A Comparative Analysis of U.S., Canadian and Solvency II Capital Adequacy Requirements in Life Insurance

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Abstract

The solvency regulation of life insurance companies in Canada, U.S. and the European Union is undergoing significant changes. The main reasons for the changes include (1) the increased complexity of insurance products requiring a more realistic approach to risk measurement; (2) changes in insurance accounting; and (3)the need to level the playing field in the EU market.

The main goals of this paper are:

- To demonstrate and explain some of the more important differences among the current U.S. and Canadian regulatory capital regimes, and the proposed EU Solvency II standard formula.

- To support the use of economic valuation principles in the solvency assessment of life insurance companies.

Illustrative regulatory capital calculations for a hypothetical 30-year non-renewable term-life insurance portfolio are presented in the paper.

1   INTRODUCTION

The solvency regulation of financial institutions is undergoing significant changes in many countries and regions around the world. The globalization and integration of financial services, ever increasing complexity of insurance and financial products, the need to level the playing field, increased protection to customers and significant advances in the theory and practice of modern risk management are among the reasons for the changes in solvency regulation.

The Basel II Capital Accord [BIS, Basel Committee on Banking Supervision, 2004], first published in June 2004, is the banking industry's most recent attempt at harmonizing the regulatory capital and risk management requirements for internationally active banks. Insurers in the European Union will soon be regulated under the new Solvency II standard [European Commission, 2009, Linder and Ronkainen, 2004, Eling et al., 2007] which is currently expected to become effective in 2012. Solvency II provides a comprehensive and holistic risk and capital management framework for insurers, and similarly to Basel II, uses a three-pillar concept. The pillars are (1)

quantitative capital requirements; (2) supervisory review; and (3) public disclosure and market discipline.

In Canada and the United States, the solvency regulation of insurance companies has been undergoing review and significant changes are expected in the near future. In the United States, the C3 Phase I [American Academy of Actuaries, 2002] and C3 Phase II [American Academy of Actuaries, 2003] projects resulted in new capital requirements for interest-sensitive products (for example, single premium life and annuities) and variable annuities that are based on a set of high level guiding principles rather than the old regime of set rules and mandated assumptions. The C3 Phase III project proposes to extend the principle-based framework to traditional life insurance and annuity products. The principle-based reserving projects in the US fall under the purview of the Solvency Modernization Initiative which was adopted by the NAIC in 2008 to analyze international solvency standards and propose related enhancements to the U.S. regulatory system. In Canada, changes to reserving and capital requirements are also being planned in anticipation of the adoption of International Financial Reporting Standards (IFRS) on January 1, 2011 by all public insurance companies.

A common underlying theme in the proposed changes outlined above is the transition to solvency supervisory frameworks that are more principle-based rather than relying on a standard set of rules to calculate life insurance company reserve and capital requirements. A principle-based reserve and capital measurement framework allows a better alignment of regulatory capital with the true economic risks to which a financial entity is exposed. It is important to note, however, that the principle-based systems that are evolving in each of the jurisdictions are taking different paths. For example, the proposed Canadian and US capital measurement frameworks [American Academy of Actuaries' C3 Life and Annuity Capital Work Group, 2008, Joint Committee of OSFI, AMF, and Assuris, 2008a,b, MCCSR Advisory Committee, 2007] are generally based on the Conditional Tail Expectation risk measure rather than the EU Solvency II's Value-At-Risk metric.

The main purpose of our paper is to outline and illustrate some of the more important differences among the current U.S. and Canadian regulatory capital regimes and the standard formula of the Solvency II framework using a hypothetical term-life insurance portfolio as an example. As noted above, all three regulatory regimes are currently in a state of flux as they are being fine-tuned to reflect the reality of complex insurance products and competitive global insurance markets. Understanding the differences in the capital formulas will aid the regulator of each jurisdiction in the strategic calibration of the life insurance capital requirements. From the viewpoint of an internationally active insurer, a comparative analysis of the regulatory capital formulas can reveal opportunities for regulatory capital arbitrage. In principle, the Solvency II regulatory framework requires an economic assessment of assets, liabilities and solvency capital requirements [European Commission, 2008]. The current Canadian and US statutory reserve and capital calculations are based on statutory valuation practices of assets and liabilities that are, for the most part, not consistent with an economic valuation approach. As part of our analysis, we will also demonstrate the significant benefits of the economic valuation perspective relative to these statutory valuation practices in the solvency assessment of insurance companies.

In recent years, term insurance has become the most prevalent life insurance product that is being issued by insurance companies. It is therefore appropriate that we used this product in our illustrative calculations. However, the case for economic valu-

ation is clearly much stronger when products containing financial guarantees and complex embedded derivatives are considered in conjunction with the hedging activities of the insurance companies which utilize capital market instruments [Hardy, 2003, Boyle and Hardy, 1997].

The remainder of the paper is structured as follows. Section 2 provides an overview of the regulatory capital requirements under the current U.S. and Canadian regimes, as well as requirements under the Solvency II standard formula. The life office model that was used as the basis of the illustrative calculations that are presented in this paper is described in Section 3. In Section 4, we compare the capital requirements under the three regulatory regimes for two variations of the life office model that has been described in Section 3. Finally, the main conclusions of the paper are outlined in Section 5.

2 OVERVIEW OF MINIMUM CAPITAL ADEQUACY STANDARDS

In this section, an overview of the regulatory solvency capital requirements for life insurance companies under each of the US, Canadian and Solvency II approaches will be presented. In particular, the US and Canadian approaches summarized below relate to the determination of capital requirements for term insurance business under the current regulatory regimes. The description of the Solvency II framework is based on the Solvency II Framework Directive which was adopted in July 2007.

2.1 MINIMUM CONTINUING CAPITAL AND SURPLUS REQUIREMENTS: CANADA

The Office of the Superintendant of Financial Institutions (OSFI) is the federal regulator of life insurance companies in Canada. OSFI is an integrated regulator, and as such, is also charged with the responsibility of supervising banks, private pension plans and other financial institutions. A clear advantage of having an integrated regulator for financial institutions is the enhanced and efficient coordination in the solvency regulation of financial institutions in different sectors.

2.1.1 Valuation of Assets and Liabilities

In order to fulfill its mandate of solvency supervision of the life insurance industry, Canada's OSFI uses the audited financial statements of insurers that have been prepared in accordance with Canadian GAAP. Canadian GAAP life insurance liabilities are measured using the Canadian Asset Liability Method (CALM) that is described in Section 2320 of the CIA Standards of Practice [Actuarial Standards Board, 2009]. The CALM requires the actuary to project asset and liability cash flows under alternative interest rate scenarios at the valuation date. For a given scenario, the asset cash flows are projected forward assuming a specific investment strategy, investment return for each asset, credit default rate for each asset, and inflation rate. The amount of liabilities for that interest rate scenario is then defined as the statement value of the assets required at the valuation date that will generate a surplus (assets minus liabilities) of zero at the last projected liability cash flow. The policy liabilities can be negative since there is no artificial floor under

CALM. The CIA Standards prescribe 9 interest rate scenarios which have the risk-free interest rates at the balance sheet date as the starting point. In addition to the prescribed scenarios, the actuary can include other scenarios that are more specific to the insurer. These additional interest rate scenarios can be either deterministic or stochastic. In either case, the policy liabilities must be at least as great as those determined in the prescribed scenario with the largest liabilities.

All the liability cash flows are projected under the CALM and include policy benefits, premiums and expenses associated with the in-force policies at the valuation date. Each valuation assumption is determined as the sum of a explicit best estimate assumption and a margin for adverse deviation. The margin for adverse deviation provides for the misestimation or deterioration of the best estimate. The CIA Standards specify low and high margins for each valuation assumption. For example, the low and high margins for the mortality assumption are specified as an addition of 3.75 and 15 deaths per thousand divided by the best-estimate curtate expectation of life at the insured's projected attained age. Margins for other assumptions are generally between 5% and 20% of the best estimate.

As mentioned above, OSFI relies on Canadian GAAP financial statements in assessing the solvency of life insurers. The valuation of invested assets under Canadian GAAP depends on their classification as either held-for-trading (HFT) or available-for-sale (AFS) under section 3855 of the CICA Handbook. The held-for-trading designation is the most prevalent for reserve assets among Canadian life insurers. In contrast, surplus assets are commonly designated as available-for-sale (AFS). From OSFI's viewpoint [Office of the Superintendent of Financial Institutions, 2008], the capital value of HFT assets is their fair or market value. On the other hand, AFS debt assets are effectively carried at amortised cost in determining the insurer's available capital. The unrealized investment gains and losses that are recorded in Accumulated Other Comprehensive Income (AOCI) on the Canadian GAAP balance sheet are deferred for regulatory capital purposes using the argument that the AFS debt will likely never be sold.

2.1.2   Regulatory Capital

The Minimum Continuing Capital and Surplus Requirements for Life Insurance Companies (MCCSR) guideline [Office of the Superintendent of Financial Institutions, 2008] includes the risk based capital formula for life insurers and guidance on how to calculate the amounts that are needed in the formula. The OSFI guideline also defines the capital that is available to meet the minimum standard.

There are two important triggers or levels of capital based on MCCSR: the minimum and supervisory target capital requirements. A life insurer's minimum capital requirement is the sum of the capital requirements for each of five risk components. The component capital requirements are determined using factor-based or other methods that are applied to specific on- and off-balance sheet assets or liabilities. An example of a method that is not factor-based is the use of stochastic internal models to determine the regulatory capital for segregated funds, subject to model calibration standards specified by OSFI. The risk-based factors for qualifying participating policies are usually 50% of the factors for non-participating policies.

The five risk components are:

- Asset default (C-1) risk: Risk of loss resulting from on-balance sheet asset default and from contingencies in respect of off-balance sheet exposure and

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related loss of income; and the loss of market value of equities and related reduction of income.

- Mortality/morbidity/lapse risks: Risk that assumptions about mortality, morbidity and lapse will be wrong.

- Changes in interest rate environment (C-3) risk: Risk of loss resulting from changes in the interest rate environment other than asset default.

