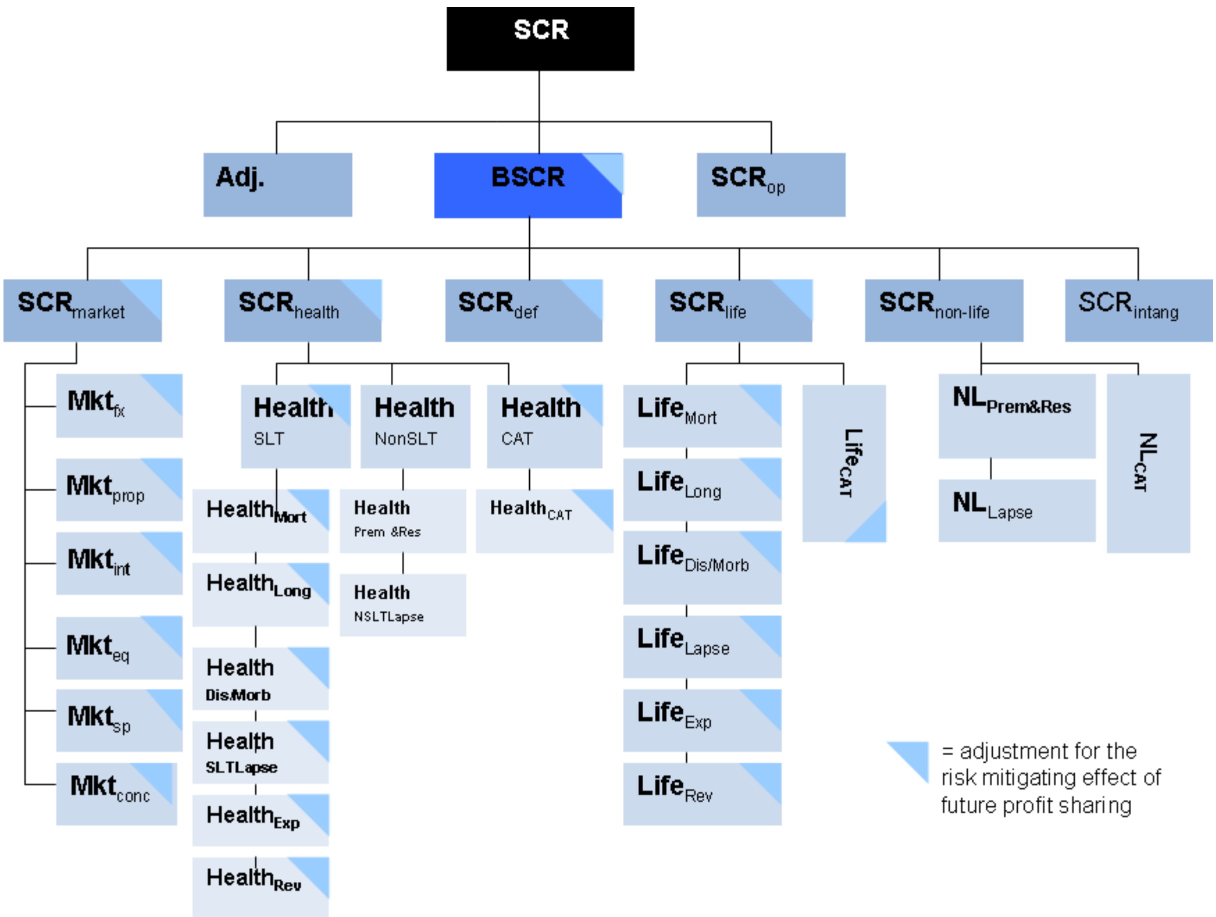

Figure 4: Solvency Capital Requirement: General Structure
CEIOPS (2010)

To ensure that the different modules of the standard formula are calibrated in a consistent manner, the calibration objective, i.e. a VaR risk measure calibrated to a confidence level of

99.5% and a time horizon of one year, has been applied to each individual risk module (EC, 2009). Insurance companies take account of the effect of risk mitigation techniques, provided that credit risk and other risks arising from the use of such techniques are properly reflected in the Solvency Capital Requirement. Risk mitigation includes both traditional and non-traditional risk transfer instruments on the asset side (e.g. financial hedging) and on the liability side (e.g. hedging instruments, reinsurance).

Operational risk and intangible assets risk are not integrated in the standard formula, especially considering the correlation matrix. The capital charge for operational risk is calculated using a simple factor-based approach, i.e. a percentage of premiums and technical provisions. In addition the capital requirement will not exceed 30% of the Basic Solvency Capital Requirement. Where the available capital calculation allows for the value of intangible assets, the risks inherent to intangible assets should be considered in the standard calculation of the SCR. The capital charge is calculated as a percentage of the fair value of the intangible assets. This risk module has been added to the QIS V.

Adjustments for the loss-absorbing capacity of technical provisions and deferred taxes will take account of the risk mitigating effect provided by future discretionary benefits of life insurance contracts, to the extent insurance companies can establish that a reduction in such benefits may be used to cover any unexpected losses when they arise (EC, 2009). In a nutshell, it concerns products whose some of the underlying risk is borne by policyholders. Both conditional and pure discretionary benefits are to be considered to be loss-absorbing.

The standard model for calculating the SCR includes models for the following risks: market, life insurance, health insurance and non-life insurance risks.

The market risk model is calculated as a combination of the capital requirements for at least the following sub-modules: interest rate, equity, property, currency, spread, and concentration risks[23]. Market risk modules are based either on a risk-based approach or a scenario-based approach. For the latter, the capital requirement is determined as the impact of a specified scenario on the net asset value of the company (a NAV approach). The net asset value is defined as the difference between assets and liabilities. The change of NAV resulting from the scenario is referred to as ΔNAV[24].

[23] For a definition of each risk see CEIOPS (2010).

[24] ΔNAV is defined to be positive where the scenario results in a loss of NAV.

The capital charge for interest rate risk is determined as the result of these two pre-defined scenarios: ΔNAV due to an upward and a downward shock in the term structure of interest rates combined with specific alterations in the interest rate implied volatility[25]. The inclusion of a specific interest rate implied volatility stress is a valuable improvement compared to QIS IV and in line with increasing complexity of insurance portfolios. The volatility shocks are relevant only where insurers' asset portfolios and/or their insurance obligations are sensitive to changes in interest rate volatility, for example life insurers where liabilities contain embedded options and guarantees.

Since the QIS IV, the structure of the equity risk sub-module has evolved significantly. There are two possible methods to calculate the equity risk capital charge: a standard approach and a "duration based" approach (limited to certain types of assets and liabilities). Under the standard approach, a specific mechanism is used to avoid unintended pro-cyclical effects (in particular a rise in the equity charge in the middle of a crisis[26]). For the determination of the standard equity module, two indices (*Global*[27] and *Other*) are considered. In a first step, the capital charge for the level stress for both indexes is derived as the result of a pre-defined stress scenario (-32% for *Global* index and -45% for *Other* index in the QIS IV, respectively -39% and -49% in the QIS V). Then capital charges for the level stress are aggregated using a prescribed correlation matrix. In a second step, as the interest rate module, volatility stresses are calculated. In a final step, the equity capital charge is the result of combination of the capital charges for the level and the volatility stresses using a prescribed correlation matrix. Life insurers whose all assets and liabilities are ring-fenced and with a long duration of the liabilities (over 12 years) may apply the "duration based" approach. In this case the pre-defined stress scenario for level equity risk is 22%.

