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# *Educational Note*

# Margins for Adverse Deviations for Property and Casualty Insurance

## Committee on Property and Casualty Insurance Financial Reporting

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*Members should be familiar with Educational Notes. Educational Notes describe but do not recommend practice in illustrative situations. They do not constitute Standards of Practice and are, therefore, not binding. They are, however, intended to illustrate the application (but not necessarily the only application) of the Standards of Practice, so there should be no conflict between them. They are intended to assist actuaries in applying Standards of Practice in respect of specific matters. Responsibility for the manner of application of Standards of Practice in specific circumstances remains that of the member in the property and casualty insurance practice area.*

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# Memorandum

**To:** Members in the Property and Casualty Insurance Practice Area

**From:** Tyrone G. Faulds, Chairperson
Practice Council

Kevin A. Lee, Chairperson
Committee on Property and Casualty Insurance Financial Reporting

**Date:** December 23, 2009

**Subject:** **Educational Note: Margins for Adverse Deviations**

In accordance with the Institute's Policy on Due Process for the Approval of Guidance Material Other than Standards of Practice, this educational note has been prepared by the Committee on Property and Casualty Insurance Financial Reporting, and has received final approval for distribution by the Practice Council on December 23, 2009.

As outlined in subsection 1220 of the Standards of Practice, "*The actuary should be familiar with relevant Educational Notes and other designated educational material*." That subsection explains further that a "practice which the Educational Notes describe for a situation is not necessarily the only accepted practice for that situation and is not necessarily accepted actuarial practice for a different situation." As well, "Educational Notes are intended to illustrate the application (but not necessarily the only application) of the Standards, so there should be no conflict between them."

If you have any questions or comments regarding this educational note, please contact Kevin A. Lee at his CIA Online Directory address, kevin.lee@iao.aon.ca.

TGF, KAL

## 1. INTRODUCTION

### Purpose

The purpose of this educational note is to provide guidance to actuaries in the selection of margins for adverse deviations for property and casualty (P&C) insurers. This educational note also provides useful guidance for an actuary conducting a valuation of policy liabilities (i.e., claim and premium liabilities) for an enterprise that is not an insurer but whose operations include benefits that an insurer may provide (e.g., self-insurers and captive insurers).

A margin for adverse deviations reflects the degree of uncertainty of the best estimate assumption. The Standards of Practice (paragraph 1740.42) state that

> "Deviation of actual from expected experience may result from one or more of the following:
>
> error of estimation, which may be favourable or adverse. Except in the simplest cases, it is not possible to determine expected experience with complete confidence. Past experience data may be insufficient or unreliable. Future conditions may differ from the conditions that generated the past experience.
>
> deterioration or improvement of the expected experience as a result of influences which the actuary does not anticipate.
>
> statistical fluctuation, which also may be favourable or adverse."

This educational note is meant to be sufficiently flexible to allow for future developments in this rapidly evolving field, particularly in light of International Financial Reporting Standards (IFRS) and the increasing use of stochastic techniques in the valuation of policy liabilities. Actuaries may derive margins for adverse deviations using an explicit approach for deterministic analyses of policy liabilities or using stochastic techniques. For deterministic analysis, the range of acceptable margins is set out in subsection 2260 of the Standards of Practice. For stochastic analyses, there is no specific statistical measurement or percentile mandated by the Standards of Practice for P&C insurance (Standards of Practice, subsection 2270). This differs from the Standards of Practice for life insurance which mandate the use of a conditional tail expectation (CTE) approach between CTE(60%) to CTE(80%). However, as presented later in this educational note (sections 8 and 9), some examples prepared by the Risk Margin Working Group (RMWG) of the International Actuarial Association (IAA), show that a range of CTE(60%) to CTE(80%) may be too high for many traditional P&C lines of insurance.

Actuaries are reminded that the purpose of margins for adverse deviations in an analysis of policy liabilities is to reflect the degree of uncertainty of the best estimate assumptions. Thus, the margins for adverse deviations are not expected to be so high that the probability of an unfavourable development is less than 1% or 5% (i.e., scenarios under dynamic capital adequacy testing).