- Segregated funds risk: Risk of loss arising from guarantees embedded in segregated funds.

- Foreign exchange risk: Risk of loss resulting from fluctuations in currency exchange rates.

The definition of available capital comprises two tiers, tier 1 (core capital) and tier 2 (supplementary capital), and involves certain deductions, limits and restrictions. The quality of available capital is assessed based on considerations such as its permanence, its being free of mandatory fixed charges against earnings and its subordinated legal position to policyholder obligations. Tier 1 capital is of the highest quality with respect to the aforementioned attributes.

Tier 2 capital fails to meet either of the first two attributes. Tier 2 is further split into three subcomponents: 2A, 2B, and 2C. The MCCSR ratio is determined as available capital divided by required capital. The minimum required MCCSR ratio is 120%. The twenty percent loading is meant to provide for those risks that are not explicitly addressed in the MCCSR formula, for example, operational, strategic and legal risks. The supervisory target MCCSR ratio is 150%. Each insurer is expected to set a target capital level that is no less than the supervisory target. In addition, the tier 1 target capital ratio should be at least 70% of the supervisory target, that is, an MCCSR ratio of at least 105%.

In addition to meeting the minimum capital requirements specified above, the Appointed Actuary is required to conduct dynamic capital adequacy testing (DCAT) on an annual basis. DCAT is an exercise that is meant to identify plausible adverse scenarios that could potentially jeopardize the financial health of the insurer. Usually, the base scenario will be consistent with the insurer's business plan, and accordingly, will reflect anticipated new business. Generally, the forecast period for life insurance business is five fiscal years. The actuary would also detail the necessary actions to reduce both the likelihood and severity of any identified plausible threat to the insurer's solvency in the DCAT report.

2.2   U.S. NAIC RISK BASED CAPITAL FORMULA

In the United States, the National Association of Insurance Commissioners (NAIC) creates model laws for the regulation of life insurance. Through an accreditation system, the member states will adopt versions of the model laws and this effectively promotes harmonization in regulation among the states. The brief overview of the valuation system of liabilities in the U.S. that is provided below is primarily in the context of the traditional life insurance products.

2.2.1 Valuation of Assets and Liabilities

In the U.S., the statutory valuation of traditional life insurance reserves is strongly rules-based.

The mortality assumptions and interest rates that are used in the valuation are prescribed [Lombardi, 2006]. The infrequently updated Commissioners Standard Ordinary (CSO) mortality tables form the basis for the mortality assumption. The maximum valuation interest rates are based on the monthly average of the composite yield on seasoned corporate bonds, as published by Moody's Investors Service, Inc. An interesting feature of the NAIC valuation standard is that the valuation basis for a particular policy is determined by the policy issue date and is "locked-in" for the entire duration of the policy. The Commissioner's Reserve Valuation Method (CRVM) is a modified net premium method that is required to be used for determining the statutory minimum reserves. Under the CRVM, policy lapses and expenses are not explicitly considered. Rather, the conservative nature of the valuation method, and the prescribed mortality and interest rate assumptions implicitly provides for these assumptions. The intended conservatism of the U.S. statutory accounting practices results in a skewed presentation of financial results for a given insurance company. For example, the U.S. annual statement would show the value of new business in a given year as a loss, or a sunk cost, irrespective of the underlying economic value of the business.

The valuation of assets for annual statement purposes is very detailed and complex. The valuation of assets should conform to the statutory accounting practices that have been prescribed or permitted by the state in which the insurance company is incorporated. The NAIC Accounting Practices and Procedures Manual has generally been adopted as a component of prescribed or permitted practices by the states. The Securities Valuation Office (SVO) of the NAIC values all the securities held by most insurers in the U.S. on a uniform basis. The methods that are primarily employed to value assets are market value, amortized cost, equity method, and book value (cost). Investments in bonds are generally carried at amortized cost or values as prescribed by the state. Intangible assets, furniture and equipment, unsecured receivables and deferred taxes that are not realizable within a year are examples of assets that are considered nonadmitted and therefore not shown in the balance sheet. There are also quantitative restrictions on certain investments such as limits on lower-rated securities and foreign investments.

The Asset Valuation Reserve (AVR) and Interest Maintenance Reserve (IMR) are tools that were established to moderate the impact of investment gains or losses on surplus. Realized gains and losses resulting from changes in interest rates on fixed income investments are deferred in the Interest Maintenance Reserve and amortized into investment income over the remaining life of the investment sold. The Asset Valuation Reserve is used for smoothing the impact of credit default and equity gains and losses on the insurer's surplus.

2.2.2 Regulatory Risk Based Capital

The U.S. NAIC risk based capital (RBC) system [National Association of Insurance Commissioners, 2008] for life and health insurers was instituted in 1992 by the adoption of the Risk-Based Capital for Life and Health Insurers Model Act. The primary goal was to define a minimum level of regulatory capital that reflected all

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asset and liability risks to which an insurer was exposed. Consequently, the US RBC rules are very detailed and complex.

Like the Canadian MCCSR formula,the U.S. RBC formula uses a bottom-up approach to risk measurement. The Authorized Control Level RBC (ACL RBC) for life insurance is defined by the following formula:

ACL RBC $= C_0 + C_{4a} + \sqrt{C_{1c}^2 + C_2^2 + C_{4b}^2 + (C_{10} + C_{3a})^2}$

Where

- C_0: Asset Risk-Affiliates

- C_{1cs}: Unaffiliated common stock and affiliated noninsurance common stock components

- C_{10}: Asset Risk-Other (excluding common stock)

- C_2: Insurance Risk

- C_{3a}: Interest Rate Risk and Market Risk

- C_{4a}: Business Risk

Generally, the RBC formula determines regulatory capital for a given risk by applying an RBC factor to an exposure amount obtained from the annual statement. However, the C-3 RBC Phase I [American Academy of Actuaries, 2002] and C-3 RBC Phase II [American Academy of Actuaries, 2003] capital requirements for interest sensitive products (such as single premium life and annuities) and variable annuities, respectively, are based on cash flow testing.

The RBC ratio is obtained by dividing the total adjusted capital (TAC) by the ACL RBC. If the RBC ratio falls below one of five predefined levels, a certain regulatory "action level" will be triggered. For example, if the ratio falls below 70%, the state insurance commissioner must take control of the insurer.

2.3 EUROPEAN UNION SOLVENCY II STANDARD FORMULA

The high-level principles that underpin the Solvency II architecture are enshrined in the Framework Directive Proposal which was adopted by the EU parliament in July 2007. A primary goal of the Solvency II framework is to harmonize the regulation of insurance companies that conduct business in the EU member states. The design of Solvency II was informed by the IASB's work on insurance contracts [International Accounting Standards Board, 2001, 2003, 2004], related research of the International Association of Insurance Supervisors (IAIS) [International Association of Insurance Supervisors, 2002, 2004, 2005] and the International Actuarial Association (IAA)[International Actuarial Association, 2004], among others. The Solvency II supervisory framework is based on a three-pillar approach similar to the banking industry's Basel II [BIS, Basel Committee on Banking Supervision, 2004]. The three supervisory pillars are:

- Quantitative requirements for measuring capital adequacy (Pillar I)

- A supervisory review process including review of risk management practices (Pillar II)

- Increased transparency and reporting requirements (Pillar III)

2.3.1 Valuation of Assets and Liabilities

Under Solvency II, assets and liabilities should be valued using economic principles [European Commission, 2008]. Whenever possible, assets and liabilities should be marked to market. In the instances when marking to market is not possible, mark to model approaches should be used. Marking to model is any valuation which has to be benchmarked, extrapolated or otherwise calculated from a market input. The economic valuation of assets and liabilities of insurance companies is consistent with the direction of the International Financial Reporting Standards (IFRS) [International Accounting Standards Board, 2001, 2003, 2004].

Insurance liabilities are assessed at their current exit value, which is the value at which they "could be transferred, or settled, between knowledgeable willing parties in an arm's length transaction" [European Commission, 2008]. They should be valued in a prudent, reliable and objective manner. Hedgeable components of the liability cash flows are carried at the market price of the hedge portfolio of liquid financial instruments. If the hedge portfolio is such that the remaining basis risk is immaterial, the cash flows can be considered hedgeable. Liability cash flows that are not hedgeable are determined as the sum of the best-estimate liability and a cost-of-capital risk margin. The best-estimate liability is defined as the probability-weighted average of the present value of all future liability cash flows using the relevant risk-free interest rates. The best estimate liability should be assessed using a relevant and reliable actuarial method. Ideally, the method should be part of actuarial best practice and should sufficiently capture the technical nature of the insurance liabilities. The cost-of-capital risk margin is the present value of the cost of meeting future solvency capital requirements to support the run-off of the insurance portfolio (see the formula in the Appendix for more detail). The cost of capital for any given future year is obtained as the product of the cost-of-capital rate and the solvency capital requirement for non-hedgeable risks. The cost-of-capital rate is the return on capital that is assumed to be required by a fictitious investor who will assume the insurance liabilities upon the default of the insurer. The Fourth Quantitative Impact Study (QIS 4) [European Commission, 2008] assumed a cost-of-capital rate of 6% but the final value has yet to be determined.

For the purposes of setting the best estimate assumptions, the insurance portfolio should be segmented into homogenous risk groups. Further, the calculation of the cost of capital risk margin requires that the portfolio be segmented into lines of business that could be transferred to a third party.

2.3.2 Regulatory Risk Based Capital

Solvency II will establish two levels of capital requirements:

- The Minimum Capital Requirement (MCR) - the threshold at which companies will no longer be permitted to trade

- The Solvency Capital Requirement (SCR) - the target level of capital below which companies may need to discuss remedies with their regulators

The SCR may be calculated using the prescribed standard model or a company's internal model subject to supervisory approval. The calculations from the internal model can be benchmarked against the output of the standard model. Under Solvency II, the economic balance sheet of the insurer is projected one year into the future, with respect to both new and old business. Over the one-year horizon, assumed changes in the risk factors are modeled and the impact on the economic balance sheet is measured to determine the required regulatory capital. The Solvency Capital Requirement is determined as the amount of regulatory capital such that the insolvency probability is less than 1 in 200 over the one-year horizon.