The property capital charge is determined as the result of a pre-defined scenario, a 25% (QIS V, 20% in the QIS IV) fall in real estate benchmarks.

[25] The implied volatility may be defined as the market's assessment of the underlying asset's volatility, as reflected in the option price. Implied volatilities are typically found by first equating observed option prices to theoretical prices (e.g. using a Black-Scholes model) and then solving for the unknown volatility parameter, given data on the option contracts and the underlying asset prices. Implied volatility, a forward-looking measure, differs from historical volatility because the latter is calculated from known past prices of a security.

[26] This mechanism is required to operate such that the equity shock lies within a band of 10% either side of the underlying standard equity stress. For further explanations see Article 106 EC (2009) or CEIOPS (2010).

[27] Comprises equity listed in European Economic Area and OECD countries.

The currency risk is determined as the highest result from two pre-defined scenarios: a 25% (QIS V, 20% in the QIS IV) change, rise and fall, in value of all other currencies against the local currency.

The capital charge for spread risk is by far the most complicated. Spread risk charge reflects the change in the value due to a move of the yield curve relative to the risk-free term structure. The capital charge is divided in bonds, structured credit products, mortgage loans and credit derivatives modules. They are determined using a complex combination of scenario, rating class, duration and risk measurement.

Market risk concentration presents an additional risk to an insurer because of an additional volatility that exists in concentrated asset portfolios and the additional risk of partial or total permanent losses of value due to the default of an issuer. The concentration risk charge depends on rating of each counterparty and the exposure against it.

The counterparty default risk module reflects possible losses due to unexpected default, or deterioration in the credit standing of the counterparties in relation to risk mitigating contracts (reinsurance contracts and financial derivatives), corporate bonds, structured assets and credit derivatives. There is a distinction between rated and unrated counterparties. The determination of capital charge for rated counterparties is based on the Basel II approach using the estimated loss-given-default (LGD) of an exposure and the probability of default (PD) of the counterparty. The capital charge for unrated counterparties is factor-based.

A number of the life underwriting risk stresses are based on a ΔNAV approach. The life underwriting risk module will be calculated as a combination of the capital requirements using a prescribed correlation matrix for at least the following sub-modules: mortality, longevity, disability and morbidity, life expense, revision, lapse and life catastrophe risks. Mortality (15% increase in assumed mortality rates, 10% in the QIS IV), longetivity (a permanent 25% decrease in mortality rates for each age), disability (increase of 50% in disability rates for the next year, together with a permanent 25% increase in disability rates at each age in following years, respectively 35% and 25% in the QIS IV), expense (10% increase in assumed future expenses and 1% per annum increase of the anticipated expense inflation rate), lapse (50 % variation in the assumed rates of lapsation plus a mass lapse scenario), revision (increase of 3% in the annual amount payable for annuities exposed to revision risk) and catastrophe (an absolute 1.5 per mille increase in the rate of policyholders dying over the following year) risks are based on pre-defined scenarios.

The health underwriting risk module is split into three sub-modules: health that is practised on a similar technical basis to that of life assurance, health that is not practised on a similar technical basis to that of life assurance and catastrophe risk. It will be calculated as a combination of the capital requirements using a prescribed correlation matrix. Risk modules are based on a ΔNAV approach or a factor-based approach. The catastrophe risk charge is scenario-based.

The capital charge for non-life underwriting risks is derived by combining the capital charges for the non-life sub-risks: premium and reserve risks and catastrophe risk using a correlation matrix. The premium and reserve risk modules are divided by lines of business and geographic areas. They depend on the loss ratios, the standard deviation of the combined ratio and a variable measuring volume premiums. The catastrophe risk charge is computed using natural catastrophes and man-made scenarios.

The level of the Minimum Capital Requirement (MCR) will be calibrated to the VaR of the available capital of an insurance undertaking subject to a confidence level in the range of 85% over a one-year period (EC, 2009). Insurers have to calculate the MCR at least quarterly and report the results of that calculation to supervisory authorities. Under the QIS V, MCR is calculated using a combined approach. It will be calculated as a linear function of a set of variables: the insurer's technical provisions, written premiums, capital-at-risk, deferred tax and administrative expenses. In addition, MCR will not fall below 25% nor exceed 45% of the company's SCR.

3.3.1.2.2 The Swiss Solvency Test

As Solvency II, the SST applies an economic total balance-sheet approach. The figure below summarizes all the basic concepts applied in the Swiss Solvency Test.

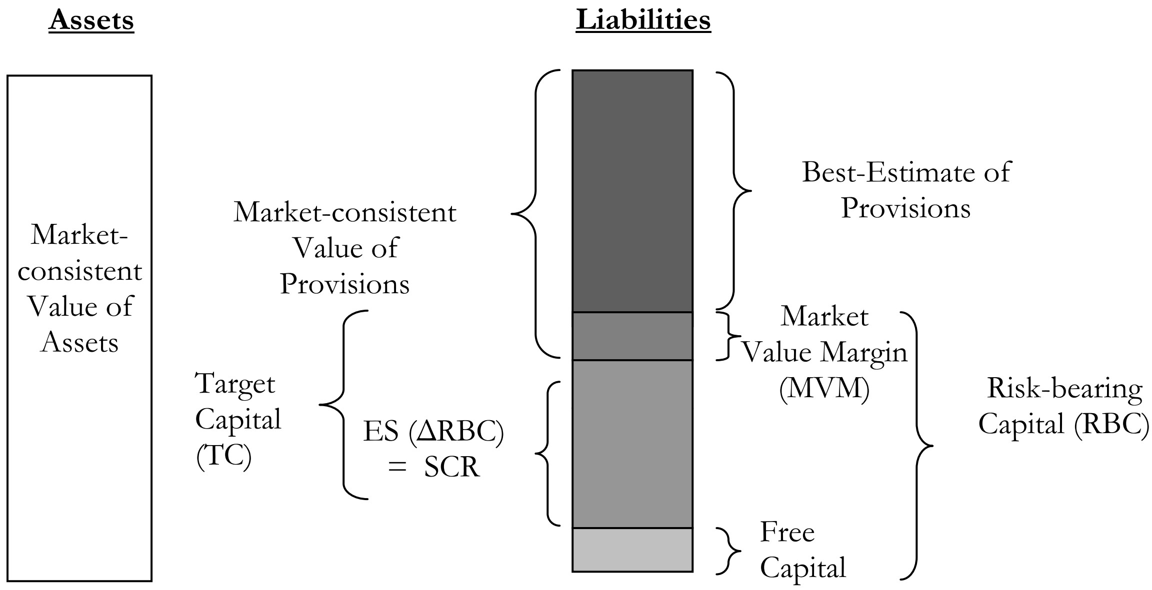

Figure 5: Swiss Solvency Test: an Economic Total Balance-Sheet Approach.

The Target Capital (TC) is made up of 2 elements (see FOPI, 2006a): (1) the analytical part of the TC (called Solvency Capital Requirement, SCR), a 1-year risk capital, defined as the expected shortfall (ES) of the change of risk-bearing capital (Δ*RBC,* defined as market value of assets minus the best-estimate of provisions, equivalent to available capital) during one year at a confidence level α. The SCR captures the risk that the economic balance sheet of the company at t_1 differs from the economic balance sheet at t_0; (2) a market value margin (MVM) defined as the cost of regulatory capital necessary to run-off all the insurance liabilities (see section 3.3.2.1.1).