### Cost of Capital Methods

The focus of this educational note is on margins for adverse deviations that are derived either from deterministic or stochastic analyses. Some actuaries have recently suggested using a cost of capital approach as a further approach to determining margins for adverse deviations. This educational note, however, does not address a cost of capital method. While the Committee on Property and Casualty Insurance Financial Reporting (PCFRC) believes that costs of capital methods are an important area of future development for P&C actuaries, many unresolved issues surround the use of such methods. For example, actuaries are still grappling with the issue of the

basis to be used for the determination of capital. Options for capital include economic capital, regulatory required capital, rating agency capital, capital used for pricing, and other bases. Similarly, challenges remain to determine the cost basis, including how frequently the cost should be updated and whether it should vary by contract or claim type or by duration of contract or claim. Details regarding cost of capital methods and risk margins can be found in the April 15, 2009 report, Measurement of Liabilities for Insurance Contracts: Current Estimates and Risk Margins, prepared by the Risk Margin Working Group (RMWG) of the International Actuarial Association (IAA).[1]

**Topics for Future Research**

Throughout this educational note, reference is made to the evolving environment within the actuarial community with respect to risk margins. There is continuing development in the area of stochastic valuation and statistical modeling techniques and capital requirements. International Financial Reporting Standards Phase II will have an important influence on risk margins. It is recognized that this educational note is unable to address all issues related to margins for adverse deviations. Two important areas that are not addressed are correlation and diversification. Nevertheless, both have a potential role to play in the development and assessment of margins for adverse deviations.

For the topic of correlation, we refer the reader to section 6.5 of the CIA's August 2001 Research Paper, Use of Stochastic Techniques to Value Actuarial Liabilities under Canadian GAAP, prepared by the Working Group on the use of Stochastic Techniques (Working Group) of the Committee on Life Insurance Financial Reporting. It is recognized, however, that further guidance on the topic of correlation specific to the valuation of P&C insurance liabilities and the determination of provisions for adverse deviations would be valuable for P&C actuaries. As well, the sensitive topic of diversification has potential regulatory implications.

Finally, there continues to be some confusion with respect to the role of process risk and the extent to which it should be recognized in the determination of margins for adverse deviations. Thought leadership and guidance on all these topics would be valuable to P&C actuaries.

**Organization of Educational Note**

This educational note includes eleven sections.

1. Introduction
2. Terminology
3. Desirable risk margin characteristics
4. Three categories of margins for adverse deviations
5. Explicit assumptions - margins for adverse deviations using a deterministic analysis
6. Relevant statistical concepts
7. Stochastic techniques
8. Three P&C product examples

[1] Copyright 2009 by the International Actuarial Association (IAA). Electronic or hard copies of the report are available for sale by the IAA. (See https://www.actuaries.org/ORDER_FORM2_EN.cfm for more information.)

9. Quantile approaches
10. Comparison of risk margin methods
11. Documentation and reporting

**Information Sources**

In preparing this educational note, the PCFRC has relied extensively on the April 15, 2009 report, Measurement of Liabilities for Insurance Contracts: Current Estimates and Risk Margins, prepared by the RMWG of the IAA. Throughout the educational note, this IAA report is referred to as the "IAA Risk Margin Report." The PCFRC has also relied on the feedback received from numerous CIA members in response to the June 5, 2009 notice of intent to revise Subsection 2250 Margin for Adverse Deviations of the Practice-Specific Standards for Insurers (P&C Insurance). These comments are interspersed throughout the educational note.

## 2. TERMINOLOGY

The Standards of Practice define the margin for adverse deviations as the difference between the assumption for a calculation and the corresponding best estimate assumption. The provision for adverse deviations is the difference between the actual result of a calculation and the corresponding result using best estimate assumptions. Outside of the context of the Standards of Practice, the provision for adverse deviations is commonly referred to as "risk margin".

Paragraph 1740.40 of the Standards of Practice states that

"A margin for adverse deviations may be expressed as one of

> the difference between the assumption used for the valuation and the best estimate assumption. For example, if the actuary expects the interest rate to be 10% and assumes 8%, then the margin for adverse deviations is 2%. The provision for adverse deviations is the dollar amount of increase that results from a margin for adverse deviations. For example, if that 2% margin for adverse deviations in the interest rate assumption increase liabilities from $100 million to $120 million, then the provision for adverse deviations is $20 million [or the dollar amount of increase that results from the application of the margin for adverse deviations].
>
> a multiplier to the liabilities without provision for adverse deviations. For example, if the actuary sets claim liabilities equal to 1.1 x expected claim liabilities, then the margin for adverse deviations factor is 10% and the provision for adverse deviations is 0.1 x expected claim liabilities.
>
> an addition to the liabilities without provision for adverse deviations, determined through scenario testing.