The SCR standard formula is divided into the life and non-life underwriting, market, credit default and operational risk modules. In turn these risk modules consist of sub-risks that are aggregated using prescribed correlation matrices to obtain overall capital for each module. For example, the life underwriting risk module includes the following sub-risks: mortality, longevity, lapses and expenses. The market risk module includes interest rate risk, equity, credit-spread risk, and property risk sub-modules. For more detail on some of the formulas that were used in calculating the capital requirements in this paper, please refer to the Appendix.

In the Solvency II standard model, a combination of stress tests, scenarios and factor-based capital charges are used to determine the solvency capital for a given insurer. Essentially, a bottom-up approach is used, where the capital required to support each sub-risk is first calculated at the 99.5% confidence level. Solvency capital for each primary risk module is then obtained by aggregating the requirements of each component sub-risk using the prescribed correlation matrices. A final aggregation of the primary risk modules then takes place to determine the overall company level SCR using another prescribed correlation matrix. Solvency capital requirements are reduced for risk diversification and mitigation programs.

3   THE MODEL OFFICE

In the sections that follow, we will review some components of the current Canadian and US statutory capital frameworks, and the Solvency II standard formula. We consider only the minimum capital requirements (pillar 1) for each of the three jurisdictions. The other pillars or aspects of the statutory solvency systems, though critically important, are more subjective, and are not the subject of the current research.

The illustrative regulatory capital calculations that are presented in this paper are based on several hypothetical term life insurance portfolios that have slightly different characteristics depending on the particular example. In general, however, each of these hypothetical term-life insurance portfolios is based on the following common assumptions:

- The portfolio consists of 1,000,000 identical policies that have been issued to a group of males of the same age and other underwriting risk characteristics.

- The original term of the insurance policies is 30 years

- The premiums are level and the product is not renewable.

- The face amount of each policy is $500,000.

- The annual premium is $2 per $1,000 face amount.

- Actual expenses are 95% of the gross premium in the first year of the policy and 5% thereafter.

- Issue age: 35

- All death benefits were assumed to be paid at the end of the year of death, while premiums and expenses are paid at the beginning of the year.

- The policy issue date varies for each example

The level premium term product was chosen to be representative of all term products in the life insurance industry.

The statutory liability valuation assumptions that were used at any given solvency assessment date were determined in accordance with the actual requirements of each of the U.S., Canadian and EU Solvency II regimes on that particular date. In particular, the actual risk-free interest rates prevailing on each valuation date were used to discount liabilities under Solvency II and in determining the expected portfolio return assumption under the Canadian framework. The historical US dollar swap rates that are in shown in Table 1 of the Appendix were used to bootstrap the required risk-free zero-coupon curves.

Deficiency reserves for US liability valuations were crudely estimated by substituting the best estimate mortality assumption for the CS0 80 table and using actual gross premiums in the prospective reserve computation, and taking the excess, if any, of this quantity over the basic CRVM reserve.

There is no suggestion that the life office model described above is realistic. The essence of the model is its simplicity, which allows us to investigate and articulate important conclusions, without the distraction of the non-essential elements of a more realistic model.

4   COMPARATIVE ANALYSIS OF REGULATORY CAPITAL REQUIREMENTS

In the following sections, a comparative analysis of the current U.S., Canadian and Solvency II regulatory capital regimes for a hypothetical term-life insurance block will be presented under the two major headings: (1) Total Balance Sheet Requirement; (2) Integrated Asset and Liability Measurement.

The primary metric that will be used to compare the regulatory capital requirements is the Total Balance Sheet Requirement (TBSR). As presented in this paper, the TBSR can broadly be defined as the statutory value of assets that are required to support a given insurance operation by a solvency regulator. Specifically, we define the TBSR to be the sum of the insurer's statutory liabilities and regulatory capital. Under a TBSR approach to capital adequacy assessment, required regulatory capital is simply the difference between the TBSR and statutory liabilities. For example, the solvency capital requirements under Solvency II are based on a TBSR that has been calibrated to a 99.5% confidence level. The TBSR approach to determining capital requirements has been proposed by the International Actuarial Association (IAA) [International Actuarial Association, 2004] as a consistent and harmonizing

basis for international insurance solvency assessment. The regulators in the U.S. and Canada will, in the future, also determine capital requirements for all life insurance products using the total balance sheet perspective [Joint Committee of OSFI, AMF, and Assuris, 2008a,b, MCCSR Advisory Committee, 2007, American Academy of Actuaries' C3 Life and Annuity Capital Work Group, 2008]. Another metric that we will use in comparing results across jurisdictions is "free capital", which we define as the amount of available capital (statutory surplus) in excess of required capital. In other words, free capital is the actual dollar amount of capital that can be used to pay shareholder dividends, repurchase shares, or embark on business expansion projects at the discretion of the shareholders. As such, the amount of free capital can be directly compared across jurisdictions regardless of the differences in statutory accounting practices.

Currently, the assessment of capital adequacy in Canada and the U.S. is based on the MCCSR and U.S. RBC ratios, respectively, as described in previous sections. The total balance sheet capital requirements corresponding to these RBC threshold ratios will be determined for each of the two jurisdictions for comparison with the equivalent amount under Solvency II.

The focus of the analysis presented in this paper is on target capital requirements, roughly defined to be the minimum amounts of regulatory capital that do not require the direct corrective action of the insurance supervisor. Specifically, references to supervisory target capital should be interpreted as follows:

- Canada: Regulatory capital corresponding to an MCCSR ratio of 150%

- United States: Company Action Level RBC (i.e. 200% of the ACL RBC)

- European Union: Solvency Capital Requirement

Additionally, the following analysis does not consider the different definitions of available capital under the three jurisdictions, that have been noted already in previous sections. The categorization of the different elements in the capital structure of a typical insurance enterprise, and the corresponding tier-specific regulatory capital requirements, are an important aspect of any solvency system but are outside the scope of the current study.

Finally, it should also be noted that the results for the EU Solvency II standard formula are based on the framework calibration parameters that were used in the fourth quantitative impact study (QIS 4). It is understood that these parameters may be recalibrated based on further work of the CEIOPS.

4.1 Solvency Valuation Assumptions

The assumptions that were used to determine the statutory balance sheet and capital requirements in accordance with the Canadian, EU Solvency II standard formula and the US NAIC regulatory frameworks are listed in the table below.

Valuation Assumption	US NAIC	Canada	EU Solvency II
mortality	CSO 80 ultimate, non-smoker, male	parametric (Makeham) + CIA High margin	parametric (Makeham) A=0.0007, B=0.00005, C=1.08
lapse	nil	4% - 20% margin	4%
expense	nil	first year: 95% of gross premium renewal years: 5% of gross premium	first year: 95% of gross premium renewal years: 5% of gross premium
discount rates	based on policy issue-year	expected portfolio return (based on current risk-free rates)	current risk-free interest rates

4.2   Total Balance Sheet Requirements

In this section, we compare the total balance sheet requirements and free capital amounts that have been calculated for a hypothetical term-life insurance portfolio in accordance with the current U.S., Canadian and EU Solvency II standard formula regimes.

In addition to the core assumptions that were presented in Section 4.1, the following additional assumptions apply to the hypothetical term-life insurance portfolio that underlies the results of this section:

- Issue year of all policies: 2003

- Solvency assessment date: December 31, 2008

- U.S. maximum statutory valuation rate: 4.75%.

- Reserve asset strategy: Default-free debt securities are assumed to be exactly matched with the projected liability cash flows which are based on valuation assumptions that are each derived using the conservative or high-end of the range of margins permitted by the CIA Standards of Practice.

- Surplus asset strategy: Invested in a 60 - 40% combination of 30 year and 10 year default-free zero coupon securities.

To allow a direct comparison of capital requirements across jurisdictions, it was also conveniently assumed that the market and book values of the zero coupon bonds were equal at the solvency assessment date.

Figure 1 shows a graph of the required total balance sheet capital for the hypothetical term life insurance portfolio that has been determined in accordance with the requirements of the three jurisdictions. The amounts shown are all expressed as percentages of the best estimate liability (BEL).

For the given situation, the following important observations can be made from Figure 1:

- The EU Solvency II standard formula TBSR appears to be calibrated conservatively, relative to the other two regimes, subject to the stated assumptions.
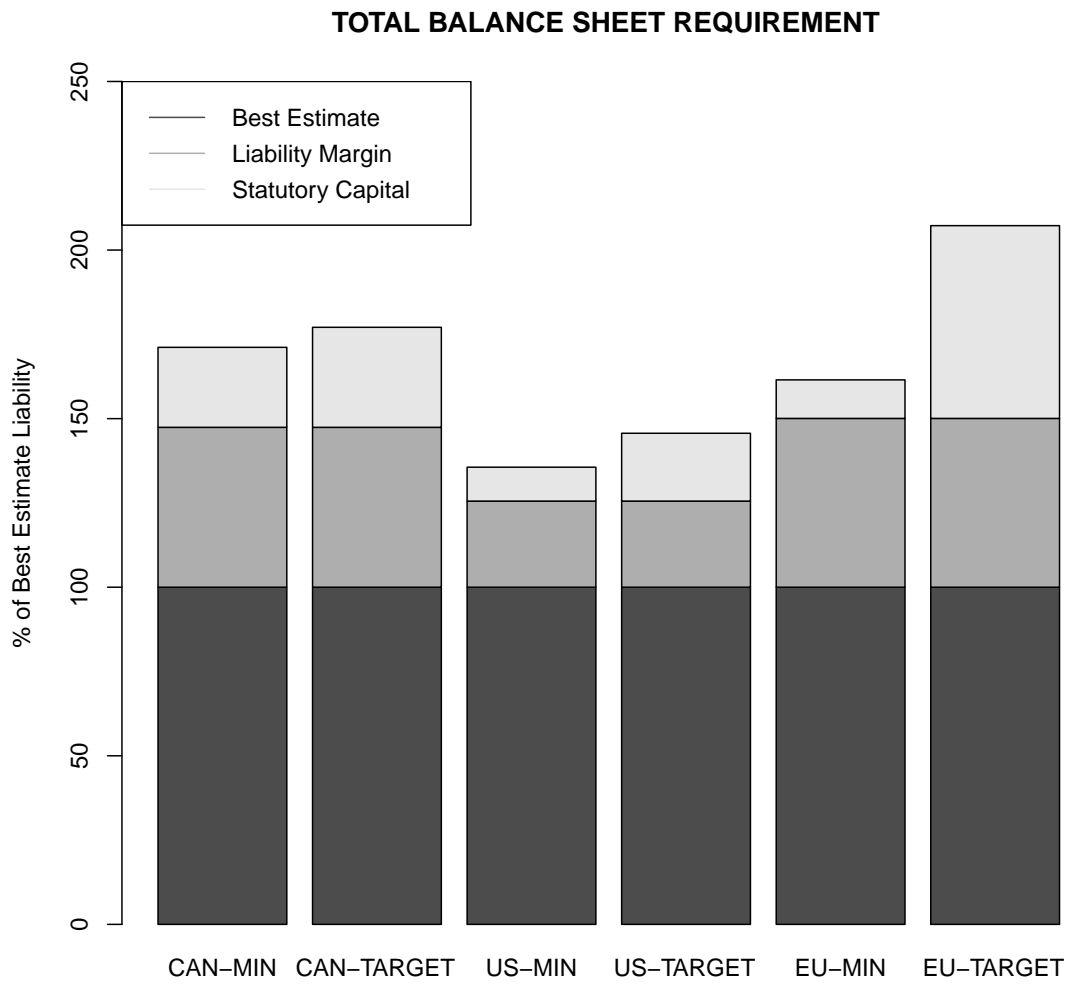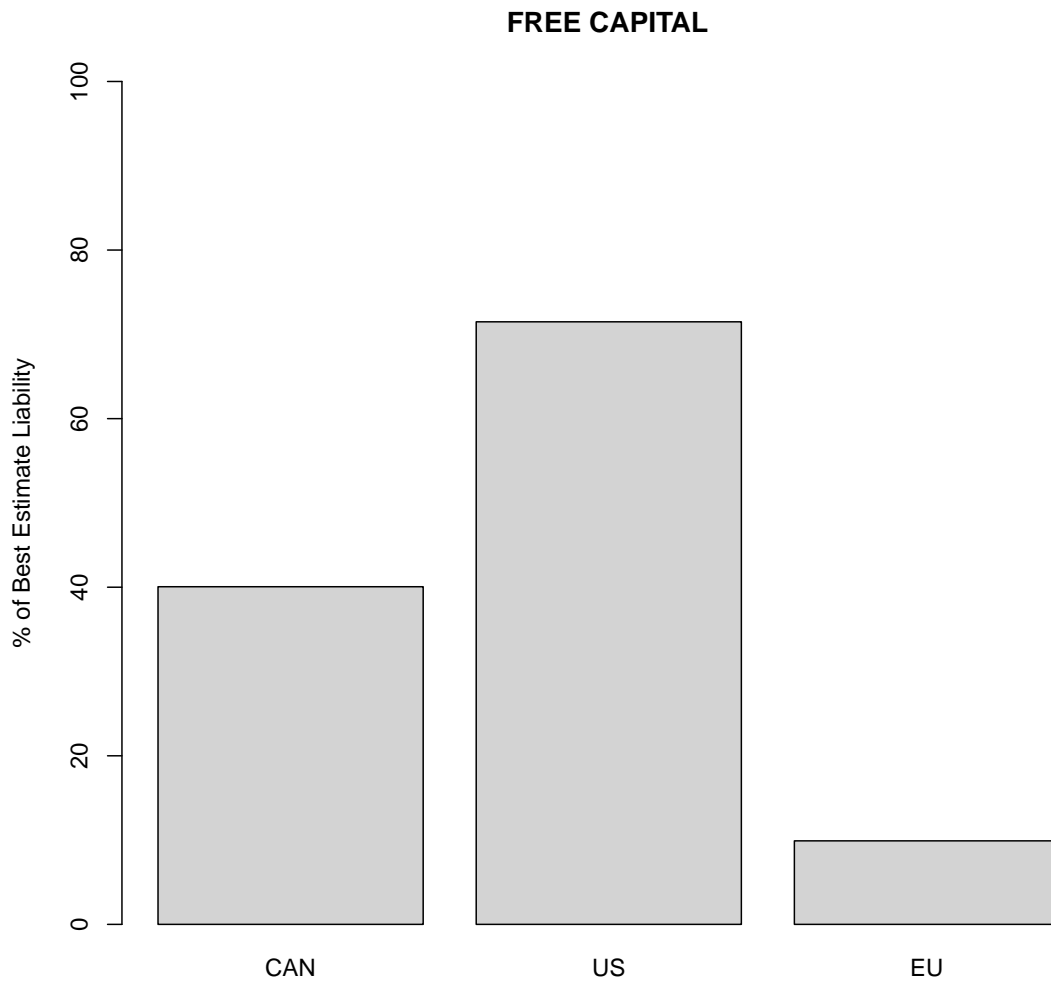
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TOTAL BALANCE SHEET REQUIREMENT

Figure 1

FREE CAPITAL

Figure 2

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The conservative calibration of the EU Standard formula is deliberate and provides the necessary motivation for insurers to use internal models in determining capital requirements.

- As shown in the graph, statutory solvency liabilities that have been determined in accordance with Canadian and U.S. rules are below the corresponding amount under Solvency II. In fact, the target total balance sheet capital requirement (i.e. liabilities + capital) under the U.S. NAIC rules is less than the Solvency II liability. Assuming that the Solvency II liability, as calculated, is a reasonable estimate of the current exit value, the situation depicted in the graph would mean that there would not be enough funds to secure the policyholder's obligations in the event of insolvency of an insurer regulated under U.S. rules. The main reason for the significantly lower capital requirements under the U.S. rules is the high statutory interest rate of 4.75% that was used to value liabilities. The prescribed interest rate of 4.75% was sufficiently high to offset the embedded conservatism in the mortality and lapse (or lack thereof) assumptions used in calculating U.S. statutory reserves. The valuation of liabilities under the Canadian and Solvency II approaches reflected the low-interest rate environment prevailing on December 31, 2008 and was based on the swap rates shown in Table 1 of the Appendix. Specifically, both the Canadian and Solvency II liabilities were calculated by discounting future liability cash flows using risk-free discount rates. Therefore, the only sources of difference between the Canadian and Solvency II liabilities in the current example are the mortality and lapse valuation assumptions.

  Due to the locked-in nature of U.S. valuation assumptions by policy issue-year, two life insurance policies that are identical in every respect (current age of the insured, remaining term of the policy, coverage amount, premium, etc) except the year of issue and original term of the policy will have different regulatory capital requirements. Further, when interest rates are falling there will be a bias towards undervaluing liabilities for policies issued in years when market interest rates were higher. The opposite effect would be expected when interest rates are increasing. Therefore, for a given insurer and at any given moment, the aggregate liability valuation bias with respect to interest rates will depend on the history of interest rates as well as the volume of new business that was issued in each previous year. If interest rates are assumed to be cyclical, the valuation biases could be expected to cancel out over time for a mature insurer. However, since interest rates can have prolonged periods in which they are either trending up or down, the assumption that the biases will net out cannot be justifiably relied upon.

  In the situation presented above, the U.S. statutory reserves might reasonably be inferred to be insufficient to assure the regulator that the insurer will be able to meet all policyholder benefits, both as a going-concern and in the event of immediate bankruptcy. On the other hand, when statutory valuation interest rates are much lower than market rates, resulting in extremely conservative reserves (relative to prevailing economic conditions), insurers will be incentivized to arbitrage the regulatory capital requirements through reinsurance, securitization or other innovative capital market transactions.

- Figure 2 shows that the low capital requirements under the U.S. NAIC model result in an amount of free capital that is significantly greater than correspond-

ing amounts for the other two jurisdictions. If the amount that is deemed to be free capital is funneled to shareholders through share repurchase programs, for example, the insurer is left in a very compromising financial condition in the eyes of the Canadian and European Solvency II insurance regulators.

- The total capital requirements for the Canadian regulatory system that have been illustrated in Figures 1 and 2 are based on liabilities that have been calculated using the conservative ends of the suggested ranges for the valuation margin assumptions as prescribed by the Canadian Institute of Actuaries. If the low-end of the suggested valuation margin assumption ranges had been used, results for the Canadian regulatory approach would be less conservative than shown in the above figures.

  Since the determination of the Canadian GAAP liability requires the subjective input of the actuary, it is possible to have multiple balance sheet measurements of the same liability depending on the level of valuation margins that each actuary deems to be professionally appropriate.