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. 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. Using the expected shortfall, the answer is:

$$\boxed{ES_{\alpha}\left(RBC(1)\middle|RBC(0)=TC\right)=MVM}$$ or

$$TC = -ES_{\alpha}\left(\frac{RBC(1)}{1+r_1^{(0)}} - RBC(0)\right) + \frac{MVM}{1+r_1^{(0)}}$$ where $r_1^{(0)}$ is the current one-year interest rate.

The standard model for calculating the SCR includes models for the following risks: market, non-life insurance, life insurance, health insurance and credit risks whereas other risk categories (e.g. catastrophe risk) are covered by scenario analysis. Operational risk is not integrated into the model, but is instead considered on a qualitative basis within the SST report. There is a standard model for health, life, and non-life insurers. The standard model is set up as a stochastic risk model. All standard models except for credit risk results are a probability function that describes the stochastic nature of the change of risk-bearing capital (RBC) due to modelled risk factors (see FOPI, 2006a). For the credit risk, same approach as Basel II has been adopted.

The standard asset model for market risks, equally used for life, non-life and health insurance, includes interest rate, foreign exchange, real estate, equity and credit spread risks. The market risk module which stems from variations of assets and liabilities induced by the evolution of external economic factors or influences, called risk factors, on the market is based on the risk metrics model developed by J.P. Morgan[28]. Currently, the model consists of 81 risk factors like stock indices, real estate indices, implicit volatilities, exchange rates, etc.

The sensitivities of the insurer's assets and liabilities to market risk factors must be identified, as follows:

RBC is a function of risk factors:

$RBC(t) = f(X(t))$ where $X(t) = (X_1(t), X_2(t), ..., X_{81}(t))$ denotes the vector of risk factors at time t with a time-invariant function f. As a simplification, the model assumes linear variation between risk factors and RBC. This means that if the share prices drop by 20%, the change in RBC is twice the change that occurs when the share prices drops by 10%.

Then $RBC(1) - RBC(0) \approx \nabla f(X(0)) \cdot Z(1)$ with $Z(1) = X(1) - X(0)$ defined as the risk factor change between 0 and 1. Z(1) is assumed to be multivariate normally distributed (with mean 0) with a prescribed covariance matrix. The regulator estimates volatilities and correlation coefficients by using 10 years of monthly returns of selected market indices. Some parameters are determined by insurers based on their own portfolios data.

Sensitivities are then defined as the partial derivatives of the risk-bearing capital according to market risk factors. They are in general approximated by a difference quotient.

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[28] Widely used in the banking sector for calculating VaR.

$$\frac{\partial f}{\partial x_i}(X(0)) \approx \frac{f(X(0)+\varepsilon_i \cdot e_i) - f(X(0))}{\varepsilon_i}$$ where ε_i is the stress factor, prescribed by the regulator.

We consider the following example. The 5-year interest rate r_5 in EUR is considered as a risk factor. If it changes, then both assets and liabilities vary, but generally not to the same extent. Assume that an increase of r_5 by 100 base points (the stress factor) entails a reduction of the assets by 2,000,000 EUR (initial market value = 40,000,000 EUR) and a reduction of the liabilities by 1,500,000 EUR (initial value = 30,000,000 EUR). The sensitivity of the RBC relative to r_5 is therefore:

$$\frac{(40{,}000{,}000 - 2{,}000{,}000 - 30{,}000{,}000 - (-1{,}500{,}000) - ((40{,}000{,}000 - 30{,}000{,}000)}{100\ \text{bp}} = \frac{-5{,}000\,\text{EUR}}{\text{bp}}$$

The interpretation of this is that the RBC decreases by 5,000 EUR if the 5-year interest rate rises by one base point. Sensitivities are then aggregated taking in account their volatilities and correlation coefficients between market risk factors, both parameters being prescribed by the standard model.

A Basel II approach is used in the standard model for credit risk. All credit risks are included except the reinsurers' default risk (treated via a scenario) and the credit spread risk. In order to avoid arbitrages' possibilities between bank and insurance sectors, the quantitative method must be closed as possible as the one adopted by the bank's regulator (FOPI, 2004).

The life insurance model is defined by seven risk factors (mortality, lapse rate…). As the asset model, risk factors are assumed to be normally distributed. The insurer calculates the sensitivity of the RBC to each factor on a one-year period. It is also assumed that the change of RBC is linear. Sensitivities are aggregated taking into account volatilities and correlation between life risk factors.

The aim of the non-life model is to determine the distribution of the annual change of the RBC due to the variability of the technical result. Unlike most non-life insurance models, the Swiss model is not a factor-based. The non-life model result is the most complex part of the SST because it requires finding separate distributions for small and large claims and change in provisions (reserving risk) which then need to be aggregated by a convolution method. The standard model does make life easier by offering predefined distributions and parameters. For instance, large claims are modelled via a compound Poisson distribution, i.e. the claims number being Poisson distributed. The claims severity is assumed to be Pareto distributed for each line of business with the possibility to determine some parameters based on own company's data. A distribution-based model contains a great degree of freedom to be adapted to small as well to large companies. Catastrophe risk is included via the scenario analysis.

The standard health model considers three lines of business: individual health care costs, individual daily allowance and daily allowance for groups. The aim of the health model is to determine the distribution of the annual change of the RBC due to the variability of the technical result. For each of the lines, mean and standard deviation are estimated on the basis of companies' historical data. The results are then aggregated using assumptions on the correlations between the cash-flows of the lines.

Risks not covered for by the standard models are treated via scenarios (2001/2002 stock market crash, currency crisis, Russian crisis, catastrophe risk as pandemic or natural catastrophe…). They are defined as events that have a very small probability of occurring and have a negative effect on the RBC. Scenarios defined by the regulator as well as company specific scenarios have to be evaluated and, if relevant, aggregated within the target capital calculation.

The results of the standard models must be combined with the evaluations of the scenarios. The first step comprises the aggregation of the asset and the liability (life, non-life and health) distributions to one so-called analytic distribution. Calculating the 1-year risk capital on this analytic distribution gives the probability function which describes the situation of the company if none scenarios happen. A scenario results in a probability function. All functions are aggregated with the standard or internal models using weighted averages, weighted are given by the probabilities of the scenarios. These weights are predefined by the Swiss regulator. The result is a global distribution function where the 99 % TailVaR now can be applied to obtain the Solvency Capital Requirement. It is not the final figure, since the results of the two next steps (credit risk and market value margin) have to be added. This final number is the Target Capital.

Finally, the Minimum Solvency is a rules-based minimum capital analogue to the Solvency I rules.

3.3.1.2.3 US Risk-Based Capital

A separate risk-based capital (RBC) formula exists for each of the primary insurance types: life, property/casualty (non-life), and health (see NAIC, 2009). Each formula utilizes a generic formula approach rather than a modelling approach, although the life RBC formula has recently incorporated some modelling related to interest rate risk (internal modelling and scenarios).

The formulas establish a minimum capital level, the RBC, required to cover the insurer's risks. The Authorized Control Level RBC (ACL RBC) is equal to the RBC multiplied by a 0.5 factor.

The ACL RBC is then compared to the Total Adjusted Capital (TAC[29]), roughly equivalent to the available capital. As discussed previously, based on this RBC ratio, there are five levels of intervention. As the RBC ratio of less than 200 percent requires a "company action", it negates the effect of the 0.5 adjustment.