## 3. DESIRABLE RISK MARGIN CHARACTERISTICS

In its Second Liabilities Paper (2006, paragraph 57), the International Association of Insurance Supervisors (IAIS) addresses the issue of risk margins. The IAIS takes the position that "without prescribing any one method at this stage, the IAIS believes that any methodology for calculating the risk margin should share certain characteristics." The paper continues,

> …Irrespective of the particular methodology used, an appropriate method…should reflect the inherent uncertainty in the expected future cash flows and would be expected to exhibit the following characteristics:

a. The less that is known about the current estimate and its trend; the higher should be the risk margins

b. Risks with low frequency and high severity should have higher risk margins than risks with high frequency and low severity

c. For similar risks, contracts that persist over a longer timeframe should have higher risk margins than those of shorter duration

d. Risks with a wide probability distribution should have higher risk margins than those risks with a narrower distribution

e. To the extent that emerging experience reduces uncertainty, risk margins should decrease, and vice versa.

The International Accounting Standards Board (IASB) identified the same properties as being desirable (IASB Discussion Paper, 2007, Part 2: Appendix F, pages 34-35).

The IAA Risk Margin Report states that

"A risk margin methodology should[2]:

1. Apply a consistent methodology for the entire lifetime of the contract;
2. Use 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. Vary by product (class of business) based on risk differences between the products;
5. Be easy to calculate;
6. Be consistently determined between reporting periods for each entity that is, the risk margin varies from period to period only to the extent that there are real changes in risk;
7. Be consistently determined between entities at each reporting date, that is, two entities with similar business should produce similar risk margins using the methodology;
8. Facilitate disclosure of information useful to stakeholders;
9. Provide information that is useful to users of financial statements;
10. Be consistent with regulatory solvency and other objectives; and
11. Be consistent with IASB objectives."

The characteristics cited by both the IAIS and the IAA are consistent with the characteristics noted in the actuarial Standards of Practice. According to paragraphs 1740.43 and 1740.44 of the Standards of Practice,

[2] The RMWG of the IAA notes that some of the characteristics are taken from a Groupe Consultatif study of risk margin methods: 2007, Solvency II Risk Margin Comparison, February 2006, http://www.gcactuaries.org/documents/ceiops_rmcomparison_130206.pdf.

1740.43 "A larger margin for adverse deviations (compared to the best estimate assumption) is appropriate if

the actuary has less confidence in the best estimate assumption,

an approximation with less precision is being used,

the event assumed is farther in the future,

the potential consequence of the event assumed is more severe, or

the occurrence of the event assumed is more subject to statistical fluctuation."

1740.44 "A smaller margin for adverse deviations is appropriate if the opposite is true."

## 4. THREE CATEGORIES OF MARGINS FOR ADVERSE DEVIATIONS

For P&C insurance, the Standards of Practice set three categories of margins for adverse deviations,

claims development – the margin for claims development is a percentage of the claim liabilities excluding provision for adverse deviations.

recovery from reinsurance ceded – the margin for recovery from reinsurance ceded is a percentage of the amount deducted on account of reinsurance ceded in calculating the premium liabilities or the claim liabilities, excluding provision for adverse deviations.

investment return rates – the margin for investment return rate is a deduction from the expected investment return rate per year.

The Standards of Practice note that, according to how considerations so vary, the selected margins should vary between premium liabilities and claim liabilities, among lines of business, and among accident years, policy years, or underwriting years, as the case may be.

## 5. EXPLICIT ASSUMPTIONS – MARGINS FOR ADVERSE DEVIATIONS USING A DETERMINISTIC ANALYSIS

Subsection 2260 of the Standards of Practice applies to the selection of a margin for adverse deviations in a deterministic analysis. Specific levels of margins are set out for each of the three categories.

| Category | Low Margin | High Margin |
|---|---|---|
| Claims development | 2.5% | 20% |
| Recovery from reinsurance ceded | Zero | 15% |
| Investment return rates | 25 basis points | 200 basis points |

The IAA Risk Margin Report refers to this Canadian approach to determining risk margins as "explicit assumptions."

Paragraphs 2260.01 and 2260.03 of the Standards of Practice state

2260.01 "*The actuary should select a margin for adverse deviations for an assumption that is at least as much as the amount defined by the low margin for adverse deviations and is not excessive.*"

2260.03 "Usually, a selection above the high margin for adverse deviations would be considered excessive."

It is important to recognize that paragraph 2260.04 of the Standards of Practice specifically notes that there may be circumstances in which the selection of a margin for adverse deviations above the high margin would be appropriate "for unusually high uncertainty or when the resulting provision for adverse deviations is unreasonably low because the margin for adverse deviations is expressed as a percentage and the best estimate is unusually low."

**Margin for Claim Development**

The following pages present numerous examples of considerations for the actuary when selecting a margin for adverse deviations. These considerations should not be viewed as an exhaustive list of all considerations, but rather as representative of key issues that the actuary would consider when selecting margins for each of the three categories. In some circumstances, the listed consideration may not be relevant or applicable. An actuary would often derive unique considerations specific to the organization for which he or she works.