To gain further insight on the sources of difference among the regimes, Figure 3 shows the following component requirements corresponding to the total balance sheet requirements that have been illustrated in Figure 1:

- Best Estimate Liability (BEL)

- Cost of capital risk margin (CCM)

- Mortality: volatility risk (Mort-Vol)

- Mortality: catastrophic risk (Mort-Cat)

- Mortality: parameter risk (Mort-Parm)

- Lapse risk

- Implicit liability margin

- Underwriting risks

- Business risk

- Operational risk (Op)

- Interest rate risk

- Diversification credits

- Miscellaneous risks (Misc)

The Best Estimate Liability (BEL), which is obtained by discounting the best-estimate insurance cash flows at the risk-free discount rates has been taken as the basic building block upon which all solvency margins are then added, whether implicitly as in the US liability valuation margin, or explicitly. It is the same for all three jurisdictions. Consistent with the total balance sheet approach, Figure 3 does not distinguish between required solvency margins that are included in either

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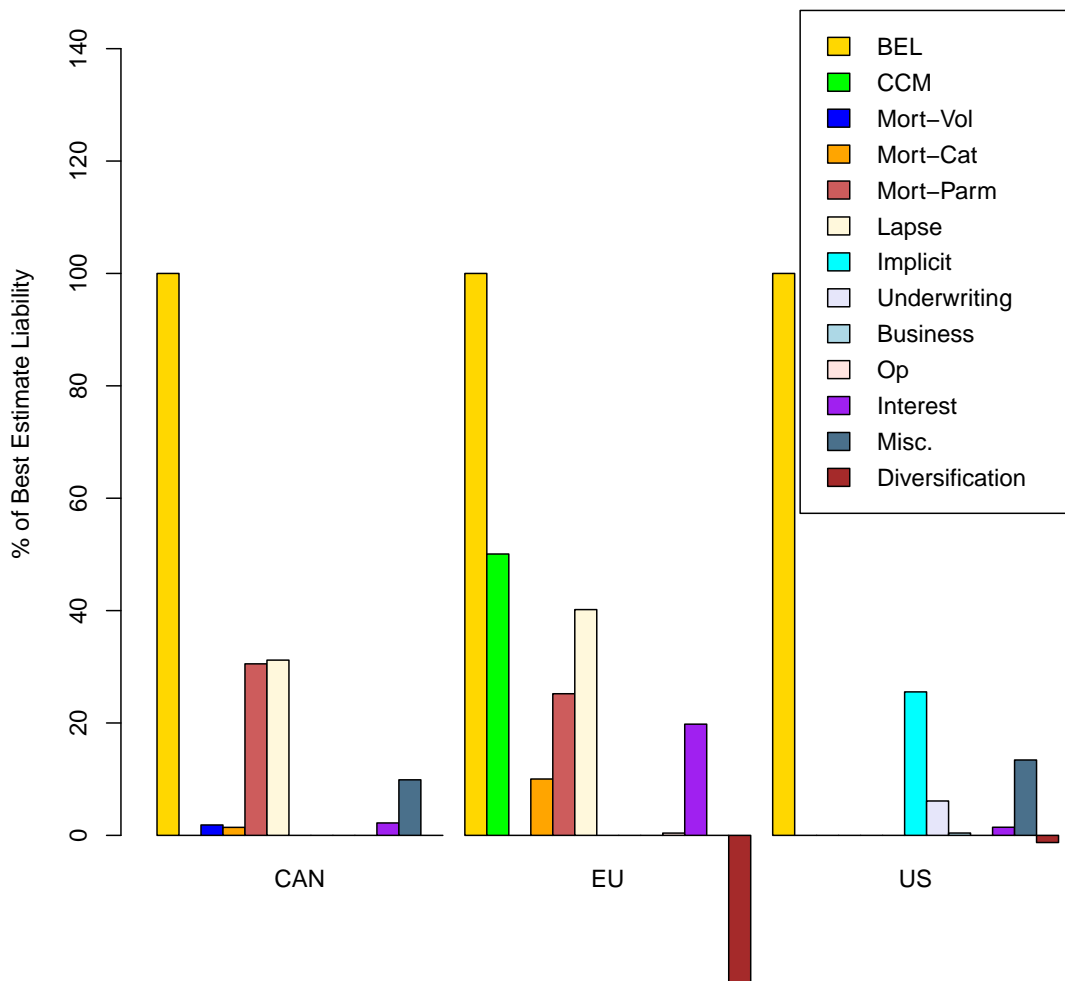**TARGET TOTAL BALANCE SHEET REQUIREMENT**

Figure 3

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statutory liabilities or capital. The differences in the categorization and comprehensiveness of risks covered in the regulatory capital formulas are hinted from the graph.

For the hypothetical term insurance portfolio, and subject to the given assumptions, the following main observations can be made with respect to the detailed graph of the total balance sheet capital requirements above:

- The diversification credits under Solvency II are very significant for the hypothetical term-life insurance portfolio. There are no diversification credits under the Canadian regulatory capital system. The US NAIC RBC formula recognizes the benefits of diversification across risk types, although generally more modestly than the EU Solvency II standard formula.

- The solvency margins under the EU Standard formula are calculated to achieve a 99.5% confidence level over a one year period at the enterprise level. In contrast, the total solvency buffer (i.e. liability margins plus regulatory capital) under the Canadian and U.S. regimes has no specific confidence level attached to it. Further, under the U.S. and Canadian regulatory frameworks, there is no assurance that the solvency margins will not be double counted in both reserves and capital.

- The interest rate risk capital amounts for the U.S. and Canada are significantly less than the corresponding amount that has been determined using the EU Solvency II standard formula. The RBC factors for interest rate risk that have been used to determine the capital amounts for Canada and the U.S. are 1.5% and 1.15%, respectively. The factors are applied to the statutory value of liabilities to determine the amount of capital for interest rate risk. It is worth noting that since the liability cash flows are assumed to be exactly matched with zero coupon bonds, there is no provision for reinvestment/disinvestment risk in the Canadian liability valuation model. The Solvency II economic value total balance sheet approach defines interest rate risk capital as the change in economic surplus based on an adverse non-parallel shift in the term structure of risk-free interest rates. In the current example, the surplus portfolio has a high duration since it is invested in a combination of 30-year and 10-year zero coupon securities. As a result, the Solvency II framework results in a much more significant capital requirement for interest rate risk relative to the other jurisdictions.

- Other than the cost of capital margin, which is a market value adjustment for the solvency liability, all the solvency margins under Solvency II are counted as capital. The inclusion of all risk margins in capital results in increased transparency and a more reliable solvency assessment of a given life insurer since the solvency liability is then a more realistic measure of the actual obligation to policyholders. In addition to the regulatory capital requirement for a given risk, the Canadian actuary will also include a margin for adverse deviation in the valuation assumption for that risk. The margin for adverse deviation is intended to provide for the misestimation of and deterioration in the best estimate assumption. Clearly then, the Canadian statutory liability is a very biased estimate of the obligation for policyholder benefits. In the U.S., the margins for adverse deviation that are included in the statutory liabilities are implicit.

- The required statutory capital for underwriting risks is much smaller under the US NAIC model compared to the other regimes. The exposure base for determining the solvency margin for underwriting risks under the US NAIC standard is the net amount at risk, and decreasing percentages are progressively applied to higher level tranches to reflect diminishing risk from larger insurance portfolios. Underwriting risk margins under the Canadian and EU standard formula frameworks are primarily based on changes in the reserve requirements due to a prescribed change in the underlying risk factors, and are therefore more risk sensitive and portfolio-specific.

- The opaqueness of the US NAIC regulatory system is partly evidenced by the relative magnitude of the margin designated in the graph as "Miscellaneous". The miscellaneous provision refers to capital amounts that are determined by application of arbitrary factors or loadings to account for additional risks that have not been explicitly considered in the formula. Under the U.S. NAIC approach the miscellaneous risk margin refers to the difference between Company Action Level RBC (defined to be the target capital in this paper) and the Authorized Control Level RBC. In Canada, the miscellaneous provision refers to the fact that the supervisory target MCCSR ratio is 150% rather than 100% of the MCCSR. There are no miscellaneous provisions under the EU system since all risk margins are explicitly accounted for.

- Solvency II capital requirements do not include a margin for mortality volatility risk. The significance of this component can be expected to rise with increased skewness in the distribution of life insurance amounts and with decreasing size of the portfolio.

4.3   Integrated Measurement of Assets and Liabilities

The economic valuation of assets and liabilities that underpins the Solvency II approach has several advantages which include having a consistent solvency balance sheet with figures that are all comparable dollar for dollar. Under Solvency II, the economic valuation of insurance liabilities is independent of the manner in which the investment assets backing the liabilities are deployed.

The independence of the liability valuation to the asset strategy follows directly from the definition of technical provisions:

—For the unhedgeable components of liability cashflows, technical provisions are calculated as the sum of the best estimate liability (discounted at risk-free rates) and the cost of capital risk margin. As discussed already, the calculations for the cost of capital margin and the best-estimate liability are both independent of the asset-side of the balance sheet.

—With respect to the hedgeable liability cashflows, technical provisions are determined as the market price of the hedge portfolio of financial instruments. Again, the determination of liabilities does not depend on the nature of the supporting assets.

In the Solvency II framework, therefore, changing the composition or investment strategy of the insurance company's supporting assets will not impact the amount of available capital (surplus) since the value of liabilities does not depend on assets. However, the amount of free capital will change with the composition of the supporting asset portfolio since different assets will attract different solvency capital requirements.

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Under the U.S. NAIC life insurance solvency framework, as already noted, valuation assumptions for liabilities are locked-in based on the policy issue date. To accommodate the formulaic nature of the statutory reserves, various asset valuation adjustment mechanisms are employed by U.S. regulators. These arbitrary mechanisms include the use of non mark-to-market asset valuation methods, the Interest Maintenance Reserve (IMR) and Asset Valuation Reserve (AVR).

In Canada, the value of policy liabilities is the book value of supporting assets. The adequacy of the supporting assets is assessed in a scenario-wise cash flow projection which requires subjective assumptions such as the anticipated portfolio credit loss rates, return premiums on risky investments and the exercise of borrower and issuer options. Section 2340 of the CIA Standards of Practice [Actuarial Standards Board, 2009] provides some guidance on the derivation of these valuation assumptions. In a given adverse scenario under the Canadian method, the anticipated future investment premiums under that scenario are used to reduce overall reserve requirements. This capitalization of the subjective investment premiums creates perverse incentives for the regulated insurance companies. Most critically, the perverse incentives can include increased investment in risky securities to reduce regulatory reserve and capital requirements. In light of the potential vulnerability of the Canadian solvency regulatory system to this exploitation, a very strong regulatory governance process is required to ensure that the assumed investment strategy for the purpose of establishing the statutory liabilities correlates strongly with the actual real-time investment management process. The strong regulatory review process is also required to vet the "realistic" assumed net investment premiums in the liability valuation model.

