

# Analysis of Methods for Determining Margins for Uncertainty under a Principle-Based Framework for Life Insurance and Annuity Products

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## Foreword

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## 1. EXECUTIVE SUMMARY

Over recent years, the United States has been considering the development of a principle-based framework for the statutory financial reporting of insurance contracts. Margins for uncertainties are a required and critical element in developing assumptions under a principle-based framework for statutory reserving. The objective for this research project is to identify, review and compare approaches to determine margins for uncertainty in actuarial assumptions based on existing literature and studies, and original research. In addition, the project is intended to examine the approaches identified and compare the appropriateness of these under a principle-based framework. This research report will serve as educational material for practitioners to help develop knowledge of the possible approaches for setting margins for life and annuity business. It will also assist the NAIC's Life and Health Actuarial Task Force in finalizing the guidelines around determining margins for uncertainties.

Broadly speaking, the various approaches to determine margins for uncertainties can be split into two basic categories:

- Bottom-up approaches
- Top-down approaches

Bottom-up approaches quantify the overall margins by adding margins on each individual assumption. The top-down approaches determine the margins on an aggregate basis across all risk types and assumptions, relative to best estimate liabilities or required capital.

Both categories of approach have their pros and cons. For example, the bottom-up approaches have the attribute of providing explicit feedback loops by individual assumption, which allow management, auditors and regulators to monitor the appropriateness of reserving in light of emerging experience. However, they also pose one particular challenge to actuaries: whether and how to take into account the diversification effects between risks. On the other hand, top-down approaches explicitly quantify the margins relative to best estimate liabilities or required capital at an aggregate level, implicitly addressing the diversification issue.

In general, bottom-up approaches are typically more consistent with setting margins on individual assumptions under a "principle based approach". This is because the proposed PBR framework requires actuaries to prudently consider individual risk factors and associated margins for uncertainties. However, top-down approaches can often be applied to help calibrate and test the aggregate level of margins.

Through our research, we identified a number of different approaches to quantifying margins for uncertainty:

1. Factor based approaches
2. Discount related methods
3. Judgment based on experience studies
4. Stress Testing / Sensitivity Testing

5. "Quantile" and distribution methods
6. Stochastic modeling
7. Cost of Capital method
8. Calibration to the Capital Markets or Insurance Pricing

Of these approaches, the first two would typically not be considered appropriate for determining margins for uncertainty under a principle-based approach. Specifically, the PBR framework requires insurance companies to follow certain principles and determine their reserves according to their company's specific situation.

As such, due to their nature of implicitly incorporating conservatism, factor based approaches are unlikely to be considered appropriate under the proposed PBR framework. In particular, they typically involve limited judgment relating to the company's specific situation. Similarly, discount related methods are difficult to use in developing margins for individual risk factors. Hence this approach also does not fit well into the proposed PBR framework.

Further, the last two approaches listed above, namely the cost of capital method and calibration to the capital markets or insurance pricing, are generally top-down approaches, so they may be more useful to help calibrate and test the aggregate level of margins as discussed above.

Where relevant, section 5 discusses how each approach can be applied to determine margins for specific assumptions. Of course, certain approaches may not be applicable in relation to certain assumptions (for example, due to the nature of the underlying risks involved). The assumption types considered within our research, together with the approaches that would typically be applicable to determine margins for each assumption, are outlined below.

	Mortality	Expenses	Expense inflation	Default costs	Policyholder behavior
Factor based approaches	✓	✓	✓	✓	✓
Discount related methods	Not typically applicable to individual assumptions				
Judgment based on experience studies	✓	✓	✗	✗	✓
Stress testing / sensitivity testing	✓	✓	✓	✓	✓
"Quantile" and distribution methods	✓	✗	✗	✓	✓
Stochastic modeling	✓	✗	✓	✓	✓
Cost of capital	✓	✗	✗	✗	✗
Calibration to capital markets or insurance pricing	✓	✗	✗	✗	✗

✓	Approach can typically be used for this assumption	✗	Approach typically not appropriate
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In addition, our research also considered the approach to setting margins for uncertainty around reinsurance related assumptions required under the proposed PBR framework.

Section 6 of the report provides an assessment of the various approaches to quantifying margins for uncertainty considered within our research. The assessment is performed in relation to the following key criteria, which we believe are important attributes for a good approach to setting margins for uncertainties under a principle-based framework:

1. **Consistency with proposed principle-based framework:** How consistent is the approach with the "principles" set out in the valuation manual, VM-20?
2. **Degree of transparency:** How explicit are the margins generated using the approach? Can the margins be easily monitored, audited and disclosed?
3. **Ease of calculation:** How complex are the calculations and modeling required to quantify the margins?
4. **Stability of calculations between reporting cycles:** How stable is the approach between valuations? Does it enable companies to build valuation models that do not require significant changes between reporting cycles?
5. **Ease of implementation:** Are there any significant practical complexities involved in implementing the approach?
6. **Calculation accuracy:** Does the approach consistently produce the required level of conservatism? Do the calculated margins respond as theoretically expected to changes in the environment, methodology and underlying data?
7. **Minimizing the opportunity for manipulation:** Does the approach reduce the risk of manipulation? Can the generated margins be easily subjected to independent testing? How significant is the level of subjective judgment required to determine the margins using this approach?
8. **Reducing over-reliance on historical data:** Does the approach overly rely on company experience or other historic data to quantify the margins?
9. **Incorporates validation versus historical data:** Does the approach make appropriate reference to incorporate available information from company experience or other historic data to validate the appropriateness of margins?
10. **Uniformity by size of company:** Can the approach be easily implemented by different sized companies? Is the approach cost-prohibitive for relatively small companies to implement?
11. **Explicitly covers individual risk factors:** Can the approach be applied to explicitly develop the margins for uncertainties for individual risk factors (as opposed to aggregate margins across multiple risk factors)?

12. **Allows for consideration of diversification effects:** Can the approach easily take account of the correlation between individual risk factors so that the diversification effects can be considered in the aggregation across risk factors?

13. **Ease of communication:** How easy is it to communicate the approach (both the methodology and results) to senior management, regulators and investors?

14. **Ease of monitoring:** How easy it is to monitor changes in the margins and track the variation of actual versus expected experience for individual risk factors?

A summary of our assessment is outlined in the following table, which is explained in further detail in sections 6.2 and 6.3.

	Factor based	Judgment based on experience studies	Stress testing / sensitivity testing	"Quantile" and distribution	Stochastic modeling	Cost of capital	Calibration to capital markets
Consistency with proposed PBR	✗	✓	✓	?	✓	✗	✗
Degree of transparency	✗	✓	✓	✓	✗	✗	✓
Ease of calculation	✓	?	✓	✓	✗	✓	?
Stability of calculations	✓	✗	✓	?	✗	✓	✗
Ease of implementation	✓	?	✓	✗	✗	✓	✗
Calculation accuracy	✗	?	?	?	✓	?	?
Minimizing opportunity for manipulation	✗	✗	✗	✓	✓	✗	?
Reducing over-reliance on historical data	✓	✗	?	✗	✓	✓	✓
Incorporates validation versus historical data	✗	✓	?	✓	✓	✗	✗
Uniformity by size of company	✓	✗	✓	?	✗	✗	✗
Explicitly covers individual risk factors	✓	✓	✓	✓	✓	✗	✗
Allows for consideration of diversification effects	✗	✗	✓	?	?	✓	✓
Ease of communication	✓	✓	✓	✓	✗	✗	✓
Ease of monitoring	✗	✓	?	?	?	✗	✗

✓	Pros	?	Varying by situation	✗	Cons
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Before using the information set out in this report, we recommend readers review the limitations set out in section 2.4. In particular, we would like to highlight the following points:

- At the time this research was performed, the most recent draft version of VM-20 was dated September 22, 2008 (which is the version we refer to throughout this research report as "VM-20"). Subsequently, a revised draft dated January 22, 2009 was issued by the Life and Health Actuarial Task Force (LHATF) of the National Association of Insurance Commissioners (NAIC). Where appropriate, we have updated this research report to reflect certain differences between these drafts of VM-20. However, throughout this report, all references to VM-20 relate to the draft version dated September 22, 2008. In addition, any subsequent changes to VM-20 could clearly impact the relevance of the information provided in this report.
- As educational material, this research report is not intended to provide definitive answers or make recommendations in relation to preferred methods or approaches under a PBR framework. In addition, it is not intended to provide a comprehensive overview of the factors that should be taken into consideration when determining margins for uncertainty. Instead, the report is intended to provide the reader with some preliminary information that may help in these considerations.

## 2. BACKGROUND

Over recent years, the United States has been considering the development of a principle-based framework for the statutory financial reporting of insurance contracts. Broadly speaking, a "Principle-Based Approach" (PBA) refers to valuation approaches based on generally accepted actuarial principles and individual company experience. In a statement made in March 2007<sup>1</sup>, the American Academy of Actuaries noted:

*"A Principles-Based Approach of statutory Risk-Based Capital (RBC) and minimum reserve requirements incorporates the following common statements.*

- 1. Captures all of the benefits and guarantees associated with the contracts and their identifiable, quantifiable and material risks, including the 'tail risk' and the funding of the risks.*
- 2. Utilizes risk analysis and risk management techniques to quantify the risks and is guided by the evolving practice and expanding knowledge in the measurement and management of risk. This may include, to the extent required by an appropriate assessment of the underlying risks, stochastic models or other means of analysis that properly reflect the risks of the underlying contracts.*
- 3. Incorporates assumptions, risk analysis methods and models and management techniques that are consistent with those utilized within the company's overall risk assessment process. Risk and risk factors explicitly or implicitly included in the company's risk assessment and evaluation processes will be included in the risk analysis and cash flow models used in the PBA. Examples of company risk assessment processes include economic valuations, internal capital allocation models, experience analysis, asset adequacy testing, GAAP valuation and pricing.*
- 4. Permits the use of company experience, based on the availability of relevant company experience and its degree of credibility, to establish assumptions for risks over which the company has some degree of control or influence.*
- 5. Provides for the use of assumptions, set on a prudent estimate basis, that contain an appropriate level of conservatism when viewed in the aggregate and that, together with the methods utilized, recognize the solvency objective of statutory reporting.*
- 6. Reflects risks and risk factors in the calculation of reserves and capital that may be different from one another and may change over time as products and risk measurement techniques evolve, both in a general sense and within the company's risk management processes."*

Similarly "Principle-Based Reserving" (PBR) refers to an approach to calculating insurance liability reserves in a manner consistent with the principles outlined above.

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<sup>1</sup> "Updated Principles-Based Approach Principles from the American Academy of Actuaries Consistency: Principles, Summary, Definitions & Report Format Work Group", dated March 5, 2007 (see [www.actuary.org/pdf/life/principles\\_march07.pdf](http://www.actuary.org/pdf/life/principles_march07.pdf))

The American Academy of Actuaries (AAA) Life Practice Council is working closely with the Life and Health Actuarial Task Force (LHATF) of the National Association of Insurance Commissioners (NAIC) to draft the life insurance Valuation Manual (VM). VM-20 is the section of the Valuation Manual which defines the minimum reserve valuation standard for individual life insurance policies subject to a principle-based reserve valuation. The most recent draft version of VM-20 was dated September 22, 2008 (which is the version we refer to throughout this research report as "VM-20"). On November 20, 2007, the AAA also published a discussion draft of an actuarial standard of practice (ASOP) titled "Standards for Principles-Based Reserves for Life Products" (the "AAA PBR Standards"). Appendix 1 provides a summary of the key elements of VM-20 and the PBR ASOP as they relate to this research report.

Margins for uncertainties are a required and critical element in developing assumptions under a principle-based framework for statutory reserving. Prudent margins are required for selected risk factors that are neither stochastically determined nor prescribed, according to the requirements of VM-20.

## 2.1 Background of This Project

The primary purpose of this research project is to create reference materials that identify and compare different approaches for quantifying the margins for uncertainties in actuarial assumptions required under the PBR framework. This research report will serve as educational material for practitioners to help develop knowledge of the possible approaches for setting margins for life and annuity business. The report will also assist the LHATF in finalizing the guidelines around determining margins for uncertainties.

Throughout this report, we will use the terms "margin", "risk margin" and "margin for uncertainty" interchangeably to refer to the margins for uncertainties in actuarial assumptions required under the PBR framework as outlined in VM-20.

The objective for this research project is to identify, review, compile and compare approaches to determine margins for uncertainty in actuarial assumptions based on existing literature and studies, and/or original research. In addition, the project is intended to examine the approaches identified and compare the appropriateness of these under a principle-based framework.

This report describes various existing and potential approaches to determine prudent margins for uncertainties in relation to reserving assumption under a PBR framework. It also outlines some advantages, disadvantages and practical implementation issues of the different methods. In addition to describing methods to develop margins for individual risk factors, the report also includes some initial considerations regarding the requirement to test or calibrate margins at an aggregate level. Finally, the report identifies some areas that could be further explored in future research.

As educational material, this research report is not intended to provide definitive answers or make recommendations in relation to preferred methods or approaches under a PBR framework.

## 2.2 Key Elements of This Project

As discussed in section 3 below, margins are required both in relation to reserves for future liabilities ("reserves") and also in setting capital. This research focuses on setting margins for uncertainty in relation to the assumptions used to determine reserves.

As outlined in VM-20<sup>2</sup>, there are three basic categories of actuarial assumptions under the proposed PBR framework:

1. Prescribed assumptions
2. Stochastically determined assumptions, based on a prescribed CTE level, which must include at a minimum interest rate movements, equity movements, and separate account fund performance
3. Prudent estimate assumptions, which must be used for all assumptions that are not prescribed or stochastically modeled.

VM-20 defines a prudent estimate assumption as "a deterministic assumption, used to represent a risk factor developed by applying a margin to the anticipated experience assumption for that risk factor." The margins are intended "to derive a prudent estimate assumption to provide for estimation error and adverse deviation." Further, the margins "should be directly related to the level of uncertainty in the risk factor for which the prudent estimate assumption is made, whereby the greater the uncertainty, the larger the required margin, with the margin added or subtracted as needed to produce a larger minimum reserve than would otherwise result without it."

This research project focuses on potential methods to develop such margins for uncertainty on individual "anticipated experience" (or best estimate) assumptions, including mortality, lapses and policyholder behavior. It does not address margins for those economic assumptions that are required to be stochastically modeled under the current proposals.

The key elements of this research report include:

- Theoretical and accounting background to setting margins for uncertainties in actuarial assumptions (section 3)
- Introduction and generic comparisons of various methods to develop margins for uncertainties for individual risk factors, together with a high level introduction to methods that may be used to test or calibrate aggregate margins (sections 4 and 6)
- Outline and discussion of key attributes and practical issues regarding each method as it relates to specific assumptions (section 5)
- Suggestions for areas of potential future research (section 7)

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<sup>2</sup> "VM-20" is used throughout this report to refer to the version of the PBR life valuation manual ("VM-20: Requirements For Principle-Based Reserves For Life Products") dated September 22, 2008

## 2.3 PwC Research Approach

Working with the Project Oversight Group (POG) formed by the Society of Actuaries (SOA), the PricewaterhouseCoopers (PwC) team has conducted detailed research and prepared this report.

Our research approach included:

- Compiling and reviewing existing research papers from industry and academia
- Synthesizing the key issues and discussions around setting margins in the reserving process
- Conducting internal research regarding the methods being used under different frameworks and within different companies where we have experience<sup>3</sup>

## 2.4 Study Limitations

The relevance and appropriateness of the various approaches discussed in this report clearly depend on company specific factors and accounting policies. As such, readers should be aware of the limitations of this research report, which include:

- This research focuses on life and annuity products
- No explicit quantitative analysis was conducted to quantify the impacts of various methods in setting margins. Therefore some quantitative information being discussed may not represent the current situation for companies in the United States.
- Some sections contain the researchers' opinions from original research and may not be relevant for certain insurance entities
- At the time this research was performed, the most recent draft version of VM-20 was dated September 22, 2008 (which is the version we refer to throughout this research report as "VM-20"). Subsequently, a revised draft dated January 22, 2009 was issued by the Life and Health Actuarial Task Force (LHATF) of the National Association of Insurance Commissioners (NAIC). Where appropriate, we have updated this research report to reflect certain differences between these drafts of VM-20. However, throughout this report, all references to VM-20 relate to the draft version dated September 22, 2008. In addition, any subsequent changes to VM-20 could clearly impact the relevance of the information provided in this report.

As educational material, this research report is not intended to provide definitive answers or make recommendations in relation to preferred methods or approaches under a PBR framework. In addition, it is not intended to provide a comprehensive overview of the factors that should be taken into consideration when determining margins for uncertainty. Instead, the report is intended to provide the reader with some preliminary information that may help in these considerations.

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<sup>3</sup> The results presented in this report have been synthesized, combined, and otherwise altered in a way to preserve the substance of the results without disclosing any confidential information relating to specific clients.

### 3. MARGINS FOR UNCERTAINTIES UNDER DIFFERENT THEORETICAL CONTEXTS

During our research, we observed many different terminologies for the margins applied under various financial reporting frameworks, including provisions for adverse deviation, risk margins, margins for uncertainties, risk allowance, profit margins. Although each of these terms has different meanings or definitions under different contexts, they generally address the same concept: the requirement to incorporate prudent margins on insurance company balance sheets to help cover both fluctuations in assets and liabilities with regard to the timing or amount of future cash flows and misestimates of the expected value of estimated future cash flows.

This section provides high level background information regarding the requirement to hold margins for uncertainty and how the margins fit into different solvency and performance measurement reporting frameworks. Specifically, this section covers the following topics:

- How the margins for uncertainties discussed fit into major existing regulatory reporting frameworks
- The objectives of margins for uncertainties
- Uncertainties covered by the margins
- The relationship between margins for uncertainties, best estimate liabilities, capital and profit margins
- Desirable characteristics of margins for uncertainties
- Other key considerations

#### 3.1 Margins for Uncertainties within Reporting Frameworks

Issues relating to margins for uncertainties need to be discussed in the context of a specific financial reporting framework. Firstly, it is important to understand whether the reporting framework is designed to establish a standard industry-wide level of confidence in insurers' abilities to meet future obligations *or* to establish entity specific results. More generally, is the framework designed to measure an insurer's ability to meet its obligations under alternative future scenarios *or* to measure the funds that are expected to be available to investors under these scenarios (with appropriate adjustment for risk)?

The industry-wide approach requires one-size-fits-all rules to be applied to all companies while the entity specific framework is often established in a manner more consistent with a principle-based approach. Under an industry-wide framework, methods to set margins for uncertainties are often less important as most assumptions are typically prescribed. The entity specific framework, however, relies extensively on the judgment of individuals, auditors and regulators. There is a global trend away from prescribed industry-wide approaches, towards entity specific solvency and performance measurement frameworks.

Furthermore, there are two distinctive views under which various regulators are seeking to establish entity specific principle-based solvency and performance measurement reporting frameworks:

- *Liability run-off* which measures an insurer's ability to meet its obligations under alternative scenarios
- *Exit value* which measures (on a risk-adjusted basis) the funds that are expected to be available to investors

The liability run-off view considers the total amounts required to cover uncertainties such that an insurer is able to fund, with a certain level of confidence, all future liability cash flows and associated expenses to mature existing (pooled) insurance contracts. The total amounts required in addition to best estimate liabilities are the sum of margins for uncertainties (sometimes after addressing diversification effects) and the required capital supporting the insurance policies. The boundary between liability margins and required capital will be discussed later in this section. The requirements are determined based on the nature, timing and amount of future policy cash flows.

The liability run-off view, which is perhaps the most familiar view to actuaries, assumes insurance companies keep and maintain the insurance contracts they have entered into with their policyholders until contract termination due to maturity, death, surrenders or replacement. Under this view, both regulators and policyholders are afforded security (with a certain level of confidence) that insurance companies are able to cover their future obligations over the lifetime of the pooled contracts.

The exit value view treats the insurance contracts as pooled risks that could be transferred to other market participants. In order for another market participant to accept (purchase) the contractual rights and obligations of the pooled insurance policies at a reasonable price, an insurance company has to set up and incorporate a certain level of risk allowance within its liabilities. These risk margins compensate the other market participant for taking over the risks associated with the transferred business. For life insurance business, these risks include not only the volatilities in earnings and the risk that the expected value of future obligations is incorrect, but also guarantees and options provided to policyholders as well as any frictional costs, illiquidity and operational risks. This risk allowance is reflected within both margins for uncertainties and risk based capital under an exit value view. The risk margins are part of the cost of bearing risks and are regarded as an additional amount associated with the uncertainties inherent in the future returns of the pooled insurance contracts.

Although closely related, these two views are distinct ways to value insurance business. The liability run-off view emphasizes the regulatory or policyholder standpoint to assess and manage the uncertainties in the liability cash flows. The exit value view is primarily from the standpoint of investors in insurance business. This difference is further discussed below.

### 3.2 The Objectives of Margins for Uncertainties

Before examining specific approaches for establishing margins for uncertainties, it is important to understand the objectives of these margins. This is closely related to the nature and underlying economics of insurance business. Although insurance can be viewed in different ways, the "simplified" nature of this business is that policyholders are transferring the risks that they could not diversify on their own to an insurance company that is able to pool different risks together and take advantage of this risk diversification. By entering into contracts with insurance companies, policyholders are paying a price, the premiums or fees, in exchange for a "promise" that they will get reimbursed entirely or partially for potential future losses.

Given both policyholders and insurance companies are dealing with events happening in the future, they both have to face the uncertainties embedded in the insurance contracts. Policyholders are subject to risks with uncertain timing and loss amounts, which they wish to transfer to an organization that can secure their future for a reasonable current "loss" (i.e. the policy premium or fees). Insurance companies, on the other hand, also face the uncertainty that they may mis-estimate the timing and amount of the aggregate losses they are pooling together across numerous policyholders.

From the regulator perspective, both margins for uncertainties and capital are functioning to create "buffers" to cover the uncertainties that insurance companies face (i.e. the risk that the costs to fulfill insurers' obligations to policyholders are higher than anticipated in setting policy fees and premiums).

In addition, there are two broad views of risk margins or margins for uncertainties:

- Prudent provisions to cover adverse deviation in future obligations
- Compensation for bearing risks

The view of margins as prudent provisions to cover adverse deviation is primarily from the policyholder and regulatory perspectives. Under this view, the margins are intended to absorb shocks arising from uncertain future scenarios that might threaten an insurance company's ability to pay policyholder benefits. The margins absorb the development of adverse experiences relative to current "best estimate" insurance liabilities. Canadian GAAP and US GAAP for traditional products are both financial reporting systems that effectively treat margins for uncertainties under this view.

The main theoretical advantages underlying this approach are:

- It is designed to reduce the risk of negative profit and loss statement (P&L) impacts;
- It establishes reserves at a level that help ensure, with a high degree of confidence, that the insurer will be able to meet future policyholder obligations in the long-term; and
- Insurance companies are able to identify their sources of profits and losses by analyzing the deviations of actual experiences from expectations and adding the release of the margins for uncertainties in the liabilities. Generally, assuming experiences emerge as

expected, the release of the margins as the business matures would represent insurance company profits.

The view of margins as compensation for bearing risks is the investor's perspective, reflecting the fact that the investor can transfer the risks to another market participant and free up invested capital. The insurance company is a means of pooling investors that want to invest in insurance risk. This view of margins can be naturally linked to the exit value framework described above. Solvency II<sup>4</sup>, Market Consistent Embedded Value (MCEV), US GAAP FAS 157 (fair value accounting), Swiss Solvency Testing, and the proposed approach under IFRS Phase II<sup>5</sup> are examples of financial reporting systems that are based on this point of view. The IASB's discussion paper titled "Preliminary Views on Insurance Contracts" has clearly defined the risk margins as one of the three "building blocks" of insurance liabilities. Under the IASB proposals, the risk margins should be "*an explicit and unbiased estimate of the risk margin that market participants require for bearing risk*". If a deep and liquid market existed, this margin could be easily and explicitly observed and identified from market transactions.

VM-20 implies that the proposed US PBR approach has adopted the view that margins for uncertainty are intended to be prudent provisions to cover adverse deviation in future obligations. Specifically, paragraph C.5.4.1 of VM-20 states that the margins are intended to "*provide for adverse deviations and estimation error in the prudent estimate assumptions*".

### 3.3 Uncertainties Covered by the Margins

The total amount of assets available to mature future obligations consist of both reserves and economic capital (or regulatory risk based capital). The boundary between margins for uncertainties included within reserves and required capital is subject to debate. While both serve to provide an allowance to mitigate future uncertainties or risks, they are generally considered to meet different objectives. Generally the industry consensus is that margins for uncertainties in reserves are intended to cover volatilities under normal situations or non-severe economic shocks while economic capital is used to cover risks under more extreme tail events and severe shocks. For example, a low probability, high impact catastrophe type mortality event (such as a widespread avian flu epidemic) would typically be covered by economic capital rather than the margins for uncertainties within insurance reserves.

Based on our research of existing literature, there are four main types of uncertainties that need to be included in the margins within insurance liabilities:

- Random fluctuation in the individual risks or losses arising from pooled insurance policies
- Uncertainties with regard to the mis-estimate of experience assumptions and the changes in those assumptions
- Uncertainties with regard to the use of inappropriate trend assumptions (e.g. mortality improvement)

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<sup>4</sup> Solvency II is the proposed risk-based solvency framework for European Union insurers.

<sup>5</sup> As outlined in the IASB discussion paper "Preliminary Views on Insurance Contracts" dated May 2007

- Uncertainties with regard to the assumed relationships between risk factors (which will typically need to be addressed in conjunction with the assessment of diversification impacts arising across risk factors)

Random fluctuation refers to the inherent volatilities of individual risks (e.g. mortality, morbidity, lapses, etc) which may result in losses on pooled insurance contracts. This type of uncertainty is driven by the random nature of the statistical distribution for a finite pool of risks. If this was the only area of uncertainty, then one could determine the probabilistic distribution of losses and the random volatility could be measured using the standard deviation of the losses (since sampling error is generally treated as following a standard normal distribution). Alternatively, the uncertainty could be approximated by stochastically simulating the loss distribution.

The mis-estimate of mean experience refers to uncertainties in the best estimate liabilities resulting from issues such as sampling errors, other credibility issues, or changes in environment<sup>6</sup>, meaning that the assumed experience assumptions are inappropriate to begin with or are no longer appropriate. This type of uncertainty covers the risks that best estimate liability established today is not representative of realities in the future. Allowance for this type of uncertainty is often determined based on the application of prudent actuarial judgment as (with the exception of sampling error) it does not follow a known statistical distribution.

The use of inappropriate trend assumptions refers to the fact that actuaries often need to allow for trends within the experience anticipated for future uncertain cash flows (e.g. mortality improvement). These trend assumptions are typically based on judgment and actual experience on individual assumptions or aggregate losses. Similar to the mean experience assumptions, actuaries could mis-estimate the assumptions required in relation to these trends. Allowance for this type of uncertainty is also often determined based on the application of prudent actuarial judgment, past experiences and potential future evolvments. Similar to mis-estimate of the mean, uncertainty with regard to the use of inappropriate trend assumptions does not follow a known statistical distribution.

### **3.4 The Relationship between Margins for Uncertainties, Best Estimate Liabilities, Required Capital and Profit Margins**

As mentioned in section 2, this paper focuses on setting margins for uncertainty to allow for risk within insurance liabilities rather than required capital. However, it is important to understand the relationship between margins for uncertainties within liabilities, required capital and profit margins.

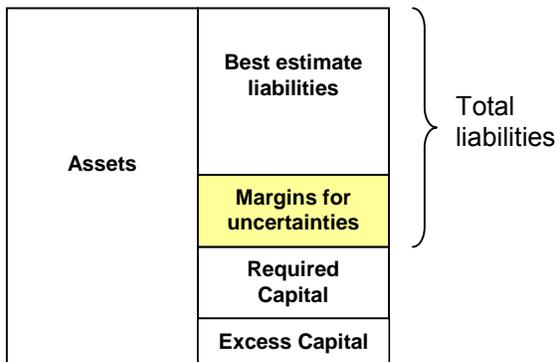
#### **3.4.1 Relationship with Best Estimate Liabilities**

It is subject to debate whether margins for uncertainties should be established as part of the best estimate liabilities, as an element of required capital, or as an explicit liability item on the balance sheet. Generally most existing and proposed frameworks treat the margins for uncertainties as one component of insurance liabilities in addition to best estimate liabilities.

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<sup>6</sup> This refers to typical (non-extreme) changes in relevant environmental factors that are continually occurring, rather than more extreme "paradigm shifts".