The RBC models for life, non-life and health businesses are described below. Common risks include asset, credit, underwriting and business risks. The non-life and health formulas place more emphasis on insurance risks whereas life formula is the only one which explicitly models the interest rate risk. The formulas recognize the correlation between various types of risk, applying a covariance calculation to determine the appropriate RBC i.e. using a square root for interactions between risks. This covariance approach takes account that all risks cannot occur simultaneously. But the RBC formulas apply a simplistic covariance calculation to the multiple risk areas, assuming a covariance of either 0 or 1. There is a lack of covariance terms in the square roots. Moreover the formulas assume independence between some risks in the square roots (e.g. between C_0 and C_{3a}). Finally they exclude affiliate insurers and off-balance sheet risks from the square root, assuming independence with all other risks.

$$RBC_{Life} = C_0 + C_{4a} + \sqrt{(C_{1o} + C_{3a})^2 + (C_{1cs} + C_{3c})^2 + C_2^2 + C_{3b}^2 + C_{4b}^2}$$ where

C_0: Asset risk, Affiliates

C_{1o}: Asset risk, All other assets

C_{1cs}: Asset risk, Common stock and certain unaffiliated/ affiliated assets

C_2: Insurance risk

C_{3a}: Interest rate risk

C_{3b}: Health credit risk

C_{3c}: Market risk

C_{4a}: Business risk, Non-health

C_{4b}: Business risk, Health

$$RBC_{Non-Life} = R_0 + \sqrt{(R_1)^2 + (R_2)^2 + (R_3)^2 + (R_4)^2 + (R_5)^2}$$

R_0: Asset risk, Affiliates

[29] Sum of the capital and surplus, 50% of dividend liability and the asset valuation reserve (ARV).

R_1: Asset risk, Fixed income investments

R_2: Asset risk, Equity investments

R_3: Credit risk (recoverables, reinsurance)

R_4: Underwriting risk, Reserves

R_5: Underwriting risk, Net written premiums

$$RBC_{Health} = H_0 + \sqrt{(H_1)^2 + (H_2)^2 + (H_3)^2 + (H_4)^2}$$

H_0: Asset risk, Affiliates

H_1: Asset risk, Other invested assets

H_2: Underwriting risk

H_3: Credit risk

H_4: Business risk

The Asset risk, Affiliates represents the capital requirement to protect the insurer against defaults of affiliates. The Asset risk, Other (including credit risk and market risk) represents the risk of default of principal and interest or fluctuation in fair value of assets.

Interest rate risk (for life insurers only) comprises losses due to changes in interest rates and mismatch of asset and liability cash-flows. For some life products, interest rate risk is modeled using scenarios. The amount of capital requirement is greatest on products where the policyholders have guarantees in their favor and where the policyholders are most likely to be responsive to interest rate changes. The interest rate risk has been broken in three categories: low, medium, and high risks. Risk categories vary by the withdrawal provision, i.e. whether there is substantial penalty for early withdrawal.

Insurance/Underwriting risk encompasses inadequate pricing and underestimation of claims reserves, including risk associated with adverse mortality and morbidity. Property/Casualty companies calculate an underwriting risk for reserves and for premiums. These calculations reflect the risk of pricing and reserving errors.

Business risk represents the wide range of general business risks faced by insurers, i.e. poor management, poor business....The characteristics of these risks are difficult to quantify in a general way for all companies and are not included in the other risk categories. Business risk is simply quantified using a percentage of premiums or liabilities.

For each risk category, basic values are defined and taken from the balance sheet. Each basic value is then multiplied by risk factor defined by the American regulator, a factor-based approach. Factors do not generally vary by company, but some vary by volume of business or level of asset concentration. Some factors are also risk-sensitive, e.g. the fixed income risk factor becomes progressively higher for bonds of lower quality according to NAIC classification.

In most states, the RBC system is specifically referenced in state law, so changes to the formulas are automatically implemented in the states. There are no internal models per se but the RBC includes inputs from companies so that the resulting calculation is tailored by the company's own data. However it is limited to the life insurance interest/ market risk capital requirements for specific life insurance.

The American RBC raises questions regarding its true usefulness in addressing the problem of insurer insolvency. Studies suggest that RBC measure alone is a poor predictor of insurer insolvency and that FAST ratios have greater predictive power than RBC ratios (Cummins *et al.*, 1995; Cummins *et al.*, 1999).

3.3.1.2.4 Comparison

Where European systems apply risk measures on stochastic probabilities, the RBC formula is not calibrated to a VaR or a TailVaR target. However, internal models used by US insurers for calculating reserving and capital requirements may be calibrated based on a risk measure approach. Therefore European approach to determine solvency requirements is risk-sensitive whereas US RBC is mainly based on static factors and accounting data reported in the audited statutory annual statement. However some RBC factors are supposed to be graded by risk, as they are higher for those items with greater underlying risks and lower for less risky items, e.g. risk factors higher for bonds of lower quality rating. Additionally some factors are based on companies' past data and take then account the insurer's risk level.

All models differentiate insurance activities along business segment (life, P&C, health and reinsurance activities) although American reinsurers are not subject to federal RBC legislation[30]. In Europe, there is no model specific to reinsurers but in Switzerland they are required to have an adequate internal model to calculate their risk.

[30] These might be subject to regulation in their domicile state.

Regarding risks covered by the different legislations, some differences have to be highlighted. Catastrophe risk is not included in the NAIC model and operational risk is not yet calculated in the Swiss solvency assessment nor included in the US RBC. However in the latter case operational risk could be interpreted as part of the business risk. The Swiss regulator argues the lack of data and experience available regarding this specific subject. The SST considers operational risk on a qualitative basis. As regards to catastrophe risk, it is more difficult in the context of factor-based models, e.g. risk-based capital models, to differentiate catastrophe with normal claims. Hence, catastrophe risks are better measured in European dynamic models. Solvency II operational risk is calculated as simple factors applied on total earned premiums and insurance technical provisions. Operational risk losses result from complex and non-linear interactions between risk and business processes. It is clear that other indicators such as the internal control environment, which are hard to express in quantitative capital requirements, are also major predictors of operational losses. Then the operational risk may be more suitably dealt with by governance rules as at the moment, realistic modelling of this risk is difficult, and depending crucially on risk management and internal control of a company.

In Europe, most risk charges are truly risk-based using scenarios or risk factors. The majority of the scenarios are prescribed, but the effects may differ from company to company depending on the risk exposure. This makes the scenario approach risk-sensitive and risk-specific. However where Solvency II uses essentially deterministic scenarios (for market risks) and catastrophe scenarios (natural and man-made) for non-life and health risk modules, the SST goes one step further. It requires to perform a significant higher number of scenarios (market-based, accident, pandemic, terrorism…) and applies market-wide scenarios, e.g. a Russian crisis or a major reinsurer bankruptcy.

Solvency II and the SST uses different approaches for quantifying non-life risks. Unlike most non-life insurance models, including Solvency II, the Swiss model is not a factor-based model. The SST non-life model is based on predefined distributions. Naturally it implies a greater risk model, as there is always the possibility that the underlying risk distribution has been wrongly specified. Moreover the underlying distribution might not be stable over time. To guard against too much faith being placed in a specific risk model and its assumptions, it would be important to vary the implicit model parameters in a specified range, similar to what is done in stress testing. We could obtain the sensitivity of specific results. Under the Solvency II project non-life risks are including in the form of factor-based calculations using gross premiums and claims expenditures of the accounting year as variables. The major advantage of a factor-based approach is its simplicity, which makes it easy to apply for a wide range of companies, but this comes at the cost of decreased risk-sensitivity. The factor-based components are less risk-sensitive, because a reduction in capital requirements is achieved by reducing the size rather than the risk profile. The Swiss system goes then further in the risk-sensitive approach.