Further, given the diverse investment protocols of the regulated insurance entities, the challenges of a regulatory system that links liability valuation to assets are not trivial. To illustrate some of these challenges in the context of the Canadian GAAP liability valuation, regulatory capital calculations were performed for the hypothetical term life insurance portfolio that was considered in the Total Balance Sheet Requirement section. The projected liability cash flows were, however, assumed to be matched with defaultable zero coupon debt rather than default-free zero coupon bonds. The bond cash flows that are used to match liabilities are reduced for anticipated credit default based on the valuation actuary's expectations. Alternatively, the allowance for anticipated credit loss on the insurer's investments can be reflected in the CALM as a basis point charge to the expected portfolio return or yield. In this paper, the subjective net credit spread for a given bond investment is defined as follows:

net credit spread = bond yield − risk-free yield − anticipated credit-default loss rate

The following graphs summarize, with respect to the hypothetical term-life insurance portfolio, the solvency liability, statutory capital and free capital amounts for each of the three regimes under varying assumptions of the assumed net credit spread under the Canadian GAAP liability model. As noted already, the illustrated situation assumes that the term-life insurance cash flows are perfectly matched with the risk-adjusted cash-flows of defaultable zero coupon bonds [1].

Figure 4 reveals the following:

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[1]In particular, a highly diversified portfolio of Standard and Poor's BAA investment grade bonds is assumed to avoid the consideration of asset concentration risks under the U.S. and EU Solvency II Standard formula
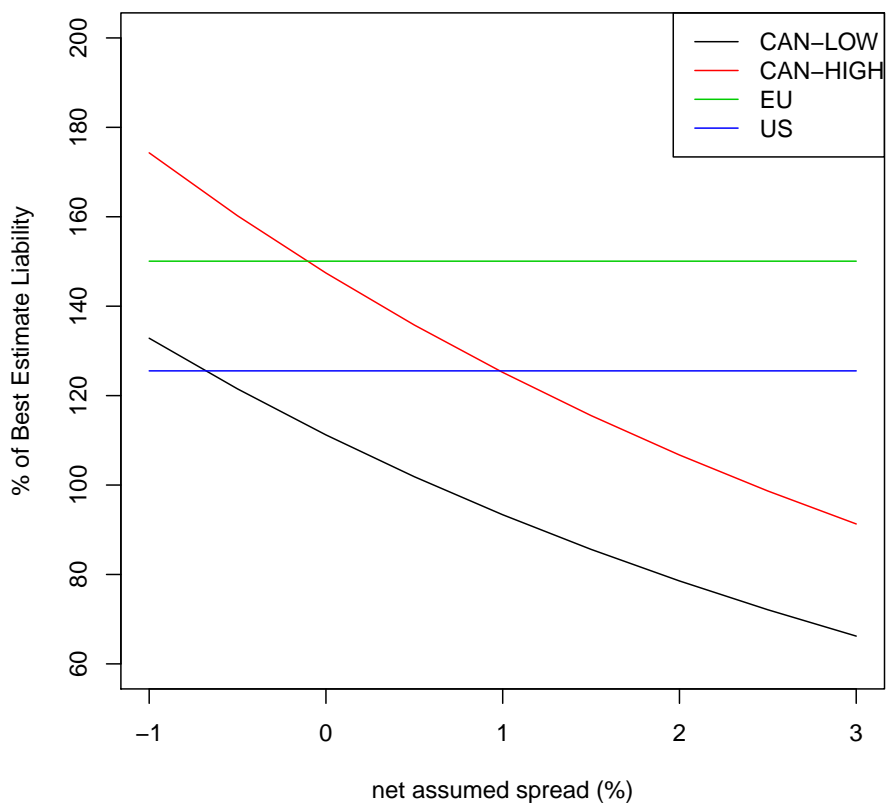
SOLVENCY LIABILITY BY ASSUMED NET CREDIT SPREAD

Figure 4

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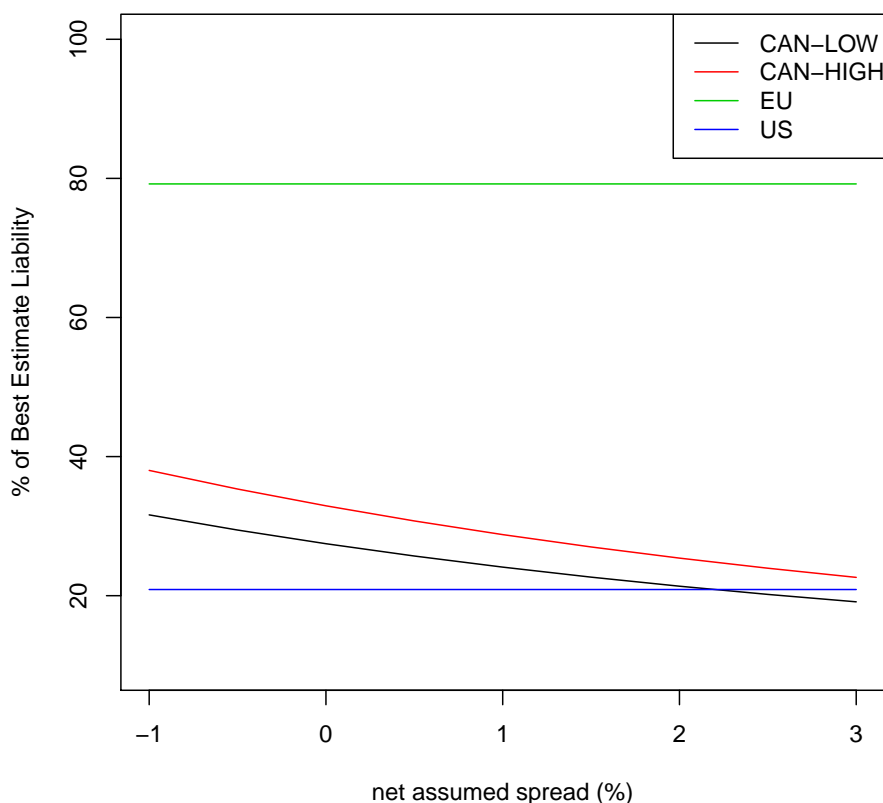**REQUIRED CAPITAL BY ASSUMED NET CREDIT SPREAD**

Figure 5

- The overall conservatism of the Canadian capital adequacy framework relative to other jurisdictions depends on the subjective valuation assumptions of the actuary.

- The allowable variation in the Canadian GAAP liabilities can be seen to be very great. The lines labeled as "CAN-LOW" and "CAN-HIGH" correspond to Canadian GAAP liabilities that have been calculated using the low-end and high-end, respectively, of the permissible ranges for the lapse and mortality valuation assumptions.

Figures 5 and 6 also reveal the wide variation in the statutory capital requirements that is possible under the Canadian statutory valuation model.

Figure 5 shows the same pattern that was identified in Figure 4 but from the perspective of required statutory capital. To the extent that the Canadian GAAP liability is used to determine the statutory capital requirements of other risks, for example, interest rate risk (C-3 risk) and lapse risk, the decrease in liabilities from an increase in the expected net investment premium is propagated to the required capital calculations as well.

The statutory capital requirements under the EU Solvency II standard model are much more significant for two main reasons:

1. The capital requirement for interest rate risk under the EU Solvency II standard formula is determined as the change in economic surplus for a stipulated

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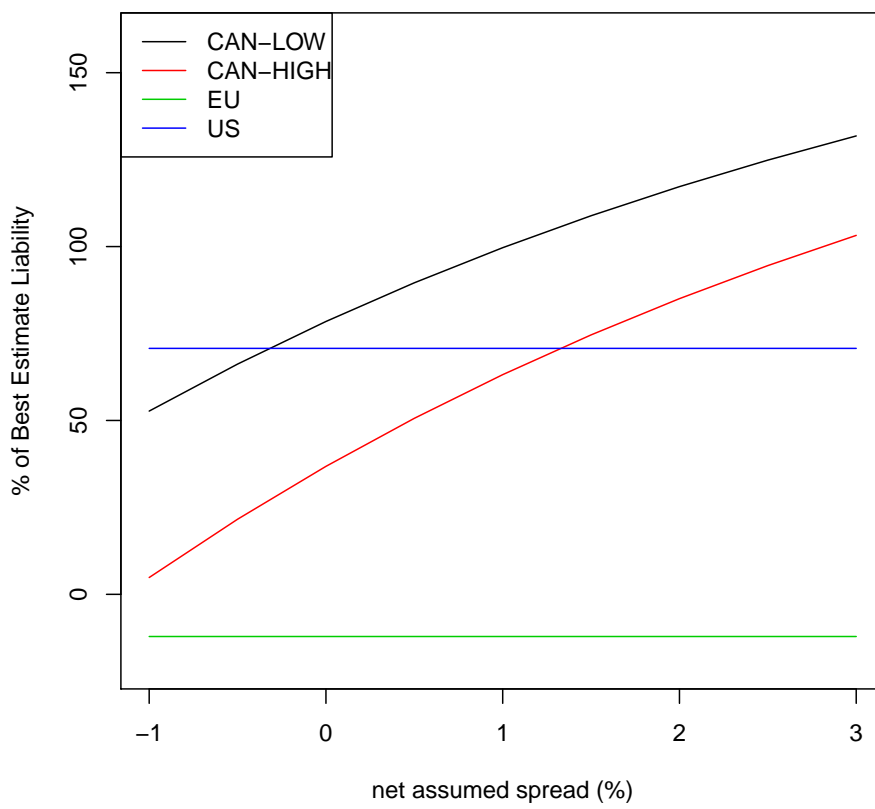**FREE CAPITAL BY ASSUMED NET CREDIT SPREAD**

Figure 6

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adverse change in the risk free term structure[2]. Since the duration of the surplus portfolio in the example is very high, the EU Solvency II standard formula produces a significant capital requirement for exposure to interest rates. On the contrary, the Canadian liability model does not make any provision for mismatch (C-3) risk since the example considered is one in which liability cashflows are perfectly matched with supporting asset cashflows implying that there is no reinvestment/disinvestment risk, at least in the model. Therefore, the interest rate exposure of surplus investments is essentially ignored under both the Canadian and U.S. models. The factor-based approaches in Canada and the U.S. determine risk-based capital for interest rate risk (C-3) as the product of a prescribed factor and statutory reserves.