Best estimate liabilities are the most likely "estimation" of insurers' future obligations. This involves the best estimate of various actuarial and economic assumptions such as mortality, withdrawal, expenses, interest rate, equity market performance, and other policyholder behaviors. Margins for uncertainties, on the other hand, are typically intended to create a cushion to cover any random fluctuation or mis-estimation errors in the best estimate liabilities. This "typical approach" is outlined in the diagram below.



### 3.4.2 Relationship with Required Capital

As noted above, while both are used to provide an allowance for future uncertainties or risks, the boundary between margins for uncertainties and required capital is challenging and somewhat judgmental to determine. In particular, it is often hard to determine how big the margins for uncertainties included in liability reserves should be and how much additional capital is required. This is even more challenging for "top-down" approaches to developing margins (discussed in the next section) where total risk allowances might be defined and quantified on an aggregate basis.

The general consensus is that margins for uncertainties should cover risks under "normal situations", that is, under situations where there are no extreme or severe financial or other experience shocks. Equivalently, the margins are intended to help ensure an insurance company can meet its future obligations in many plausible adverse future scenarios, but not those which would be considered "highly unlikely". Required capital, however, is intended as a "buffer" for more extreme "tail events". In statistical terminology, the margins for uncertainty could be defined as the difference between the 65th percentile and 50th percentile of the aggregate loss distribution, for example. The required capital could then be defined, for instance, as the difference between the 99.5th percentile and the 65th percentile of the aggregate loss distribution.

Under the IASB discussion paper regarding IFRS Phase II, required capital is defined as the amount required to "buffer" extreme tail events occurring within one year. The margin for uncertainty is defined as the amount needed to provide investors with a return on this capital. There is no defined level regarding what percentile of the loss distribution should be covered by this margin for uncertainty. Similarly, Solvency II specifically requires minimum capital levels to

be based on the 99.5th percentile of being solvent over the next 12 months (which is broadly equivalent to being able to absorb a 1-in-200-year loss event).

### 3.4.3 Relationship with Profit Margins

One question that often arises is "are the margins for uncertainty somehow related to the profit margins made by the insurance company?"

Margins for uncertainties, under certain situations, are closely related to profit margins. In particular, the release of margins for uncertainties often forms part of the profit observed in years with favorable experience. For example, under Canadian GAAP, the release of the provision for adverse deviation is one source of future profits. Also under Australian "Margins on Service" reporting, the profit margins (defined as the present value of projected future profits) act as "*a more moderate shock absorber: experience profit or loss are reflected in the current year's profit and loss, but changes to assumptions other than economic assumptions impact the profit margin first and only if the profit margin is exhausted do they impact the current year's profit and loss position*"<sup>7</sup>. Under the Australian method margins do absorb volatility in experience.

### 3.5 Desirable Characteristics of Margins for Uncertainties

The desirable characteristics of margins for uncertainties depend on the accounting or solvency framework in which the margins are developed. This research paper will not define the desirable characteristics of margins under US PBR framework. Instead we will list different descriptions from some key international literatures.

VM-20 outlines several required characteristics of margins for uncertainties:

- The greater the uncertainties in the anticipated experience assumptions, the larger the required margin. For example, a higher margin would be expected when:
  - the experience data are either not relevant or not credible;
  - the experience data are of lower quality, such as incomplete, internally inconsistent, or not current;
  - there is doubt about the reliability of the anticipated experience assumption, such as, but not limited to, recent changes in circumstances or changes in company policies; or
  - there are constraints in the modeling that limit an effective reflection of the risk factor.
- Margins should reflect the magnitude of fluctuations in historical experience of the company for the risk factor.

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<sup>7</sup> See page 8 of "Risk Margins for Life Insurance", Hoa Bui and Briallen Cummings presented to the Institute of Actuaries of Australia 4th Financial Services Forum 19-20 May 2008, Melbourne, Australia

- No margins are required when the variations in the assumptions do not have a material impact on the minimum reserve.
- The method used to determine the margin should be applied consistently on each valuation date.

In relation to setting aggregate "risk margins" as a component of the liability calculation under the proposed IFRS for Insurance Contracts, the IAA's exposure draft of "Measurement of insurance liabilities for insurance contracts: current estimate and risk margins" (March 2008) has listed five key desirable characteristics. Many of these considerations are also relevant to setting margins for uncertainties under the PBR framework.

1. The less that is known about the current estimate and its trend; the higher the risk margins should be.
2. Risks with low frequency and high severity will have higher risk margins than risks with high frequency and low severity.
3. For similar risks, contracts that persist over a longer timeframe will have higher risk margins than those of shorter duration.
4. Risks with a wide probability distribution will have higher risk margins than those risks with a narrower distribution.
5. To the extent that emerging experience reduces uncertainty, risk margins will decrease, and vice versa.

The IASB's discussion paper "Preliminary views on insurance contracts" listed 11 desirable characteristics of risk margins:

1. Applies a consistent methodology for the entire lifetime of the contract;
2. Uses assumptions consistent with those used in the determination of the corresponding current estimates;
3. Be determined in a manner consistent with sound insurance pricing practices;
4. Varies by product (class of business) based on risk differences between the products;
5. Ease of calculation;
6. Is consistently determined between reporting periods for each entity, i.e. the risk margin varies from period to period only to the extent that there are real changes in risk;
7. Is consistently determined between entities at each reporting date; i.e., two entities with similar business should produce similar risk margins using the methodology;
8. Facilitates disclosure of information useful to stakeholders;
9. Provides information that is useful to users of financial statements;
10. Consistent with regulatory solvency and other objectives; and
11. Consistent with IASB objectives.

Although the risk margins being discussed by the IASB are those proposed under a fair value context, most of the desirable characteristics in the list above are also applicable to the determination of margins for uncertainty under the proposed PBR framework.

## 3.6 Other Considerations

### 3.6.1 Diversification Effects

Section 4 will discuss two broad categories of developing margins for uncertainties: bottom-up approaches and top-down approaches. The bottom-up approaches determine the margins on individual assumptions while the top-down approaches identify the margins on an aggregate basis across all individual risks. In general, the focus of our research (and this report) is on bottom-up approaches.

One critical consideration for the bottom-up approaches is whether and how to consider the diversification effects between individual risks and, in particular, the dependence or independence of different economic and actuarial assumptions. This paper will not cover the issue of assumption dependence in detail. However, we note that the issue of diversification is important as there is clear evidence of assumption dependencies between certain risks (e.g. lapses often increase in times of economic turmoil).

As noted earlier, insurers are pooling insurance contracts to diversify the risks. It may therefore be appropriate to reflect the degree of pooling and diversification in the financial reporting framework and margin development.

The impact of diversification is an area that is still not well-developed in relevant literature, particularly in relation to financial reporting. The topic is better documented within discussions of economic capital and associated solvency frameworks (e.g. EU Solvency II) rather than in relation to margins for uncertainty within liability reserves. However, the IAA's exposure draft of "Measurement of insurance liabilities for insurance contracts: current estimate and risk margins" does discuss the issue of diversification in relation to the "risk margin" component of insurance liabilities. As noted above, this risk margin is defined to be an "explicit and unbiased estimate of the risk margin that market participants require for bearing risk". Some of the key messages from the IAA paper are summarized below:

- A risk or portfolio of risks is diversifiable if a sufficient number of dissimilar (or at least independent) risks are available to reduce the fluctuations caused by the risk or type of risk in a diversified portfolio so that the variability of the total portfolio is less than the variability of each component added together.
- For the measurement of insurance liabilities, two alternatives exist regarding the impact on liability values from risk mitigation. The first is to ignore any risk mitigation effects in the measurement of the respective liabilities. The second is to reflect a reduction of volatility in each set of risk margin calculations for insurance and annuity liabilities.
- Consideration of diversification (including diversification between portfolios) in the risk margin reflects the availability of dissimilar risks in the market, to the extent that a market

participant could diversify the risk. The rules of the financial reporting system will affect the extent to which diversification should be considered in the measurement of contracts or instruments.

- Risk margins might be based on the entity's own size but determined separately by line of business (with no allowance for inter-portfolio diversification).

### 3.6.2 Need to Test Overall Level of Margins

Testing the overall level of margins for uncertainty or the calibration of margins on an aggregate basis is another important consideration. This clearly relates to the issue of diversification discussed above in that diversification between risks will tend to result in the aggregate margins required being lower than the sum of the margins on individual assumptions.

The aggregate level of margins should be reviewed and tested relative to total best estimate liabilities or other relevant quantities (such as required capital or gross premiums). This topic is covered further in section 4.

### 3.6.3 Individual Risks to be Covered

If using a bottom-up approach as defined in section 4, it is necessary to determine which assumptions or individual risks require margins for uncertainty.

Generally there are two broad categories: risks that can be diversified within existing markets (also called hedgeable risks) and risks that cannot be diversified (also called non-hedgeable risks). Hedgeable risks include interest rate risk and equity market performance. Non-hedgeable risks include most actuarial risks such as mortality, morbidity, withdrawals, other policyholder behaviors, credit risks under reinsurance, expenses, operational risks, catastrophes, etc.

VM-20 requires an insurance company to include a margin to provide for adverse deviations and estimation error in the prudent estimate assumption for each risk factor, or combination of risk factors, which is not stochastically modeled or prescribed. Hedgeable risks (interest rate and equity performance) are required to be stochastically modeled. Thus it is necessary to consider margins for uncertainty for most non-hedgeable risks. Specifically those assumptions include (but are not limited to):

- Mortality / morbidity
- Expenses and expense inflation (although arguably the latter should be modeled stochastically along with other economic variables)
- Default costs for existing asset portfolios (which are not required to be stochastically modeled under VM-20)
- Policyholder behavior
- Reinsurance credit risks
- 3rd party revenue sharing and non-guaranteed items

Further discussions on potential approaches to determine margins for uncertainty for these specific assumptions are covered in section 5.

#### 3.6.4 Feedback Loops

Another important consideration is the feedback loops relating to the margins for uncertainty within the reporting frameworks. Specifically, the risks or uncertainties need to be monitored by insurance companies, regulators and auditors. One important characteristic of accounting frameworks is whether they can effectively establish transparent feedback loops to monitor the deviation of actual experience to expected assumptions. Different methods for developing margins should be gauged in relation to this consideration. In other words, the margins added to the insurance liabilities should ideally enable reviewers to monitor the appropriateness of the margins as an allowance for uncertainties over several reporting cycles, in particular by comparison between actual and anticipated experience.

Another aspect of the feedback loops is the linkage between valuation and pricing. In particular, valuable feedback loops can be achieved when the valuation process (especially reserving) is developed using individual risk factors with a reasonable level of granularity. The financial reporting framework should ideally encourage closer alignment between product risk profiles, liability reserves and required capital. For example, actuaries could enhance the product designs in relation to policyholder guarantee utilizations by considering previous reporting cycle feedback in relation to the sufficiency of margins on policyholder behaviors.

## 4. INTRODUCTION TO DIFFERENT METHODS FOR ESTABLISHING MARGINS

Margins for uncertainties can be determined using various methods, where appropriate, under different accounting frameworks. This section provides a generic overview of the approaches we identified through our research. Section 5 discusses how each relevant approach can be applied to determine margins for specific risks or assumptions.

### 4.1 Two Basic Approaches to Set Margins for Uncertainties: Bottom-up vs. Top-down

Broadly speaking, the various approaches to determine margins for uncertainties can be split into two basic categories:

- Bottom-up approaches
- Top-down approaches

The bottom-up approaches quantify the overall margins by adding margins on each individual assumption. The top-down approaches determine the margins on an aggregate basis across all risk types and assumptions, relative to best estimate liabilities or required capital.

Both categories of approach have their pros and cons. The bottom-up approaches have the attributes of providing explicit feedback loops by assumption, which allow management, auditors and regulators to monitor the appropriateness of reserving in light of emerging experience. Since the margins are broken-down at the individual assumption level, it is easy to review and monitor the degree of uncertainties assumed by actuaries and the variation of actual experiences from expected assumptions as the business matures.

The bottom-up approach, however, also poses one particular challenge to actuaries: whether and how to take into account the diversification effects between risks. For individual risks that are not independent of each other, the diversification effects could (in theory) be identified and allowance made for them as an adjustment to the overall insurance liabilities. Otherwise applying margins to each assumption independently might result in redundancy in the overall margins and hence overly conservative final reserves. However, quantifying the diversification effects is sometimes extremely difficult due to the complex path-dependent nature of the "pay-offs" of future cash flows. For example, the utilization of variable annuity guarantees is clearly correlated with the withdrawal assumptions. However quantifying the correlation, if possible, is time-consuming and onerous. Also history has shown that correlations tend to break down in extreme market conditions.

On the other hand, the top-down approaches explicitly quantify the margins relative to best estimate liabilities or required capital at an aggregate level, implicitly addressing the diversification issue. We will discuss several top-down approaches (e.g. the cost of capital method) in more detail in the following sections. Furthermore some top-down approaches might already implicitly consider various risks that are not considered in many bottom-up approaches. For example, the market-consistent cost of capital method (also called market value margin)

adopted by Swiss Solvency Testing uses the company's required capital in the calculation of risk margins. The required capital has often incorporated different types of asset risks (such as credit risks, liquidity risks, etc), liability risks (such as mortality risks, longevity risk), asset-liability mismatch risks (such as interest rate risks, duration mismatch risks) and operational risks (such as frauds, malpractice, reputation, etc).

However, unlike the bottom-up approaches, top-down approaches do not provide such clear and transparent feedback loops to monitor the deviation of actual experience from expected.

North America has traditionally utilized bottom-up approaches in the design of solvency and performance measurement frameworks. Conversely, the European Union is tending towards use of top-down approaches. No matter which approach is adopted, standard setters have to consider the purpose of their proposed reporting framework, the practical implementation issues, and the final goals they are trying to achieve in order to decide on an appropriate methodology for determining margins for uncertainty.

In general, bottom-up approaches are typically more consistent with setting margins on individual assumptions under a "principle based approach" (as proposed in the US). This is because the proposed PBR framework requires actuaries to prudently consider individual risk factors and associated margins for uncertainties. However, top-down approaches can often be applied to help calibrate and test the overall level of margins determined using a bottom-up approach. The calibration of overall margins is addressed further in section 4.3.

## **4.2 General Descriptions of Different Methods**

This sub-section introduces various methods to determine margins for uncertainties. In each case, it provides a brief description of the generic approach and how the approach is applied. Section 5 provides more detailed descriptions of how each method could be applied for individual assumptions.

The methods identified in our research that could be applied to either quantify the margins for individual assumptions or calibrate overall level margins are (in approximate order of increasing complexity):

1. Factor based approaches
2. Discount related methods
3. Judgment based on experience studies
4. Stress Testing / Sensitivity Testing
5. "Quantile" and distribution methods
6. Stochastic modeling
7. Cost of Capital method
8. Calibration to the Capital Markets or Insurance Pricing

In general, we note that the first two methods (factor based approaches and discount related methods) do not fit very well within a "principle based" framework. However, in the interest of completeness, we have introduced them in this paper as reference material. Further, the last two methods listed above are typically applied as top-down approaches, and therefore may be more appropriate as methods to calibrate the overall level of margins under the PBR framework.

#### 4.2.1 Factor Based Approaches

This method refers to the application of factors that actuaries incorporate in the reserving process. Insurance companies may be required to apply factors prescribed by regulators, or they may determine the factors themselves based on regulatory guidance and company policies. In either case, the factors result in unspecified conservativeness (established at an implicit confidence level) being embedded in the assumptions or reserving methods. For example, the existing US GAAP reporting framework is a typical example of a factor based method, where factors (known as provisions for adverse deviation or PADs) are applied to the reserving assumptions to make prudent allowance for risks such as mortality.

The PBR framework requires insurance companies to follow certain principles and determine their reserves according to their company's specific situation. Due to their nature of implicitly incorporating conservatism, factor based approaches may not be the ideal choice under the proposed PBR framework. In particular, they typically involve limited judgment relating to the company's specific situation.

To avoid confusion, the factor based approaches introduced in this section are those that involve limited actuarial judgment, lack the support of experience studies or otherwise incorporate unspecified implicit conservatism. Another method introduced in section 4.2.3 (namely actuarial judgment based on experience studies) might also involve applying factors to best estimate assumptions. However, these methods are treated as two different approaches in this research report.

#### 4.2.2 Discount Related Methods

Historically, discount related methods have been widely used. However, they are typically only used to set aggregate risk margins, rather than risk margins for individual assumptions (with the possible exception of investment assumptions).

The methods involve creating margins implicitly by modifying the discount rates used in calculating the insurance liabilities. The modification can be either addition or subtraction to the base discount rates. Generally any cash outflows should be discounted using lower rates (subtraction) while cash inflows should be discounted using higher rates (addition). Another approach is to change the discount rates used for future net cash flows. Historically, P&C insurance reserving has often used a discount rate method to incorporate margins for uncertainty by *not discounting* the future cash flows when calculating current liabilities. In this case, if the "real" discount rate is 5%, then the margin for uncertainties equal the difference between the sum of future net cash flows and the present value of future net cash flows valued using a 5% discounting rate.

There are a number of variations of discount related methods, for example:

- Net asset returns minus/plus a margin
- Risk adjusted returns
- Stochastic discount factors (deflators)

Some reserving methodologies use net asset returns to discount the cash flows for the policy liability valuations. Actuaries are able to create margins in the insurance liabilities by adjusting (typically reducing) the net asset returns. However, there are two key disadvantages to this approach. First, it is difficult to quantify the margins. Second, the margins generated are implicit and not transparent.

The method of risk-adjusted returns discounts the future expected cash flows using a risk free rate minus a margin. In theory, the margin is determined based on the risk distribution of the business and could vary by type of products and other policy characteristics such as durations. This approach provides a reasonable indication of risk taking patterns and it is easy to benchmark against other companies. However, there is no "standard" approach to quantify the margin to apply to the discount rate, and it is often very difficult to develop a straightforward approach to ensure the margin captures all relevant risks.

It is worth emphasizing that discount rate methods are difficult to use in developing margins for individual risk factors. The approach also does not fit well into the current PBR framework set out within VM-20. Therefore we do not consider this method further within our research report.

#### 4.2.3 Judgment Based on Experience Studies

Under this approach, margins determined based on experience studies are applied to best estimate assumptions to generate a prudent liability. This method is a bottom-up approach as defined earlier in this section. Examples of applying this method to set margins include:

- Adjust the base mortality, withdrawal, expense, or other non-financial assumptions by a factor that is based on experience studies (e.g. adjustments derived from actual-to-expected ratios) to increase the insurance liabilities.
- Assume floors on risk factors (e.g. mortality for life products) that would lead to higher reserves. Or implement caps on risk factors (e.g. renewal premium as % of first year premium) that act to reduce reserves. Or assume wider or narrower "bands" for certain assumptions that vary by factors such as policy size / net amount at risk / separate account in-the-moneyness. For example, companies could assume a maximum cost of insurance (COI) charge of 5 per 1000 net amount of risk in future projections in the reserving.
- Use adjusted<sup>8</sup> policy "lifetimes" that results in higher reserves.

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<sup>8</sup> This may require an increase or decrease in policy lifetimes depending on the type of product (e.g. annuity or term insurance).

- Make the formula used for dynamic assumptions (such as lapse rates or guarantee utilizations driven by separate account in-the-moneyness) more conservative so that they result in higher reserves.

The best estimate assumptions would be developed based on all available knowledge at that time, using actuarial judgment to generate the most realistic expectation of future experience including an allowance for any assumed future trend. The prudent margins should be developed to take into account the random fluctuations, errors due to mis-estimating the means, and potential errors in the assumed trends. The level of margins should reflect the magnitude of fluctuations in historical experience of the insurance company for each selected risk factor. Greater uncertainty should result in higher margins.

The addition or subtraction of margins should result in an increase of insurance liabilities. The margins should also be tested (using methods such as sensitivity testing or stress testing) to ensure that appropriate margins are selected.

This approach to setting margins is widely used by actuaries to develop their assumptions and provisions for adverse deviations in almost every solvency and performance reporting framework reviewed. For example, Canadian GAAP, US GAAP (FAS 60), UK Individual Capital Assessment Standards (ICAS), and Australian Margin on Service (MoS) have all published guidelines around using historic experience studies to determine the risk margins for non-financial assumptions in the reserving of insurance contracts.

Generally speaking, actuaries examine the past experiences (within a defined study period) and identify the patterns of loss or risk distributions driven by individual risk factors such as mortality or withdrawals. They also seek to justify the appropriateness of the chosen assumptions and margins on a prospective basis. Prudent estimation is required and any changes in assumptions or margins must typically be supported with evidence that indicates the need for change.

There is extensive literature and documented examples of company practice regarding how to conduct experience studies. In addition, several actuarial organizations have developed actuarial standards surrounding the application of actuarial judgment based on experience studies to determine margins for uncertainties. For example, the following practices are highlighted in the actuarial educational note "Use of Actuarial Judgment in Setting Assumptions and Margins for Adverse Deviations" published by the Canadian Institute of Actuaries in 2006:

- The appropriateness of margins should be reviewed at an aggregate level. Actuaries are required to consider the interrelationships of assumptions and any potential undesirable compounding of margins. For example, for a universal life policy with investment options and crediting interest guarantees, actuaries should consider establishing three different margins:
  - a margin for policyholders' investment allocation;
  - a margin for crediting interest rate spread;
  - another implicit margin by adversely shifting the policyholders' fund mix in unfavorable interest rate scenarios where minimum guarantees kick in.

- In addition, actuaries should consider the offsetting risk positions in setting margins. For example, the mortality risk of life business and longevity risk of annuity business naturally offset each other, and this should result in a lower aggregate margin.
- In relation to the Canadian Asset Liability Method (CALM), companies who have riskier investment practices or greater mismatches should establish higher margins than those with better controls on investment practices.

It is worth noting some disadvantages of this method. In particular, the method is highly subject to the interpretation and judgment of actuaries and senior management. It also requires the credibility of the experience data to be taken into account. Practical consistency would be difficult to achieve among different companies, especially when considering variations such as the sophistication of experience data between different sized companies. Therefore, this approach can be subject to manipulation. In order to be credible in light of this risk of manipulation, the use of this method should include explicit requirements for detailed disclosures and a governance process that incorporates an appropriate level of review as part of the reporting framework.

Further, conceptually the choice of margins should be made so that the liabilities are established at a desired confidence level and the margins are determined over the joint distribution of all future outcomes across all relevant risk factors. However, significant judgment is required to estimate the confidence level implied by a chosen level of margins, and this process is only made harder when considering the joint distribution across multiple risk factors. As discussed in the following section, stress testing can be useful to help test the appropriateness of margins jointly across multiple risk factors.

#### 4.2.4 Stress Testing / Sensitivity Testing

Sensitivity testing is another well-developed technique in the actuarial world. We note that sensitivity testing is required by VM-20 to justify the chosen margins for uncertainties. For example, actuaries may vary the mortality assumption to test the impact of this parameter on the insurance liabilities.

The following are several key components of sensitivity testing:

- Identify the key assumptions. If a change in a key assumption increases reserves or capital, the actuary would typically need to be able to support why an additional margin should not be added.
- Create deterministic scenarios to shock key assumptions. Note that tests should be extreme enough to generate reasonable changes in reserves.
- Identify the sensitivities of reserves to key assumptions.

The table below shows an illustrative example of sensitivity testing for a block of variable annuity products.

#	Sensitivity Test	Impact on Reserve
1	50% increase in surrenders	Increase reserve by \$1,600 million
2	Reduce premium continuance by 50%	Increase reserve by \$320 million
3	Reduce separate account growth by 100%	Increase reserve by \$1,210 million
4	Double inflation	Increase reserve by \$430 million
5	Double normal allocation of renewal premiums to General Account in down scenarios	Increase reserve by up to \$270 million
6	Increase GMWB / GMIB in-the-moneyness by 200%	Increase reserve by \$2,450 million

Sometimes the sensitivity modeling process can be complex and time-consuming. Two potential approaches to reduce runtimes include: reducing the number of scenarios used to perform the test; and compressing the seriatim data into aggregate model points.

Sensitivity testing can be used in conjunction with stress testing (as described below) to determine margins for uncertainties for individual risks or assumptions. For example, we have seen examples where companies varied (shocked) the mortality and withdrawal assumptions under different assumed future levels of insurance option utilizations (such as non-lapse guarantee of UL products and policy loan levels) to test the sensitivities of insurance liabilities to individual risk factors. The purpose of this practice was to test the sensitivities under various different plausible future scenarios.

Stress testing is another popular technique used to quantify and justify margins for uncertainty. Typically, stress testing involves varying multiple assumptions simultaneously in a consistent manner. As such it is generally more useful to set or test the level of aggregate margins across multiple risks. In particular, stress testing can be useful to help determine whether the sum of individual risk margins (for individual assumptions) makes an appropriate allowance for any diversification benefit arising across the risk factors.

Generally, deterministic scenarios will be developed to "shock" the future expected cash flows (and hence the insurance liability determined as the present value of future cash flows). The margins could be considered appropriate when the best estimate liability plus the margins would allow the company to survive under the desired severity of adverse scenarios.

As noted above, the scenarios tested generally cover several key drivers of the risk factors (e.g. mortality, withdrawal, interest rate, etc). The statutory Cash Flow Testing in the US is a typical example of stress testing. The table below is an example of deterministic scenarios used to perform stress testing under the so-called "New York 7 scenarios".

#	Scenario	Interest rate	Equities
1	Base scenario	Base assumptions (e.g. 10 year treasury rate)	Base assumptions (e.g. 10 year treasury rate)
2	Graduate increase	Uniformly increasing over 10 years at 0.5% per year and level after	Zero growth for 10 years and use base assumptions after that
3	Up-down	Uniformly increasing over 5 years at 1% per year and then uniformly decreasing at 1% per year to the original level at the end of 10 years, then level after that	Zero total return for 5 years, then double overall return for 5 years, then use base after that
4	Pop-up	Use immediate jump of 3% and then level after that	Equity values drop instantly by 25%, then use base assumption after that
5	Graduate decrease	Uniformly decreasing over 10 years at 0.5% per year and then level after that	Same as #2
6	Down-up	Uniformly decreasing over 5 years at 1% per year and then uniformly increasing at 1% per year to the original level at the end of 10 years, then level after that	Same as #3
7	Pop-up	Use immediate drop of 3% and then level after that	Same as #4

Another example of deterministic stress testing scenarios could include:

	Mortality	Lapses	Interest rates
Scenario 1	125% of Best Estimate	110% of Best Estimate	Current - 100 bps
Scenario 2	125% of Best Estimate	110% of Best Estimate	Current + 100 bps
Scenario 3	75% of Best Estimate	90% of Best Estimate	Current - 100 bps
Scenario 4	75% of Best Estimate	90% of Best Estimate	Current + 100 bps

One difficulty in using sensitivity and stress testing is the calibration of the chosen scenarios to appropriately reflect the desired level of confidence. This calibration is typically left to the judgment of the actuary performing the testing. As above, a key positive aspect of this approach is that it can also be performed at a different level of aggregation (i.e. across multiple products and/or risk factors) to help test the appropriateness of overall margins.

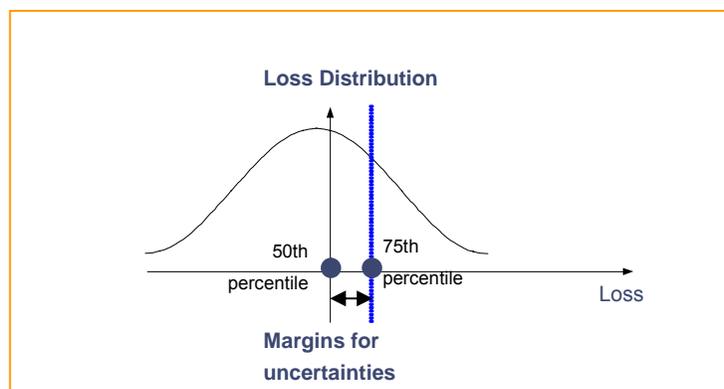
#### 4.2.5 "Quantile" and Distribution Methods

The "quantile" and distribution methods refer to certain statistical approaches to determine the margins, which could include:

- Confidence interval or percentile levels of risk factors
- Conditional Tail Expectation (CTE) (also called Tail Value at Risk or TVaR) measurement of risk factors
- Multiples of the second or higher moments of the risk distribution

The use of confidence intervals or percentile levels is the most widely discussed method in the materials researched. It determines the extra amount required in addition to the expected value of losses such that the actual losses will be less than the amount of the established liability with the chosen level of confidence over a pre-defined time horizon. This is commonly referred to as the Value at Risk (or VaR) approach.