For each consideration, there is a spectrum between the situation necessitating a low margin or a high margin. For many insurers, the particular circumstances for any one consideration may dictate the selection of a margin between the low and high values set out in the Standards of Practice. When an actuary is faced with a situation in which some considerations indicate a low margin and others indicate a high margin, the actuary would use professional judgment to determine the priority of considerations and the resulting final margin.

For the claims development margin, considerations are related to

insurer's operations (claims management, underwriting, and other),

data on which the estimate is based, and

line of business.

| **TABLE 5.1 Claims Development** | | |
|---|---|---|
| **Considerations Related to Operations – Claims Management** | | |
| | **Low Margin Situation** | **High Margin Situation** |
| Systems affecting claims handling procedures | stable and consistent | significant changes in coding procedures, kind of loss codes, claims processing system, other |
| Claims management<br>- leadership<br>- personnel | stable and strong | lack of consistent leadership, high turnover of personnel |
| Adequacy of staffing | stable and adequate, consistent use of internal and external adjusters | inadequate staffing, shift from internal to external adjusters (or vice-versa) |
| Guidelines for claims handling | specific and consistent guidelines | absence of guidelines, significant changes |
| Procedures for/philosophy regarding:<br>- opening claims<br>- minor claims<br>- major claims<br>- defending claims<br>- closing claims<br>- claims expenses | specific and consistent guidelines | absence of guidelines, significant changes |
| Procedures for establishing case outstanding | specific and consistent guidelines | absence of guidelines, significant changes |
| Relative adequacy of case outstanding | stable and consistent | significant changes |

| **Considerations Related to Operations – Underwriting** | | |
|---|---|---|
| | **Low Margin Situation** | **High Margin Situation** |
| Systems affecting underwriting | stable and consistent | significant changes |
| Underwriting:<br>- leadership<br>- personnel | stable and strong | lack of consistent leadership, high turnover of personnel |
| Adequacy of staffing | stable and adequate | inadequate staffing |
| Guidelines for underwriting | specific and consistent guidelines | absence of guidelines, significant changes |

| **Considerations Related to Operations – Other** | | |
|---|---|---|
| | **Low Margin Situation** | **High Margin Situation** |
| Technology and processing systems | stable and consistent | significant changes |
| Internal controls | specific and consistent controls | absence of controls, significant changes |
| Accounting systems | stable and consistent | significant changes |

**Considerations Related to the Data on which the Estimate is Based**

| | **Low Margin Situation** | **High Margin Situation** |
|---|---|---|
| Volume of losses and premiums in each period | stable, high volume | volume changes significantly from period to period |
| Homogeneity in data grouping | significant homogeneity | limited homogeneity |
| New exposure | credible historical experience available | absence of credible historical experience |
| For reinsurers:<br>- relationships with ceding companies<br>- types of treaties<br>- attachment points<br>- limits | stable | high turnover or significant changes |
| History of credible loss development experience | available | unavailable or limited |
| Mix of business | stable | significant changes |
| Stability of historical loss development experience | high | low |
| Potential influence of large losses | limited effect on loss experience | significant effect on loss experience |

| **Considerations Related to the Line of Business** | | |
|---|---|---|
| | **Low Margin Situation** | **High Margin Situation** |
| Environment<br>- legislative<br>- judicial<br>- government | stable,<br>no changes expected,<br>or no recent changes | recent changes<br>or changes likely |
| Length of tail | short | long |
| Latent claims | low potential<br>for latent claims | high potential<br>for latent claims |
| Liability exposure | limited or none | high |
| Excess of loss exposure | limited or none | high |
| Coverage and/or policy form | stable | significant changes |
| Compensation system (e.g., tort or no-fault) | stable | significant changes |
| Retention of the insurer | stable | change over the<br>experience period |

A change in the Standards of Practice effective December 31, 2009 increased the high margin of the claims development from 15% to 20%. While the previous Standards of Practice allowed for actuaries to select a margin above 15% in situations of unusually high uncertainty, in practice very few P&C actuaries selected margins for adverse deviations for claims development greater than 15%.

The intent of the increase in the high margin is to make clearer to P&C actuaries that selection of 20% in times of great uncertainty is acceptable. For example, it may be appropriate for an actuary to select a margin of 20% for the following:

> Automobile insurance in a specific province that is undergoing significant change due to tort reform or legal challenge to recently introduced tort reform,
>
> Introduction of a new line of business or operations in a new province for which there is limited relevant data from which to estimate policy liabilities,
>
> Significant change expected in future claims due to an increase in retentions and limited data for estimating the effect of such a change,
>
> Economic upheaval such as the financial crisis of the fall of 2008 and its effect on long-tail lines of insurance such as directors' and officers' liability.