All models ignore some risks that turned out to be important in retrospect, e.g. liquidity risk. But it is worthy to note that American regulators apply liquidity stress tests to evaluate the exposure of insurers to the liquidity risk. It is clear that this risk is less important than for banks. But recent developments show rationales for a higher supervision of liquidity issues. The reliance on ratings is another critical point. Contrary to Solvency I, ratings are essential under Solvency II and in the SST[31]. The financial crisis has made clear that relying heavily on ratings can be misleading and dangerous. Insurers and regulators should thus be cautious to substitute their own due diligence by a rating, as rating agencies' methodologies are not really transparent.

Europeans systems apply mainly a prospective view, i.e. capital measurement based on expected future volume experience using assumptions about changes in a company's profile (e.g. rate of policy renewal rates) and the market (future returns on investments, volatility of losses, and so on), whereas US standards apply mainly retrospective approach, i.e. based on past measures[32]. For instance, the Solvency II SCR covers existing business, as well as the new business expected to be written over the next twelve months (EC, 2009).
The time horizon in all models is set to one year. Risks in insurance arise from items that generally exist over very different time periods from one day to some decades. The industry often chose one year as a good approximated measure as it is in line with reporting period used by most companies. Whereas this one-year period can be justified for non-life business and its shorter business cycle, life insurers are based on longer time horizon. Therefore for life insurers a longer time horizon would possibly produce more reliable results (Eling and Holzmüller, 2008). A good alternative approach would be the one developed in the Netherlands in the context of the Financial Assessment Framework (see section 4 for further explanations). Together with a Solvency Test which quantifies insurance and financial risks on a one-year horizon, a Continuity Analysis deals with long-term risks such as strategic policy or long-term management actions.

[31] For instance in the calculation of the credit risk.

[32] There are also some counterexamples. For instance, the underwriting risk for property/casualty companies is based on business written in the coming 12 months.

European systems use a sophisticated approach for the diversification effect and the interaction among different risks, the Swiss technique being the most advanced. European regimes introduce correlation matrices and convolution methods. For instance, QIS V uses correlation matrices for inter-modular and intra-modular diversification. However, Solvency II and the SST standard models focus mainly on linear correlation even though the literature suggests that solely considering linear correlation is inappropriate when modelling dependence structure between heavy-tailed and skewed risks, which are frequent in the insurance context (see Embrechts *et al.*, 2002; Eling and Toplek, 2009). For instance, the 11 September, 2001 terrorist attacks resulted in large losses for insurance companies both from their underwriting business and the related capital market plunge.

In the US and under the Solvency II project, for the final diversification effect, the models include interactions among risk categories by using a square root. This covariance approach takes account that all risks will not occur simultaneously. But the RBC formulas assume the individual risks to be independent. This independence assumption leads to an underestimation of capital requirements (Feldblum, 1996).

The use of internal models is fully recognized under Solvency II and in the SST but not under the US RBC, although compulsory for insurers engage in certain types of business[33]. US internal models are applied because the standard formula does not capture some type of risks. But there is no prior approval of the model required. Regulators rely upon the company's actuaries to attest the appropriateness of the models and its results (Vaughan, 2009). US companies have also the possibility to use their own data to calculate some risk factors. In Europe, internal models are not compulsory, except for Swiss reinsurers, but strongly recommended. Under the Solvency II directive, if the insurer fails to comply with the requirements underlying the internal model, the regulatory may also require insurers to revert to calculating the Solvency Capital Requirement in accordance with the standard formula (EC, 2009).

Internal models calculate capital requirements that more closely matched risks of insurers and promote a culture of risk management. To develop internal models, companies need incentives to properly manage their risks. Obviously using internal models complicates the job of supervisors who need the required technical abilities to understand models. The possibility that regulators do not clearly understand risk models is one of the major drawbacks in the use of internal models. Contrary to Europe, NAIC speaks in favour of an incremental use of internal models. It is true to say that European way of implementing internal models may be seen as a "big bang" approach as

[33] The interest rate risk for particular life insurance products.

the entire regulation framework will undergo changes. However, insurers already use internal models. So their recognition under Solvency and in the SST is merely a way of formalizing and improving the existing situation.

Finally the approach used to calculate minimum requirements is diverging as the Solvency II MCR is risk sensitive, based on a VaR simplified version of the standard model, whereas the Minimum Solvency under the SST is based on Solvency I, i.e. through the multiplication of specific factors with premiums or claims for non-life insurers and with mathematical provisions for life insurers. This approach does not reflect the risk exposure encountered by insurers. Under US standards, absolute minimum requirement varies by state and by line of business and not with the insurer's risk profile.

3.3.2 Valuation of Assets and Liabilities

As an economic approach is applied for calculating capital requirements in Europe, a market-consistent valuation of all assets and liabilities should be used. Market consistent refers to values that are consistent with those observed in deep and liquid financial markets and therefore draws a distinction between market-consistent valuation and observed pricing practices in the insurance markets (CRO FORUM, 2008). Insurance premiums rates and prices are not considered as an adequate basis for the valuation of insurance liabilities because primary insurance markets are illiquid and inefficient and because pricing practices in the primary insurance markets are driven by a range of considerations beyond the economic value of the liabilities generated. Assets (liabilities) will be valued at the amount for which they could be exchanged (transferred, or settled) between knowledgeable willing parties in an arm's length transaction (EC, 2009). All assets and liabilities must be evaluated including embedded options and guarantees. Where market consistent value is not possible, mark to model[34] procedures should be used. When marking to model, undertakings will use as much as possible observable and market consistent inputs. Finally assets and liabilities valuation must be in line with international developments in accounting[35].

One goal of the Solvency II directive is to harmonize rules throughout European countries for the valuation of assets and liabilities. In contrast, US assets and liabilities valuation requirements vary across different states and the valuation methods required can be especially complicated (see

[34] Marking to model is any valuation which has to be benchmarked, extrapolated or otherwise calculated from market inputs.

[35] For instance International Financial Reporting Standards (IFRS) definition of fair value

Cummins and Venard, 2007). In many cases, the state commissioner can exercise some discretion in the methods required, though are generally subject to the constraint that they must be consistent with the guidelines provided in the NAIC model laws. Asset valuation varies, primarily based on market/fair value principles. Other methods as amortized cost or book value are applied as well. For statutory purposes insurer assets fall into three overlapping categories: invested assets, non-invested admitted assets, and non-admitted assets. Invested assets are admitted assets that generate income whether through interest, dividends, rent, or capital gains, i.e. bonds, stocks (common and preferred), mortgage loans, real estate, policy loans, and cash. Asset valuation standards typically require the use of amortized values for bonds, and market or cost value for stocks (depending on whether they are common or preferred). Mortgage loans are valued at unpaid balances and real estate at the lower of book or market value.