This method was described (for regulatory purposes) and prescribed by the Australian Regulator (APRA) in the "Prudential Standard GPS 210 – Liability Valuation for General Insurers" (i.e. Property & Casualty insurance). In the Australian solvency reporting for general insurance, actuaries set the risk margins to equal the 75th percentile of the distribution of discounted ultimate future payments less the best estimate (e.g. 50th percentile of the distribution). This idea is shown in the chart below.



However, we also note that this method has a number of limitations. For example, where losses are *normally* distributed, the mean and the median are equal<sup>9</sup>. However, for a skewed distribution, the mean estimate diverges from the median. Insurance claims often have skewed distributions and sometimes highly skewed distributions. Therefore, in using this technique to determine a risk margin, it must be noted that the confidence interval is not a foregone conclusion but an assumption that must be selected. The selection of the confidence interval should take into account relevant factors, which may include the level of the mean estimate, the degree of skewness of the distribution and the purpose of the valuation with regard to the company's appetite for risk. In particular, for highly skewed loss distributions, it is possible that

<sup>9</sup> As mentioned earlier, mis-estimates of the mean and uncertainties regarding trends are generally not normally distributed.

the mean (i.e. best estimate of losses) could fall above the selected percentile being used to determine risk margins (even though this percentile is greater than the median).

The CTE method is a modified percentile approach that combines the percentile and mean values of different cases. It basically calculates the mean of the losses within a certain band (or tail) of pre-defined percentiles. With the CTE method, the margin is calculated as the probability weighted average of all scenarios in the chosen tail of the distribution less the mean estimate (which may or may not be the median, i.e. the 50th percentile). The CTE method is an improvement over the percentile (VaR) method discussed above since it smoothes some extreme claims (or statistical outliers).

The key advantage of the CTE is that since it applies fundamentally the same calculation technique as the mean estimate, it has the benefit of consistency and it also reflects the skew of the distribution in the risk margin. For example, the CTE over the 75% confidence level (often referred to as CTE(75)) of a claim distribution is the expected value of all claims that fall into in the highest 25% of the claim distribution. The margin in this case would be taken as CTE(75) less the mean (i.e. best estimate) of claims.

Generally the extreme (tail) scenarios are very difficult to assess when actuaries are trying to determine an appropriate loss distribution to reflect all scenarios, primarily due to the lack of reliable data for extreme events. As such, a disadvantage of this method is its high reliance on the tail expectation of loss distributions. Additionally, the CTE does not reflect any assessment of risk appetite so will not target a market consistent valuation.

The CTE measurement approach for specific assumptions is discussed further in section 5.

The final "quantile" approach involves setting the margins for uncertainty to equal a multiple of the second or higher moment of the risk distribution. For example, a company could calculate the sample variance or the 3rd moments of sample mortality (or death benefits relative to death exposures). They could then add a percentage of variances to the mean assumption to derive the mortality parameter where the percentage multiplier is determined to target a certain level of confidence. For example, the mortality assumption could be set equal to the sample mean plus 0.1 times the sample variance. Similarly, if a risk parameter is known to be normally distributed, setting the assumption to equal the sample mean plus 0.675 times the sample standard deviation would result in risk margins calibrated to approximately the 75th percentile.

#### 4.2.6 Stochastic Modeling

It is becoming increasingly popular for actuaries to use stochastic modeling in the valuation of insurance liabilities.

VM-20 specifies that margins for uncertainty are required for assumptions that are neither stochastically determined nor prescribed. We note that the stochastic modeling discussed in this section does not relate to the stochastically determined assumptions. In VM-20, the stochastically determined assumptions refer to hedgeable risk factors such as equity market performance and interest rates, where actuaries are required to use an Economic Scenario Generator (ESG) to run thousands of scenarios and select an appropriate percentile from the simulated results to value insurance liabilities allowing for these hedgeable risks.

Some other solvency reporting frameworks also require stochastic modeling to be used to model hedgeable risks. The Canadian Asset Liability Method (CALM) is one typical example, under which policy liabilities for segregated fund products (called variable products in the US) are set equal to the value of supporting asset determined using the CTE measure (with a prescribed level of confidence<sup>10</sup>) based on stochastically generated scenarios.

In addition, it is possible to use stochastic approaches to help determine the margins for uncertainties required for non-hedgeable assumptions such as mortality, expenses and policyholder behaviors. In particular, as discussed above, one uncertainty the margins are intended to cover is the random fluctuation of risk factors. Such fluctuations could be modeled stochastically. For example, stochastic models of mortality and lapse rates have been used in some companies to develop their mortality and lapse assumptions.

Where stochastic modeling is used to help quantify the margins for non-hedgable risks, the approach applied typically involves the following steps:

- Fit a probabilistic distribution to the risk factors being modeled (e.g. mortality or withdrawal rates). This can be based on historic experience, academic research and/or actuarial judgment.
- Stochastically simulate liability results under thousands of different scenarios (each one sampling randomly from the risk factor distribution for the parameter of interest). The intrinsic risk factor volatilities can be measured based on the simulated results.
- Quantify the required assumptions and margins by taking an appropriate percentile from the distribution of simulated results. Where required, the precise assumption for the parameter of interest can be determined based on the specific scenario that generated liabilities at the chosen percentile. The margin for uncertainty can then be set equal to the sampled parameter in this scenario less the best estimate assumption for the parameter.

Much literature exists regarding how to build stochastic models to value insurance assets and liabilities, and to a lesser extent, how to develop margins for uncertainties for specific risks and assumptions. The literature covers both practical and theoretical issues. For example, in 1992, Lee and Carter proposed a stochastic mortality forecasting model, which has been widely documented in academic literature and applied in industry practice<sup>11</sup>. Under their model, Lee and Carter assume the logarithms of death rates follow certain simple linear relationships with mortality variations, expressed in terms of a linear regression formula. The Lee-Carter model will be further introduced in section 5, where we will provide some additional background regarding how it can be applied to quantify margins for uncertainty in the mortality risk factor.

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<sup>10</sup> The prescribed level is between CTE 60 and CTE 80 according to the Canadian Institute of Actuaries. For example, see CIA's Educational Note: "Considerations in the Valuation of Segregated Fund Products" by the Committee on Life Insurance Financial Reporting (11/2007)

<sup>11</sup> See Ronald D. Lee and Lawrence Carter, "Modeling and Forecasting the Time Series of U.S. Mortality", Journal of the American Statistical Association, Vol. 87, September 1992

Given the volume of relevant academic research in this area (some of which are listed in Appendix 3), this paper will not try to summarize specific theoretical modeling methodologies. Instead this report will seek to outline possible ways to use the theory of stochastic modeling in relation to quantifying margins for uncertainty.

#### 4.2.7 Cost of Capital Method

The cost of capital method is based on the concept that the margins for uncertainty should reflect the cost of holding capital to back the underlying risks being modeled. This is consistent with the view of margins being required to compensate an insurance company for bearing the risks (as discussed in section 3).

Under the cost of capital (CoC) method, the margins for uncertainty are set equal to the required capital multiplied by the excess of the company's weighted average cost of capital over an appropriate risk free rate. The generic approach typically follows the steps outlined below:

1. Determine the required capital for a block of policies or product line based on the risks to which the company is exposed. The capital used may be based on regulatory capital, economic capital, rating agency capital or a mix of these (such as the highest of all three).
2. Project the future required capital over the lifetime of the liabilities relating to this business.
3. Calculate the company's weighted average cost of capital. There are various methods to determine the cost of capital, for example using the CAPM model to determine the cost of equity.
4. Calculate the present value of the product of required capital and cost of capital from time zero until all of the business has matured, discounting using an appropriate risk free rate.

The following is a modified example quoted from "The Swiss Experience with Market Consistent Technical Provisions - the Cost of Capital Approach" (2006) published by the Swiss Federal Office of Private Insurance.

**Example:** Assume that a company has a required capital of 100 at  $t = 0$ , composed of 50 for asset credit risk, 20 for interest rate risk and 30 for mortality risk. Assume the asset portfolio consists of government bonds and equities. Further assume the best estimate reserve is 100 and that the business will mature over the next 3 years. Also assume the company's weighted average cost of capital is 10%.

Then there are 3 steps to calculate the margins using a cost of capital method:

1. Project future required capital for the next 3 years (say 100 at  $t=0$ , 80 at  $t=1$ , 15 at  $t=2$ , 8 at  $t=3$ ) using the assumed asset allocation and projected best estimate liabilities.

2. Assume a flat 5% US swap curve as the risk free discount rate, then the present value of required capital =  $\frac{80}{1.05} + \frac{15}{1.05^2} + \frac{8}{1.05^3} = 96.7$
3. Then the margin for uncertainties is equal to  $96.7 * 10\% = 9.67$

An alternative approach is to calculate the market-consistent risk margin using the cost of capital method based on the excess of the market-consistent cost of capital (varying by specific ratings) over risk free rates. This is discussed in the paper "Economic Measurement of Insurance Liabilities: The Risk and Capital Perspective" (Rubin, Lockerman, Tillis, Shi, 2008). This paper states that:

*"...In addition to economic capital being market-based, the cost of capital also is a market-based number... To illustrate [a company calculating risk margin using a market consistent cost of capital]...suppose a company's economic capital is equal to \$100. Also assume that, due to either rating agency or regulator concerns, the total capital held is \$150. Now assume that the company's capital structure consists of 70% equity with a cost of 500 basis points over the London inter-bank offered rate (LIBOR) and 30% debt with a cost of 50 basis points over LIBOR ... if economic capital is the amount needed to properly size equity, then the cost of capital should be based on the price of equity times economic capital plus the price of debt times excess capital. This results in a risk charge of \$5.25 (= (\$100 \* 5%) + (\$50 \* 0.5%))...."*

In the above example, the implied risk margins based on the market consistent cost of capital approach would be \$5.25.

In applying the cost of capital method, there are a number of issues that need to be resolved:

- **What definition of required capital should be used in the calculations?**  
As noted above, the insurance company could use regulatory capital, economic capital, rating agency capital or a mix of these as the projected capital required to support the liabilities. However, even within these different definitions, there are various methodologies that can be applied to develop the capital calculations. If there is no standard definition of required capital, the comparability of this method between companies (or even within a company between different lines of business) may be reduced.
- **Determining the capital in respect of individual risk types**  
If using the CoC approach to set margins for uncertainty in respect of individual assumptions (or equivalently risk types), for example mortality, it is necessary to isolate that part of the capital requirements relating to the specific assumption (or risk type). This is not always straight forward due to interactions between different risks within the capital modeling and allowance for diversification benefits at an aggregate level.
- **The circularity issue**  
In the approach outlined above, risk margins are dependent on the required capital. However, required capital is typically defined to be the excess capital required above the insurance liability (which is the best estimate liability plus the margins for uncertainty). To

avoid this circularity issue, Swiss Solvency Testing uses the best estimate liability (rather than the total insurance liability) to define required capital. However, it is subject to debate whether this is theoretically the most correct approach, since it implicitly assumes the risk margins are part of the capital requirement rather than the insurance liability.

Given the complexities and limitations noted above, the cost of capital method is not particularly well suited as an approach to determine margins for uncertainty under the proposed PBR framework. As such, this paper will not extensively discuss the CoC method. For those interested in this approach, it is covered in detail in various international literatures, especially in relation to IFRS Phase II, Swiss Solvency Testing and EU Solvency II. Some of the important reports addressing it include:

- "A Market Cost Of Capital Approach To Market Value Margins", published by the CRO Forum in 2006
- "Measurement Of Liabilities For Insurance Contracts: Current Estimate And Risk Margins", published by the IAA Risk Margin Working Group in 2008
- "The Swiss Experience with Market Consistent Technical Provisions - the Cost of Capital Approach", published by the Swiss Federal Office of Private Insurance in 2006
- "A Global Framework for Insurer Solvency Assessment", published by the IAA Insurer Solvency Assessment working group in 2004
- "Market Value Margins for Insurance Liabilities in Financial Reporting and Solvency Applications", published by GNAIE in 2007.

As mentioned above, within the proposed PBR framework, the cost of capital method may be most useful in calibrating or testing the overall level of margins established in addition to best estimate reserves. Indeed, there have already been some discussions around using cost of capital methods to measure the aggregate margins under a principle-based valuation. For example, Stephen Strommen proposed one approach called "Z factors" to measure the level of aggregate risk margins under a PBR approach<sup>12</sup>. Under Strommen's proposal, the Z factor is defined as the ratio of overall margins for uncertainties in the reserves to the present value of the future capital requirements for the business being valued. The discount rate used is the average net investment return on the assets supporting the liabilities being valued. The Z factor translates the margins into a percentage of required capital (instead of a percentage of best estimate reserves) by considering the projected future economic capital required to mature future obligations. The formula used to calculate the Z factors is as follows:

$$Z = \frac{\text{TotalPBR} - BE}{PV(EC)}$$

where "*TotalPBR*" represents the total PBR reserve, "*BE*" represents the best estimate reserve, and "*EC*" represents economic capital.

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<sup>12</sup> See Stephen J. Strommen, "Setting the Level of Margins in a Principles-Based Valuation Using a Cost-of-Capital Approach with Exponential Utility", *Financial Reporter*, Issue No. 65, June 2006

The Z factor approach is essentially one type of cost of capital method that can be used to calibrate and test the overall level of margins. One significant advantage of this approach is that, once disclosed, regulators or auditors could clearly measure the level of prudence actuaries have assumed in their reserving, with a higher Z factor corresponding to a higher level of conservativeness. One disadvantage of this approach is the difficulty in calculating the present value of future economic capital requirements when insurers do not already have an established economic capital model in place.

#### 4.2.8 Calibration to the Capital Markets or Insurance Pricing

Calibration to the capital markets and insurance pricing are both top-down approaches as discussed in section 4. As such, they are potentially most useful in testing the calibration of overall margins allowing for diversification between different risk factors. The use of these approaches for this purpose is discussed further in section 4.3.2.

Another potential approach to determine margins for uncertainty is to use information available from the pricing of risk in the capital markets. The theory underlying this approach is that, in a deep and liquid market, the market participants are pricing the risks of the financial instruments they are purchasing. These risks will include the volatility of the underlying cash flows and the risks of mis-estimating the mean experience and future trends relating to these cash flows (i.e. the sources of risk for which margins for uncertainty are required).

For example, insurance companies could use the capital market price of longevity bonds (over an applicable risk free rate, such as 3 month LIBOR) to quantify the margins for uncertainty around the longevity risk factor (for annuity type business). However, this approach is subject to limitations such as whether there is really a deep and liquid market existing to trade the applicable longevity risks. Furthermore, the capital market instrument price may include a loading to cover various types of risks (that investors are taking) such as credit, information disparity, operational risk, liquidity, catastrophes, paradigm shifts and so called "black swan events". Many of these types of risks would actually be more appropriate to consider as margins within required capital rather than the margins for uncertainties within liabilities.

In any case, the capital market pricing of risks could serve as an indicator for testing the adequacy of the margins set using other methods. For example, if the margins for uncertainties for longevity assumptions developed using other methods are higher than the spread indicated by longevity bonds, it is possible that too much risk allowance is being made in the margins. Such considerations will be further discussed in the next sub-section.

The insurance product price at issue could also serve as a source to quantify or test margins for uncertainty. A required profit margin is generally embedded within the pricing of insurance products. It is possible to argue that this margin reflects an allowance for the risks that insurance companies are taking. For example, the Australian "Margin on Services" (MoS) framework explicitly includes the present value of future profit margins as part of the insurance liabilities. However, it is also subject to debate whether profit margins in the pricing of insurance contracts can also contain elements reflecting "economic profits" as a result of a company's marketing considerations, distribution expertise and other information that are not relevant to the uncertainties we are considering in this paper.

### 4.3 Calibration of Overall Margins

The calibration of risk margins to "hard dollar" amounts is another important step for regulators and insurance companies to understand the aggregate level of conservatism in the overall liabilities. There are several ways to test and calibrate the overall level of margins relative to best estimate liabilities or required capital, for example:

- Comparing the level of liabilities both with and without margins
- Using other methods to test the overall margins
- Calibration to market price

#### 4.3.1 Comparing the Liabilities Calculated With and Without Margins

Comparing the liabilities that are calculated with and without margins is the simplest way to calibrate the overall level of margins. It is also the method outlined in the exposure draft of the US PBR framework. The approach involves comparing the difference in insurance liabilities that are determined using assumptions with and without margins for uncertainties. This difference between these calculations represents the aggregate dollar amount of margins relative to best estimate insurance liabilities.

The limitations of this approach include the fact that it does not provide a clear picture of whether the margins incorporated in best estimate assumptions are sufficiently conservative or too large. It also does not directly address whether there is an appropriate allowance for diversification between risk factors within the aggregate margins.

#### 4.3.2 Using Top-down Methods to Calibrate Margins Determined by Bottom-up Methods

This is a more complicated method to calibrate the overall margins. VM-20 implies that bottom-up approaches should generally be used to develop the margins. Bottom-up approaches often have many advantages over top-down approaches. However, they also require an additional step to calibrate the margins and ensure an appropriate allowance has been made for diversification benefits between risk factors within the overall aggregate level of margins.

Top-down approaches such as the cost of capital method could be used to test the level of aggregate margins determined using bottom-up approaches. In addition, the diversification effects could also be estimated by looking at the differences between the overall margins developed under top-down and bottom-up approaches. For example, as discussed earlier, the cost of capital method can be used to calculate the overall margins as a percentage of a company's required capital. Using the aggregate required capital after allowing for diversification benefits will result in the derived aggregate risk margins implicitly allowing for diversification between risk factors.

In using the cost of capital approach to calibrate margins, actuaries need to either convert the bottom-up margins to be expressed relative to required capital, or convert the top-down margins to be expressed relative to insurance liabilities.

#### 4.3.3 Calibration to Market Price

We did not observe many *practical examples* of calibrating aggregate margins to the capital market (with a few exceptions relating to economic capital valuations) or insurance contract

pricing, even though some accounting literature (e.g. US GAAP FIN 45 and SFAS 157) have required this approach in valuation. However, there are some relevant discussions in the papers we reviewed.

In particular, Appendix F of the IASB discussion paper "Preliminary Views on Insurance Contracts" describes the calibration of market prices. It states *"margins should be as consistent as possible with observable market prices. Therefore, the component(s) of the risk margin that relate(s) to market variables should be consistent with the observed prices from which those variables are derived"*. In addition, the paper also says *"In some cases, a replicating asset exists for some or all of the contractual cash flows arising from an insurance contract...if the fair value of the replicating asset is observable or determinable, the insurer can estimate the current exit value of those contractual cash flows..."*

## 5. APPROACHES BY ASSUMPTION

For each individual assumption (i.e. risk factor) considered within the scope of our research, this section provides commentary on:

- which of the approaches outlined in section 4 are relevant for determining margins for uncertainty for that particular assumption;
- how each relevant approach would be applied in the context of that assumption; and
- which regulatory regimes currently use each approach to set margins for that assumption type (e.g. the factor-based approach is currently used to set margins (or provisions for adverse deviation) on mortality assumptions under US GAAP).

The assumptions considered were:

1. Mortality
2. Expenses
3. Expense Inflation
4. Default Costs
5. Policyholder Behavior
6. Reinsurance
7. Non-guaranteed items and Third party revenue sharing

### 5.1 Mortality

VM-20 defines specific situations where different procedures should be applied to set the prudent mortality assumptions and margins. Specifically:

- If an insurance company does not meet certain minimum data credibility requirements, they should use a simplified method to determine the mortality assumption. The margins for uncertainties are then set equal to the differences between the rates obtained from the applicable commissioners' table and corresponding rates obtained from the associated valuation basic table (as set out using specified underwriting scoring procedures within VM-20). As such, VM-20 has defined a method to quantify the margins in the case where a company does not have credible mortality experience data.
- If a company meets the minimum credibility requirements, then the margins should be developed using appropriate methods consistent with the requirements outlined in VM-20.

VM-20 also requires the margins for uncertainty to be increased in "situations involving greater uncertainty". These situations include, but are not limited to:

- Low reliability of the company's experience studies
- Longer time since the experience data were updated
- A change in underwriting or risk selection criteria since the experience data was collected
- The data underlying the experience studies lacks homogeneity
- Unfavorable environmental or health developments
- Marketing or administrative practices or market forces (for example, the life settlement market for life insurance policies) expose the company to anti-selection risk

Appendix 1 provides further details on the requirements of VM-20.

Broadly speaking, there are three basic types of uncertainty relating to the estimation of mortality assumptions:

- **Mis-estimation of the mean mortality experience:** This refers to the company specific risk of mis-estimating the mortality assumptions due to sampling errors. This may result from issues with the underlying experience data such as low credibility (i.e. a small volume of data) or heterogeneity within the data.
- **Intrinsic volatility in the mortality experience:** This refers to the company's specific risk of random fluctuation around the (correctly) estimated mean as a result of statistical volatility. This uncertainty is typically inversely proportional to the size of the population for which mortality risk is being underwritten.
- **Uncertainties in the mortality trend:** This refers to systematic mortality risk as a result of short-term catastrophic events or longer-term errors in the estimation of mortality trends (e.g. under-estimating the long-term impact from a new disease). Uncertainty around mortality forecasts is well documented and is illustrated, for example, in work by Currie, Durban and Eilers (2004)<sup>13</sup> which shows that mortality improvement cannot be forecast with any degree of precision. This is partly due to a lack of historical experience to help in the parameterization of trends.

At the time of writing, we understand there are ongoing discussions regarding possibly prescribing the mortality improvement assumption within VM-20. In this case, the margin for uncertainty relating to mis-estimating the mortality trend would effectively be prescribed under VM-20. However, this is still an outstanding item to be further considered by the LHATF.

As discussed in section 3, the impacts from certain "tail risks" such as catastrophic mortality events are typically not considered as part of the margins for uncertainties, but instead are incorporated in the determination of required capital (which is held in addition to insurance liabilities).

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<sup>13</sup> Iain D. Currie, Maria Durban and Paul H.C. Eilers, P.H.C., "Smoothing and forecasting mortality rates" (2004), *Statistical Modeling*, Vol. 4, No. 4, 279-298

Based on a comprehensive review of available literature and industry practice, we identified the following approaches that could be used to set margins on mortality assumptions. Each of these is discussed in detail in the following sub-sections.

- Factor based approach
- Actuarial judgment based on experience studies
- Stress testing / sensitivity testing
- Quantile and distribution methods
- Stochastic modeling
- Cost of capital method
- Using information from capital market pricing

Before proceeding, we note that the margins for mortality risk will typically affect the best estimate assumption in opposite directions for life and annuity products, since annuity products are embedded with longevity risk. Further, actuaries should also consider the mortality tables (e.g. 2001 VBT, 2008 VBT or a company's own mortality tables) they will adopt as base mortality assumptions in the reserving. Regardless of the approach used to set margins for uncertainty, actuaries should note that different mortality tables may already have different margins implicitly embedded on top of base mortality rates, particularly where the table chosen is based on a different population than that to which the assumptions will apply.

### 5.1.1 Factor Based Approaches

A scalar factor can be applied to the best estimate assumptions for mortality rates, life expectancy or death claims. An example of such a factor applied to adjust mortality rates is shown below:

$$q'(x,t) = a(t) * q(x,t) + b(t)$$

where  $a(t) = 0.95$ ,  $b(t) = 0$  for all  $t$  would imply a constant 5% mortality improvement on all age groups in all future periods. This may be appropriate as an adjustment to incorporate conservative margins in the mortality assumptions for annuity business.

US GAAP for traditional products is an example of a reporting framework that allows conservative assumptions for mortality to be developed in this manner. Specifically, explicit Provisions for Adverse Deviation (PADs), which are usually expressed as a percentage increase or reduction to the valuation table, are applied to the best estimate assumptions.

Factors can also be applied to claims, for example:

$$c'(t) = a(t) * c(t) + b(t)$$

where  $a(t) = 1.05$ ,  $b(t) = 0$  for all  $t$  would imply a constant 5% increase in claims at all future periods.

In addition, global regulatory regimes have long been exploring factor based adjustments to base mortality tables as a way to model mortality improvements. For example, in the UK, a sub-committee of the Continuous Mortality Investigation Bureau developed a factor based mortality improvement model to be applied to the UK 1992 series of mortality tables. In their model, it is assumed that for all experiences, males and females, “lives” and “amounts”:

$$q(x,t) = q(x,0) * RF(x,t)$$

where  $q(x,t)$  is the rate of mortality “ ${}_xq$ ” for a life attaining age  $x$  in the calendar year  $(1992 + t)$ . Note that time is measured in years from 1992 and that  $q(x,0)$  is the “1992 base rate”. A detailed formula for the reduction factor  $RF(x,t)$  is prescribed as a function of age and calendar year to reflect cohort trends.<sup>14</sup>

### 5.1.2 Judgment Based on Experience Studies

Under this approach, a company may conduct experience studies to look at the mean mortality experience, standard deviation of experience and  $p\%$  confidence interval of experience (i.e. a range in which  $p\%$  of the sample data are covered). A constant mortality adjustment factor as described in the factor based approach above, for instance, can then be estimated based on the historical deviation between actual experience and expected experience (where “expected experience” is based on the current best estimate assumptions). For example, the adjustment could be derived to ensure that  $p\%$  of adverse historic experience will fall within the range generated by taking the best estimate assumption plus/minus the adjustment factor.

Under Canadian GAAP for life products, the additional provisions for adverse deviations (PfAD) for the mortality rate per 1,000 are required to fall within the range of 3.75 and 15, each divided by the best estimate curtate expectation of life at the insured’s projected attained age<sup>15</sup>. The valuation *educational note* describes various situations where the minimum appropriate margins should be set as the average of the low and high margins in this range. Examples of such situations are low credibility of experience data, existence of anti-selection risk, and where the cohort of risks lacks homogeneity. Otherwise, actuaries are required to apply judgment to determine the appropriate level of margins under the guidance of the educational note. For annuity products, the low and high ranges for PfADs are a reduction of 5% and 15% (respectively) to the best estimate assumption. Similarly, the selected margins should be based on companies’ historic experience and actuarial judgment, and should be supported with evidence such as sensitivity testing.

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<sup>14</sup> See “Letter and enclosure from C G Kirkwood, Chairman of the Executive Committee of the CMI, to Appointed Actuaries, 31 March 1999: Continuous Mortality Investigation Reports No 17 (CMIR17) - 1999 (*Includes Graduation of the 1991-94 Mortality Experience - the “92” Series Standard Tables*)”, UK Actuarial Profession, 1999

<sup>15</sup> See Committee on Life Insurance Financial Reporting, “Margins for Adverse Deviations”, Canadian Institute of Actuaries, November 2006, page 17 (see [www.actuaries.ca/members/publications/2006/206132e.pdf](http://www.actuaries.ca/members/publications/2006/206132e.pdf))

A scalar factor to be applied to life expectancy (LE) can also be approximated through experience studies. For instance, a factor  $a(i)$  for major life expectancy provider<sup>16</sup>  $i$  can be estimated from experience data such as actual-to-expected ratios of life expectancies. This factor can then be applied to develop an adjusted life expectancy assumption (LE') as follows:

$$LE'(i) = a(i) * LE(i)$$

A risk margin can then be calculated as the difference between liabilities estimated using the original LE and liabilities estimated using LE'. Note that the factor  $a(i)$  would be linked to the credibility of the actual-to-expected claim study, where lower credibility should lead to lower factors.

The approach summarized in the above example may be especially useful when companies lack experience data for older age policies (e.g. universal life or 30 year term issued at ages over 70) that are exposed to larger anti-selection risks (e.g. life settlement or premium financing). However, actuaries using this approach should be aware of several facts. Over the past few years, Life Expectancy Providers have changed life expectancy tables used to calculate LE. For a given risk, the change in life expectancy tables has resulted in a significant lengthening of LE. Additionally, the life expectancy tables used vary among the different Life Expectancy Providers. In selecting a scalar factor to be applied to LE, there needs to be an understanding of both the life expectancy table used to calculate the LE and its appropriateness to the underwriting risk being evaluated.

When setting margins based on experience studies, actuaries generally group the policies into different cohorts. The grouping of similar types of policies (e.g. term, whole of life, universal life, variable life, SPDA, FPDA, variable annuity, etc) often depends on the key characteristics of the pooled policies such as issue year, distribution methods, policy durations, tax status, level of COI guarantees, etc. The level of granularity of policy grouping is often more of an issue for larger or multi-line companies than smaller or mono-line companies.

In addition to the credibility of the experience data, there are a number of key factors to be considered when setting the margins for mortality rates based on actuarial judgment. For example, these may include:

- The comprehensiveness of underwriting practices
- Policy pools with a higher portion of substandard lives should have higher margins (that lead to higher reserves)
- Joint life policies typically require different margins than single life policies (higher or lower margins depend on whether the policy is "first-to-die" or "last-to-die")
- Exposure to anti-selection from policyholders
- Exposure to anti-selection from third parties (e.g. life settlement or premium financing providers)

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<sup>16</sup> Life Expectancy Provider means companies that provide life expectancy estimates on the insured for pricing purposes. There are five major life expectancy providers, namely AVS, Fasano Associates, ISC Services, 21st Services, and EMSI.