The above examples are only intended to be illustrative of potential situations for which the actuary may choose to select a claims development margin greater than 15%. However, it is important to recognize that the above situations may not always necessitate a claims development margin greater than 15% and the decision will be based on the actuary's assessment of the uncertainty around the mean estimate.

The change in the high margin from 15% to 20% was not intended to shift all selected margins for P&C insurers. Many actuaries currently select between 10% and 15% for many of the longer-tail lines of P&C insurance. These claims development margins are selected based on a review of the numerous considerations underlying the actuary's estimate of claim liabilities and premium liabilities. It is not expected that these margins would change simply due to the increase in the high margin. However, if there has been a notable change in the environment and in the

actuary's assessment of the various considerations that influence the selection of the margin for adverse deviations, then a change may be justified.

**Margin for Recovery from Reinsurance Ceded**

The following table presents considerations for the actuary when selecting the margin for recovery from reinsurance ceded.

**TABLE 5.2 Recovery From Reinsurance Ceded**

| | **Low Margin Situation** | **High Margin Situation** |
|---|---|---|
| Proportion of related party reinsurance | low | high |
| Ceded loss ratio | low | high |
| Ceded commission rate | low | high |
| Unregistered reinsurance | none | significant |
| Reinsurers under receivership or liquidation | none | significant |
| Reinsurers with weak financial condition | none | significant |
| Signed reinsurance contract/cover notes | yes | no |
| Claim coverage disputes with reinsurers | none | significant |
| Reinsurance with balance sheet exposure[3] | limited or none | significant |

**Margin for Investment Return Rates**

The margin for adverse deviations for investment return rates addresses several different types of risk, such as

mismatch risk between payment of claims and availability of liquid assets,

error in estimating the payment pattern of future claims, and

asset risk including credit/default risk and liquidity risk.

The following table summarizes considerations related to the selection of an explicit margin for investment return rates.

[3] Balance sheet exposure is defined as: ceded unearned premium + outstanding loss recoverable from assuming company + amounts due from assuming company – amounts due to assuming company – cash or securities held as security from assuming company.

**TABLE 5.3 Investment Return Rates**

| | **Low Margin Situation** | **High Margin Situation** |
|---|---|---|
| Matching of assets and liabilities | cash flows are well-matched | significant mismatch of cash flows |
| Quality of assets | high | low |
| Reliance on capital gains | minimal | high |
| Capital losses | minimal | high |
| Length of claim settlement period | short | long |
| Claim payment pattern | stable | significant variability |
| Determination of interest rate | based on insurer's asset portfolio | not based on insurer's asset portfolio |
| Projected cash flow | positive | negative |
| Asset default risk | low | high |
| Asset valuation issues | none | significant |
| Concentration by type of investments | not a concern | significant concern |
| Concentration within types of investments | not a concern | significant concern |
| Current economic conditions | strong economy | recession |
| Investment expenses | low | high |

It is important for actuaries to recognize that in an economic environment of low interest rates, mismatch risk and credit/default risk remain nevertheless. While following Standards of Practice, an actuary could derive a discount rate adjusted by margin for adverse deviations that is less than 0%. In practice, actuaries may limit the discount rate to 0% in such situations.

Two alternative formula-based approaches for deriving the margin for investment return are described below. These approaches should not be considered to be an exhaustive list of acceptable methods, but rather as examples of the types of quantitative approaches actuaries could consider when determining the explicit margin for investment returns. These formulas assume a non-stochastic approach and thus the resulting margins would be subject to the limits set out in the explicit margin approach (i.e., low margin limit of 25 basis points and the high margin limit of 200 basis points).

**Weighted Formula**

The weighted formula relies on defined variables,

*i*PM = interest rate for discounting based on notional matching of the individual insurer's portfolio of assets to claim liabilities prior to margin for adverse deviations

*i*AM = interest rate for discounting after margin for adverse deviations

*i*RFM = interest rate of risk-free bonds, which reasonably match the payout of the claim liabilities, at least as measured by duration

*k* = a factor between 0% and 100% to reflect a reasonable estimate as to the percentage by which *i*RFM would need to be adjusted to reflect a plausible shortening of the uncertain duration of the claim liabilities due to misestimation of the payment pattern coupled with a plausible shift in the yield curve.