The RBC formulas use the data reported in the audited statutory annual statement, which utilize conservative accounting rules adopted by the NAIC. The emphasis on an accounting rather than a financial risk view in the US makes the risk profile of insurers less accurate. According to Cummins *et al.* (1994), ignoring potentially large differences between accounting and economic values gives a misleading picture of insurer resources and reduces the ability of a risk-based capital system to assist regulators and encourage greater safety of weak companies. Moreover if regulators place more emphasis on financial risk assessment than accounting values, insurers will have greater incentives to reduce their risk level by using risk transfer methods such as catastrophe risk financing devices (for further explanations, see Klein and Wang, 2007).

3.3.2.1 Technical Provisions

3.3.2.1.1 European Systems

Technical provisions need to be established in order for the company to fulfil its insurance obligations towards policyholders and beneficiaries (EC, 2009). The methodology applied to calculate the technical provisions is rather similar in the European Union and in Switzerland, whereas there is no equivalent for the American scheme. The calculation of technical provisions will be based on their current exit value. It reflects the amount an insurer would expect to have to pay today if it transferred its contractual rights and obligations immediately to another company. The calculation of technical provisions must be market-consistent and company-specific information will only be used in so far as that information enables insurers to better capture the characteristics of the underlying insurance portfolio (EC, 2009).

There are no liquid markets for insurance liabilities, i.e. technical provisions, except in the case of hedgeable risks arising from insurance obligations. Where the future cash-flows associated with insurance obligations can be replicated using financial instruments for which a market value is directly observable on a deep, liquid and transparent market, the value of technical provisions will be determined on the basis of the market value of those financial instruments. A perfect hedge or replication is one that completely eliminates all risks associated with the liability. In practise perfect hedges are expected to be relatively rare (CEIOPS, 2008). The figure 6 contains example of each type of risk (CRO FORUM 2008):

SOURCES OF EXPOSURE		TYPES OF RISK: Hedgeable	TYPES OF RISK: Non-hedgeable
	Financial	• 10-year USD, EUR or Yen cash-flow or interest rate option • 10-year equity option	• 60-year USD, EUR or Yen cash-flow or interest rate option • 15-year emerging markets cash-flow • 30-year equity option
	Non-financial	• Screen-or exchanged-traded CAT risks • Actively traded securitised risks	• Most insurance risks • Policyholder behaviour

Figure 6 : Hedgeable and Non-hedgeable Risks

For non-hedgeable risks, the best estimate of provisions is less than the price of that liability on a market (market-consistent valuation based on the transfer price). The reason is that the liability carries a run-off risk for which the liability taker wants to be indemnified. Therefore the market-consistent value of liabilities is defined as the best estimate of liabilities plus a market value margin (MVM). The best estimate of liabilities corresponds to the present value of expected future cash flows, taking into account all the cash in and out flows required to settle the insurance obligations over their lifetime, including all expenses, future discretionary bonuses, embedded financial guarantees and contractual options. The best estimate will be calculated by discounting the expected cash-flows using the relevant risk-free interest rate term structure.

The market value margin (MVM) is the additional cost, above the best estimate, of providing regulatory capital to support the insurance obligations over the lifetime of the portfolio, following financial distress of the company. The desired outcome would be that in case of insolvency of insurer 1 another insurer (named insurer 2) would take over the portfolio of assets and liabilities. As the goal of the regulator is to protect the policyholder, MVM aims to reach this objective by protecting policyholders against risks emanating beyond the 1-year time horizon. It is assumed that at the end of the time horizon the insurer 1 has sufficient assets to cover the technical provisions but has no available capital beyond that. In this case, there are two ways forward: either the undertaking is recapitalised to the level of the solvency capital or the insurance obligations are transferred to another undertaking. In the second case, the external entity must make risk capital available for the run-off. MVM is the smallest amount of capital which is necessary, so that the insurer 2 would be compensated for the risk, or more precisely for the capital cost due to having to hold regulatory capital until the run-off of the portfolio, when taking over the first insurer's assets and liabilities.

The MVM is calculated using the Cost-of Capital (CoC) method, by determining the cost of providing an amount of eligible own funds equal to the solvency capital (Solvency Capital Requirement, SCR) necessary to support the insurance obligations over their lifetime. The SCR covers risks which emanate during a 1-year time horizon. MVM covers risks during the whole run-off of the portfolio after the time horizon. Then there is no double-counting. MVM is calculated by a three-step approach.

1. Determine the SCR for years 1,2,3… until the whole run-off of the portfolio. This is the critical step, especially the determination of risks to be included into the future SCRs.
2. Discount the future SCRs using the risk-free yield curve and determine the present value.
3. Multiply the present value of future SCRs with the CoC factor, which is set to 6% under Solvency II and in the SST. The result is the MVM.

$$MVM = CoC * \sum_{t>1} SCR(t)$$

The Swiss regulator justified this CoC factor as follows (FOPI, 2006b). The CoC for an insurer is calibrated to the regulatory requirement. The capitalization required under the Swiss Solvency Test is based on a 99% TailVaR. This corresponds to approximately 99.6% to 99.8% Value-at-Risk or a strong BBB rating. The observed CoC for A or AA rated company is within the range of 3% to 4.5%. The Swiss regulator assumed that the cost of capital for BBB companies is higher and 6% was deemed to be a reasonable estimate.

The calculation of the MVM is quite similar between Swiss and European models. The main difference is the treatment of the market risk. Under the Solvency II project, it is assumed that the risks to be taken into account are operational risk, underwriting risk with respect to existing business and counterparty default risk with respect to reinsurance ceded. So future SCRs do not include any market risk. In the SST, future SCRs bear some market risks.

Finally MVM is explicitly integrated into the Target Capital when excluding of the Solvency II SCR. MVM has no equivalent in the American system. European systems go then one step further into the policyholders' protection as the MVM is equivalent to the amount insurance companies would expect to have to pay today if it transferred its contractual rights and obligations immediately to another firm.

3.3.2.1.2 US RBC

In the US, valuation of reserves for non-life insurers is principles-based, including an implicit risk margin. The approach calculates the greatest present value of the deficit under stochastic scenarios. It applies a TailVaR to determine the required reserves, including a minimum floor based on a prespecified deterministic scenario. Life insurance companies must establish reserves using a rules-based valuation (Vaughan, 2009). The regulatory system requires that US life reserves are determined using conservative mortality and interest rate assumptions. Other risks than mortality and interest rate risk are not explicitly recognized. However, the American regulatory authorities proposed a revised methodology.

3.3.3 Own funds

Under Solvency II, own funds correspond to an insurance undertakings' available financial resources which can serve as a buffer against risks and absorb financial losses, where necessary (EC, 2009). The determination of the amounts of own funds eligible to cover the EU Solvency and Minimum Capital Requirements is based on a three-step process. In a first step, the amounts of available own funds must be identified. Own funds are the sum of (1) items on the balance-sheet, or "basic own fund items". It comprises the available capital (i.e. the excess of assets over liabilities) and subordinated liabilities. (2) Items not on the balance-sheet, or "ancillary own fund items". It comprises commitments that undertakings can call upon in order to increase their financial resources, such as unpaid share capital or initial fund that has not been called up, letters of credit and guarantees or any other legally binding commitments received by insurance companies.

In a second step, as own fund items possess different qualities and provide for different levels of absorption of losses, those own fund items will be classified into three tiers, depending on their nature and the extent to which they meet five key criteria (subordination, loss-absorbency, permanence, perpetuality and absence of servicing costs).