- Riders or features attached to the policies that might lead to higher or lower mortality risk exposures
- Sales, marketing or underwriting factors that may attract a specific demographic of policyholders

### 5.1.3 Stress Testing / Sensitivity Testing

This method has been widely used by actuaries in many countries for a number of years, both in relation to mortality and other assumptions.

In relation to setting margins for mortality assumptions, actuaries could perform sensitivity tests using different levels of future mortality, assign a probability to each scenario tested and then take an appropriate weighted average of the various resulting liabilities to determine the margin to add to the best estimate liability in respect of mortality.

For instance, scenarios can be generated to test:

- a range of mortality improvement factors<sup>17</sup>;
- randomized mortality jumps caused by short-term catastrophe events.

The following example is one simplified illustrative example of sensitivity testing. In this example, the reserve changes are 2 to 3 times the relative changes in the mortality assumptions. This implies that the liabilities are quite sensitive to the mortality rates. In this type of case, actuaries typically assume larger margins compared with similar products that have lower sensitivities.

Term Life (Face = 1000, reserve w.o margin = 3.898)							Res chg as % of
Scenario	Base mortality	shock mortality	Factor to mortality	Reserves	reserve chg		best estimate reserve
1	2008 VBT	-10%	90%	3.004	(0.894)		-23%
2	2008 VBT	+5%	95%	3.225	(0.673)		-17%
3	2008 VBT	+5%	105%	4.3023	0.404		10%
4	2008 VBT	+10%	110%	5.234	1.336		34%
5	2008 VBT	+15%	115%	5.5987	1.701		44%

Sensitivity testing can address each potential scenario individually. Hence it is often relatively easy for management to understand and apply. Modeling efforts are also typically relatively moderate. However, correlations are usually dealt with outside the sensitivity tests, possibly through broader stress testing as discussed in section 4.

The use of stress tests and scenario analysis to assess the aggregation of risks is explored in the UK within the Individual Capital Assessment process (ICAS)<sup>18</sup>.

<sup>17</sup> See for example, "ICAS - the way forward" presentation by Phil Roberts to the UK Actuarial Profession, 29 November 2004 (see [www.actuaries.org.uk/\\_data/assets/pdf\\_file/0004/29965/roberts.pdf](http://www.actuaries.org.uk/_data/assets/pdf_file/0004/29965/roberts.pdf))

<sup>18</sup> See for example, "A Guide to the ICA Process for Insurers", 2 February 2007 (see [www.abi.org.uk/Members/circulars/viewAttachment.asp?EID=14698&DID=13551](http://www.abi.org.uk/Members/circulars/viewAttachment.asp?EID=14698&DID=13551))

#### 5.1.4 "Quantile" and Distribution Methods

Quantile methods require estimates of the parameters relating to the statistical distribution of the variable being considered. These can either be estimated from historical experience (by fitting an appropriate distribution to the experience or calculating sample statistics) or using academic judgment (to determine a distribution). The standard parameters required may include the first and second moments of the distribution such as mean ( $\mu$ ) and standard deviation ( $\sigma$ ), and possibly higher moments such as kurtosis. Such higher moments are most useful when attempting to allow for skewness in the underlying statistical distributions.

Margins for uncertainty around mortality rate assumptions can then be chosen based on these parameters. For example, mortality assumptions for term business may be taken as  $(\mu + K\sigma)$ , where  $K$  is chosen to give the desired level of conservatism. Equivalently, mortality assumptions for annuity business may be taken as  $(\mu - K\sigma)$ . In each case, the margins for uncertainty would be equal to  $K\sigma$ .

As noted above, the mortality margins could be determined empirically. In this case, the sample means and standard deviations could be estimated from the historic experience for a group of relevant policies over a chosen exposure period (e.g. 5 years). For example, the mortality rates on a block of term business could be defined as the net death benefits over the average exposure in one policy year. The margins for uncertainty could then be determined based on a chosen level of confidence. For instance, assume the mortality rates per 1000 sum insured are normally distributed with mean 1.65 and standard deviation 0.5 (based on sample statistics). If we wanted to target a 75% confidence level for the margins, then we could set them equal to 0.675 times the sample standard deviation. In this case, the prudent mortality assumption would be equal to  $1.65 + 0.675 * 0.5 = 1.99$ . It is important to note that:

- This method relies extensively on historical data, so companies should ensure they have a large enough volume of data to provide credibility to this analysis.
- The assumption that mortality rates are normally distributed is unrealistic, but used for simplicity in the above example.
- There is an implicit assumption that liabilities vary monotonically with the underlying assumption of mortality rates. Otherwise considering only boundary values of the confidence interval is not sufficient to arrive at the required level of confidence.
- It is sometimes appropriate to use higher moments of the distribution, such as kurtosis, in setting the margins for uncertainty. We have introduced one example of using kurtosis in the discussion on setting margins for asset default cost (see section 5.4.3 below).

As discussed in section 4, two main (statistical) distribution approaches are Value at Risk (VaR) and Conditional Tail Expectation (CTE). Similar to the "quantile" approach, application of these approaches also requires a distribution to be fitted to the variable of interest, either through actuarial judgment or estimation based on historical data. In these cases however, all parameters necessary to fully define the distribution are required.

The value at risk (VaR) measure is defined as the mortality rate (or equivalently the amount needed to pay mortality claims) when it arises with probability  $\alpha$ <sup>19</sup>. In other words, the  $\alpha$ -VaR measure ( $V_\alpha$ ) represents the mortality rate (or equivalently amount needed to pay claims) that with probability  $\alpha$  will not be exceeded. This can be expressed as follows:

$$V_\alpha = \inf\{V : \Pr[Q \leq V] \geq \alpha\}, \quad Q = \text{mortality rate, and } 0 \leq \alpha \leq 1$$

or equivalently,  $V_\alpha = \inf\{V : \Pr[C \leq V] \geq \alpha\}$ ,  $C = \text{claims, and } 0 \leq \alpha \leq 1$

The margins for uncertainty are then determined as the difference between two percentiles (e.g. the 65th and 50th percentiles - i.e.  $V_{65} - V_{50}$ ).

Like the  $\alpha$ -VaR risk measure, CTE( $\alpha$ ) is defined for some confidence level  $\alpha$ , such that  $0 \leq \alpha \leq 1$ . CTE( $\alpha$ ) is the expected mortality rate (or equivalently expected claim cost) given that the rate (or cost) is in the upper  $(1 - \alpha)$  quantile of the distribution. In other words, the mean of the mortality rates (or costs) in the "worst"  $(1 - \alpha)$  part of the distribution.

$$CTE_\alpha = E[Q | Q > V_\alpha] \text{ or equivalently, } CTE_\alpha = E[C | C > V_\alpha]$$

Because CTE( $\alpha$ ) is the mean mortality rate (or cost) given that it lies above the VaR at level  $\alpha$ , a choice of 70% CTE (for example) is usually more conservative than a 70% VaR. CTE( $\alpha$ ) will be equal to the VaR( $\alpha$ ) only if  $\alpha = 0$  and therefore for any  $\alpha$  greater than zero, the CTE( $\alpha$ ) will be greater than the mean, which makes it a better choice than the VaR measure.

### 5.1.5 Stochastic Modeling

The deterministic mortality assumption used in a best estimate projection typically reflects the expected mean mortality rates. However, mortality experience also has intrinsic "random volatility" that can be modeled stochastically.

In particular, it is possible to develop a theoretical model of mortality rates, similar to an Economic Scenario Generator (which is used to simulate economic variables such as equity market performance). Such models can be used to simulate future scenarios that estimate internally consistent sets of mortality rates, with each scenario incorporating an element of random "noise" based on the stochastic theory underlying the model. Actuaries can then use these simulated scenarios as the basis to generate an empirical distribution of underlying mortality rates for different types of products (or equivalently an empirical distribution of insurance liabilities based on varying levels of future mortality).

An example of how this method may be applied in practice is given below:

- Select an appropriate dynamic mortality model (some examples such as Lee-Carter, Cairns-Blake-Dowd and P-spline models are described below).

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<sup>19</sup> For the purposes of setting margins for liability reserving,  $\alpha$  is often fixed somewhere in the range between 55% and 75%.

- Use this model to generate a large number of future possible scenarios for mortality rates.
- Apply appropriate simulation techniques to project the death benefits (or annuity values) based on each of these scenarios. References to selected possible simulation techniques as they relate to the Lee-Carter family of models are included below.
- Use the simulated results to generate an empirical distribution of liability values by ranking the liabilities produced under each scenario in order of increasing magnitude.
- Apply one of the methods described in section 5.1.4 (e.g. VaR or CTE) to determine a risk margin for the mortality assumption based on selecting appropriate percentiles from the empirical distribution of liability values.

A practical example of how mortality can be modeled stochastically is outlined in the SOA research paper "Analysis of Long-Term Multiple Decrement Contracts"<sup>20</sup>. The paper highlighted four types of errors (uncertainties) that could be modeled stochastically:

- Underwriting risk (i.e. the mis-estimation of mean)
- Volatility (i.e. random fluctuation of mortality)
- Morality catastrophe (which as discussed previously, would typically not be included in the margins for uncertainties incorporated within insurance liabilities, but rather within the additional required capital)
- Trend (e.g. uncertainties from medical advancement)

Modeling dynamic mortality is not a new concept for actuaries. One famous family of models is the Lee-Carter model that was introduced in section 4. This has been widely used in mortality trend fitting and projection for a number of years. In addition, the United States Census Bureau population forecast has used it as a benchmark for their forecast of US life expectancy, and the two most recent Social Security Technical Advisory Panels have recommended adoption of the method, or forecasts consistent with it, by the trustees.

Mathematically, the Lee-Carter model<sup>21</sup> can be represented as follows:

$$\text{Log } (m(x, t)) = a(x) + b(x) * k(t) + \text{error}(x, t)$$

In this model,  $m(x, t)$  is the central death rate for age  $x$  at time  $t$ . The model decomposes this time series of age-specific death rates into two sets of age-specific constants  $a(x)$  and  $b(x)$ , and a time varying mortality index  $k(t)$ . In addition,  $\text{error}(x, t)$  represents a random error term.

<sup>20</sup> Matthew Clark and Chad Runchey, "Stochastic Analysis of Long-Term Multiple-Decrement Contracts", Actuarial Practice Forum, August 2008, Society of Actuaries (see [www.soa.org/library/journals/actuarial-practice-forum/2008/august/apf-2008-08-clark.pdf](http://www.soa.org/library/journals/actuarial-practice-forum/2008/august/apf-2008-08-clark.pdf))

<sup>21</sup> Ronald D. Lee and Lawrence Carter, "Modeling and Forecasting the Time Series of U.S. Mortality", Journal of the American Statistical Association, Vol. 87, September 1992

Actuaries can build computer simulation programs (stochastic mortality generators) to generate a series of mortality rates according to the model stated above. The factors  $a(x)$ ,  $b(x)$  and  $k(t)$  could be calibrated using company or industry specific information. The generated error terms  $error(x,t)$  can then be used to quantify the margins for uncertainties by using the VaR or CTE methods, for example, as discussed above.

The term  $k(t)$  can also be modeled as a standard Brownian motion and/or combined with Markov chains to capture various systematic mortality/longevity trends.

Practical analytical derivations are rarely possible for the Lee-Carter family of models. This is because two different sources of uncertainty need to be combined (errors in the estimation of the Lee-Carter model parameters and forecast errors in the projected stochastic time series of ARIMA parameters). Also the indices of interest (e.g. life expectancies, expected annuity values) are complex non-linear functions of the model parameters.

In order to address this problem, simulation techniques are suggested in various papers as a means of measuring risk and hence can be used by companies to calculate risk margins. Renshaw and Haberman (2008)<sup>22</sup> have conducted an extensive comparative study of three such simulation techniques (semi parametric bootstrap, parametric Monte-Carlo and residual bootstrap), in the context of Poisson bilinear (Lee-Carter) modeling and linear modeling.

In addition to the Lee-Carter family of models (including various extensions to the original method), some other stochastic mortality models discussed in recent academic literature include the Cairns-Blake-Dowd and P-spline models. A useful paper comparing these various approaches was co-authored by Andrew Cairns in 2007 and is titled "A quantitative comparison of stochastic mortality models using data from England and Wales and the United States". This paper assesses and quantitatively compares several stochastic mortality models using population data.

As there are numerous techniques described in existing literature, some criteria for selecting a good stochastic mortality model are noted below.

- As with any other mortality model, the force of mortality should be kept positive.
- The model should be consistent with historical data.
- The long-term future dynamics of the model should be biologically reasonable.
- The model should capture both the mortality trend over time and the age-specific changes for different age groups. Currie, Durban and Eilers (2004)<sup>23</sup> analyzed historical

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<sup>22</sup> Steve Haberman and Arthur Renshaw, "On Simulation-Based Approaches to Risk Measurement in Mortality with Specific Reference to Binomial Lee-Carter Modeling" (2008), Society of Actuaries "2008 Living to 100 and Beyond Symposium Monograph" (see [www.soa.org/library/monographs/retirement-systems/living-to-100-and-beyond/2008/january/mono-li08-6a-haberman.pdf](http://www.soa.org/library/monographs/retirement-systems/living-to-100-and-beyond/2008/january/mono-li08-6a-haberman.pdf))

<sup>23</sup> Iain D. Currie, Maria Durban, and Paul H.C. Eilers, "Smoothing and forecasting mortality rates" (2004), *Statistical Modeling*, Vol. 4, No. 4, 279-298

trends in mortality to show that the rate of improvement has varied significantly over time and that the improvements have varied substantially between different age groups.

- The model should incorporate a mortality jump process explicitly to address short-term catastrophic events such as avian flu. However, mortality jumps should have transitory effects on mortality rates because most of the mortality jumps caused by short-term catastrophic events should fade away after one or several periods.
- On the other hand, long term deviations in mortality improvements from those anticipated should not be mean-reverting to a pre-determined target level, even if the target is time dependent and incorporates mortality improvements.
- When a simulation technique is used for risk assessment purposes, different choices for the constraints which are needed to fit the model should not result in widely differing confidence and prediction intervals.

#### 5.1.6 Cost of Capital Method

The cost of capital method could also be used to quantify the margins for uncertainty in relation to mortality assumptions. This method was introduced in section 4.

Similar to the cost of capital (CoC) method used in Market Consistent Embedded Value (MCEV) reporting (which is an approach prescribed by the European CFO Forum<sup>24</sup>) for all non-hedgeable risks, the CoC method consists of three basic steps:

- Step 1 - Project a future stream of capital required to back mortality risk over the lifetime of the policies (e.g. using either a 99.5% confidence interval over a one year time horizon as required under the Solvency II framework, another definition from the company's internal economic capital model, or the projected capital required to obtain a targeted rating from rating agencies).
- Step 2 - Recognize that there is a cost involved in raising this capital and equate this cost to the risk margin within liability reserves. The cost is calculated as the product of the required capital to back mortality risk (calculated in Step 1) and a chosen cost of capital reflecting the spread of return demanded by investors.
- Step 3 - Discount the stream of capital costs (calculated in Step 2) using a risk free rate (e.g. US swap rates or LIBOR) to arrive at the risk margin to be added to the best estimate liability.

As mentioned in section 4, the cost of capital is often taken as a weighted average cost of capital for the whole company taking into account the varying spreads required for insurance risk, market risk, operational risks, paradigm shifts, liquidity risk and other company specific risk factors. Thus it is often challenging to use this method to quantify the margins for individual risk factors such as mortality, even when the required capital calculated in step 1 above can be isolated for that particular risk factor.

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<sup>24</sup> See CFO Forum, "Market Consistent Embedded Value Principles" dated June 2008 available at [www.cfoforum.nl](http://www.cfoforum.nl)

In addition, we note that some actuaries believe that economic capital should be funded by equity, while additional capital (in excess of economic capital) is funded by debt. In this case, where economic capital is used in the cost of capital approach, the cost of capital used should essentially be the cost of equity.

### 5.1.7 Calibration to the Capital Markets

If a relevant capital market instrument (such as a derivative contract) exists or a synthetic replicating portfolio can be constructed from existing instruments, a risk margin can theoretically be approximated as the cost of perfectly hedging the underlying mortality or longevity risk. This assumes that the market is sufficiently liquid and efficient to reduce the impact of liquidity premiums and potential super-economic profits.

For example, to calibrate the implied market price of risk explicitly, Wang (1996, 2000, 2001) has developed a method, namely the Wang transform<sup>25</sup>, for pricing risks that has been widely used as a universal framework that unifies financial and insurance pricing theories. For a full description of Wang's transform, please refer to Chen and Cox's paper "Modeling Mortality with Jumps: Transitory Effects and Pricing Implication to Mortality Securitization" (2007).

Wang's transform could also be used in calibrating risk margins. Specifically, for a given insurance liability  $X$  with known cumulative distribution function (CDF)  $F(x)$ , the Wang transform involves a risk adjusted CDF  $F^*(x)$ :

$$F^*(x) = \Phi [\Phi^{-1}(F(x) - \lambda)]$$

where  $\Phi$  is the standard normal distribution function and  $\lambda$  is the market price of risk (also called the Sharpe Ratio, which is defined as the additional excess return per unit of volatility). The assumptions relating to  $F(x)$  can be determined through experience data or academic judgment and  $F^*(x)$  is estimated through the distribution of market prices of the underlying security, which is assumed to have priced in  $\lambda$ .

Therefore, if  $X$  has a normal or lognormal ( $\mu, \sigma^2$ ) distribution, then after applying the Wang transform,  $X$  is also normally distributed with  $\mu^* = \mu + \lambda\sigma$  and  $\sigma^* = \sigma$  (where  $\mu^*$  and  $\sigma^*$  are the mean and standard deviation parameters of the transformed distribution of  $X$ ). In these cases, as shown in the Chen and Cox paper mentioned above, Wang's transform is intrinsically a replication of CAPM (if  $X$  is assumed to have a normal distribution) or the Black-Scholes formula (if  $X$  is assumed to have a lognormal distribution) which can be used to determine a volatility factor.

Other papers have also proposed the use of Wang's transform to quantify margins for uncertainties. In the US insurance industry, there exists at least one practical (life insurance company) example of using Wang's transform to quantify the risk margin in implementing a fair value calculation<sup>26</sup>. A brief introduction of how Wang's transform was used by this company to calculate the risk margins under US GAAP FAS 157 is summarized below:

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<sup>25</sup> See for example, Shaun Wang, "Cat Bond Pricing Using Probability Transforms" (2004) (see [http://rmictr.gsu.edu/Papers/WP04\\_6.pdf](http://rmictr.gsu.edu/Papers/WP04_6.pdf))

<sup>26</sup> Vadim Zinkovsky, "Risk Margins to the Non-Market Risks under FAS 157: Suggested Approach", Financial Reporter, December 2007, Issue No. 71

- Assume a Normal distribution for the insurance liabilities and calculate the risk margin as  $\lambda\sigma$  where:
  - $\lambda$  = market price of risk, calibrated base to cost of capital; and
  - $\sigma$  = standard deviation of the present value of future cash flows due to mortality risk
- Validate that the “market price of risk” developed to calculate the risk margin is consistent with observable market data
- Validate  $\sigma$  by assuming certain statistical distributions for mortality

From a practical perspective, some existing financial instruments linked to mortality that have been introduced in recent years might serve as a source to quantify or test the margins for uncertainties for mortality assumptions. In particular, this method might serve as a source for actuaries to test the level of margins for uncertainty developed using other approaches.

For example, actuaries could look at the spread on longevity bonds to help determine the margins for longevity assumptions for annuity products. The rationale underlying this is that the spread (bond yield over risk free rate) is mainly intended to provide compensation for the longevity risk that the bondholders are underwriting (with perhaps a few basis points for the liquidity and credit risks).

As mentioned in section 4, we note that this method has some significant limitations in the current environment. In particular:

- With certain specific exceptions (such as longevity bonds) it is often hard to isolate the impact from individual risk factors within the pricing of capital market instruments. For example, securitizations often transfer not just mortality, but also expense, lapse and investment risks. As noted above, even “pure” instruments such as longevity bonds may have their pricing distorted by impacts from liquidity and credit risks.
- Calibrating to capital market prices typically only reflects systematic mortality risks that are common to the whole industry and population. Therefore, the company should also take into consideration other relevant practical issues in setting risk margins for mortality assumptions. These may include:
  - Differences between the company's insured population and the population on which the capital market instruments have been written.
  - Whether the options in the contract give rise to a significant risk of anti-selection.
  - Changes in market segmentation (such as impaired life annuities) which, in the light of developing experience, may require different assumptions for different parts of the policy class.
  - The natural hedging internally of life and annuity mortality risks.

Some examples of mortality derivatives that have been introduced in recent years, and which could in theory be used to help determine margins for mortality assumptions, are summarized in the paper "Pricing Death: Frameworks for the Valuation and Securitization of Mortality Risk"<sup>27</sup>. Selected elements of the relevant discussion in that paper are outlined below.

- *Mortality Bonds*: Swiss Re launched a successful mortality bond in 2004, which was basically a form of catastrophe bond that had to be paid back in full except in cases of exceptionally bad mortality experience. Specifically, the repayment of principal was linked to a combined mortality index of mortality rates experienced in five developed countries. The credit spread at issue of 135 basis points equated to a risk neutral probability of about 0.04 that the principal would not be repaid at all. This is equivalent to a catastrophe event that would happen approximately once every 75 years in real world terms. Such information could be used by a company to calibrate a specific risk margin for mortality catastrophe risk. Notice that the catastrophe risk being covered by this bond might be correlated with financial markets (e.g. as a result of the impacts on financial markets of 9-11 or the Kobe earthquake in 1995). Therefore consideration should be taken when aggregating the mortality risk margin with other risk margins associated with economic and financial market assumptions.
- *Longevity Bonds and Survivor Swaps*: These are traded instruments where counterparties swap a fixed series of payments for a series of payments linked to the number of survivors in a given cohort. To date, there have not been many issues relating to these securities and they have not been particularly popular. For example, the European Investment Bank and BNP Paribas decided to withdraw their 2004 longevity bond due to the lukewarm reception. Similarly, only a small number of survivor swaps have been arranged on an over-the-counter basis. They are not traded contracts; therefore, they only reflect the specific risks of the counterparties involved in the transaction. Thus, any risk margins calculated using the pricing information from survivor swaps should be treated with caution (unless there is a clear correspondence between the insured population for which the margins are being developed and the population on which the survivor swaps are based). When such instruments become more popular and common, calibration to market prices may become a more relevant approach.

## 5.2 Expenses

The margin for uncertainty on expense assumptions should cover the risk of underestimating expenses due to:

- Initial under-calculation of the expense amounts (i.e. mis-estimation of the mean).
- Mis-estimation of subsequent increases in the amount of expenses. This clearly overlaps with considerations around the expense inflation assumption, which is discussed in the following sub-section.

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<sup>27</sup> Andrew J.G. Cairns, David Blake, and Kevin Dowd, "Pricing Death: Frameworks for the Valuation and Securitization of Mortality Risk", March 2006, ASTIN, Vol. 36, No. 1

Of the approaches introduced in section 4, the following could be appropriate to set margins for expenses:

- Factor based approach
- Actuarial judgment based on experience studies
- Stress Testing / Sensitivity Testing

#### 5.2.1 Factor Based Approach

Actuaries could multiply the best estimate of future expenses by a chosen factor to reflect the potential risk of underestimation. This approach is currently adopted under US GAAP accounting, which recommends the addition of PADs on top of best estimate maintenance expenses. The appropriate level of PAD would depend on the company's experience and its expectations around future expense inflation (since US GAAP does not require explicit allowance for future expense inflation). Canadian GAAP has similar requirements to include margins on expense assumptions by considering some additional factors such as future expense trends, marketing factors, unstable new business sales, impacts from lapses, changing regulatory environments, and other factors.

#### 5.2.2 Judgment Based on Experience Studies

Instead of applying an "arbitrary" factor to the best estimate expense assumption as in the above approach, companies can also study historical experience to determine an appropriate level of margins for uncertainty.

For example, similar to mortality, actuaries can look at experience data and calculate the sample mean and variance of historic expenses. Based on a chosen level of confidence, they can then determine an appropriate margin for the expense assumption. For example, companies may use  $(\mu + K\sigma)$  as the expense assumption, where  $\mu$  is the best estimate expenses (based on historic data),  $\sigma$  is the sample standard deviation, and  $K$  is a scalar factor (such as 0.5 or 1, depending on the level of conservatism required in the margin,  $K\sigma$ ).

We note that there is significant overlap between this approach and the factor based approach summarized in section 5.2.1. In particular, the factors in the latter are usually determined with at least some reference to historic experience.

#### 5.2.3 Stress Testing / Sensitivity Testing

Actuaries could use sensitivity testing to evaluate the significance of expense assumptions, and help determine the magnitude of margins to add to the best estimate assumption.

Under this approach, companies could develop various scenarios to shock the level of future expenses. This may include explicit increases in the level of base expenses, various levels of future wage inflation or a change in future premium tax rates, for example. As for other parameters such as mortality, a probability can then be assigned to each scenario and a weighted average of resulting future expenses used to determine the appropriate margins.

### 5.3 Expense Inflation

The draft US PBR proposals point out that the actuary should consider whether unit costs should be treated in the projection as subject to inflation. For example, if a company's best estimate expense assumptions already allow for the effect of inflation, then the risk margin calculated using the approaches described in section 5.2 above may already incorporate a margin in relation to expense inflation. In this case, caution should be taken not to double count inflation risks through "margins on margins".

Conversely, if a company isolates the effects of future (price and wage) inflation in setting prudent best estimate assumptions for future expenses, then various approaches can be applied to set a margin for this component of the expense assumptions. Where possible, the approach used should ensure the expense inflation assumptions (and associated margins) are consistent with the assumptions used for interest rates, equity returns and other economic variables. In the context of the proposed US PBR framework, which requires the use of stochastic modeling to allow for uncertainties in relation to such hedgable financial risks, it may therefore be most appropriate to incorporate expense inflation within these stochastic models.

Where a company chooses to isolate the assumption for expense inflation, but not to incorporate this within their stochastic model, other potential approaches to quantify the margins for uncertainty relating to expense inflation include:

- Factor based approach
- Stress Testing / Sensitivity Testing

Possible sources for setting the best estimate expense inflation assumption include the CPI index or the rate selected by the Social Security Administration for its long-term intermediate projection. Inflation can also be derived from the market. For example, differences in yield between 10-year treasury securities and 10-year treasury inflation protected securities (TIPS) could be used to determine the market's expectation for future inflation.

#### 5.3.1 Factor Based Approach

A factor based approach involves applying a multiplicative scalar factor to the best estimate inflation rate, and using this adjusted rate to project the future expenses. For example, if an actuary assumes a future inflation rate of 5%, an additional 5% margin applied to this assumption would result in a prudent estimate assumption for future expense inflation of 5.25% ( $= 5\% * 1.05$ ). The excess of the liability calculated using 5.25% expense inflation over the liability calculated using 5% expense inflation would represent the expense inflation risk margin.

#### 5.3.2 Stress Testing / Sensitivity Testing

Sensitivity testing would again involve considering various scenarios relating to future increases in expenses. It may be hard to isolate the impacts arising from inflationary factors as opposed to other causes such as mis-estimates in the mean expense assumption. However, the scenarios tested may include, for instance:

- a one time long-term increase in expenses;

- a permanent flat increase in the base expense inflation assumption;
- a mean reversing spike in the level of expenses or expense inflation;
- an increasing trend or cyclical variation in the base expense inflation assumption.

The stress testing would involve calculating the impact on liabilities from these various future scenarios of expense inflation, deciding how to weight the scenarios (based on a chosen confidence level) and using this weighted average impact to derive the expense inflation margin. This is very similar to the discussions around using stress testing for other assumptions.

### 5.3.3 Stochastic Modeling

Another approach for dealing with uncertainties around expense inflation is to stochastically model inflation in a similar manner to interest rates and equity returns. As noted above, this is arguably the optimal method from the perspective of consistency with the proposed PBR framework.

In using this approach, actuaries first have to assume a mathematical model to simulate how expense inflation will vary in conjunction with other stochastically modeled parameters such as interest rates and equity returns. As with other stochastically modeled risk factors, the company would then generate a large volume of simulated scenarios based on randomly selecting from the stochastic distribution for expense inflation (and other related economic variables). They can then choose an appropriately adverse percentile from the distribution of empirical results to make allowance for the uncertainties inherent in the expense inflation assumption.