The formula for *i*AM, the interest rate for discounting after margin is

$$i\text{AM} = \text{minimum}\ (i\text{PM},\ i\text{RFM} \times (1.00 - k)),$$

and, thus, the margin for investment return rate is defined to be

$$\text{Margin for Adverse Deviations} = i\text{PM} - i\text{AM} = i\text{PM} - \text{minimum}\ (i\text{PM},\ i\text{RFM} \times (1.00 - k)).$$

This approach treats the market spread between the return on matched risk-free bonds and other investments as a risk premium (whether from liquidity risk, default risk, or other risks) which would be removed for discounting purposes. A high value of *k* would result in a higher margin for adverse deviations, and a low value of *k* would result in a lower margin. An advantage of using this type of formula is that it is easily adaptable to the principles-based approach of IFRS Phase 2.

**Explicit Quantification – Three Margins**

This approach estimates the margin for investment return as the sum of three margins,

asset/liability mismatch risk margin,

timing risk margin, and

credit risk margin.

**Asset/Liability Mismatch Risk Margin**

The asset/liability mismatch risk margin is based on the formula,

coverage ratio

× (asset duration – liability duration)/liability duration

× interest rate movement in run-off period

where,

$$\text{coverage ratio} = \frac{\text{premium liability + claims liability}}{\text{investments + installment premiums}}$$

The actuary could estimate the interest rate movement in the run-off period based on a review of the interest rate movement over an extended period of time (e.g., twenty-five to fifty years).[4]

For example, assume the liability duration is two years. The actuary could then review the two-year change in investment rates as follows:

Y$i$ = base year yield,

Y$i$+2 = yield two years after $i$,

(Y$i$+2 –Y$i$) / Y$i$ = two-year change.

The interest rate movement in the run-off period could be estimated by multiplying the base year yield for a risk-free bond with similar duration to the liabilities by one standard deviation of the change for the same duration. For example, assume that the base year yield for three-year government of Canada bonds is 2.68% and one standard deviation of the two-year changes is 29%. Then the interest rate movement in the run-off period is equal to 78 basis points (2.68% x 29%). If the coverage ratio is 100%, the asset duration is five years, and the liability duration is two years, then the asset/liability mismatch risk margin based on the formula is 117 basis points.

[100% coverage ratio × ((5 years – 2 years) / 2 years) × 78 interest rate movement]

**Timing Risk Margin**

The timing risk margin could be estimated using the formula for determining discounted liabilities.

$$\text{Present Value (PV)} = \sum_{t}^{\infty} \frac{L_t}{(1.00+d)^t},$$

where $L_t$ = paid losses in $t$,

$d$ = discount rate, and

$$\sum_{t}^{\infty} L_t = L$$

$$= \frac{L}{(1.00+d)^D},$$

where $D$ = duration of liabilities

If the duration of liabilities, $D$, is shortened by 10%, then the reduction in discount is equivalent to decreasing the discount rate ($d$) by approximately 10%. More precisely,

$$\frac{L}{(1.00+\hat{d})^D} = \frac{L}{(1.00+d)^{0.90D}},$$

where $\hat{d}$ is the discount rate adjusted for timing risk

[4] The reader is referred to the CIA "Report on Canadian Economic Statistics 1924-2008," which can be found at: http://www.actuaries.ca/members/organization/PC/IP/PC_IP_Docs_e.cfm?CODE=IP.

If the liability duration is two years and the discount rate is 3.50%, then $\hat{d}$ is 3.1445%, and consequently, the timing risk margin is 36 basis points (3.50% - 3.1445%).

**Credit Risk Margin**

The final component of this approach is the credit risk margin. The credit risk margin could be estimated by comparing the yield curves of high quality bonds, such as federal, provincial, municipal, utilities, the big five Canadian banks, and other corporate organizations. If a bond produces a higher yield than a risk-free government bond with similar maturity (i.e., a corporate bond generates higher yield than a Government of Canada bond with similar maturity), the investors in the bond market conclude that the issue of that corporate bond has credit risk. The extra yield on the corporate bond represents what the market considers to be credit risk spread; the latter is usually measured in basis points over the government bond with similar maturity.

For illustration purposes, assume that the portfolio has a credit risk margin of 40 basis points.

**Total Margin**

The total margin for investment return is equal to:

Asset/liability mismatch risk margin + timing risk margin + credit risk margin

= 117+ 36 + 40 = 193 basis points

**Other Considerations**

Investment expenses would be deducted from the portfolio yield before any calculations are performed. If the liabilities in a foreign currency are greater than the supporting assets in that foreign currency, then foreign exchange risk would be considered. Finally, if the bond portfolio is not sufficient to support the policy liabilities, the preferred and common stock expected total return rate would be included in the calculation.

Sometimes, bond investors demand liquidity and prefer government bonds over corporate bonds. This could increase the yield on corporate bonds as well as the difference between the bid and asked prices. However, this preference is difficult to quantify. Except in a chaotic market (e.g., September 2008 – March 2009), the extra yield due to poor liquidity would be ignored.