2. The capital requirement for credit risk under the EU Solvency II model[3] is also significantly greater than the corresponding requirements of the other two regimes. Under the Solvency II standard formula, the capital requirement for the credit spread risk of the insurer's bond portfolio is determined as the product of three factors: bond portfolio duration, a factor dependent on credit quality and the market value of the bonds[4]. Hence, as for the capital requirement for interest rate risk, the high duration of the asset portfolio (around 19 years) creates a significant exposure to credit spread risk. On the other hand, under the factor-based approaches of the U.S. and Canada, the capital requirement for credit default risk is determined by multiplying a prescribed factor with the amount of statutory assets.

Finally, Figure 6 shows the variation of free capital by net credit spread. Clearly, the risk-return tradeoff that underlies the Canadian capital adequacy calculations encourages excess risk taking by the regulated insurance companies, since the penalty for increased risk (i.e. increase in capital requirements) is not guaranteed to materially offset the impact of the commensurate increase in expected return (i.e. reduction in reserves). In fact, it appears that a higher assumed return not only results in lower reserve requirements, but lower capital requirements as well.

In summary, the asset-liability link which underpins the CALM framework creates an unwarranted incentive for regulated insurers to arbitrage the regulatory capital requirements by re-engineering their investment portfolios with a bias to riskier asset classes and strategies when matching longer-dated cash flows. An economic valuation of liabilities would eliminate such perverse incentives by completely de-linking liability valuation from the valuation and investment strategy of the assets backing the liabilities.

5   CONCLUSION

In this paper, illustrative calculations of the capital requirements for a simple term-life insurance portfolio under the current U.S., Canadian and the Solvency II regulatory regimes have been presented. In comparing the capital requirements under the three regimes, several disadvantages of the current Canadian and U.S. frameworks were identified. From a solvency assessment viewpoint, it appears that the total

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[2]See Appendix for the prescribed non-parallel shift in the risk-free term structure.
[3]Per QIS 4 specifications.
[4]See Appendix and references for more details.

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balance sheet and economic principles approach of the Solvency II regime provides a compelling alternative to the current U.S. and Canadian regulatory approaches. The advantages of an economic valuation approach are more evident when complex insurance products that have embedded optionality and guarantees are considered. Further, since insurance companies frequently use capital market instruments to implement hedging programs for managing balance sheet exposure to market risks, the use of market-consistent techniques for appraising the overall solvency balance sheet appears to be a natural progression for solvency regulators.

In Canada, public insurance companies are set to adopt International Financial Reporting Standards (IFRS) as of January 1, 2011. Since the IFRS are based on economic valuation principles [International Accounting Standards Board, 2001, 2003, 2004], regulatory capital requirements in Canada are being reviewed to accommodate the new accounting framework. The new MCCSR framework will be calibrated using a total balance sheet requirement approach. As of the current date, the new standard module for market risk [Joint Committee of OSFI, AMF, and Assuris, 2008b] has already been drafted and finalised by Canada's OSFI, the federal insurance regulator. It is expected, however, that CALM will continue to be used when companies initially adopt IFRS on January 1, 2011 since Phase II of the IFRS insurance valuation project is yet to be finalized. In the U.S., there are also various initiatives underway to revamp and modernize the solvency regulatory system. In particular, the Solvency Modernization Initiative of the NAIC aims to create a state-of-the-art solvency surveillance system for U.S. based insurers. In the European Union, efforts to finalize the Solvency II framework for implementation are continuing. Various consultation papers on level 2 measures have been issued and will be issued in 2009 by the CEIOPS. A fifth quantitative impact study (QIS 5) is also on the horizon as Solvency II regulators prepare for the implementation of the new regulatory reforms by all European Union insurers toward the end of 2012.

With the impending solvency regulatory reforms for insurers operating in Canada, U.S. and the European Union, it is worthwhile for supervisors to benchmark the competitiveness of their proposed quantitative capital requirements against those of other regimes to minimize opportunities for regulatory capital arbitrage. In the present age of highly fluid global capital, to the extent that the international competitiveness of a regulatory capital regime can have implications for the viability of the regulated insurance enterprises, this benchmarking exercise will yield results than can be used to further strengthen the macro-calibration aspects of the system. In this paper, regulatory capital arbitrage opportunities that can arise for international insurers seeking to optimize the use of scarce capital resources were illustrated. In that vein, the economic value framework was shown to be superior to the other approaches presented since it provides an objective and consistent solvency benchmark for determining appropriate capital requirements. In conclusion, the move to a statutory solvency balance sheet and regulatory capital requirements that are determined using economic valuation principles will enable better solvency supervision and will reduce inconsistency and regulatory arbitrage in a global insurance market.

References

Actuarial Standards Board. Standards of Practice - Practice-Specific Standards for Insurers. February 2009.

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American Academy of Actuaries. Principle-Based Risk-Based Capital Report. December 2002.

American Academy of Actuaries. Recommended Approach for Setting Regulatory Risk-Based Capital for Variable Products with Guarantees (Excluding Index Guarantees). September 2003.

American Academy of Actuaries' C3 Life and Annuity Capital Work Group. Presentation to the National Association of Insurance Commissioners Life Risk Based Capital Work Group. September 2008.

BIS, Basel Committee on Banking Supervision. Basel II: International Convergence of Capital Measurement and Capital Standards: A Revised Framework. June 2004.

Phelim P. Boyle and M.R. Hardy. Reserving for Maturity Guarantees: Two Approaches. *Insurance: Mathematics and Economics*, 21(2):113–127, November 1997.

Martin Eling, Hato Schmeiser, and Joan T. Schmit. The Solvency II Process: Overview and Critical Analysis. *Risk Management and Insurance Review*, 10 (1):69–85, 2007.

European Commission. QIS4 Technical Specifications. March 2008.

European Commission. Solvency II Directive. April 2009.

M.R. Hardy. *Investment Guarantees: Modelling and Risk Management for Equity-Linked Life Insurance*. Wiley, New York, 2003.

International Accounting Standards Board. Draft Statement of Principles (DSOP) on Insurance Contracts. November 2001.

International Accounting Standards Board. Exposure Draft ED 5 Insurance Contracts. 2003.

International Accounting Standards Board. IFRS 4 Insurance Contracts. November 2004.

International Actuarial Association. A Global Framework for Insurer Solvency Assessment. 2004.

International Association of Insurance Supervisors. Principles on Capital Adequacy and Solvency, Principles 5. January 2002.

International Association of Insurance Supervisors. A New Framework for Insurance Supervision. Towards a Common Structure and Common Standards for the Assessment of Insurance Solvency. October 2004.

International Association of Insurance Supervisors. Towards a Common Structure and Common Standards for the Assessment of Insurance Solvency: Cornerstones for the Formulation of Regulatory Financial Requirements. October 2005.

Joint Committee of OSFI, AMF, and Assuris. Framework for a New Standard Approach to Setting Capital Requirements. November 2008a.

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Joint Committee of OSFI, AMF, and Assuris. Standardized Approach for Calculating the Solvency Buffer for Market Risk. November 2008b.

Ulf Linder and Vesa Ronkainen. Solvency II Towards a new insurance supervisory system in the EU. *Scandinavian Actuarial Journal*, 2004(6):462–474, 2004.

Louis J. Lombardi. *Valuation of Life Insurance Liabilities*. ACTEX Publications, Inc., 2006.

MCCSR Advisory Committee. Canadian Vision for Life Insurer Solvency Assessment. November 2007.

National Association of Insurance Commissioners. Life Risk-Based Capital Report. 2008.

Office of the Superintendent of Financial Institutions. Minimum Continuing Capital and Surplus Requirements (MCCSR) for Life Insurance Companies. December 2008.

APPENDIX I: DATA

Table 1: US Dollar Swap Rates From December 31, 2000 to December 31, 2008
Source: http://www.federalreserve.gov/

	Maturity							
Date	1	2	3	4	5	7	10	30
2008-12	1.62	1.76	2	2.19	2.34	2.54	2.7	2.69
2007-12	4.29	4	4.06	4.18	4.31	4.52	4.76	5.1
2006-12	5.25	5.02	4.94	4.93	4.94	4.97	5.03	5.18
2005-12	4.84	4.85	4.87	4.89	4.92	4.96	5.01	5.19
2004-12	3.02	3.38	3.61	3.81	3.99	4.29	4.63	5.25
2003-12	1.5	2.22	2.83	3.29	3.66	4.16	4.65	5.38
2002-12	1.57	2.17	2.73	3.14	3.47	3.99	4.48	5.31
2001-12	2.44	3.56	4.33	4.8	5.11	5.5	5.82	6.2
2000-12	6.18	6.06	6.07	6.11	6.14	6.2	6.27	6.41

APPENDIX II: REGULATORY CAPITAL FORMULAS AS USED IN THE EXAMPLES

MINIMUM CONTINUING CAPITAL AND SURPLUS REQUIREMENTS CALCULATIONS: CANADA

Asset Default (C-1) Risk

Asset Default Risk Capital = Asset Default Factor × Statement Value Of Assets

The asset default factor used for A-rated corporate bonds was 1% per MCCSR guideline.

Mortality Risk

Gross Mortality Risk Capital = Volatility Risk Capital + Catastrophic Risk Capital

Volatility Risk Capital = 2.5 × A × B ×E/F
where:

- A is the standard deviation of the projected death claims in the year immediately following the valuation date.

  It is calculated by the following formula:

  $$A = \sqrt{\sum q(1-q)b^2}$$

  where q is the valuation mortality and b is the death benefit for the policy.

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- B is defined as follows:

$$B = \max\left(1, \ln D\right)$$

  where D is the Macaulay Duration of the projected net death claims for the term-life insurance portfolio at a discount rate of 5%

- E is the total net amount at risk for the term-life portfolio

- F is the total face amount

Catastrophic Risk Capital $= \alpha \times C \times E/F$ where:

- $\alpha = 10\%$

- C is next year's death claims

- E is the total net amount at risk

- F is the total face amount

Lapse Risk

Lapse risk capital is calculated as Reserve_A - Reserve_B where:

- Reserve_A is the actuarial reserve for the term insurance portfolio that has been calculated using appropriate valuation assumptions and the CALM methodology.

- Reserve_B is the actuarial reserve that has been recalculated using a more conservative lapse assumption i.e. an additional 15% margin to that already assumed in the valuation. For example if a 10% margin had already been assumed in the valuation, Reserve_B will be based on a lapse margin assumption of 10% + 15% = 25%.