When applying this approach, actuaries have to address a number of challenges in modeling the inflation parameter, including:

- Developing a robust theoretical model for expense inflation, which is often modeled as a blended mix of underlying price inflation and salary inflation variables.
- Allowing for the correlation between inflation and other economic risk factors. In particular, correlation between expense inflation and other economic assumptions such as price inflation, salary inflation, interest rates, currency exchange rates and equity market returns, should be taken into consideration where possible. One way to achieve this is to use a single Economic Scenario Generator (ESG) to generate future scenarios covering all economic assumptions in a consistent manner. The correlation matrixes required in using this approach could be estimated based on appropriate historical data.

Although forecasting inflation is one of the hottest topics in the academic world of economics, we have not seen any practical examples of insurance companies implementing stochastic inflation models to determine a margin for uncertainty in the underlying expense inflation assumption.

## 5.4 Default Costs

In any asset model, a major assumption that is closely related to credit risk is the assumption of default costs. Most generally, a company can construct a default cost table calculated on the basis of historical default rates and recovery rates showing the amount that is expected to be lost upon default by asset duration<sup>28</sup>.

Under the current proposals for the US PBR framework, a company is required to incorporate margins for uncertainty relating to default costs on assets held at the time of the valuation<sup>29</sup>. Specifically, VM-20 states:

*"Default cost assumptions for starting assets subject to credit default risk, including both cash market assets and derivative instruments under which the company buys or sells credit default protection, shall reflect prudent estimates of default costs over a lifetime of the assets consistent with the type of asset and quality rating."*

In the US and Canada currently, the so called "explicit" assumption approach is used for defining risk margins and margins for adverse deviation (MfAD). In the case of specifying a margin for default costs, the standard of practice in both countries does not explicitly specify how these margins should be calculated.

A number of the approaches discussed in section 4 can be applied to determine the margins for uncertainty on "starting assets", in particular:

- Factor based approach
- Stress Testing / Sensitivity Testing
- "Quantile" and distribution Methods

The following sub-sections consider each of these potential approaches in turn.

It is worth noting that many life and annuity writers can often predict their expected payouts with reasonable accuracy and buy financial instruments with maturities that match these payouts relatively closely. However, an insurance company is still vulnerable to falling asset values, because at any moment its liquidity depends on existing assets of various types and ratings which are subject to the risk of default. An insurance company portfolio might include government bonds, corporate bonds, common stock, preferred stock, and other more exotic

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<sup>28</sup> For example, see Marc N. Altschull, "Investment Actuary Symposium: Modeling Credit Risk", Risk and Rewards, February 2001, Issue 36

<sup>29</sup> At the time this research was performed, the most recent draft version of VM-20 was dated September 22, 2008. A revised draft dated January 22, 2009 was subsequently issued, which also required margins for uncertainty relating to default costs on assets held at the time of the valuation. However, we understand that subsequent discussions have indicated that default costs are likely to be prescribed within VM-20 and therefore will not need a margin for uncertainty.

instruments<sup>30</sup>, the key difference being that each asset class is subject to a different default risk and expected return.

#### 5.4.1 Factor Based Approach

In their book "Life Insurance: Products and Finance" (2000), Atkinson and Dallas describe a method for measuring asset default risk by assigning one-year asset default factors to different categories of assets. In the example they discuss, asset default factors are based on asset default probabilities and could be developed based on a company's historic experience or on industry benchmarks.

Additional margins can be defined stochastically in the form of multiplicative provisions for adverse deviation (PADs) applied to the annual default factors and ratings transition factors. The table below shows a simplistic example of this approach for an insurance company with the specified portfolio. When assets equal reserves, the weighted average asset default factor can be applied to the "pre-margin" liability reserve for each policy year to determine the contribution to each policy year's "post-margin" liability.

Asset Type	Portfolio Weight	Annual Default Probability	Factor + PAD	Weight x Probability x Factor
A	32%	0.00%	1	0.00%
B	30%	0.17%	1.3	0.07%
C	28%	1.00%	1.5	0.42%
D	10%	1.90%	2	0.38%
WA Asset-Default Factor				<b>0.87%</b>

In a dynamic model, the asset default factors and PADs could be applied separately to each asset category. The dynamic asset model could then calculate the weighted average (WA) asset default factor based on the mixture of assets at any point in time<sup>31</sup>.

#### 5.4.2 Stress Testing / Sensitivity Testing

Stress testing can be defined as a "process for testing the business of a company through cash flow projections into the future under a variety of scenarios of possible (unfavorable) experience". Following the method specified in A. Chow's "Stress Testing: Insurance Companies in Canada", 2006, the risk margin for the default cost assumption could be specified in the following manner:

- Select the projection period - for asset defaults, the length of the business cycle is often a good period
- Project future experience over this period under a series of specific plausible adverse scenarios

<sup>30</sup> Including instruments that generally do not incorporate high risk charges but could become very risky in distressed market environments (e.g. the 2008 credit crunch).

<sup>31</sup> David B. Atkinson and James W. Dallas, "Life Insurance Products and Finance: Charting a Clear Course" (2000), book published by Society of Actuaries

- Calculate the impact on liabilities under each scenario

After the stress scenarios are specified, a probability reflecting the likelihood of each scenario is assigned. Next a weighting is assigned to each scenario based on its likelihood, such that the average weighting across all scenarios results in a "blended" scenario that targets the desired level of confidence for the margin. Finally, the weighted-average financial impact across all scenarios is calculated, with the excess of this amount over the best estimate default costs being established as the margin for uncertainty. This margin would then be added to the best estimate liability reserve.

A simplified hypothetical example of the above approach is outlined in the following table. Note that the probabilities specified relate to the likelihood of a default over the entire period the asset will be held.

	Scenario	Probability of Outcome	Weighting	Loss if scenario occurred
1.	Default of smallest single exposure rated "BB" or below	40%	40%	\$2M
2.	Default of the largest single exposure rated "BBB" or below	25%	30%	\$20M
3.	Default of an "average size" exposure rated "A" or below	10%	20%	\$30M
4.	Default of three "average size" exposures rated "BBB" or below	5%	10%	\$45M

Based on the above weightings and hypothetical probabilities of each outcome, the weighted average default cost under these scenarios will be targeting a confidence level around the 75th percentile. This is based on holding margins that target a blended average of scenarios that occur at the 60th, 75th, 90th and 95th percentiles. Specifically:

$$75\% = 40\% * (1 - 40\%) + 30\% * (1 - 25\%) + 20\% * (1 - 10\%) + 10\% * (1 - 5\%)$$

The total weighted average provision required for default costs under these scenarios is approximately \$17.5M (= 40% \* \$2M + 30% \* \$20M + 20% \* \$30M + 10% \* \$45M). Assuming the best estimate of default costs is \$10M, say, the implied margin for uncertainty is \$7.5M. As noted above, this level of margins would be targeting approximately the 75th percentile confidence level.

#### 5.4.3 "Quantile" and Distribution Methods / Stochastic Modeling

A "quantile" approach to specifying the risk margin for asset default costs is a reasonable choice of approach because of the vast amount of historic credit default data available. Using this data, a distribution of credit default costs can be defined by the insurer either parametrically or empirically. Given the default distribution and its parameters, the measure which is used to quantify the risk margin will be a function mapping the default cost distribution to the set of real numbers.

The following examples of applying quantile approaches to determine risk margins for default costs loosely follow the methodologies set out in "Investment Guarantees in Equity-Linked Insurance: The Canadian Approach", M. Hardy, 2002, and "Introduction to Risk Measures for Actuarial Applications", M. Hardy, 2006.

Let  $Z$  be the default cost distribution and let  $H$  be a function mapping the distribution to the "post-margin" default cost in the space of real numbers (i.e.  $H : Z \rightarrow \mathfrak{R}$ ). In other words,  $H$  acting on  $Z$  defines the default cost including the risk margin. The following measures for specifying the risk margin on default costs could be defined as shown in the following sub-sections.

#### 5.4.3.1 Expected Value Approach

$$H(Z) = (1 + \alpha)E(Z), \alpha \geq 0$$

In the above equation,  $E(Z)$  represents the best estimate assumption for the mean of the default cost distribution and  $\alpha$  represents a scalar provision for adverse deviation (PAD) applied to the mean. The "expected value approach" is arguably the easiest way to deterministically specify the risk margin and it also satisfies the definition of an "explicit" approach for setting the risk margin since it is calculated as a function of the "best estimate" of the expected default cost.

It should be noted that the "expected-value approach" discussed in this section will produce essentially the same result as the factor-based approach discussed in section 5.4.1 when (i) historic data is used to calibrate the table in the factor based approach and the default cost distribution in the quantile approach; and (ii)  $\alpha$  in expected value approach =  $PAD$  in deterministic factor-based approach

#### 5.3.3.2 Higher Moments Approach

The higher moments approach builds upon the expected value approach by incorporating the variance as well as higher moments of the default cost distribution (such as skewness and kurtosis). The rationale for including higher moments comes from the fact that a symmetric distribution (i.e. one which could be fully specified using only the mean and variance) is almost never applicable when considering asset defaults. Fitting a symmetric distribution, for example the normal distribution, to default costs would presume that for every "increase" in asset defaults there is an identical in magnitude but opposite "decrease". Since the financial reality is far from being this "equal" on average, a better choice would be a skewed, possibly heavy-tailed distribution. Such a distribution would accommodate the possibility of large default costs with small probabilities.

In this case, we could use the following measure to determine the "post-margin" default cost to incorporate in the liability reserves:

$$H(Z) = E(Z) + \alpha\sqrt{\text{Var}(Z)} + \beta Q(Z), \alpha \geq 0$$

Again,  $E(Z)$  represents the best estimate assumption for the mean of the default cost distribution.  $\sqrt{\text{Var}(Z)}$  is the standard deviation of the distribution and  $Q(Z)$  represents some higher moment of the distribution of  $Z$ , such as kurtosis.

#### 5.3.3.3 Value at Risk - VaR ( $\alpha$ )

The value at risk (VaR) measure is defined as the amount needed to pay the default cost when it arises with probability  $\alpha$ , where (for liability margin purposes)  $\alpha$  is often fixed to be, say, 55% or 65%. In other words, the  $\alpha$ -VaR measure ( $V_\alpha$ ) represents the default cost that with probability  $\alpha$  will not be exceeded.

$$V_\alpha = \inf \{V : \Pr [C \leq V] \geq \alpha\}, \quad C = \text{default cost, and } 0 \leq \alpha \leq 1$$

For example, if using an empirical distribution based on historic default costs, let  $N$  be the total number of observations used to specify the default cost distribution. Then after ordering the default costs, the  $\alpha^{\text{th}}$  quantile measure is the  $(N\alpha)^{\text{th}}$  value of the ordered default costs.

Of course, practical implementation of the above approach is significantly more complex when it is being used to determine margins for a diversified portfolio of assets consisting of various different asset classes across multiple rating categories. However, even in these cases, historic default data can be used to fit distributions to the default costs for each asset class and rating bucket. Stochastic modeling based on Monte Carlo simulation techniques (randomly sampling from the fitted default cost distributions) can then be used to generate empirical distributions of the aggregate default costs. If  $N$  simulations are performed, then the above approach can again be used to determine the margins.

The margins for uncertainty would then be set equal to the excess of the chosen  $\alpha$ -VaR measure over the best estimate of default costs (e.g.  $V_{65}$  less the best estimate default costs).

A problem with the VaR( $\alpha$ ) risk measure is that it could be less than the mean for non-symmetric, heavy-tailed distributions (depending of course on the choice of  $\alpha$ ). This problem is further magnified by the high sample variability which makes the choice of a large number of observations (i.e. large  $N$ ) even more important. These issues with the VaR( $\alpha$ ) measure are overcome in the next risk measure considered.

#### 5.3.3.4 $100\alpha$ % Conditional Tail Expectation - CTE( $\alpha$ )

Like the  $\alpha$ -VaR risk measure, CTE( $\alpha$ ) is defined for some confidence level  $\alpha$ , such that  $0 \leq \alpha \leq 1$ . CTE( $\alpha$ ) is the expected default cost given that the cost is in the upper  $(1 - \alpha)$  quantile of the distribution. In other words, CTE( $\alpha$ ) is the mean of the default costs in the "worst"  $(1 - \alpha)$  part of the distribution. Specifically:

$$CTE_\alpha = E[C | C > V_\alpha]$$

Because CTE( $\alpha$ ) is the mean default cost given that it lies above the VaR at level  $\alpha$ , a choice of say 65% CTE is usually more conservative than a 65% VaR. CTE( $\alpha$ ) will be equal to the VaR( $\alpha$ ) only if  $\alpha = 0$  and for any  $\alpha$  greater than zero, CTE( $\alpha$ ) will be greater than the mean, which makes it a better choice than the VaR measure. Further, since CTE looks at the "worst"  $(1 - \alpha)$  part of

the distribution, "the estimate is more robust with respect to sampling error than the quantile method"<sup>32</sup>.

One way to select an "appropriate" CTE level when setting the risk margin for default costs is through advisory regulation. For example, in Canada, the March 2002 report of the CIA Task Force on Segregated Fund Investment Guarantees advocates a "standard range of practice for establishing the policy liabilities between CTE(60%) and CTE(80%)". The report argues further that a choice for CTE above 80% "*would not normally be an acceptable practice as the resulting coverage would be excessive. Provision for more catastrophic, implausible or unknown events is done through required capital*".

CTE measures can be derived numerically using similar approaches to those described for VaR in section 5.3.3.3.

## 5.5 Policyholder Behavior

Policyholder behaviors are generally viewed as non-hedgeable risks, meaning the risk of adverse impacts arising from this behavior cannot typically be diversified away through investing in traded financial instruments. The discussion draft of AAA PBR Standards requires actuaries to develop anticipated policyholder behavior assumptions within their cash flows models. These assumptions generally cover (but are not limited to):

- Withdrawal and lapse rates
- Premium payment patterns
- Benefit and option utilizations (e.g. utilization of guaranteed living benefits on variable annuities, policy loan utilizations, guaranteed rate policy extensions)
- Investment allocations
- Other options

As noted above, VM-20 requires margins for uncertainties be reflected in prudent estimate assumptions for risk factors that are neither prescribed nor stochastically determined. The policyholder behavior assumptions listed above fall into the category for which such margins are required.

VM-20 also states that the margins for uncertainties should be a function of whether companies have credible experience data. In the absence of relevant and fully credible data, the margins should be determined such that the policyholder behavior assumption is shifted toward the conservative end of the plausible range of behavior. In addition, sensitivity testing of the assumptions listed above is required to help establish the margins although VM-20 does not articulate specific methods to perform the sensitivity tests.

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<sup>32</sup> For example, see Mary Hardy "Investment Guarantees in Equity-Linked Insurance: The Canadian Approach", 2002 (see [www.actuaries.org/AFIR/colloquia/Toronto/Hardy.pdf](http://www.actuaries.org/AFIR/colloquia/Toronto/Hardy.pdf))

This section will describe how the different approaches for determining margins for uncertainties introduced in section 4 can be applied to policyholder behavior assumptions, and how some existing financial reporting frameworks approach this issue.

In some instances, it may be appropriate to use "dynamic assumptions" (e.g. varying variable annuity living benefits with the in-the-moneyness of guarantees) to model certain types of policyholder behavior. In addition to the discussions relating to assumptions for specific behaviors, section 5.5.5 discusses the general use of dynamic assumptions as well as setting margins for dynamic assumptions.

### 5.5.1 Margins for Withdrawal / Lapse

As discussed earlier, the risk margins are intended to allow for uncertainties in mean estimations, errors in assumed trends and random volatilities in the loss distribution of the particular risk factor for which assumptions are required. Withdrawal and lapse rates are one of the key assumptions for most life and annuity products, and errors in the best estimate assumptions for these parameters would typically have significant impacts on the liabilities calculated. Our review of research and industry practice identified the following methods that may be applicable to set margins for policyholder lapse and withdrawal assumptions:

- "Quantile" approach
- Actuarial judgment based on experiences
- Stress testing / sensitivity testing
- Stochastic modeling

#### 5.5.1.1 "Quantile" Approach

Under this approach, companies could set the margins equal to a multiple of the standard deviation, variance or higher moments of the risk distribution for lapse, surrenders or partial withdrawals. For example, insurance companies could calculate the sample mean and variance of historical monthly or annual lapse rates and set margins equal to a factor multiplied by the sample standard deviation. The multiplicative factor will be determined based on the targeted confidence level (which often lies in the range 55% to 75% for liability reserving purposes).

Specifically, a company could take the sample mean (based on historic monthly/annual lapses) and add  $x\%$  multiplied by the sample standard deviation (e.g.  $x = 100\%$ ) to set the "prudent estimate" lapse assumption. For certain types of business such as lapse supported products (e.g. Term to 100 in Canada and long-term care products), the company may need to reduce the lapse rates by  $x\%$  multiplied by the sample standard deviation to ensure the adjusted assumption is more prudent than the best estimate.

As noted above, the multiplicative factor can be determined based on a targeted level of confidence,  $\alpha$ . However, if using this approach, it will be necessary to assume a statistical distribution for the underlying risk factor. For example, if the risk factor is normally distributed, setting the margins equal to 0.675 times the sample standard deviation will target a confidence level of  $\alpha = 75\%$ .

An alternative approach is to directly assign a probability distribution to the lapse or withdrawal rates (or corresponding cash flows) and then calibrate the risk margins using the standard approach based on selecting a desired percentile from this distribution. For example, the margins for uncertainty could be set equal to the 65th percentile less the 50th percentile of the distribution for lapse rates. However, we note that we have not seen any practical examples of setting margins for uncertainty relating to lapse and withdrawal rates using this method, potentially due to the significant theoretical challenges in determining an appropriate distribution "fit" for lapses, surrenders or partial withdrawals.

#### *5.5.1.2 Actuarial Judgment Based on Experience Studies*

To the extent that companies have credible volumes of experience data, the margins on withdrawal and lapse assumptions could be determined using actuarial judgment based on experience studies for similar products. With this approach, margins for uncertainties are generally expressed as a series of multipliers to the best estimate lapse rates, surrender rates or partial withdrawal rates. The experience studies are generally performed (and margins determined) based on grouping policies by appropriate factors such as issue age, policy duration, distribution channel, tax status and premium size. This is discussed further later in this sub-section.

When using this approach, it is often the case that the level of margins will be linked to the degree of actual historical experience deviation from the best estimate assumptions. For example, the margins would be lower for policy cohorts with an actual-to-expected ratio closer to 1.

It is worth noting that the margins for uncertainties should lead to appropriate increase in insurance liabilities, which may require either an addition or subtraction to the best estimate withdrawal / lapse rates. The choice between addition and subtraction may need to vary by policy distribution method, interest scenario, issue age, policy duration and certainly types of products, as well as the effect of other assumptions and margins. In UK solvency reporting, if assumed withdrawals would reduce the liability, then zero withdrawal rates must be assumed.

The method described here is the approach currently used in the Canadian Life Insurance Financial Reporting (generally called Canadian GAAP) framework, where future policy benefit reserves are based on best estimate assumptions plus provisions for adverse deviations. Canadian GAAP requires that the margins for withdrawal or partial withdrawal fall within the range of 5% - 20% of the best estimates. In addition, sensitivity testing may be required to justify the chosen level of margins.

The level of granularity at which margins are determined should be selected to strike a reasonable balance between the theoretical ideal and practical constraints (such as the granularity of experience studies). In practice, reasonable grouping of policies with similar characteristics are allowed to determine the margins and run sensitivity testing. However, it is not permitted to group lapse-supported products with non-lapse supported products. For example, term to 100 policies being sold in Canada should not typically be mixed with traditional whole life policies.

Also under Canadian GAAP, the education note "Margins for Adverse Deviation" (2006) produced by the Canadian Institute of Actuaries, lists several key situations that could lead to choosing margins in the upper end of the 5%- 20% range noted above. These situations include:

- low credibility of experience data
- future experience difficult to estimate
- best estimates likely to deteriorate in the future
- changes in the economic environment that may adversely impact the assumption being considered
- significant policyholder anti-selection risk.

This is also the approach currently used for certain traditional life insurance products under US GAAP FAS 60. "Actuarial Standards of Practice No. 10"<sup>33</sup> states *"in selecting assumptions that include provisions for the risk of adverse deviation, the actuary should consider the degree to which the assumption is subject to such risk in total and at each future duration. Provision for the risk of adverse deviation should be reasonable in the actuary's judgment."* Under US GAAP, there is an additional layer of margin calibration to ensure that the aggregate net liability determined using assumptions plus margins is at least as high as a similarly calculated net liability determined using best-estimate assumptions only (i.e. before adding margins for adverse deviations).

It is worth noting that where this approach is adopted, allowance should be made for possible outcomes in the future that may arise as a result of foreseeable changes in environment. For example, under the UK solvency reporting framework, the Financial Service Authority (FSA) requires that a prudent margin for withdrawal assumptions should be "validated both in relation to recent experience and to variations in future experience that might arise as a result of reasonable foreseeable changes". The "Integrated Prudential Sourcebook for Insurers" also states that *"In particular, where estimates of experiences are being made well into the future, the assumptions should contain margins that take into account the increased risk of adverse experience arising from changed circumstances. Firms should also consider the possibility of anti-selection by policyholders and of variations in persistency experience for different classes and cohorts of business."*

Marketing practices may also have important impacts on future withdrawal activities. VM-20 states that *"A higher margin is appropriate for partial withdrawal and surrender assumptions where the company's marketing and / or administrative practices encourages anti-selection."* Further discussion relating to marketing factors is included in section 5.5.2 below.

#### **5.5.1.3 Stress Testing / Sensitivity Analysis**

To the extent that companies do not have fully credible experience, the margins on lapse and withdrawal assumptions are generally determined either more conservatively using the same

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<sup>33</sup> ASOP No. 10: "Methods and Assumptions for Use in Life Insurance Company Financial Statements Prepared in Accordance with GAAP", revised March 2000, Actuarial Standards Board (see [www.actuarialstandardsboard.org/pdf/asops/asop010\\_068.pdf](http://www.actuarialstandardsboard.org/pdf/asops/asop010_068.pdf))

approach described in the section above, or using stress testing / sensitivity testing to assess the impacts of lapses and withdrawals under appropriate shock scenarios. In the case of sensitivity testing, only the lapse or withdrawal rates would be varied (with all other variables fixed) to assess the impact on liabilities and help determine the margins for uncertainties. In some cases, the sensitivity testing of lapse or withdrawal assumptions could be performed in conjunction with other policyholder behavior risk factors or interest rate scenarios. For example, actuaries could test the sensitivity of liabilities to withdrawal rates by running them under low, medium and high interest rate scenarios. Similarly, the sensitivity to lapses could be tested under low, medium and high utilizations of insurance guarantees such as Guaranteed Minimum Withdrawal Benefits (GMWB). The margins could be determined using probability weighted averages of the low, medium and high scenarios.

With stress testing, various deterministic scenarios using different levels of lapse or withdrawal rates, combined with consistent changes in other factors such as interest rates and mortality, can be utilized to test the appropriateness of aggregate margins including those for lapse and withdrawal assumptions.

In performing the sensitivity and stress testing, companies generally assign a probability to each scenario tested and take an appropriate weighted average of the various resulting liabilities to determine the margins to add onto the best estimate assumptions.

#### 5.5.1.4 Stochastic Modeling

Stochastic modeling could be used to help develop the margins for uncertainties around lapse and withdrawal assumptions in the following ways:

- Using a stochastic lapse generator to simulate potential future scenarios that can help quantify the uncertainty arising from the random volatility associated with lapse rates.
- Reflecting certain allowances for uncertainties through the application of dynamic lapse modeling for products such as variable annuities.

#### Stochastic Lapse Generator

Similar to the approach described for using a Stochastic Mortality Generator, actuaries could stochastically model the random fluctuations in lapse and withdrawal rates. For example, assume:

$$lapse(x,t,i) = base\ lapse(x,t,i) + excess\ lapse(x,t,i), \text{ where } x \text{ is the issue age, } t \text{ is the policy duration and } i \text{ represents the scenario}$$

In the model above, base lapses are the best estimate lapse assumptions developed from experience studies and excess lapses are the random variable that is used to model the variation between actual lapses and the best estimate assumptions.

Further, assume that the excess lapse term is log-normally distributed:

$$excess\ lapse_i \sim \log\ normal(\mu, \sigma), \text{ where } \mu \text{ and } \sigma \text{ are the parameters of this lognormal model}$$

In the model above, the parameters could be calibrated using historical data and might vary by issue age and/or duration. Computer models can then be used to generate thousands of random scenarios relating to future lapse rates and the quantile approaches previously described (such as VaR or CTE) could be used to quantify the margins for uncertainties.

However, it is worth noting that it may be difficult to select an appropriate probability distribution for lapse rates (e.g. in the above example, companies would need to justify the appropriateness of the lognormal distribution used for the excess lapse term).

### Use of dynamic lapse modeling

Embedded guarantees on life insurance and annuity products (e.g. GMxBs<sup>34</sup> for variable annuities) have become increasingly popular in recent years. To reflect the impact of these guarantees on policyholder behavior, many companies use "dynamic lapses" to model policyholder behavior in withdrawing their funds from separate accounts. Dynamic lapse modeling involves treating policyholder persistency as a function of the "in-the-moneyness"<sup>35</sup> of the guarantees being offered. According to a 2007/8 SOA survey<sup>36</sup>, around 95% of participants stated that they model dynamic lapses for living benefits riders on variable annuities (where lapse rates will decrease when the in-the-moneyness of the benefits increases).

It becomes challenging to analyze the margins for uncertainties when lapse and withdrawal rates are dynamically linked to the equity markets or interest rate levels. Guaranteed benefits pose great risks to insurance companies in the tail of the loss distributions. As such, insurance companies often run thousands of stochastic scenarios (on interest rates and equity market performance) using models called Economic Scenario Generators to help calculate their liability in relation to the guarantees. In this complicated modeling process, lapses are dynamically varied according to the in-the-moneyness of guarantees and other benefit features. Specifically, lapses (or partial withdrawals) are adjusted using a formula mapping to various levels of in-the-moneyness (and possibly the utilization of guarantees). For example, for a given "band" of in-the-moneyness, the base lapse rates may be multiplied by 0.9, whereas for a band that is deeper in-the-money, the adjustment factor may be 0.7 (reflecting the fact that policyholders are less likely to withdraw their funds when they would be giving up more valuable guarantees).

The overall liabilities will be set based on selecting appropriate percentiles from the empirical liability distributions produced from the thousands of stochastic scenarios.

In this type of modeling, margins for uncertainty on lapse and withdrawal assumptions can be implemented using various approaches, such as:

- In the dynamic lapse formula, an additional margin could be applied to lapse and withdrawal rates to make them more conservative when in-the-moneyness deepens.

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<sup>34</sup> GMxBs refers to various types of guarantee often incorporated in annuity products, including guaranteed minimum death benefits (GMDBs) and guaranteed minimum income benefits (GMIBs).

<sup>35</sup> Basically a measure of the excess of value of the guarantees over current account values.

<sup>36</sup> See Policyholder behavior in the tail Risk Management Section Working Group's, "Policyholder behavior in the tail Variable Annuity guaranteed benefits survey/C3 phase II 2007 and 2008 results", Society of Actuaries, 2008

- In mapping lapse adjustment factors to different levels of in-the-moneyness, more conservative "bands" could be used to produce more conservative lapse rates.

Determining margins for partial withdrawal is another challenging task. Policyholders could utilize the partial withdrawal to deepen their in-the-moneyness of their guarantees. We have not seen a "standard" approach to determine margins for partial withdrawal assumptions. However, we have seen examples where partial withdrawal rates are back-solved assuming a conservative ratio of guarantee over account value.

We note that when valuing investment guarantees for equity-linked products in Canada, and in particular "segregated fund investment guarantees" (which resemble deferred variable annuities in the US) for which liabilities are simulated stochastically, lapses are not modeled dynamically but an 8% per annum lapse rate must generally be assumed (with a 10% per annum rate used for "to age 90" guaranteed minimum death benefits)<sup>37</sup>.

#### 5.5.1.5 Other Considerations

There are a number of other important factors that actuaries generally take into account in setting margins for lapse and withdrawal rates. These factors typically include:

- Existence and level of surrender charges
- The level of company crediting rates versus market interest rates
- Existence and utilization of free future partial withdrawal features, minimum withdrawal guarantees or non-lapse guarantees
- Existence and utilization of policy loans

#### 5.5.2 Margins for Premium Payment Patterns

This section relates to products that have flexible future premium payment features or future premiums that are not under contractual commitment. For example, this may include universal life type life products and variable annuities that do not have pre-scheduled premium payments.