## 6. RELEVANT STATISTICAL CONCEPTS[5]

The subject of risk margins has received extensive review by numerous international organizations in the past several years including the IAIS, the IASB, and the IAA. Increasingly, actuaries and other insurance professionals are turning to advanced statistical methods as well as internal models for the analysis of risk margins. It is important to recognize that these are evolving areas with ongoing research, both theoretical and practical, by actuaries working with P&C insurers.

It is not the intent of this educational note to present a detailed discussion of statistics. It is expected that actuaries using stochastic methods for the determination of margins for adverse deviations have expertise in the fundamentals of statistical modeling, which are not addressed in this educational note. This section, however, briefly describes key risk concepts needed to understand and evaluate stochastic risk margin approaches. These key concepts include a risk

[5] Much of this section is copied directly from the IAA Risk Margin Report.

distribution, normal distribution, standard deviation, coefficient of variation (CV), skewness, and the rate at which claim or contract obligations, as applicable, are settled.

A risk distribution (or, simply, distribution) gives the probabilities that different outcomes of an uncertain process will occur. The normal distribution is a well known probability distribution. It has a form that requires two parameters, the mean (or probability-weighted average) that indicates its central point and the standard deviation that indicates its width or uncertainty. The normal distribution is sometimes described as well-behaved for the following reasons. First, it is symmetric in that, for each "good news" scenario, there is an identical and equally likely "bad news" scenario. Second, risk measures such as confidence levels and conditional tail expectations depend only on the standard deviation. Thus, there is a fixed relationship between risk measures based on standard deviation, confidence levels, or conditional tail expectations. Finally, the central limit theorem demonstrates that the sum of any set of homogeneous and uncorrelated risks will approximate the normal distribution as the number of risks increases to infinity.

However, the normal distribution is often not appropriate for P&C insurance situations, since there are rarely enough risks involved, individual risks are seldom symmetric, and the risks are usually correlated through inflation, environmental factors, court decisions, etc. The total claim distribution is only similar to "normal" in extremely large portfolios of risks with, at most, partial correlations involved.

The relative width of a risk distribution can be defined by its CV, which equals the standard deviation divided by the mean. This statistical measure is useful because a standard deviation of 1 million is small if the mean is 100 million, but large if the mean is 500,000. The CV is 1% in the first case and 200% in the second case.

Most P&C insurance risks have a high probability of having no claim or contract obligation during a reporting period. In some cases there may be a small probability of having a partial or small claim amount or obligation, with an even smaller probability of having a large claim. Statistically, distributions like this are described as having 'positive skewness' or being 'skewed'. They involve a parameter that represents the degree of skewness (represented by $\gamma$, the Greek lower case gamma) that is greater than zero. The normal distribution, because it is symmetric, has zero skewness.

Combining many contracts in a pool or portfolio often reduces but does not eliminate skewness. For some types of coverage, natural catastrophe coverages, for example, combining contracts may not reduce skewness, since such loss events either do not occur or arise under many contracts simultaneously.

Another factor that can affect the value of a risk margin is the time it takes to settle a claim or contract obligation. The risk distribution and the settlement times can be related, as claims or obligations that take longer to settle often have greater skewness and larger CV.

## 7. STOCHASTIC TECHNIQUES

Stochastic simulations can be powerful techniques for quantifying risk exposures underlying P&C insurance policies. These methods generate many possible future paths for the underlying variables, thereby producing a probability distribution of values for the risks. Such techniques can permit a deep understanding of the risk/return profile and allow for effective pricing, valuation, and management. However, as with any sophisticated tool, users require a full understanding of stochastic risk modeling for successful implementation and rational interpretation.

Actuaries using stochastic approaches to determine margins for adverse deviations may also be using stochastic methods in their determination of policy liabilities (i.e., claim liabilities and/or premium liabilities). As it is beyond the scope of this educational note to address stochastic modeling techniques except as they apply to the determination of provisions for adverse deviations, the reader is referred to the CIA's August 2001 Research Paper, Use of Stochastic Techniques to Value Actuarial Liabilities under Canadian GAAP prepared by the Working Group on the use of Stochastic Techniques (Working Group) of the Committee on Life Insurance Financial Reporting. Specifically, the PCFRC recommends a review of

> Section 3. When to Use Stochastic Simulation Methods for Actuarial Liability Valuation,
>
> Section 4. General Overview of the Stochastic Valuation Method for Actuarial Liability Valuation,
>
> Section 6.5. Correlation, and
>
> Section 7. Practical Issues.