In a third step, as tier 2 and tier 3 items do not provide for full absorption of any losses in all circumstances, it seems necessary to limit their recognition for supervisory purposes:

- with respect to the SCR, the proportion of tier 1 in the eligible own funds should reach at least 1/3, and the proportion of tier 3 should be no higher than 1/3.
- with respect to the MCR, ancillary own fund items are not eligible, and the proportion of eligible tier 2 items should be limited to 1/2.

The SST and the US RBC standards do not identify different own funds' categories. They only identify one overall amount of own funds. Solvency II own funds fit approximately the Swiss risk-bearing capital (RBC) definition. The Swiss RBC is primarily defined as the difference between the value of the assets and the values of the liabilities. Liabilities contain all types of capital which can freely be used by the company in a situation of distress, i.e. liabilities which are legally bound or are promised to any of the stakeholders except the shareholders (e.g. dividends, own shares, loans which can be converted into shares…) (Luder, 2005).

Under the US standards, the own funds corresponds to the Total Adjusted Capital (TAC). TAC is the sum of statutory capital and surplus, any voluntary reserves held by the insurer, one-half of the insurer's policyholder dividend liability, and, in the case of life and health insurance, the asset valuation reserve (AVR). There are also limitations regarding the quality of capital resources. Accounting guidance limits values on some items as goodwill and provides for certain assets to be fully "non-admitted" or not counted toward surplus as letters of credit.

3.3.4 Investments

As the new Solvency II valuation standards take due account of credit and liquidity characteristics of assets, as the Solvency Capital Requirement captures all quantifiable risks, and as all investments are subject to the "prudent person" principle, member States should not require insurance undertakings to invest their assets in particular categories of assets (EC, 2009). This is a major difference with the Solvency I legislation. Currently, regulators merely define upper limits for investments in each asset class. The "prudent person" principle requires insurance companies to invest assets in the best interest of policyholders, adequately match investments and liabilities,

and pay due attention to financial risks, such as liquidity and concentration risks. As Solvency II, the SST does not prescribe any investment rules.
Whereas SST and Solvency II require only principles, the US regulation includes certain limits[36] on the amounts or relative proportions of different assets that insurers can hold to ensure adequate diversification and limit risk. For instance, US regulatory standards for bond investments include restrictions on the quantities (i.e. the proportion of admitted assets) of certain classes of bonds that can be held[37] and on the amount of bond holdings that can come from a single institution. This is another illustration of principles- vs. rules-based approaches. Quantitative rules are easy to implement and to interpret but they have also drawbacks. They are not flexible and cannot be rapidly adjusted in response to economic developments or structural changes in securities markets.

3.4 Qualitative Aspects

The Solvency II pillar II comprises the qualitative elements of the new regulatory regime such as governance, risk management, internal control and supervisory. As part of their risk management system and their business strategy, all insurance undertakings should have a regular practice of assessing their overall solvency needs with a view to their specific risk profile: Own Risk and Solvency Assessment (ORSA, EC, 2009). That assessment includes, at least, the overall solvency needs taking into account the specific risk profile, approved risk tolerance limits and the business strategy of the company and the extent to which the risk profile deviates significantly from the assumptions underlying the SCR. It includes risks not countable in pillar I and the evaluation of the quality of the risk transfer, especially the reinsurance.

Pillar II focuses on the roles of supervisory authorities (Supervisory Review Process, SRP). One aim of the European Commission is to harmonize the European market by strengthening cooperation between European regulators. Following the SRP, supervisory authorities may in exceptional circumstances set a capital add-on for an insurance company if the supervisory authority concludes that: (1) the risk profile of the company deviates significantly from the assumptions underlying the Solvency Capital Requirement as calculated using the standard formula or an internal model because certain quantifiable risks are captured insufficiently; and/or

[36] Depending on each state's rules.

[37] From class 1 to class 6 depending on the bonds' risk, class definitions are based generally on the ratings provided by the Securities Valuation Office (SVO) of the NAIC.

(2) the system of governance of the company deviates significantly from the standards laid down in the directive (EC, 2009).

The Swiss Quality Assessment (SQA) constitutes a central element of the Swiss insurance supervision regime. The main focus of a qualitative insurance supervision is on corporate governance, risk management, and internal control (FOPI, 2007). The regulator relies on the method of self-assessment which has to be validated. Companies have to establish that their risk management is appropriate to their risk profile. FOPI also verifies whether an effective internal control system is established and implemented. The SQA is equivalent to the ORSA that will be carried out by EU companies. The SQA also includes qualitative risks as operational risk.

The American regulation authorities do not require companies to implement enterprise risk management systems, nor any explicit requirements to provide a document that includes an assessment of risks. However, qualitative aspects can be addressed by additional state's rules. In addition, the Model Audit Rule[38] provides the foundations of a sound risk management by requiring documentation, testing and management's attestation regarding internal controls over financial reporting. But so far these requirements have been targeted to specified products and business functions and not on a broader area. Finally US regulators use a variety of solvency-focused tools as on-site examinations, off-site financial analysis, required independents audits or stress-testing. Instead of concise and limited principles, as in Europe, US companies are required to implement or comply with a multitude of rules and requirements leading to a higher regulation complexity. This is another drawback of a rules-based system.

3.5 Information Disclosures

The Solvency II pillar III is devoted to information and reporting to policyholders, investors, employees or supervisory authorities. The objective is to provide the market with sufficient information to enable it to properly exercise its disciplinary condition.

Under the Solvency II directive, insurance companies will be required to publicly disclose, on an annual basis, a "Report on their Solvency and Financial Condition". That report will contain, among others things, the following elements: a description of the system of governance and an assessment of its adequacy for the risk profile of the company, a description, for each category of risk, of the risk exposure, concentration, mitigation and sensitivity and a description of methods

[38] See e.g. Lindberg (2007).

used for the valuation of assets and liabilities (EC, 2009). This should be sufficiently complete to allow policyholders and investors to have a deep overview of the company. However, supervisory authorities will permit companies not to disclose information if competitors can gain significant undue advantage.

In Switzerland, a SST report summarizes quantitative and qualitative aspects of insurance companies (FOPI, 2004). It has a mandatory minimum content prescribed by the regulator. It is to be provided to the Swiss regulator on an annual basis and has to be signed-off by the CEO. All relevant information to understand the target capital calculation has to be part of the SST report. It contains information varying from the methodology used for valuing assets and liabilities, the description of the internal models, the scenarios used or the description of risk mitigation techniques. The risk management and the risk governance have to be described within a separate report (the risk management report). This report contains all elements related to the risk strategy, including the risk objectives and risk appetite, the allocation of responsibility and the tasks of the involved functions, the risk reporting process… Insurance companies report to supervisors such that 3rd party can understand the results. The SST does not require a public disclosure which is a major difference with the Solvency II directive. Solvency II goes a step further towards transparent markets.

US insurers have to provide a document with over 100 pages of reporting. This centralized document allows states to do analyses that compare insurers to peer groups from across the country. Insurers are also required to file a supplement to their annual statement titled "Management's Discussion and Analysis". This discussion include, among other things, following financial information: any material changes to an insurer's invested asset mix and quality distribution and the potential impact to liquidity, adequacy of the insurer's policy or loss reserve and any material changes between years, and any material trends in capital and surplus, events that could result in cash flow changing in a material way. The primary objective of this document is to disclose information that enables regulators to enhance their understanding of the insurer's financial position. Indeed the American factor-based approach can cause misreporting (Holzmüller, 2009). Misstatements of financial figures can cause an equivalent reduction of capital requirements. For instance, misreporting premiums might lead to a reduced risk charge. Disclosure requirements appear then to be far more important in factor-based models compared to principles-based approaches. As the SST, the US RBC standards do not require public disclosure.