Uncertainty around future premium payment patterns is another key component of policyholder behavior for which assumptions are often required. Companies may therefore need to determine a margin that takes into consideration the following uncertainties:

- Policyholders do not have a contractual commitment to pay future premiums.
- Policyholders may fund their policies with lower amounts than assumed (or observed historically) due to random fluctuations in policyholder behavior.
- Policyholders may choose to make their future deposits in less favorable ways than assumed due to impacts from other unexpected factors such as an economic downturn,

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<sup>37</sup> See Canadian Institute of Actuaries, "Report: CIA Task Force report on Segregated Fund Investment Guarantees", March 2002 (see [www.actuaries.ca/members/publications/2002/202012e.pdf](http://www.actuaries.ca/members/publications/2002/202012e.pdf))

unusual interest rate movements, equity market underperformance, marketing factors, or the launch of more competitive products from competitors.

- Other market participants may obtain a vested interest in a contract and will develop a premium pattern to maximize their economic benefit.

In US companies, actuaries generally determine future premium assumptions as percentages of the first year premiums. The percentages applied may vary by product design, distribution method, age, policy duration and sometimes interest rate scenarios. This is common practice for products such as universal life, variable universal life and variable annuities. For the purpose of projecting future cash flows, the first year premiums may be taken as the target premiums, illustrated premiums, billed premiums or even minimum premiums stated in the contracts.

Under the existing financial reporting frameworks we researched, no specific requirements<sup>38</sup> were articulated in relation to the assumed future premium pattern. For example, under the current UK solvency framework, the valuation manual does not articulate any methods, although it does emphasize that the method should be "sufficiently prudent taking into account, in particular, the risk of voluntary discontinuance by the policyholder".

The draft AAA PBR Standards require that "*while historical experience, when available, is often a good basis for such assumptions, the actuary should exercise care about assuming the past behavior will be indefinitely maintained*". This standard implies that setting margins for future premiums should not only consider the historical premium payment patterns, but also research regarding the anticipated "future experiences".

Actuaries could determine margins for uncertainties for premium payment patterns by:

- explicitly adjusting renewal premium payments to be more conservative; or
- implicitly taking future premium payments into consideration in the margins for withdrawal assumptions or other relevant assumptions.

If companies elect to apply explicit margins to future premiums, there are at least four methods that could be applicable in setting the margins for renewal premium patterns:

- Assuming no renewal premiums
- Actuarial judgment based on historic renewal premium experiences
- Sensitivity testing
- Factor-based methods (e.g. make a fixed 5% relative adjustment to the level of future premiums - increasing or decreasing them as required to make the liability more conservative). However, as mentioned in section 4, this approach does not fit well into the PBR framework.

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<sup>38</sup> The "guaranteed insurability" discussion within IASB's discussion paper on IFRS Phase II may be one exception, but this is not yet formally adopted within a financial reporting framework.

The first method is straightforward. If renewal premiums are not recurring under contractual commitment, companies could assume no future premiums for their in force blocks. In this case, the margins for uncertainties are the "negative" best estimate renewal premiums. This method is more applicable when companies do not have credible experience data or experience data does not demonstrate a clear trend or pattern for future premiums. This is also the method used in UK statutory reporting for some types of products under certain situations.

If insurance companies have credible experience data that enable actuaries to analyze the historic premium payment patterns, the margins could be determined based on prudent actuarial judgment. For example, companies could reduce their renewal premium factors (based on first year premium or target premiums for UL-type or variable annuities) to the level of renewal premiums observed under past stressed economic conditions. For example, if a company observes their renewal premiums are 10% of the first year premium under favorable economic conditions and 5% of the first premium under adverse economic conditions, they could use an assumption of 5% across all future policy years to incorporate a margin within the assumption.

Alternatively, the margins could be derived based on selecting a level of renewal premiums that corresponds to a chosen percentile within the historic experience data. For example, if 65% of historic experience data indicates that renewal premiums fall within the range of 0% to 7% of the first year premium, then it may be appropriate to use the 7% factor as the "prudent estimate assumption". This approach would then implicitly incorporate a margin targeting approximately the 65% confidence level.

Where there is a lack of credible historical data, insurance companies generally incorporate higher margins to increase the liabilities. In the above examples, it may then be appropriate to assume future premiums at a level of 2% of the first premium (for example) to reflect the lack of confidence in the historic data. Alternatively, the premium factors could be based on experience studies for similar types of products, or from reinsurance companies or industry inter-company studies.

Sensitivity testing could also be performed to assess the level of margins by fixing other risk factors and only varying the renewal premium assumptions. The more sensitive liabilities are to the renewal premium assumption, the more conservative margins would typically be considered. The approach to performing sensitivity testing will be similar to that already described in relation to other assumptions.

The determination of assumptions and margins for premium payment patterns is generally performed using policy groupings. Indeed, the current version of the draft AAA PBR Standards state "*The actuary should consider the desirability of making multiple premium payment assumptions, by subdividing the cell of business into several projection cells, each with a separate payment pattern assumption. If this is not done, and the actuary decides to use one average pattern for the cell, the actuary should consider making use of sensitivity testing...*" In practice, the level of grouping may vary by the nature of the products, but generally should include the optionality of products (e.g. withdrawal guarantees), distribution methods, age, policy duration, underwriting classes, tax qualification status (for annuities), and sometimes the face amount or account values.

In addition, there are a number of key factors that can significantly impact the future premium payments, such as marketing factors, past funding levels, interest rate movements, equity market performance and marketing factors. Actuaries may consider or even model the correlations of these factors with the future premium payment patterns. Each of the factors would independently or dependently lead to either higher or lower premium payments. It may also be appropriate to apply different levels of margins for uncertainty based on the current (and, where appropriate, anticipated future) status of these factors. For example, where a factor is likely to lead to lower future premium payments, it may be appropriate to include higher margins for uncertainty within the future premium payment assumptions.

In particular, marketing factors are often an important consideration among those factors. The current version of PBR standards lists several factors that may lead to *low* premium payments. These include:

- Marketing emphasis on coverage (as opposed to saving accumulations)
- Marketing emphasis on premium flexibility
- Illustrations featuring quick-pay premiums

The standard also listed some factors that may lead to high premium payments:

- Marketing emphasis on savings accumulations or tax advantages
- Pre-authorized transfers
- Bonuses for higher premiums or assets

### 5.5.3 Margins for Benefit / Option Elections or Utilizations

This section considers the broad category of benefit or option utilizations that policyholders can select in addition to the base contractual rights under their policies. The benefits or options embedded with insurance contracts can include:

- Term conversions
- Rights to increase or extend the coverage with limited or no additional underwriting
- Guaranteed renewal rates
- Policy loans
- Partial withdrawals (which were covered in an earlier section)
- Non-lapse guarantees for life products (e.g. secondary guarantees for universal life)
- Annuitization at guaranteed rates
- Guaranteed living benefits under variable annuities (e.g. GMWBs)

Election of policy options is one of the most important assumptions for many life and annuity products, especially non-traditional products such as universal life type products, equity indexed

annuities, variable annuities with guarantees and some other combo products with multiple or single riders.

Similar to other policyholder behaviors such as withdrawal and future premiums, actuaries have to determine an appropriate level of margins to take into consideration when setting assumptions for these options. The margins should typically allow for the following factors and uncertainties:

- Policyholders may behave in less favorable ways than assumed (or historically observed) due to random fluctuations in their behavior.
- Policyholders may behave in less favorable ways due to impacts from other unexpected factors (but not extreme tail events) such as mild economic downturns or changes in the competitive environment.
- Assumed trends may not accurately represent policyholder future behaviors.

It is subject to debate whether policyholders are sophisticated enough to maximize their own benefits by leveraging existing optional benefits being offered. However, general consensus is that certain product designs such as guaranteed living benefits for variable annuities do impact policyholder behaviors such as withdrawals, premium payments, investment allocations, annuitizations, and election of other riders. It is also important to note that policyholders' perceptions of the optional benefits being offered may also significantly impact their future behaviors. Therefore marketing or sales illustrations are often important considerations in setting assumptions and margins in relation to benefit or option utilizations.

Regardless of how many factors are considered in the modeling of policyholder behaviors, there are generally three broad types of approach to setting the margins for uncertainties:

- Assume that policyholders will maximize the value (both financial and utility) of policy options today.
- Assume that policyholders will become more aware of the value associated with the options and thus maximize the value of them in the future.
- Anticipate the course of action that the policyholders are most likely to choose.

The first two approaches are more objective and straightforward than the third. Specifically, under the first two approaches, companies have typically incorporated the margins implicitly within the base assumptions and modeling methodology by assuming full usage of the embedded options and guarantees. The third approach usually results in the most realistic projection of policyholder behaviors but is also subject to higher uncertainties in relation to the mis-estimation of mean future experience.

In general, the first two methods may be more applicable where there is a lack of credible experience data. Indeed, the draft AAA PBR Standards states *"At any duration for which relevant data do not exist, the actuary should consider taking into account what action will maximize the value of the policy from the point of view of any impartial investor who owns the*

policy". VM-20 also states *"Margins for policyholder behavior assumptions shall assume, without relevant and credible experience or clear evidence to the contrary, that policyholders' efficiency will increase over time"*.

In the case where there is fully credible experience data, the discussion draft of AAA PBR Standards states *"Unless there is clear evidence to the contrary, anticipated policyholder behavior assumptions should be consistent with relevant past experience and reasonable future expectations"*. However, it does not articulate specific methods to be used for determining margins for uncertainties.

A comprehensive review of relevant research and industry practice identified the following methods that may be applicable to set margins on policyholder option election assumptions:

- Actuarial judgment based on experience studies
- Stress Testing
- Stochastic modeling and quantile method

#### *5.5.3.1 Actuarial Judgment Based on Experience Studies*

It is open to debate to what extent historical experience should be used to develop the assumptions relating to option utilizations. Many practitioners believe that past experience alone is not sufficient for insurance companies to value the options embedded in insurance contracts. This is not only because the market dynamic keeps changing, but also because a significant amount of guarantees were introduced to the market with limited history and have not been exposed to different economic cycles with severe financial shocks. As such, experience data may not be able to provide sufficiently robust estimations of the possible future losses from these options. For example, the UK's "Integrated Prudential Sourcebook for Insurers" states *"Past experiences may be used as a guide, but only if this is likely to give a reasonable estimate of future experience. For example, past experience of take-up on a cash payment option instead of an annuity would not be a reliable guide if, in the past, market rates exceeded those guaranteed in the annuity but no longer do so. Similarly, past experience on the take-up of options may not be relevant in the light of the assumptions made in respect of future interest rates and mortality rates in the valuation of the benefits"*.

This argument also applies to using historical data to determine the margins for uncertainty.

If using the judgment based on past experience, it is therefore clear that the margins for uncertainties should be determined prudently by considering both past experience and the potential for differing future experience. For example, the UK's "Integrated Prudential Sourcebook for Insurers" requires *"...take-up rates for guaranteed annuity options should be assessed on a prudent basis with assumptions that include margins for adverse deviations that take account of current experience and the potential for future change. The firm should reserve for option take-up at least at a prudent margin over current experience for options shortly to vest...In view of growing uncertainty over take-up rates for projections further in the future, for guaranteed annuity option dates 20 years or more ahead at least a 95% take-up rate assumption should be made"*.

In order to ensure that the margins for uncertainties increase the policy liabilities, it may be necessary to consider both addition and subtraction of margins to the assumptions varying by interest rate scenario, age, policy duration and other relevant parameters. In practice, policies may be grouped according to similar characteristics for this purpose (e.g. fixed annuities with 3% guaranteed annuitization options could be combined into one cohort).

#### *5.5.3.2 Stress Testing / Sensitivity Testing*

Deterministic sensitivity testing can be performed for various scenarios of policyholder behavior either for individual options or benefit utilizations, or multiple for factors simultaneously.

It is also possible to perform the testing in conjunction with scenarios for other risk factors such as mortality, withdrawals, equity performance or interest rates. Where this type of stress testing is performed, it is important to vary sets of assumptions consistently, rather than just varying the policyholder option assumption and other parameters independently. Such stress testing can be useful to assess the overall financial impacts of varying assumptions. As for other assumptions, a weighted average of the impacts from various potential future "stress scenarios" can be used to help calibrate the margins for uncertainty.

Sensitivity testing can be performed to test the appropriateness of the selected margins in terms of their impacts on the overall liabilities. This can help understand the relative importance of each individual risk factor, for example the GMWB election assumption.

Generally, it may be necessary to stress test and sensitivity test key assumptions both independently and in conjunction with other relevant assumptions before determining a selected level for the margin for uncertainty.

#### *5.5.3.3 Stochastic Modeling and Quantile Methods*

This section covers setting margins for equity linked guarantees such as guaranteed living benefits for variable annuity contracts.

Where there are considerable variations in the cost of options that are dependent on the future economic environment, it is generally appropriate to use stochastic modeling to simulate the future experience and determine the margins for uncertainties.

One approach to doing this would be the traditional percentile or VaR approach previously discussed. Specifically, companies could stochastically simulate the impact of option utilizations based on thousands of possible future economic scenarios. They could then rank the simulated results and select an appropriate percentile (based on a targeted confidence level). The margin for uncertainty would then be set equal to this percentile less the best estimate impact.

Another, often favored, approach is using Conditional Tail Expectation (CTE) as described earlier in sections 4 and 5. For example, the CTE measurement is used in the current Canadian reporting framework for both the valuation of guarantees and to determine the total balance sheet requirement including solvency capital. This measurement is easily understood and has been implemented by Canadian companies to value their equity-linked guarantees using stochastic simulations.

If this approach is adopted, there are two main uncertainties for which margins are required in the stochastic modeling:

1. market uncertainties; and
2. model parameter uncertainties.

To address the first uncertainty, actuaries can allow for a certain level of market fluctuations by using a CTE measurement at an appropriate confidence level to derive the margin for uncertainties. Companies could use a higher level of confidence to set up the margins depending on the assumed level of volatility in the market.

To address the parameter uncertainty, actuaries could add provisions to allow for the effect of parameter uncertainties in their stochastic model. The parameters here are the key inputs that actuaries have assumed in their economic scenario generator. For example, if Geometric Brownian Motion is assumed to be the driving mechanism for volatility in equity funds, the parameters include the yield curve, the fund volatilities and the correlations between fund returns. We have not seen any practical examples of this approach being applied, but did observe related academic discussions in our research. For example, the paper "Investment Guarantees in Equity-Linked Insurance: The Canadian Approach" (2002) by Mary Hardy illustrated a Bayesian approach to set the margins for parameter uncertainty. Specifically, the paper suggested using Markov Chain Monte Carlo techniques to generate a sample from the joint posterior distribution of the parameters. The posterior distribution mixes any prior information about the model parameters with information relating to future trends. The process can be applied in the regime switching lognormal model with two regimes (an approach which is extensively elaborated in Hardy's book "Investment Guarantees: Modeling and Risk Management for Equity-Linked Life Insurance"). Further details relating to this technique can be found in the paper referenced above.

Another important technique for determining assumptions relating to option elections and benefit utilizations is the use of dynamic assumptions. For example, under this approach, the level of elections or utilizations could vary in relation to the in-the-moneyness of guarantees). The use of dynamic assumptions is covered more broadly in following section 5.5.5.

#### 5.5.4 Margins for Investment Allocation

In projecting future cash flows for certain products whose benefits are linked to equity markets, it is necessary to make assumptions regarding the short-term or long-term breakdown of investment allocations between available funds. The uncertainties relating to these investment allocation assumptions include:

- potential mis-estimation of the split between separate account and general account allocations, which leads to an understatement of best estimate liabilities;
- potential mis-estimation of the separate account fund allocations leading to an understatement of best estimate liabilities; or
- inappropriate allowance for long-term investment allocation trends, which do not correctly reflect the actual future experiences.

Generally past experience would serve as a key source for actuaries to determine the assumptions and margins for investment allocations. Such experience would typically be analyzed for groups of policies with similar characteristics such as surrender charge designs, age, distribution methods, policy duration, and levels of guaranteed crediting interest rates. Clearly actuaries would take into consideration the level of market interest rates and equity performance that are expected to occur in the future.

In addition to actuarial judgment based on experience, other approaches that may be used to set margins for investment allocation assumptions include:

- Sensitivity testing, in a manner similar to the approaches outlined earlier in this section. Indeed, the current version of the AAA PBR Standards requires sensitivity testing to be performed in relation to investment allocation assumptions.
- Stochastic modeling, again in a manner similar to the approach described earlier in this section (e.g. in relation to the take-up rate on economic options).
- Dynamic methods that link the investment allocation with market interest rates and equity index returns. The approach used here would involve the application of stochastic models and follow a similar methodology to that described for "dynamic lapse modeling" earlier in this section. If adopting the dynamic methods proposed here, it is worth noting that policyholders' investment allocations generally lag market movements (depending on the level of sophistication in policyholders' investment decisions).

In practice, actuaries may also need to consider whether policyholders are subject to contractual investment or fund allocation restrictions (for the purpose of risk management). The margins for uncertainties would typically be lower for products with such restrictions.

#### 5.5.5 Dynamic Assumptions on Policyholder Behavior

In some instances, it may be appropriate to use "dynamic assumptions" (e.g. varying variable annuity living benefits with the in-the-moneyness of guarantees) to model certain types of policyholder behavior. Where appropriate, this approach has been addressed briefly in the above sections relating to the assumptions for specific behaviors.

This section discusses more broadly the general use of dynamic assumptions as well as setting margins for dynamic assumptions.

##### 5.5.5.1 Introduction to Dynamic Assumptions

For certain products such as variable annuities offered with living benefits or interest sensitive products with non-lapse guarantees, there may be a link between policyholder behavior (e.g. benefit utilization) and other variables (e.g. the relative "in-the-moneyness" of guarantees). In particular, there are often correlations between benefit utilization and equity market performance or the interest rate environment. The utilization of income or withdrawal guarantees on variable annuities, for example, is expected to be lower in bull markets than in bear markets.

As such, some insurers use so-called dynamic assumptions to relate certain policyholder behaviors with equity market performance or interest rate movements. According to a 2007/8

SOA survey of policyholder behavior in relation to variable annuity guarantees<sup>39</sup>, over 70% of survey participants indicated that they model dynamic utilization for income and withdrawal benefits and 95% of surveyed companies use dynamic lapses for living benefits.

Some practical examples of applying dynamic assumptions in relation to policyholder behavior include:

- Dynamic lapses: lapses may be varied with in-the-moneyness of guarantees
- Dynamic fund allocations: the split of policyholder investments between separate account and general accounts (e.g. for variable life or variable annuity products) may be varied based on underlying economic conditions
- Dynamic election rates: for example, for variable annuity living benefits (e.g. GMWB, GLWB<sup>40</sup>, GMIB or GMAB)
- Dynamic crediting interest rates: crediting rates for UL type products may vary based on the crediting rates of competitors and/or market interest rates (although such assumptions are outside the scope of this research)

With dynamic lapse rates, companies generally use a formula to vary the lapses inversely with the in-the-moneyness of guarantees. For example, the dynamic lapses for a variable annuity policy with GMIB could be defined in the following way:

- $lapse_t = base\ lapse_t * dynamic\ factor_t$ , where t is the policy duration;
- $dynamic\ factor_t = \max\{1 - 2.5 * ITM_t, 25\%\}$ , where  $ITM_t$  represents the in-the-moneyness of guarantees at duration t;
- $ITM_t = \frac{guaranteed\ minimum\ annuitization\ base_t}{account\ value_t} - 1$

More information on dynamic lapses can be found in section 5.5.1.4.

Dynamic fund transfers could be approached in a similar way to allow for varying fund allocations. Companies generally use a formula to drive the allocation between general accounts and separate accounts. For example, when the separate account returns are higher than general account crediting rates, companies could assume an x% increase in transfers from the general accounts to separate accounts, and vice versa.

The use of dynamic election rates for variable annuity guarantees has become popular practice in recent years, especially within FAS 157 valuations under US GAAP and when modeling the hedging requirements for living benefit guarantees. Companies generally assume an increased

<sup>39</sup> See Policyholder behavior in the tail Risk Management Section Working Group's, "Policyholder behavior in the tail Variable Annuity guaranteed benefits survey/C3 phase II 2007 and 2008 results", Society of Actuaries, 2008

<sup>40</sup> Guaranteed Lifetime Withdrawal Benefits

level of living benefit utilizations when the guarantees' in-the-moneyness deepens. There are significant variations in company practices around modeling dynamic election rates. One of the simplest approaches is to use a formula similar to the example above for dynamic lapse rates to link the election rates with the level of in-the-moneyness of the guarantees.

There are a few practical challenges regarding the current use of dynamic assumptions within the insurance industry. For example:

1. Insufficient historical data relating to policyholder behavior under different economic cycles. This makes it challenging to verify the appropriateness of the dynamic assumptions<sup>41</sup>.
2. The application of dynamic assumptions assumes a certain level of policyholder efficiency and sophistication, which some believe lacks theoretical justification.

#### *5.5.5.2 Margins for Dynamic Assumptions*

The major uncertainties relating to dynamic assumptions include:

- inappropriateness of the dynamic formula being applied
- mis-estimate of the relationship between risk factors and behavior drivers (e.g. lapses and in-the-moneyness of guarantees)
- inappropriateness of the assumed trend (e.g. assuming policyholder sophistication does not change over time)

It is generally challenging to determine margins for uncertainties relating to dynamic assumptions. In particular, the types of uncertainty relating to dynamic assumptions are more complex than simple sampling errors and thus are generally not normally distributed. Based on the literature we reviewed, we did not observe any examples (either academic or practical) that focused on setting margins for dynamic assumptions. In our view, actuarial judgment and stress testing are likely to be the most applicable approaches to set margins for dynamic assumptions.

In particular, actuaries could apply an appropriate level of conservatism in the dynamic formula that will lead to increased reserves. The level of conservatism could be determined by analyzing historic experience and considering likely future trends. In taking this approach, actuaries could analyze historical data from their own companies or from industry surveys to observe the pattern of the dynamically determined assumptions under different economic cycles (such as adverse movements in equity markets and interest rates). The experience relating to severe economic shocks (e.g. the 2008 financial crisis) may be the most valuable data to analyze.

In order to increase the volume of historic data, experience for similar types of guarantees could be used. For example, experiences relating to the utilizations under GMWBs could be used to support the derivation of dynamic assumptions for utilization of GMABs or vice versa (if one or the other lacks credible experience data). However, when adopting this approach, caution should be exercised to ensure the appropriateness and relevance of the combined data pool.

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<sup>41</sup> However, we observe that a few companies are conducting experience studies around dynamic assumptions to gain data credibility.

In addition, industry surveys (such as the variable annuity living benefits surveys published by LIMRA on a quarterly basis) could serve as an external source to track the differences between a company's own assumptions and industry experiences. Generally the greater the difference, the higher the margins for uncertainty should be set.

Stress testing and sensitivity testing can also be used to help understand the overall impact of dynamic assumptions on the reserving for groups of policies or riders. These techniques could be applied in a similar manner to that outlined for other assumptions elsewhere in this report.

## 5.6 Reinsurance

Under VM-20, there are two broad categories for reinsurance assumptions:

- reinsurance assumed; and
- reinsurance ceded.

### 5.6.1 Reinsurance Assumed

Margins for uncertainty relating to reinsurance assumed may be necessary in relation to both:

- the underlying assumptions used to determine reinsurance liabilities; and
- the additional risk that the ceding company defaults on its obligations.

#### 5.6.1.1 Margins Relating to Reinsurance Liabilities

Reinsurers assume the risks from the business they have accepted and, as such, need to hold liabilities in relation to the accepted risk. In estimating these liabilities, reinsurers need to make assumptions regarding the future experience in relation to items such as mortality and expenses. The margins for uncertainties relating to these assumptions can typically be determined in a similar manner as direct business using the approaches described above.

However, in some cases, there may be additional complexities or issues regarding the use of these techniques. For example:

- Reinsurers often have to base experience studies on grouped data that contains less detail than that available to direct writers.
- Reinsurers often reduce the uncertainty arising from random volatilities relating to individual risk factors by holding larger, more diversified portfolios than direct writers.
- As noted in the current exposure draft of the AAA Standards for Principles-Based Reserves for Life Products: *"In setting assumptions, the actuary should consider any actions that have been or are, in the actuary's judgment, likely to be taken by the ceding company and that could affect the expected mortality or other experience of the assumed policies."* Such "other experience" may relate to withdrawal and lapse rates, revenue sharing assumptions (such as experience rebates), and benefit and option utilizations.

- A reinsurer may need to consider the level of risk retained by the ceding company and how this may impact underwriting and claims management.

Reinsurers are often able to review and assess both the assumptions and the (implicit or explicit) margins for uncertainty provided by the ceding company. Based on this assessment, the reinsurer's actuaries will be able to decide whether additional margins are required for the assumed business.

As noted above, any additional margins should be determined and tested in the same manner as for direct business. However, the level of margins may be lower than those required for the same type of direct business, since the liabilities will already incorporate the margins applied by the direct writer.

#### *5.6.1.2 Margins Relating to Default by the Ceding Company*

In addition to the liabilities held in relation to these assumed risks, reinsurers may have to hold further liabilities relating to the risk that the ceding company may default on any of its obligations (e.g. the payment of reinsurance premiums). Specifically, VM-20 states *"If a ceding company is known to have a financial impairment, the assuming company shall determine whether a margin for default by the ceding company is necessary. If the assuming company may terminate the reinsurance upon non-payment by the ceding company, the margin may be reduced or eliminated. In cases without a known financial impairment, no margin for default is required"*.

The draft AAA PBR Standards also states *"The actuary should include a margin in the assumption and should test the aggregate margin...In addition, the actuary should consider modifying the assumptions used to project cash flows for assumed reinsurance to include a margin that has the effect of increasing the reserve if, in the actuary's judgment, such margin is necessary to reflect uncertainty regarding the receipt of cash flows from or payment of cash flows to the ceding company."*

To determine the margin for uncertainty for assumed reinsurance relating to the credit risk (or default assumption) of financially impaired ceding companies, actuaries are able to apply similar techniques to those used for the credit default assumption relating to asset portfolios. These approaches were described above in section 5.4.

Alternatively, the margins could be determined by considering the ceding company's current risk based capital ratio or credit rating from major rating agencies (e.g. AM Best, S&P, Fitch or Moody's). This information could be used to define whether the ceding company is suffering from a "financial impairment" and to deterministically specify the level of margins for uncertainty based on threshold crediting ratings or RBC ratios.

When determining the margins relating to the risk of default by the ceding company, it is important for actuaries to consider the extent to which the probability of default is dependent on the future economic conditions assumed in the specific scenario used to calculate the reserves. In addition, any security that has been provided by the ceding company should be considered to help assess the impact of financial impairments on the underlying cash flow payments.

### 5.6.2 Reinsurance Ceded

The margins for uncertainty in relation to ceded business may cover:

- Uncertainties regarding the amount or timing of cash flows received from reinsurers
- Risk of default by reinsurers

Uncertainties relating to the amount or timing of cash flows received from reinsurers primarily refers to estimates of claim payments recoverable from the reinsurer. These estimates will be derived based on assumptions relating to future experience (such as mortality and lapse rates). As such, margins relating to these uncertainties can typically be calculated using the approaches described above for mortality, expenses and policyholder behavior assumptions.

With regard to the risk of default, VM-20 states *"If a ceding company has confidential or publicly available information that an assuming company has a financial impairment, the ceding company shall determine a margin for default by the [assuming] company. In cases without a known financial impairment, no margin for default is required"*.

As for reinsurance assumed, ceding companies could apply similar techniques to those used for the credit default assumption relating to asset portfolios, as described in section 5.4. Additionally, they could use credit rating information, corporate bond or credit default swap spreads, or statutory RBC ratios to define thresholds at which to apply deterministic adjustments to the best estimate reinsurance recoveries (similar to the approach described for reinsurance assumed).

When setting margins for uncertainty in relation to ceded business, ceding companies may need to consider factors such as the level of diversification in their reinsurance portfolio. For example, all else being equal, a highly concentrated reinsurance portfolio might require higher margins than a well diversified portfolio. The underlying reason for this is that, if a ceding company has a concentrated exposure to a limited number of reinsurers, the uncertainties arising from the risk of reinsurer default are higher than for a more diversified portfolio.

After assessing the credit exposure to reinsurers, ceding companies need to consider how to apply the margins on their ceded business. However, there is no specified guidance with regard to how these margins should be reflected in valuing ceding companies' reinsurance assets. Some potential approaches to establishing the margins for uncertainties include:

- reduce the amount of reinsurance claim receivables;
- multiply the best estimate reinsurance assets by the probability of reinsurer default;
- increase the discount rates used to value reinsurance assets; and
- explicitly reduce the reinsurance assets by considering reinsurers' non-performance risks (e.g. their credit standing) relative to their capital and reserves.