Changes in Interest Rate Environment (C-3) Risk

The C-3 RBC factor is based on the type of insurance product as well as the remaining guarantee period under the contract. The C-3 risk capital for the term insurance portfolio was calculated as follows:
C-3 Interest Rate risk capital = C-3 RBC Factor $\times$ Policy Reserves

The C-3 RBC factors that were used in the calculations varied by the remaining guarantee period at the valuation date and were based on the following table:

Factor	Guarantee Period
0.01	Less than 5 years
0.02	Less than 10 years, greater than or equal to 5 years
0.03	Greater than 10 years

In addition, the above factors were halved since the term life product that was considered does not have guaranteed cash surrender values.

NAIC RISK BASED CAPITAL CALCULATIONS

The calculations were based on the 2008 NAIC Life Risk-Based Capital Report.

Asset Default (C-1) Risk

Asset Default Risk Capital = Asset Default Factor × Statement Value Of Assets

The asset default factor used for A-rated corporate bonds was 0.40%.

Insurance (C-2) Risk

Life RBC factors are applied to each tranche of net amount at risk in accordance with following table:

Net Amount at Risk	Factor
First 500 Million	0.0023
Next 4,500 Million	0.0015
Next 20,000 Million	0.0012
Over 25,000 Million	0.0009

Interest Rate (C-3) Risk

The C-3 RBC factor is based on the type of insurance product including the presence or absence of liberal withdrawal provisions which would expose the insurer to greater risk from interest rate fluctuations. The C-3 risk capital was calculated as follows:
C-3 Interest Rate risk capital = C-3 RBC Factor × Policy Reserves

The pre-tax factor of 0.0115 which is applicable to the Low-Risk Category products was used to determine the interest rate RBC for the term-life insurance portfolio.

Business (C-4) Risk

Regulatory capital for exposure to general business risk was determined as 3.08% of the term life insurance premiums (pre-tax).

EUROPEAN UNION SOLVENCY II CAPITAL CALCULATIONS

The formulas that were used do not include the reduction in economic risk that arises from the impact of current capital losses on future profit sharing or deferred tax liabilities. The term product that was illustrated is a non-par product and we have explicitly ignored income taxes in our analysis.

Market: Credit Spread Risk

The capital charge for the spread risk of bonds was calculated as follows:
$\text{Market}_{spread} = \sum_i \text{MV}_i \cdot \text{m}(\text{dur}_i) \cdot \text{F}(\text{rating}_i)$
where:

- MV_i is the market value of each bond i subject to credit spread risk.

- dur_i is the duration of bond exposure i.

- $\text{m}(\text{dur}_i)$ is a function that relates bond duration to regulatory capital.

$$
\text{m}(\text{dur}_i) = \begin{cases} \max(\min(\text{dur}_i,8),1) & \text{if rating}_i = \text{BB} \\ \max(\min(\text{dur}_i,6),1) & \text{if rating}_i = \text{B} \\ \max(\min(\text{dur}_i,4),1) & \text{if rating}_i = \text{CCC or lower, unrated} \\ \max(\text{dur}_i,1) & \text{otherwise} \end{cases}
$$

- $\text{F}(\text{rating}_i)$ is a function of the credit rating class of the bond that is calibrated to a 99.5% VaR metric for credit spread related market value losses.

Rating	$\text{F}(\text{rating}_i)$
AAA	0.25%
AA	0.25%
A	1.03%
BBB	1.25%
BB	3.39%
B	5.60%
CCC or lower	11.20%
unrated	2.00%

Market: Interest Rate Risk

The capital charge for the interest rate risk due to the mismatch of assets and liability cashflows was calculated as follows:

$Mkt_{int} = \max(Mkt_{int}^{up}, Mkt_{int}^{down})$

where:

- $Mkt_{int}^{up} = \triangle NAV | upshock$

    The percentage increase factors in the table below are the upward shock factors to be applied to the current term structure of risk-free interest rates to determine Mkt_{int}^{up}. Assets and liabilities are revalued under the resulting scenario of increased rates and Mkt_{int}^{up} is the net change in the Net Asset Value due to the increase in rates.

Maturity	1	2	3	4	5	6	7
Factor	0.94	0.77	0.69	0.62	0.56	0.52	0.49

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Maturity	8	9	10	11	12	13	14
Factor	0.46	0.44	0.42	0.42	0.42	0.42	0.42

Maturity	15	16	17	18	19	20
Factor	0.42	0.41	0.40	0.39	0.38	0.37

- $Mkt_{int}^{downshock} = \triangle NAV | downshock$

  The percentage decrease factors in the table below are the downward shock factors to be applied to the current term structure of risk-free interest rates to determine Mkt_{int}^{down}. Assets and liabilities are revalued under the resulting scenario of decreased rates and Mkt_{int}^{down} is the net change in the Net Asset Value due to the decrease in rates.

Maturity	1	2	3	4	5	6	7
Factor	-0.51	-0.47	-0.44	-0.42	-0.40	-0.38	-0.37

Maturity	8	9	10	11	12	13	14
Factor	-0.35	-0.34	-0.34	-0.34	-0.34	-0.34	-0.34

Maturity	15	16	17	18	19	20
Factor	-0.34	-0.33	-0.33	-0.32	-0.31	-0.31

Life Underwriting: Mortality Risk

The capital charge for mortality risk was calculated as follows:

$$\text{Life}_{mort} = \sum_i \left(\triangle NAV | mortshock \right)$$

where i denotes each policy subject to mortality risk. The remaining terms are:

- $\triangle NAV$ is the change in net asset value given the mortality shock

- *mortshock* is a permanent increase of 10% applied to mortality rates at every age

Life Catastrophic Risk

The capital charge for exposure to catastrophic mortality risk was calculated as follows:

$$\text{Life}_{cat} = \triangle NAV | catshock = \sum_i \text{Net Amount at Risk}_i \times 0.0015$$

The terms in the formula are:

- subscript i denotes summation over each policy subject to mortality risk i.e. all term life policies at the valuation date

- $\triangle NAV$ is the change in net asset value given the catastrophic mortality shock

- *catshock* is an absolute increase in mortality rates of 1.5 per thousand

Life Underwriting: Lapse Risk

The formula for the capital charge for lapse risk is calculated on a policy by policy basis and is as follows:

$$\text{Life}_{lapse} = \max(\text{Lapse}_{down}; \text{Lapse}_{up}; \text{Lapse}_{mass})$$

where:

- Lapse_{down} is the capital charge for a permanent decrease in lapse rates

  $$\text{Lapse}_{down} = \sum_i \left(\triangle NAV | lapseshock_{down}\right)$$

  where $lapseshock_{down}$ is a permanent decrease in lapse rates of 50% at all policy durations where a lapse event would incur a payout that is smaller than the best estimate liability at that duration i.e. negative surrender strain

- Lapse_{up} is the capital charge for a permanent increase in lapse rates

  $$\text{Lapse}_{up} = \sum_i \left(\triangle NAV | lapseshock_{up}\right)$$

  where $lapseshock_{up}$ is a permanent increase in lapse rates of 50% at all policy durations where a lapse event would incur a payout that is greater than the best estimate liability at that duration i.e. positive surrender strain

- Lapse_{mass} is the risk capital charge for a mass lapse event. It is calculated as 30% of the sum of the surrender strains for policies where the surrender strain is positive.

Operational Risk

The capital charge for operational risk was calculated as follows:

$$\text{Life}_{operational} = \min(0.3 \times \text{BSCR}; \max(0.03 \times \text{Earned Premium}; 0.003 \times \text{TP}))$$

where:

- BSCR is the Basic Solvency Capital Requirement i.e. the sum of all the risk charges calculated above including diversification credits, and before adjustments for the risk reduction arising from future profit sharing and deferred taxes (which we have ignored in this paper).

- Earned Premium is the total earned premium (gross of reinsurance, if any) for the term life portfolio in the year following the valuation date

- TP are the Technical Provisions on the valuation date. Best estimate provisions are required to be used in the computation to avoid circularity.

Cost of Capital Risk Margin

The cost of capital risk margin was calculated using the following formula:

Cost of Capital Margin $= \sum_{t=0}^{T} crate \times SCR_t^{mkt^-} \times D(0,t)$

where:

- T is the projection horizon required to run-off all the policy liability cash flows for inforce policies at time $t=0$.

- $crate$ is the cost of capital rate which was set at 6% in QIS 4.

- $D(0,t)$ is the zero coupon risk-free bond price corresponding to maturity t at time t=0

- $SCR_t^{mkt^-}$ is the solvency capital requirement in year t with respect to underwriting and operational risks only. Specifically, market risks are excluded from this calculation.

  For the purposes of this paper, the modified solvency capital requirements (i.e. excluding market risks) for future years were determined by prorating the initial solvency capital requirement by the projected best estimate liabilities (BE).

  That is, $SCR_t^{mkt^-} = BE(t)/BE(0) \times SCR_0^{mkt^-}$.

  In turn, Best Estimate liabilities were calculated as shown below:

  $BE(t) = \sum_{r=t+1}^{T} (\text{Claims}_r \times D(0,(r-t))) - \sum_{r=t}^{T} (\text{Premiums}_r - \text{Expenses}_r) \times D(0,(r-t))$

  The policy cashflows at time t i.e. $\text{Claims}_t, \text{Expenses}_t \; and \; \text{Premiums}_t$ are based on best estimate valuation assumptions.

Minimum Capital Requirement (MCR)

The minimum capital requirement for the term life portfolio was calculated as follows:

$MCR_{term20}^{uncapped} = \alpha \times TP + \beta \times \text{Net Amount at Risk}$

A floor of 20% and a cap of 50% of the Solvency Capital Requirement (SCR) are then applied to the $MCR_{term20}^{uncapped}$. Finally, an absolute floor of 2 million Euros was applied to get the final MCR. The formula for applying the cap and floors is shown below:

$MCR_{term20}^{final} = \max(2 \text{ million Euros}, \min(50\% \times SCR, \max(20\% \times SCR, MCR_{term20}^{uncapped})))$

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