4. Other Main Insurance Regulation Systems

Important reforms of regulatory systems are going on in many countries. Australia has enacted a "General Insurance Reform Act", which sets new prudential standards for general insurance companies. It was effective from 2002. The Australian regulator (Australian Prudential Regulation Authority) has defined six prudential standards ranging from risk management, capital adequacy to reinsurance. Thanks to this reform, Australia switched from a simple factor-based model to a risk-based model.

The German insurance industry and the German Insurer's Association made an early start on preparations for Solvency II, and, together with the Federal Institute for Supervision of Financial Services, have developed two standard models, one for life and one for non-life companies. These risk-based models incorporate all controlling and monitoring-relevant risk categories but focuses particularly on asset-liability mismatch risks, reinsurance default risks, and extreme events.

In Japan[39], the first Insurance Business Law was enacted in 1900. In 1939 and above all in 1995, the insurance regulation was substantially revised to preserve the soundness of insurance businesses, and to ensure fairness and equity in business operations. This revised law allows Japanese insurers to operate in all insurance areas (life, non-life and health) under the supervision of the Financial Services Agency (FSA). FSA has independent authority to regulate and supervise insurers as well as banks and security companies. The FSA is fully responsible for ensuring the stability of the financial system in Japan and protecting depositors, insurance policyholders, and securities investors. To maintain the sound management of insurers, a solvency margin ratio was introduced as a measure of the early warning system in the Insurance Business Law of 1995. The Japanese solvency margin belongs to the factor-based models category. Since March 2002, insurers are required to disclose to the public the solvency margin ratio and its components.

Anticipating the Solvency II directive, the Netherlands developed the FTK, the Financial Assessment Framework. It has been introduced in 2008. The FTK comprises two elements: the Solvency Test and the Continuity Analysis. The Solvency Test deals with the quantification of credit, market, underwriting (life and non-life), operational and concentration risks. They can be examined by a standard or an internal model approach. The standard model combines scenario analysis (e.g. life insurance), dynamic cash-flow-based models (essentially financial risks) and a

[39] See Cummins and Venard (2007).

factor-based approach. The Solvency Test is supplemented by the Continuity Analysis which deals with long-term solvency considerations, i.e. a broader time horizon including new premiums and liabilities is considered. The Continuity Analysis assesses the financial position against the background of realistic long-term scenarios and the associated risks, the institution's strategic policy and the adjustment mechanisms such as revising the investment, indexation and contribution policies.

In the UK[40], one of the most advanced European solvency regime, the Financial Services Authority (FSA), which regulates the whole financial-services industry, proposed in 2002 a new framework for setting individual capital standards for a large range of financial firms, including banks, insurance and investments firms. FSA issued an "Integrated Prudential Sourcebook" which organizes prudential regulation by categories of risks, and not according to the company status. Such a way of doing is in line with the convergence of the banking and insurance sectors as well as with the emergence of globalized bancassurance companies. The insurance regulation is based on a two-pillar approach. Pillar I is devoted to a risk-based minimum regulatory capital requirement: the Enhanced Capital Requirement (ECR). The ECR is the complement to the Solvency I minimum capital, i.e. a twin peak's approach. The ECR's calculations are based on simulations and stochastic modelling of the future, i.e. a dynamic financial analysis (DFA) approach. Pillar II is a broader regime for assessing individual capital adequacy standards (ICAS). One main goal is ensuring that the amount of capital held by companies is proportional to their risk profile. The ICAS will add more guidance on how the companies may assess adequate capital resources. The ICAS framework is based on two key elements: (1) an internal capital assessment (ICA), to address risks not adequately captured in the pillar I requirements based on self-assessment including individual scenarios and stress-testing; (2) a supervisory tool, the individual capital guidance (ICG). The regulatory authority may advice or require the company to hold additional capital.

This list is non-exhaustive and there exists a wide variety of advanced insurance regulation systems around the word including those of Canada, Denmark, Finland, Singapore or Sweden[41].

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[40] See Sandström (2006).

[41] See for example Sandström (2006).

5. Conclusion

This paper contributes to the literature by providing an overview and comparison of the solvency systems in the European Union (Solvency II), in Switzerland (Swiss Solvency Test) and in the United States (US RBC). Other systems, such as Japanese or UK, are briefly presented as well. Our results are relevant for both regulators, especially those involved in the current Solvency II and US RBC discussions and insurers that are required to implement risk management systems.

We point out key divergences between these three approaches. The European principles-based approaches, compared to the US rules-based system, allow insurance companies to integrate risk factors in their risk management process. This could trigger innovations, as insurers are encouraged to develop and use their own risk models in order to determine the regulatory capital target. A rules-based approach has only very limited flexibility to handle individual situations and might not be very effective in assessing a wide range of insurance risk profiles.

A major difference between systems is that in Europe asset and liabilities will be market-consistently valued whereas RBC is based on US statutory accounting rules, which in many instances do not reflect the market value of assets and liabilities. The European schemes go then further by integrating an economic approach and an asset-liability perspective, including relevant qualitative elements. According to Cummins *et al.* (1999), ignoring potentially large differences between accounting and economic values gives a misleading picture of insurer resources and reduces the ability of a regulatory system to assist regulators and encourage greater safety of weak companies.

There are great differences in the way the three systems cover risks, in particular operational and catastrophe risks. Operational risk is not explicitly considered in the US regime, whereas under Solvency II it is calculated using a factor-based approach. The SST makes a qualitative assessment. Catastrophe risk is covered by scenarios under Solvency II and in the SST while ignored in the US system. Liquidity risk is also neglected by the three regulatory frameworks, even if the American regulator conducts some liquidity stress tests.

Diversification is another main difference between the solvency regimes. The SST applies the most advanced approach, i.e. the convolution method. Solvency II and US RBC use respectively correlation matrices and simple square roots. Another point of concern is the non-linear dependencies between risks. Solvency II and SST standard models focus on linear correlation even though the literature suggests that solely considering linear correlation is inappropriate when modelling dependence structures between heavy-tailed and skewed risks, which are frequent in the insurance context.

Although Solvency II and the SST have very similar principles, they apply them in different ways. European systems use different risk measures. The Solvency II VaR approach is more simple, widespread and easy to explain to top managers. However VaR is not a coherent risk measure. The TailVaR approach, applied in the SST, takes into account the cost in case of insolvency in addition of failure's probability. From a regulatory point of view it is then a better concept.

Under the Solvency II project some risks are including in the form of factor-based calculations using gross premiums and claims expenditures as variables, e.g. non-life and health underwriting risks or the operational risk module. Factor-based components are less risk sensitive, because a reduction in capital requirements is achieved by reducing the size rather than the risk profile. Therefore the approach does not take into account the level of prudence of the insurer. The SST is totally risk-sensitive, except for the operational risk. The Swiss system goes then further in the risk-sensitive approach.

To conclude, Swiss and European systems are advanced regulatory processes in comparison with American RBC although the latter system was perceived as a revolution some years ago. However, Solvency II regime has to tackle a major problem: the size of its market and the ambition of the future system. The SST with its smaller market will be easier to implement. Solvency II has to handle with a diversity of cultures and companies where the Swiss market is quite limited. This could endanger the success of the European regulatory regime. Only time and further research will tell us which system works best.

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