The first method could be achieved by adding margins to the valuation assumptions such as mortality or withdrawal rates. This approach effectively uses the margins for uncertainties

relating to the amount or timing of cash flows received from reinsurers (as discussed above) as a vehicle to allow for the risk of reinsurer default.

The second method requires an estimation of the probability of reinsurer default. Actuaries could use historic industry default data for similarly rated instruments to proxy the reinsurer's probability of default (and loss given default). Such calculations may require certain adjustments (e.g. to reflect the relative illiquidity of reinsurance recoveries compared with the actively traded financial instruments for which default data is available). The margins for uncertainty relating to the risk of the reinsurer defaulting can then be determined by multiplying the best estimate reinsurance recoveries by a factor reflecting the estimated default probability and loss given default. The reinsurance assets should be reduced by the amount of these margins to cover future uncertainties.

The third method involves modifying the discount rates used to value the reinsurance assets. An increase in the discount rate will typically result in a reduction in the value of reinsurance assets. However, as discussed in section 4, such discount related methods suffer from a lack of transparency and are often difficult to communicate to stakeholders.

The last method would be applied on an aggregate basis for all business ceded to a particular reinsurer. For example, the cost of capital method could be applied by multiplying the ceding company's weighted average cost of capital by the capital required to back the counterparty credit risk of the relevant reinsurance transactions (assuming this portion of capital can be isolated within the cedant's economic capital model, for example). The resulting risk margin would then be added to the best estimate liability (or equivalently, deducted from the value of the reinsurance assets).

## **5.7 Non-guaranteed Items and Third Party Revenue Sharing**

The assumptions relating to third party revenue sharing (such as dividends paid to other parties) and non-guaranteed items (such as crediting interest rates) may also require margins for uncertainties under the proposed PBR framework. However, at this stage, this research report has not explicitly considered the approaches that could be used to determine these margins.

## 6. ASSESSMENT OF METHODS

This section provides an assessment of the different approaches to determine margins for uncertainties introduced in sections 4 and 5. The assessment is performed in relation to several key criteria, which are listed and described in the following sub-section.

### 6.1 Criteria of Assessment

We have identified the following key criteria that we believe are important attributes for a good approach to setting margins for uncertainties under a principle-based framework:

1. **Consistency with proposed principle-based framework:** How consistent is the approach with the "principles" set out in the valuation manual, VM-20?
2. **Degree of transparency:** How explicit are the margins generated using the approach? Can the margins be easily monitored, audited and disclosed?
3. **Ease of calculation:** How complex are the calculations and modeling required to quantify the margins?
4. **Stability of calculations between reporting cycles:** How stable is the approach between valuations? Does it enable companies to build valuation models that do not require significant changes between reporting cycles?
5. **Ease of implementation:** Are there any significant practical complexities involved in implementing the approach?
6. **Calculation accuracy:** Does the approach consistently produce the required level of conservatism? Do the calculated margins respond as theoretically expected to changes in the environment, methodology and underlying data?
7. **Minimizing the opportunity for manipulation:** Does the approach reduce the risk of manipulation? Can the generated margins be easily subjected to independent testing? How significant is the level of subjective judgment required to determine the margins using this approach?
8. **Reducing over-reliance on historical data:** Does the approach overly rely on company experience or other historic data to quantify the margins?
9. **Incorporates validation versus historical data:** Does the approach make appropriate reference to incorporate available information from company experience or other historic data to validate the appropriateness of margins?
10. **Uniformity by size of company:** Can the approach be easily implemented by different sized companies? Is the approach cost-prohibitive for relatively small companies to implement?

11. **Explicitly covers individual risk factors:** Can the approach be applied to explicitly develop the margins for uncertainties for individual risk factors (as opposed to aggregate margins across multiple risk factors)?
12. **Allows for consideration of diversification effects:** Can the approach easily take account of the correlation between individual risk factors so that the diversification effects can be considered in the aggregation across risk factors?
13. **Ease of communication:** How easy is it to communicate the approach (both the methodology and results) to senior management, regulators and investors?
14. **Ease of monitoring:** How easy it is to monitor changes in the margins and track the variation of actual versus expected experience for individual risk factors?

## 6.2 Assessment of Methods Setting Margins For Uncertainties

This section discusses some of the major pros and cons of each method in relation to the criteria outlined above. A summary of this discussion is provided in the table in section 6.3.

### 6.2.1 Factor Based Approaches

Factor based methods have the advantages that they are easy to calculate, stable across reporting cycles, easy to implement, not overly reliant on the credibility of historic data or company experience, and are easy to explain to senior management. In addition, they can be implemented relatively easily by both large and small companies.

However, as discussed in earlier sections, due to the unspecified level of conservativeness and limited actuarial judgment, factor based approaches are not necessarily an ideal choice under the proposed PBR framework, which encourages the use of actuarial judgment to ensure liabilities appropriately reflect the individual risks faced by each company. In addition, they do not typically result in margins that accurately represent the underlying risk factors, and they do not account for diversification effects. Other disadvantages of factor based approaches include:

- While it is easy to monitor changes in the level of margins, it is hard to track the variation of actual versus expected experience since there is no real reference point for "actual experience".
- Where the factors are not prescribed (e.g. by a regulator), the approaches are often open to manipulation.

### 6.2.2 Judgment Based on Experience Studies

This approach is already widely used within many different accounting systems in various countries. It is also the method favored by many Canadian actuaries to establish margins for uncertainties<sup>42</sup> under the current proposals relating to IFRS for Insurance Contracts.

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<sup>42</sup> See the comments from Canadian Institute of Actuaries (dated May 16, 2008) in response to the IAA's exposure draft of "Measurement of Liabilities for Insurance Contracts: Current Estimate and Risk Margins". It states "...we

The application of judgment based on experience studies is consistent with a PBR framework, has a certain degree of transparency, clearly references historic company experiences, explicitly covers individual risk factors, and is typically easy to communicate to management, auditors and regulators. It also provides a very natural mechanism to track the variation of actual versus expected experience for individual risk factors.

However, the approach can be overly reliant on historical data and requires credibility of the data to be taken into account. It requires frequent experience studies to support the quantification process, thus it does not result in stability of calculations between reporting cycles. It is also difficult to take account of diversification effects between different risk factors on an aggregate basis. Furthermore, in certain cases, the approach could produce biased results (e.g. where there is a systematic flaw in the methodology used for experience investigations). Further, this method relies heavily on the interpretation and judgment of actuaries and senior management and might be subject to manipulation.

### 6.2.3 Stress Testing / Sensitivity Testing

Stress testing and sensitivity testing approaches have many advantages, including:

- the calculations are typically relatively easy;
- the theoretical approach and results are generally easy to communicate to management;
- the approaches are reasonably transparent;
- they can generally be implemented relatively easily within both large and small companies; and
- the methods can be applied explicitly to both individual risk factors (assumptions) and multiple assumptions simultaneously in order to facilitate consideration of diversification effects.

However, the techniques also have a number of drawbacks. In particular, they only test a limited number of "future possibilities" on a deterministic basis and therefore may be questioned in relation to their accuracy. They also rely heavily on actuarial judgment and might be subject to manipulation.

### 6.2.4 "Quantile" and Distribution Methods

One of the key advantages of "quantile" and distribution approaches is their relative transparency and ease of communication. Specifically, while the approaches are based on sound theoretical underpinnings (which make them less subject to manipulation) they can be explained very naturally based on targeted percentiles within the underlying risk distribution. Further, they are generally easy to calculate and can be used to determine margins for individual risk factors. Finally, they often make reference to historical data and relevant company experience.

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believe that the explicit assumption approach, if calibrated appropriately, can satisfy the desirable risk margin characteristics in a relatively simple and practical manner. It has served us well in Canada for many years."

However, these approaches also have a number of disadvantages. In particular:

- It can be difficult to justify the accuracy of the calculations when the risk factors being considered do not follow clearly defined probabilistic distributions.
- In certain cases, actuaries use the sample median, sample variance and other sample statistics to proxy the expected values and "true" percentiles of the distribution for the risk factor. This may result in an over-reliance on historical data and is highly dependent on the availability and credibility of that data. This type of approach is therefore often easier to implement within larger companies that have greater volumes of historic experience data.
- Further, although the approaches can be easy to implement if only using sample statistics based on historic data, they are more complex when actuaries are trying to determine a distribution to "fit" the risk factor directly. In the latter cases, it can be harder to explain the process and results to senior management.
- This approach may not adequately establish margins for changes in experience assumptions or trends.

#### 6.2.5 Stochastic Modeling

Stochastic modeling has many positive attributes, including:

- It is consistent with the PBR framework. Indeed, it is the approach required within the draft proposals to allow for hedgeable risks such as equity returns and interest rate movements.
- It provides a mechanism to reference past experience (e.g. where this is used to calibrate the model parameters) without being overly-reliant on historical data.
- It can be used to determine margins for individual risk factors, but can often also be adapted to consider multiple risk factors simultaneously. Therefore it can be used to consider the diversification effects across different risk factors. However, with each additional variable that is modeled simultaneously, there is typically a significant increase in the complexity of the model.
- The complexity of the approach, its widely documented theoretical underpinnings and the fact that the results can be analyzed for each individual scenario (including those at the percentiles representing the selected confidence levels) can reduce the scope for manipulation compared with deterministic approaches.
- The academic research conducted to support stochastic modeling for certain risk factors (e.g. mortality) can result in the approach being considered "accurate" in the sense that it responds appropriately to changes in the environment and underlying data.

Despite the many benefits outlined above, stochastic modeling also has certain drawbacks. The most significant of these relate to the complexity of the approach and the associated

implementation issues. In particular, it can be very difficult and costly to implement and, as such, might not be practical for small companies. In addition, it is usually necessary to re-run the stochastic model at each reporting cycle. Finally, it is often difficult to explain the process and results to senior management.

#### 6.2.6 Cost of Capital Method

The primary advantage of the cost of capital method is that it is directly related to the required capital. It therefore implicitly takes account of diversification effects when using economic capital as the definition of required capital (assuming the economic capital itself has allowed for diversification benefits). Further, it is relatively easy to implement and calculate *assuming* insurers have already built their economic capital models or use regulatory capital as the definition of required capital. It also provides for stability of calculations across reporting cycles and largely does not suffer from over-reliance on historical data. In addition, it is consistent with how investors may view the business.

On the other hand, as discussed in section 4, it is not always possible to explicitly consider individual risk factors using this method. Where required capital can be isolated for an individual risk factor, the advantage of implicitly incorporating diversification effects will no longer be applicable. In addition, the method is also subject to a certain degree of manipulation when calculating the Weighted Average Cost of Capital (WACC).

Other disadvantages of this approach include:

- The approach has limited transparency and can be difficult to explain conceptually to senior management, particularly when a market-consistent approach is adopted (as outlined in section 4).
- Since the method uses "required capital" as an input, it requires companies to have a model in place to project capital requirements over the lifetime of the business being considered. Hence the method may be less cost effective for smaller companies, particularly where economic capital is used as the definition of required capital and they do not already have an appropriate model in place.

The overall accuracy of margins produced using this approach would depend on the appropriateness of the chosen WACC applied in the calculation.

#### 6.2.7 Calibration to the Capital Markets or Insurance Pricing

The primary advantage of these approaches is the degree of transparency they provide by reflecting capital market inputs or company pricing practices. In addition:

- they often implicitly take account of the diversification effects between risk factors;
- they do not extensively rely on a company's historical data; and
- they are relatively easily explained (conceptually at least) to senior management.

In theory, these approaches should also minimize the risk of manipulation. However, this advantage will only be fully realized when there are deep, liquid and fully efficient markets for trading insurance liabilities.

Indeed the methods themselves are only really practical when there is a deep and liquid market to provide stable, easy to obtain, accurate and unbiased inputs. The other primary disadvantages of these methods include:

- They do not explicitly consider individual risk factors since the market pricing usually incorporates many risk categories.
- The market pricing often also makes allowance for risks that would be considered "outside" those covered by margins on insurance liabilities, such as catastrophes and "black swan" events. These risks are typically covered within required capital.
- The accuracy of the approach may sometimes be reduced through the use of out of date or biased market information to calibrate the margins. This issue is exacerbated since the approaches typically make limited reference to historic experience data to validate the calculated margins.

### 6.3 Summary of Assessments

✓	Pros
?	Varying by situation
✗	Cons

	Factor based	Judgment based on experience studies	Stress testing / sensitivity testing	"Quantile" and distribution	Stochastic modeling	Cost of capital	Calibration to capital markets or product pricing at issue
Consistency with proposed PBR	✗	✓	✓	?	✓	✗	✗
Degree of transparency	✗	✓	✓	✓	✗	✗	✓
Ease of calculation	✓	?	✓	✓ <sup>(1)</sup>	✗	✓ <sup>(2)</sup>	? <sup>(3)</sup>
Stability of calculations	✓	✗	✓	?	✗	✓	✗
Ease of implementation	✓	?	✓	✗ <sup>(4)</sup>	✗	✓ <sup>(5)</sup>	✗ <sup>(6)</sup>
Calculation accuracy	✗	? <sup>(7)</sup>	?	?	✓	?	?
Minimizing opportunity for manipulation	✗	✗	✗	✓	✓	✗	?
Reducing over-reliance on historical data	✓	✗	?	✗	✓	✓	✓
Incorporates validation versus historical data	✗	✓	?	✓	✓ <sup>(8)</sup>	✗	✗
Uniformity by size of company	✓	✗	✓	?	✗	✗	✗
Explicitly covers individual risk factors	✓	✓	✓	✓	✓	✗ <sup>(9)</sup>	✗ <sup>(10)</sup>
Allows for consideration of diversification effects	✗	✗	✓ <sup>(11)</sup>	?	? <sup>(12)</sup>	✓	✓
Ease of communication	✓	✓	✓	✓	✗	✗	✓
Ease of monitoring	✗	✓	?	?	?	✗	✗

*Footnotes:*

- (1) The calculation is often easy for approaches based on a multiple of the variance (or higher moment of the risk distribution), where sample statistics can be used. It is less simple for approaches that require a full distribution to be fitted to the risk factor.
- (2) Assuming the company has already developed a model to calculate required capital.
- (3) Difficult currently, but may get easier if deeper, more liquid markets develop in relevant capital market instruments.
- (4) Except when the approach only uses multiples of sample statistics based on historic data and simplifying assumptions (e.g. assuming the risk factor is normally distributed to determine implied confidence levels) to determine appropriate margins.
- (5) The approach is also easy to implement when based on regulatory capital (or if the company has already developed a model to calculate other forms of required capital, such as economic capital).
- (6) With the possible exception of certain very specific cases (e.g. longevity bonds, where the market spread is primarily composed of longevity risk).
- (7) Depending on data credibility and methodology used to perform experience studies.
- (8) For example, historical data can be used to calibrate the stochastic model parameters.
- (9) With the exception of mono-line companies, where the required capital could be determined to support individual risk factors (e.g. GIC products).
- (10) See (6).
- (11) Not explicitly, but a natural extension of the stress testing method does lend itself to testing the level of aggregate margins.
- (12) Stochastic modeling can incorporate varying multiple parameters simultaneously in some cases (e.g. dynamic lapses varying with economic conditions).

## 7. SUGGESTED AREAS FOR FURTHER RESEARCH

This research report considered many of the issues related to determining margins for uncertainties and discussed various possible approaches to set these margins. However, there are still several important areas that have not been fully addressed. The purpose of this section is to suggest some possible areas for future research.

### 7.1 Quantitative Comparison of Different Margin Setting Methods

This research report does not focus on quantitative comparisons between the different approaches for determining margins across various types of life and annuity products. Generally speaking, without detailed company product and business information, it would be challenging to gain a deep quantitative understanding of the likely impacts of different approaches on various business mixes. Furthermore, since the US is still in the process of developing the PBR framework, the implementation issues we have summarized in our report relate to the determination of margins under different reporting frameworks (and often from other countries). Hence they might not entirely apply to the US situation under the proposed PBR framework.

As such, the SOA may wish to initiate future research projects, with direct input and assistance from local insurance companies, relating to the likely quantitative impact of determining margins using the various approaches discussed in this report. The purposes of this future research could be:

1. To gain a quantitative understanding of different methods.
2. To "test drive" the possible implementation issues for different products and different types of company (e.g. multi-line, mono-lines, big companies, small companies, etc).

Such research may be comparable to the Quantitative Impact Studies performed by CEIOPS<sup>43</sup> around the EU Solvency II proposals.

### 7.2 Approaches to Reflect the Diversification Effects

Consideration of the diversification effects between various risk factors, and how these should impact the margins for uncertainties, is another area that is not fully addressed in this report. VM-20 does not explicitly require companies to consider these diversification effects. However, there are clear correlations between various risk factors. As such, when the margins for uncertainties on individual risk factors are aggregated on an insurers' balance sheet, it may be important to allow for the diversification effects to ensure the risk allowances are not overstated or double-counted.

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<sup>43</sup> CEIOPS is the Committee of European Insurance and Occupational Pensions Supervisors, which has now run four studies looking at the potential impacts from the proposed Solvency II regulations.

It may be considered equally important that the effects of diversification are explicitly identified and quantified to increase the transparency of the PBR financial reporting and enhance the feedback loops across different reporting cycles.

However, the issue of diversification is not only highly complex from a practical implementation perspective, but also not fully developed in the industry or academic research. To date, this topic has been covered most fully in discussions relating to economic capital rather than margins for uncertainties. Therefore, the SOA may wish to perform further research in this area.

### **7.3 Credits for Risk Mitigation Techniques**

Risk mitigation techniques refer to ways that insurance companies are able to transfer or reduce the risks they are taking. Such techniques include:

- Risk offsetting (e.g. diversification in an insurer's product portfolio offering complementary products with negatively correlated risks);
- Risk shifting (e.g. hedging for embedded guarantees or reinsurance); and
- Risk controlling (e.g. the use of risk management programs to help control investment or underwriting risks).

It is subject to debate whether insurers should take credit within margins for uncertainties to reflect such risk mitigation techniques. However, it is clear that these risk mitigating practices would somewhat reduce the uncertainties around an insurer's future obligations. For example, if an insurance company has balanced life protection business and annuity business, the mortality risk (from life protection business) is naturally offsetting the longevity risk (from annuity business). The end result is that the uncertainties around the mortality risk factor could be reduced. Another example is the hedging practices being used by insurance companies, especially those writing variable annuity. Clearly the hedging program reduces the volatility of the insurer's obligations. However, the question is should insurers take credit for hedging in setting their margins for uncertainties under the PBR framework?

This question has not been addressed in this report and may be another area that merits future research.

### **7.4 Risk Allowances to be Reflected in the Required Capital Under PBA Framework**

As mentioned in section 2, this research report focuses on setting margins for liability reserves rather than required capital. However, it is critical for practitioners to gain a deep understanding of the capital requirements under the new PBA framework. As such, the SOA may wish to sponsor future research studies focusing on developing and quantifying the risk allowances within required capital.

## Appendix 1: Relevant Excerpts from Draft Life Product Valuation Manual and Academy's PBR Standards Exposure Draft

This appendix provides excerpts from VM-20 and the exposure draft of the proposed PBR Actuarial Standards published by the AAA that are considered relevant to the determination of margins for uncertainties.

### Relevant excerpts from "VM-20: Requirements for Principle-Based Reserves for Life Products" (09/22/2008)

#### A. Purpose

1. The purpose of these requirements is to define the minimum valuation standard for individual life insurance policies subject to a principle-based reserve valuation as defined in VM-0.

#### B. Definitions

6. The term "margin" means an amount applied to an anticipated experience assumption in order to derive a prudent estimate assumption to provide for estimation error and adverse deviation. The margin should be directly related to the level of uncertainty in the risk factor for which the prudent estimate assumption is made, whereby the greater the uncertainty, the larger the required margin, with the margin added or subtracted as needed to produce a larger minimum reserve than would otherwise result without it.

19. The term "prudent estimate assumption" means a deterministic assumption, used to represent a risk factor developed by applying a margin to the anticipated experience assumption for that risk factor.

#### C.5.1 Prudent Estimate Assumptions

1. The company shall determine prudent estimate assumptions for each risk factor that is not prescribed or is not stochastically modeled. A prudent estimate assumption is developed by applying a margin to the anticipated experience assumption for the risk factor.

#### C.5.4 Assumption Margins

1. Include a margin to provide for adverse deviations and estimation error in the prudent estimate assumption for each risk factor, or combination of risk factors as allowed in C.5.4.3, which is not stochastically modeled or prescribed.

2. The choice of an appropriate margin for each assumption may result in a distorted measure of the total risk. Conceptually, the choice of margins should be made so that the final result approximates what would be obtained for the minimum reserve at the required CTE level if it were possible to calculate results over the joint distribution of all future outcomes. In applying this concept to the actual calculation of the minimum reserve, the actuary shall be guided by evolving practice and expanding knowledge base in the measurement and management of risk.

3. From a practical standpoint, it may not be possible to completely apply the concept in C.5.4.2 to determine the level of margins in the aggregate for all risk factors. Therefore, the company shall determine margins for each risk factor independently (e.g., mortality, lapse, premium patterns, etc.) using the requirements and guidance given in C.5.4.4, C.5.4.5, C.5.4.6, C.5.4.7, and C.5.4.8, unless the company can demonstrate that an appropriate method was used to jointly determine the Margin for two or more risk factors in combination.

4. The greater the uncertainty in the anticipated experience assumption, the larger the required margin, with the margin added or subtracted as needed to produce a larger minimum reserve than would otherwise result. For example, use a higher margin when:

- a. The experience data are either not relevant or not credible;
- b. The experience data are of lower quality, such as incomplete, internally inconsistent, or not current;
- c. There is doubt about the reliability of the anticipated experience assumption, such as, but not limited to recent changes in circumstances or changes in company policies; or
- d. There are constraints in the modeling that limit an effective reflection of the risk factor.

5. Greater analysis and more detailed justification for changes in assumptions are needed for risk factors that produce greater sensitivity on the minimum reserve. Higher margins shall be required unless justified otherwise.

6. Margins do not need to be established for risk factors when variations in the assumptions do not have a material impact on the minimum reserve.

7. Margins should reflect the magnitude of fluctuations in historical experience of the company for the risk factor, as appropriate.

8. Apply the method used to determine the margin consistently on each valuation date. Document any changes in the method or amounts of margin including the reason for the change.

#### **D.4 Reinsurance Assumptions**

##### **3. Credit Risk**

a. **Ceded Reinsurance.** If a ceding company has confidential or publicly available information that an assuming company has a financial impairment, the ceding company shall determine a margin for default by the ceding company. In cases without a known financial impairment, no margin for default is required.

b. **Assumed Reinsurance.** If a ceding company is known to have a financial impairment, the assuming company shall determine whether a margin for default by the ceding company is necessary. If the assuming company may terminate the reinsurance upon non-payment by the ceding company, the margin may be reduced or eliminated. In cases without a known financial impairment, no margin for default is required.

c. In setting margins to reflect potential uncertainty regarding the receipt of cash flows from a counterparty, take into account the ratings, risk-based capital ratio or other available information bearing on the probability of default by the counterparty, together with the impact on cash flows. In determining the impact on cash flows, take into account any security or other factor limiting such impact.

### **E.2.1 Procedure for Setting Prudent Estimate Mortality Assumptions**

1. Determine the company's credibility segments and mortality segments, as described in E.2.2.

2. Apply the credibility criterion described in E.2.3 to each credibility segment to determine if the credibility segment qualifies for the simplified method to determine prudent estimate mortality assumptions.

a. If the mortality experience of the credibility segment does not meet the minimum credibility level defined by the credibility criterion, the company shall use the following simplified method to determine prudent estimate mortality assumptions:

i. Use the underwriting scoring procedure described in paragraph E.2.5 below to determine the applicable valuation basic table.

ii. Set the prudent estimate mortality assumption for each mortality segment within the credibility segment equal to the mortality rates in the commissioners' table that correspond to the applicable valuation basic table determined in i. above.

b. If the mortality experience of the credibility segment meets or exceeds the minimum credibility level defined by the credibility criterion, the company shall use the following procedure to determine the prudent estimate mortality assumption for each mortality segment within the credibility segment:

i. Select a credibility procedure meeting the requirements of E.2.4 below.

ii. Use the underwriting scoring procedure described in E.2.5 to determine which of the valuation basic tables shall serve as the industry table for that mortality segment required by the selected credibility procedure.

iii. Determine the mortality experience rates and apply the selected credibility procedure to determine credibility adjusted experience rates, as provided in E.2.6.

iv. Determine margin as provided in E.2.7.

v. Set the prudent estimate mortality assumption to equal the corresponding rates in that commissioners' table for which the seriatim reserve for the mortality segment is nearest to, but not less than, the seriatim reserve based on the credibility adjusted experience rates increased by the margin.

3. Adjust the prudent estimate mortality assumptions determined in E.2.1.2 to reflect differences associated with impaired lives, or if there is a reasonable expectation that due to conditions such as changes in premiums or other policy provisions, policyholder behavior will lead to mortality results that vary from the mortality results that would otherwise be expected.

### **E.2.7 Determination of Margin [for Mortality Assumptions]**

1. For each credibility segment that qualifies for the simplified method to determine prudent estimate mortality assumptions as defined in E.2.1.2.a, the margin shall equal the respective differences between the rates obtained from the applicable commissioners' table and the corresponding rates obtained from the associated valuation basic table.

2. For each credibility segment that does not qualify for the simplified method to determine prudent estimate mortality assumptions as defined in E.2.1.2.a, the company shall determine a margin; consistent with C.5.4.4, C.5.4.5, C.5.4.6, C.5.4.7 and C.5.4.8; to add to the credibility adjusted experience rates determined in E.2.6.

3. The margins determined in E.2.7.2 shall be increased to reflect situations involving greater uncertainty, including but not limited to the following:

a. The reliability of the company's experience studies is low due to imprecise methodology, length of time since the data was updated or other reasons. The longer the time since the experience data was updated, the larger the margin.

b. The underwriting or risk selection risk criteria associated with the mortality segment have changed since the experience on which the credibility adjusted experience rates are based was collected.

c. The data underlying the credibility adjusted experience rates lack homogeneity.

d. Unfavorable environmental or health developments are unfolding and are expected to have a material and sustained impact on the insured population.

e. The company's marketing or administrative practices or market forces (for example, the secondary market for life insurance policies) expose the policies to the risk of anti-selection.

### **E.3.3 Margins for Policyholder Behavior Assumptions**

1. Margins for policyholder behavior assumptions shall be established according to the requirements of C.5.4.4, C.5.4.5, C.5.4.6, C.5.4.7 and C.5.4.8 and the requirements below.

2. To the extent that there is an absence of relevant and fully credible data, the margin shall be determined such that the policyholder behavior assumption is shifted toward the conservative end of the plausible range of behavior, that is, the end of the range that serves to increase the minimum reserve.

3. Sensitivity testing of assumptions is required to establish the margin, as discussed in E.3.4. These tests should include, but are not limited to, premium payment patterns, premium persistency, surrenders, partial withdrawals, allocations between available investment and crediting options, benefit utilization, and other option elections if relevant to the risks in the product.

4. Margins for policyholder behavior assumptions shall assume, without relevant and credible experience or clear evidence to the contrary, that policyholders' efficiency will increase over time.

5. Margins shall reflect the data uncertainty associated with using data from a similar but not identical block of business to determine the anticipated experience assumption.

6. A higher margin is appropriate for partial withdrawal and surrender assumptions where the company's marketing and /or administrative practices encourages anti-selection.

#### **E.4.2 Margins for Expense Assumptions**

1. Margins for expense assumptions shall be determined according to the requirements given in C.5.4.4, C.5.4.5, C.5.4.6, C.5.4.7, and C.5.4.8.

#### **E.5.2 Default Costs and Other Uncertainty in Timing and Amounts of Cash Flows [for Asset Assumptions]**

For both the stochastic reserve and deterministic reserve calculations:

1. Default cost assumptions for starting assets subject to credit default risk, including both cash market assets and derivative instruments under which the company buys or sells credit default protection, shall reflect prudent estimates of default costs over a lifetime of the assets consistent with the type of asset and quality rating. Default cost assumptions for reinvestment assets are already implicit in the prescribed net spreads and do not need to be explicitly modeled. Default cost assumptions for starting assets are subject to the following requirements:

...

e. Add a margin to the anticipated experience assumption for each asset class. Use higher margins (when expressed as a percentage of the credit exposure on the corresponding assets, commonly known as a "basis points charge") in situations of greater uncertainty including but not limited to the following:

i. Greater historical variability in the default rates, recovery rates, or both. Generally, the expectation is that lower quality assets will have higher margins than higher quality assets with similar maturities.

ii. Material exposures to newer asset structures that have limited historical experience;

### **E.6.3 Margins [for Revenue Sharing Assumptions]**

1. The prudent estimate of projected net revenue sharing income shall also assumed net revenue sharing income) related to the uncertainty of the revenue, creditworthiness of the provider of the net revenue sharing income. The greater the uncertainty, the larger the margin.

#### **Relevant excerpts from "Standards for Principles-Based Reserves for Life Products"<sup>44</sup>**

##### **Section 1. Purpose, Scope, Cross References, and Effective Date**

1.1 Purpose — This actuarial standard of practice (ASOP) provides guidance to actuaries when performing professional services in connection with establishing principles-based reserves for life insurance in compliance with the NAIC Standard Valuation Law (referred to herein as the Standard Valuation Law) including the NAIC valuation manual and subsequent laws or regulations where applicable.

##### **Section 2. Definitions**

2.5 Credibility — A measure of the predictive value that the actuary attaches to a particular body of data (predictive is used here in the statistical sense and not in the sense of predicting the future).

2.7 Margin — An amount applied to anticipated experience in order to derive a prudent estimate assumption to provide for estimation error and adverse deviation. The existence of a margin increases the reserves.

2.11 Risk Factor — An aspect of future experience that is uncertain as of the valuation date and that can affect the future financial results arising from the provisions of a policy. Examples include mortality, expense, policyholder behavior, and asset return.

2.13 Sensitivity Test — A calculation of the effect of varying an assumption, for the purpose of determining the significance of the assumption.

##### **Section 3. Analysis of Issues and Recommended Practices**

3.4 Anticipated Experience — The actuary should make assumptions about future experience based on the insurer's actual recent experience, if relevant and credible. To the extent the insurer's actual experience is not sufficiently relevant or credible, the actuary should consider using other relevant and credible experience, such as industry experience, appropriately modified to reflect the insurer's circumstances. The appropriate modifications should take into consideration any expected material differences in experience that could result from the company's circumstances being different from those that existed when the other experience took place. Some examples of circumstances that may be different include

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<sup>44</sup> Dated 11/20/2007 and developed by the Task Force on Principles-Based Reserves of the Life Committee of the Actuarial Standards Board formed by the AAA.

the company's underwriting practices, the market demographics, the design of the product, the economic environment, the regulatory environment, and the time period of the study. If no relevant and credible experience is available, the actuary should use professional judgment in modifying other sources of information.

The actuary should consider sensitivity testing the assumptions to determine those that have the most significant impact on resulting reserves. In general, more analysis is warranted for assumptions that have a significant impact on valuation results than for assumptions that are less significant.

#### 3.4.1 Mortality

- a. The actuary should use the most recent relevant company experience that is practicably available. Consideration should be given to the length of the observation period, recognizing the tradeoff between having insufficient data if the period is too short and having data no longer relevant if the period is too long.
- b. If relevant company experience for a particular risk class is available and has full credibility, the actuary should use that experience as the basis for deriving anticipated mortality. In situations where relevant company experience for a particular risk class is not available or does not have full credibility, the actuary should derive anticipated mortality in a reasonable and appropriate manner, using credibility methods to blend any partially credible data relevant for the risk class with other data from actual experience and past trends in experience of other similar types of business, either in the same company, in other companies (including reinsurance companies), or from other sources, generally in that order of preference. If the relevant company experience for a particular risk class and other relevant experience are insufficient to form an assumption, the actuary should use professional judgment in assessing anticipated mortality, taking into account where, in the spectrum of mortality experience, such business would be expected to fall relative to the mortality experience for other risk classes.
- c. The actuary should consider the effect that lapsation or nonrenewal activity or other anticipated policyholder behaviors has had or would be expected to have on mortality. The actuary should specifically take into account the effect of any anticipated or actual increase in gross premiums or cost of insurance charges on lapsation, and the resultant effect on mortality due to anti-selection.
- d. Anticipated mortality should be assessed on a gross basis (i.e., direct business plus reinsurance assumed, before deducting reinsurance ceded). The actuary should consider the presence of reinsurance in deriving anticipated mortality. The anticipated mortality on reinsured business, both assumed and ceded, should pertain to that on the reinsured lives and exclude the effect of experience refunds or other adjustments, however characterized in the reinsurance agreements.
- e. In determining anticipated mortality, the actuary should consider trends in mortality, whether improvements or deterioration, which have been observed in company, industry or population experience, to the extent such trends are expected to continue. If the

actuary determines that recognition of mortality trends beyond the valuation date will have the effect of increasing reserves, such trends should be incorporated into the assumptions for the cash flow projections. Otherwise, mortality trends should not be projected beyond the valuation date unless permitted by applicable law. Trends in experience should not be used in determining anticipated mortality to the extent that such trends result from temporary conditions, such as changes in underwriting rules or procedures.

### 3.4.3 Policyholder Behavior

#### a. General considerations

1. The actuary should develop anticipated policyholder behavior assumptions for the cash flow models generally including premium payment patterns, premium persistency, surrenders, withdrawals, transfers between fixed and separate accounts on variable products, benefit utilization, and other option elections.

When establishing these assumptions, the actuary should consider that anticipated policyholder behavior may be expected to vary according to such characteristics as gender, attained age, issue age, policy duration, time to maturity, tax status, level of account and cash value, surrender charges, transaction fees or other policy charges; distribution channel, product features and whether the policyholder and insured are the same person or not.

The actuary should develop anticipated policyholder behavior assumptions that are appropriate for the block of business being valued. The actuary should give due consideration to other assumptions of the valuation model when deriving anticipated policyholder behavior.

The actuary should not constrain anticipated policyholder behavior to the outcomes and events exhibited by historic experience, especially when modeling policyholder behavior of a new product benefit or feature.

The actuary may ignore certain items that might otherwise be explicitly modeled particularly if the inclusion of such items would not have a significant effect on the results.

2. Options embedded in the product, for example, term conversion privileges or policy loans, may impact policyholder behavior. The actuary should consider that as the value of a product option increases, there is an increased likelihood that policyholders will behave in a manner that maximizes their financial interest in the contract (e.g., lower lapses, higher benefit utilization, etc.) The actuary may ignore options that are not significant drivers of policyholder behavior.
3. Unless there is clear evidence to the contrary, anticipated policyholder behavior assumptions should be consistent with relevant past experience and reasonable future expectations. At any duration for which relevant data do not exist, the

actuary should consider taking into account what action will maximize the value of the policy from the point of view of an impartial investor who owns the policy (i.e., lapse the policy, persist, take out a loan, etc.) The actuary should also recognize that policyholders may place value on factors other than maximizing the policy's financial value (for example, convenience of level premiums, personal budget choices, etc.), and that the policy's full economic value to the policyholder depends not only on its currently realizable value but also on factors not available for analysis, such as the health of the insured and the financial circumstances of the beneficiaries and policyholder.

4. The actuary should exercise care in using static assumptions when it would be more natural and reasonable to use a dynamic model or other scenario-dependent formulation for anticipated policyholder behavior. Risk factors that are modeled dynamically should encompass the reasonable range of future expected behavior consistent with the economic scenarios and other variables in the model. In the absence of evidence to the contrary, it may not be necessary to model extreme or "catastrophic" forms of behavior. However, the actuary should test the sensitivity of results to understand the materiality of making alternate assumptions.

#### b. Premium Assumptions

An important element of the cash flow model is the set of assumptions about the amount of premium to be paid in each future period on policies remaining in force, and assumptions about premium persistency, the probability that a premium will be paid in a particular period. While historical experience, when available, is often a good basis for such assumptions, the actuary should exercise care about assuming that past behavior will be indefinitely maintained. For example, market or environmental changes can make historical experience less relevant. The actuary should also consider varying premium payment assumptions by interest rate scenario.

The actuary should consider the desirability of making multiple premium payment assumptions, by subdividing the cell of business into several projection cells, each with a separate payment pattern assumption. If this is not done, and the actuary decides to use one average pattern for the cell, the actuary should consider making use of sensitivity testing, which may help to determine whether the estimates of reserves or risks are significantly impacted by the use of such an approach.

For policies with fixed future premiums, the actuary should of course assume that future premium payments on in force policies will be in accordance with the policy provisions. In other situations, the actuary, in formulating assumptions about future premium payments, should consider taking into account such factors as the limitations inherent in the policy design, the amount of past funding of the policy, and the marketing of the policy.

Marketing factors that may lead to low premium payments include:

1. Marketing emphasis on coverage (as opposed to savings accumulation);
2. Marketing emphasis on premium flexibility; and
3. Illustrations featuring quick-pay premiums.

Marketing factors that may lead to high premium payments include:

1. Marketing emphasis on savings accumulation or tax advantages;
2. Pre-authorized transfers; and
3. Bonuses for higher premiums or assets.

In selecting multiple premium patterns for modeling purposes, the actuary may consider using one or more of the following patterns: target premium, illustrated premium, billed premium, minimum premium, and/or continuation of past premium levels.

c. **Withdrawal and Surrender Assumptions**

The actuary should exercise care in using static assumptions when it would be more appropriate to use a dynamic model reflecting projected interest rate environment, funding level, premium increases, and benefit triggers. In setting partial withdrawal and surrender assumptions, the actuary should consider the insured's age and gender, and the policy duration and the existence of policy loans. In addition, the actuary should consider taking into account such factors as the policy's competitiveness, surrender charges, interest or persistency bonuses, taxation status, premium frequency and method of payment, and any guaranteed benefit amounts. The actuary should consider the fact that rates of surrender can decline dramatically prior to a scheduled sharp increase in surrender benefit (sometimes known as a "cliff") caused by a decrease in surrender charge, a bonus or a maturity benefit, and rates of surrender can rise significantly after such an event.

3.4.4 **Expenses** — The actuary should review the expenses that have been allocated, for financial reporting purposes, in recent years to the block of policies being evaluated. Those expenses that are classified as "direct sales expenses" or as "taxes, licenses, and fees," should be directly allocated to the activity creating the expense. All other expenses should be allocated to the appropriate activity count (per policy, per claim, etc.) and by duration where appropriate, using reasonable principles of expense allocation and unit costs. This analysis should normally serve as the basis for projecting expenses in doing the reserve valuation, but if, in the judgment of the actuary, the expense experience is not a suitable basis for projection, other sources of data may be used (as set forth in section (b) below).

- a. **Expense Inflation** — The actuary should consider whether unit costs (particularly those other than direct sales expenses and taxes, licenses, and fees) ought to be treated in the projection as subject to inflation. Applicable law may require such an assumption. Possible sources of information about inflation assumptions are published projections of the CPI or the price deflator, such as the rate selected by the Social Security Administration for its long-term intermediate projection. The actuary may also wish to assume that future inflation rates will vary if prevailing new-money rates change. The

resulting projection of implied “real return” should be reviewed by the actuary for reasonability.

- b. Applying Recent Expense Experience — In reviewing recent experience, the actuary should be satisfied that the expenses being allocated to the block of policies being evaluated represent all expenses associated with the block, including overhead, according to statutory accounting principles. If the recent experience on the block is not, in the judgment of the actuary, a suitable basis for projection, the actuary may use experience on a closely similar type of policy within the company, or intercompany studies, provided that any regulatory approval required for such a step is obtained.

Acquisition expenses and significant non-recurring expenses expected to be incurred after the valuation date should be included in the expense assumptions. The actuary should be careful to make provision for unusual future expenses, such as severance costs or litigation costs, which may be anticipated.

If system development costs or other capital expenditures are amortized in the annual statement the actuary should reflect such amortization in the assumptions. If such expenditures occurred in the exposure period and were not amortized the actuary may exclude them from the experience, but should consider the possibility that similar expenditures will occur in the future.

In projecting direct sales expenses, the actuary may take into account recent changes in company practice, such as changes in commission rates that may not have been fully reflected in the experience. Projection of taxes, licenses, and fees should be based on a reasonable activity base (such as premium).

Recent changes in company practice, such as changes in staffing levels, that could affect “all other” expenses, may be reflected in the projection, but the actuary should, in the case of changes that are planned but not fully implemented, consider the probability that the changes will actually affect expenses.

#### 3.4.6 Reinsurance

4. Margin for Uncertainty in (ceded) Reinsurance Cash Flows. The actuary should consider modifying the assumptions used to project cash flows for ceded reinsurance to include a margin that has the effect of increasing the reserve if, in the actuary’s judgment, such margin is necessary to reflect uncertainty regarding the receipt of assumed cash flows from the reinsurer. In forming this judgment and setting margins, the actuary should take account of the ratings, risk-based capital ratio or other available information bearing on the probability of default by the reinsurer, together with the likely impact on cash flows expected to be received from or paid to the reinsurer. The actuary should consider the extent to which the probability of default is dependent on future economic conditions and thus on specific scenarios used in calculating the reserve. In determining the likely impact on cash flows, the actuary should take account of any security posted by the reinsurer or other factor limiting such

impact, to the extent such security or other factor is expected to be available to mitigate such impact. Items that should be considered by the actuary in setting a margin include any limits placed upon the reinsurer's ability to change the terms of treaty, including the presence or absence of guarantees of reinsurance premiums and allowances; past practices of reinsurers in general and the assuming reinsurer in particular regarding the changing of such terms; and the ability of the ceding company to modify the terms of the reinsured policies in response to changes in terms of the reinsurance agreement.

4. Margin for Uncertainty in (assumed) Reinsurance Cash Flows. The actuary should include a margin in the assumptions and should test the aggregate margin so produced as provided in the margin section of this standard. In addition, the actuary should consider modifying the assumptions used to project cash flows for assumed reinsurance to include a margin that has the effect of increasing the reserve if, in the actuary's judgment, such margin is necessary to reflect uncertainty regarding the receipt of cash flows from or payment of cash flows to the ceding company. In forming this judgment and setting such margins, the actuary should take account of the ratings, risk-based capital ratio or other available information bearing on the probability of default by the ceding company, together with the likely impact on cash flows expected to be received from or paid to the ceding company. The actuary should consider the extent to which the probability of default is dependent on future economic conditions and thus on specific scenarios used in calculating the reserve. In determining the likely impact on cash flows, the actuary should take account of any security posted by the ceding company or other factor limiting such impact, to the extent such security or other factor is expected to be available to mitigate such impact.

3.5 Determining Assumption Margins — After having specified the anticipated experience assumptions, the actuary should modify the assumptions for risks that are not modeled stochastically, using judgment to determine how much modification should be made for each assumption, to include a margin for estimation error and moderately adverse deviation. The resulting reserves for a group of policies should bear a reasonable relationship in the aggregate to the reserves based on anticipated experience. The actuary should ensure that assumptions that are modeled dynamically (i.e., assumed to vary as a function of a stochastic assumption, such as lapse rates or NGE rates that vary in response to interest rates) do carry an adequate margin throughout all their variations.

- a. Modifying Assumptions — The modification for a particular assumption should be such that the reserve is increased thereby. If the direction of impact of changing an assumption is not clear, the actuary should attempt to determine the nature of the change that is appropriate. If it is not practical to determine the directional impact, then the actuary need not modify that assumption. Assumptions for risks that are to be modeled stochastically need not be modified so long as a moderately adverse proportion of the stochastically generated results is used for establishing the reserve. For each assumption that is modified, the actuary should make a modification whose magnitude reflects the degree of risk and uncertainty in that assumption. When determining the

degree of risk and uncertainty, the actuary should take into account the magnitude and frequency of fluctuations in relevant historical experience, if available. In doing so, the actuary should consider using statistical methods to assess the potential volatility of the assumption in setting an appropriate margin. The additive impact of margins for all assumptions should be established at a level that provides for an appropriate amount of adverse deviation in the aggregate, even though it may seem that the margin for an individual assumption may not appear adequate on a stand-alone basis (see also section 3.5.d, “Overall Margins.”).

- b. Sensitivity Testing — The actuary may use sensitivity testing to evaluate the significance of an assumption in determining the valuation results. For assumptions that are relatively insignificant, the actuary may decide to add little or no margin to the anticipated experience assumption.
- c. Special Considerations for Mortality Assumptions — The actuary may wish to modify anticipated mortality experience in such a way as to accord with a published valuation mortality table, or may be required to do so by law or regulation. The actuary should take into consideration the degree of mortality risk and uncertainty as it varies by age and risk classification in doing so.
- d. Overall Margins — The actuary should compare the reserves based on modified assumptions (reserves with margins) with the reserves based on anticipated experience (reserves without margins), for a group of policies. For this purpose, “group of policies” may mean a line of business, or the actuary may make the comparison on several groups of policies within a line of business. The reserves with margins should be greater than the reserves without margins by an amount that could be justified as consistent with the risk on the group of policies and the regulatory requirements for reserves. For example, the actuary might relate the difference in reserves to a percentage of the present value of risk capital requirements on the group of policies.
- e. Adjusting Reserves — If the difference between reserves with margins and reserves without margins is inadequate in the judgment of the actuary, adjustments should be made in the reserves to be reported. The actuary may accomplish this by changing the assumption margins, or by adjusting the total reserves in the group of policies, using any reasonable method to allocate the difference to individual policies.

## Appendix 2: Overview of Existing Key Reports and Research Covering Margins for Uncertainties

In performing our research, we identified a number of publications that address the issue of risk margins or margins for uncertainties under different reporting frameworks. In particular, we would recommend the following publications to anyone interested in reading more on this subject.

### Margins for Adverse Deviations (Canadian Institute of Actuaries, 2006)

This educational note provides guidance to actuaries in selecting the level of deterministic margins for adverse deviations (MfADs) appropriate for the company's particular products in relation to both economic and non-economic assumptions.

In particular, guidance is provided in relation to the following assumptions and risk types.

Economic assumptions:

1. Fixed income assets: asset depreciation
  - Risk of nonpayment, reduced payment, and/or delayed payment of contractually promised cash flows
  - Bonds, mortgages, asset- and mortgage-backed securities are discussed
2. Preferred stocks: asset depreciation
  - Risk of nonpayment, reduced payment, and/or delayed payment of contractually promised cash flows
3. Investment return on derivatives
  - Risk of default of the counterparty, uncertainty on the rate of return, timing issues, netting of aggregate exposure and liquidity risk
4. Investment return on non-fixed income assets
  - Risk that the expected cash flows will not materialize which may be caused by non-payment, reduced payment, and/or delayed payment of expected income amounts, or by reduced rates of capital appreciation

Non-economic assumptions:

1. Mortality
  - An expectation of future of life should be calculated without the inclusion of a secular trend towards lower mortality rates
  - With respect to death-supported policies, a negative margin for adverse deviations or mortality improvements would increase the policy liabilities

- The actuary should ensure that the company's mortality provisions for adverse deviations are appropriate in aggregate
2. Withdrawal and partial withdrawal
    - It is appropriate to strike a reasonable balance between the theoretical ideal and the practical constraints on valuation, and use judgment as to the appropriateness and materiality of approximations used
  3. Expenses
  4. Policyholder Options

### **Use of Actuarial Judgment in Setting Assumptions and Margins for Adverse Deviations (Canadian Institute of Actuaries, 2006)**

This educational note presents considerations and examples of how to use judgment in the setting of actuarial assumptions and margins for adverse deviations (MfAD) under Canadian GAAP. This paper covers considerations for different types of assumptions and margins.

Some key extracts from this publication include:

- In setting cyclical assumptions, the cycle considered should be relatively short term, be based on a forward-looking assessment of expected experience, and only include experience caused by cyclical behavior. The actuary should establish and document a policy for setting liabilities for cyclical risks.
- Correlating assumptions may increase the provisions for adverse deviations while not appropriately reflecting future expectations. Sensitivity testing may help understand the impact on liabilities.
- The total amount of provision for adverse deviations (PfADs) should be reviewed to determine if it is appropriate in the aggregate and reflects the uncertainty in the choice of all expected assumptions. When assessing the appropriateness of aggregate PfAD levels, actuaries should consider the interrelationships of the assumptions and any potential undesirable compounding of provisions.

### **Measurement of Liability for Insurance Contracts: Current Estimate and Risk Margins (IAA, October 2008)**

This is an exposure draft prepared by the IAA Risk Margin Working Group. The purpose of this paper is to provide a broad summary of the issues surrounding potential future practices of measuring insurance contract liabilities as well as information for numerous methods of financial reporting, including both public financial reporting and regulatory reporting. The paper is centered around the three building blocks identified by IASB for the measurement of insurance liabilities - contractual cash flows, discount rates and margins over current estimates.

The paper groups the approaches for determining risk margins into four families, which satisfy the requirement of “explicit” risk margins: quantile methods, cost of capital methods, discount related methods and explicit assumption methods.

A comparison of the risk margin approaches identifies the cost of capital methods as the best fit with the IAIS and IASB guidance on desirable risk margin characteristics, closely followed by the quantile methods.

Further on the paper introduces the concept of using a reference portfolio, the idea behind which is that the individual company experience should not form the sole basis of measurement but should also take into consideration how a typical quality-rated insurer would act and value the insurance portfolio in the market. The paper concludes with specific examples of the estimation of risk margins.

#### **Risk Margins for Life Insurers (Institute of Actuaries of Australia, 2008)<sup>45</sup>**

The purpose of this paper is to familiarize Australian actuaries with the IASB Phase II approach to setting risk margins under the exit value framework. It discusses the rationale behind risk margins and the pros and cons of the various methods used to quantify them. The paper further provides two specific examples, one featuring a term insurance portfolio and one featuring a group life insurance portfolio, illustrating setting risk margins under the cost of capital and the quantile approaches.

The paper also provides a short review of international literature on risk margins.

#### **Accounting for Risk Margins (Stephen W. Philbrick, 1994)**

The purpose of this paper is to investigate how a risk margin could be incorporated in statutory accounting focusing on underwriting risk only and assuming that a satisfactory method for calculating the risk margin has already been identified. The paper defines a loss reserve risk margin called "narrow risk margin" arising from the original profit margin (which comes from the premiums paid by policyholders) and a "surplus risk margin" or earmarked surplus amount, which is associated with the equity part of the balance sheet. The two together form the broad risk margin.

The paper further specifies a formula which determines how much of a total asset requirement consistent with regulations should be established as a narrow risk margin and held as a liability on the balance sheet.

#### **IASB discussion paper "Preliminary Views on Insurance Contracts" (Appendix F) (2007)**

According to the IASB, risk margins should be one of the three building blocks in valuing insurance contracts under IFRS. The IASB has defined the risk margin as one component to compensate insurers for the bearing of risks.

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<sup>45</sup> Hoa Bui and Briallen Cummings presented to the Institute of Actuaries of Australia 4th Financial Services Forum 19-20 May 2008, Melbourne, Australia

Appendix F of the paper explicitly discusses the issue of risk margins. Specifically, it discusses the methods and considerations in developing risk margins. The overall principle for determining risk margins is that they should be an "explicit and unbiased estimation".

The paper lists ten criteria that need to be considered in order to select an appropriate approach to calculate risk margins. It also describes the desirable characteristics of the risk margins, such as higher risk margins should be associated with higher uncertainty. Since an insurer may have exposure to both market and non-market risks, which may cause joint effects, the document indicates how to calibrate the margins to the market price.

Finally, the paper lists ten possible approaches that could potentially be used to develop risk margins such as confidence levels, the CTE method, cost of capital, explicit margin within a specified range, and risk-adjusted discount rate. It also states that these approaches could be combined. However, the IASB has ruled out two approaches to set risk margins under IFRS Phase II, namely implicit (and unspecified) confidence level, and implicit (but unspecified) risk margins through the use of conservative assumptions.

### **Solvency II: Risk Margin Comparison (CEIOPS, Feb 2006)**

This discussion paper was developed by the European Actuarial Consultative Group to provide a comparison between three different approaches to the calculation of risk margins for technical provisions under the Solvency II framework. The three approaches are:

- Percentile Approach
- Cost-of-Capital Approach
- Explicit Assumption Approach

The paper does not recommend one approach over and above the others. Instead, it lays out a detailed table comparing each method's advantages and disadvantages. The criteria considered for a good risk margin are:

- Ease of calculation
- Stability of calculation between classes and years
- Consistency between different companies
- Consistency with overall solvency system
- Consistency with future IFRS Phase II
- As close as possible to market consistency
- Sit on top of best estimate (defined as mean value of discounted reserves)
- Capture uncertainty in parameters, models and trends to ultimate
- Be harmonized across Europe
- Provide a sufficient level of policyholder protection together with the MCR/SCR

Some of the challenges identified for the explicit assumption approach include lack of harmonization, limited transparency and ease of manipulation. The paper also notes that the cost of capital approach has clarity only once the required level of capital has been defined.

### **A Market cost of capital approach to market value margins (CRO Forum, 2006)**

This discussion paper explicitly lays out the CRO Forum's proposed approach to calculating risk margins: the market cost of capital (MCoC) approach.

The reasons for this preference are listed as:

- It supports appropriate risk management actions
- It provides a more appropriate reflection of risk, both in terms of risk type and between product groups
- It ensures a better response to a potential crisis in the insurance industry
- It allows for simplifying assumptions, which makes this approach easy to implement
- It is transparent, easily verifiable and understandable by the supervisor and other constituencies.
- It passes the “use test” envisioned in the Solvency II framework

The paper provides an in-depth discussion of the theoretical background of the MCoC approach, as well as how to calculate risk margins in practice using the MCoC approach (with an illustrated example). It also clarifies some of the common questions and misperceptions regarding the MCoC approach.

### **The Swiss Experience with Market Consistent Technical Provisions - The Cost of Capital Approach (2006)**

This paper, published by the Swiss Federal Office of Private Insurance in 2006, describes the concept of market consistent valuation of technical provisions within the Swiss Solvency Test (SST) and how such a valuation is best performed by (re)insurance companies.

In this paper, the steps and approach to calculating the market value margin (MVM) using the cost of capital (CoC) approach is presented not only with terms and principles, but also with examples. With Swiss experiences, the MVM proved to be risk-sensitive and distinguish high-risk from low-risk best-estimate provisions.

The paper also points out nine reasons behind the rationale for choosing the MVM approach instead of a quantile approach:

1. Policy Holder Protector
2. Transparency
3. No Double-Counting of Risks

4. Possibility of Verification
5. Ease of Calculation
6. Consistency in Application
7. Consistency with pricing
8. Consistency with EEV calculations
9. Compatibility to IFRS

### **General Insurance Reserves for Accounting and Solvency: Incorporating Provision for Risk (UK GIRO, 2006)**

This is the interim report from the Risk Margin Working Party established by the UK General Insurance Research Organising (GIRO) Committee. The paper discusses the solutions for the planned convergence in accounting and regulation of insurance in terms of risk margins in technical provisions, with the main focus relating to general insurance (P&C) liabilities. The discussion in this report relates to the "exit value" of fair value accounting.

The paper discusses three approaches to price a portfolio in real life: the percentile approach, the cost of capital approach and the assumption approach. It extensively focuses on the cost of capital approach and detailed quantitative information is provided and discussed.

The paper also points out a number of issues to be watched in practice:

- As a real transfer of value, the transfer should be supported by typical levels of capital rather than minimum levels.
- Cost of capital has many meanings and needs to reflect:
  - Income taxes
  - The ratio of market value to book value of the transferee
  - The way the frictional costs relate to financial distress, agency risk and regulatory risk make market consistent returns less than the result of a simple model.
- Disclosure of results is more helpful than disclosure of details of methodology and the amount of the market value margin (MVM) is the most important and useful disclosure.

### **Market Value Margins for Insurance Liabilities in Financial Reporting and Solvency Applications (E&Y, 2007)**

This report was prepared by Ernst & Young LLP and published in October 2007. The focus of the paper is to discuss the market value margin (MVM) for non-hedgable risks.

The report examines the cost of capital approach in two aspects:

- Measuring the fair value of insurance liabilities for financial reporting purposes

- Establishing regulatory capital standards for insurers

In-depth theoretical discussions and quantitative analysis are provided in this paper.

#### **A Global Framework for Insurer Solvency Assessment (IAA, 2004)**

This paper was prepared by the International Actuarial Associations (IAA) Solvency Assessment Working Group. The publication is often referred to as the Blue Paper or Blue Book since it was printed in blue cover. The purpose of this paper was to support the initiative of the International Association of Insurance Supervisors (IAIS) to develop a global framework for insurer capital requirements. This widely discussed paper considers the risk margins for many life products and covers many issues that are relevant to both solvency and profit reporting risk margins.

Section 3 “Capital Requirements” reviews important principles for the determination of appropriate levels of risks and describes defensive tactics for solvency protection and their role in the design of a capital requirement.

## Appendix 3: References

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<b>Title</b>	<b>Date</b>	<b>Authors / Organizations</b>
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