As noted above, actuaries who derive margins for adverse deviations using stochastic methods may derive their estimate of policy liabilities using these same stochastic methods. There is a growing interest by P&C actuaries for the use of stochastic and advanced statistical techniques applied directly to the claim development triangles, such as the Thomas Mack method or the bootstrapping method. The Mack method derives formulas for the standard error of the reserves projected by the chain ladder method. The bootstrapping method is a sampling technique that generates empirical probability distributions by using sampling with replacement in historical data. The literature on these subjects is expanding rapidly. Many commercial P&C reserving software programs now contain these applications.

Actuaries using stochastic techniques for developing margins for adverse deviations would also take into account the considerations presented in section 5 of this educational note. For example, if an actuary's stochastic analysis resulted in a claims development margin for adverse deviations of 5%, while a review of the considerations related to operations, data, and the line of business resulted in a high margin assessment, the actuary would then reconsider the selection of a 5% margin for adverse deviations. Similarly, if an actuary's stochastic analysis resulted in a claims development margin for adverse deviations of 20%, while a review of the considerations related to operations, data, and the line of business resulted in a low margin assessment, the actuary would then reconsider the selection of a 20% margin for adverse deviations.

Actuaries considering a change from a deterministic approach to a stochastic approach for the determination of margins for adverse deviations would engage in discussions with the insurer's management and auditors to determine if such a change in approach represented a potential change in accounting policy. An important consideration would be the materiality of any resulting change. Since stochastic techniques may be more subject to variability from valuation date to valuation date, ongoing communication between the actuary and the insurer's management and auditors may be required.

When using stochastic models, it is important for the actuary to recognize that the provisions for adverse deviations do not cover the inherent or statistical volatility arising from a particular model. It is expected that large and small insurers would generate similar margins for adverse deviations when using the same model. The provisions do, however, cover the uncertainty in whether the actuary has the "right" model or "right" parameters. Thus, an actuary working with large volumes of data or more years of experience will likely have more confidence that the

selected model is "correct" and the resulting margins will likely be lower for larger volume or more established data than for smaller volume or less reliable data.

**Mandating Assumptions for Stochastic Techniques**

In the CIA 2001 Research Paper, the Working Group noted that it struggled with the issue of offering some prescription around the setting of assumptions. Offering "standard assumption corridors" for certain processes and/or risk factors would mean, by implication, that the actuary would have the responsibility to justify using values outside the given range. While this would offer valuable guidance to practitioners and might narrow the range of accepted practice, the working group concluded that establishing reasonable ranges for broad use (by life insurers) was impractical, inappropriate, and unmanageable for the reasons that

it would entail very significant and time-consuming testing and review of experience data from across the industry,

it would potentially require a large number of possible assumptions or variations in assumptions to be covered,

it would be difficult to anticipate all the unique company circumstances that can legitimately affect the valuation results and therefore cause the prescription to be inappropriate,

ranges would need periodic updating to reflect emerging experience, and

it would undermine the integrity and responsibility of the Appointed Actuary.

These considerations are equally applicable to P&C insurers today, and so this educational note does not include mandated assumptions for the use of stochastic techniques. The actuary is reminded of his or her responsibility to ensure that the methods, assumptions and approximations used in the valuation of policy liabilities are reasonable and appropriate to the contracts being valued and furthermore that this responsibility is typically magnified when the valuation employs some form of stochastic testing.

**Sample Products**

Stochastic modeling will typically be of benefit when dealing with products characterized by skewed cost distributions with low frequency of occurrence, but high severity of impact and/or material variability in the cost distribution. For example,

stop loss reinsurance,

catastrophic P&C insurance risks,

credit, warranty, and mortgage guarantee insurance, and

long-tail lines of business such as professional liability.

**Stop Loss Reinsurance**

Individual stop loss cover is used by insurers to limit their risk exposure to the claims costs incurred by a specific covered insured to a threshold (or deductible) amount over a specified time period. Aggregate stop loss is used by insurers to limit their risk exposure to the claims costs incurred by an aggregated number or group of specific risks. Stop loss reinsurance may be evaluated by simulating the random variables that affect the insured event. The skewness of the cost distribution typically will increase as the threshold level is increased.

**Catastrophic P&C Insurance Risks**

Given the occurrence of an insured catastrophic event shortly before the valuation date, the actuary may find stochastic methods valuable for estimating claim liabilities. An insured catastrophic event may be evaluated by simulating the effects of the particular catastrophic event using stochastic models to provide a representation of the severity using methodologies based on various analytical, engineering, and empirical techniques.

**Credit, Warranty, and Mortgage Guarantee Insurance**

Credit, warranty, and mortgage guarantee are examples of P&C insurance lines in which coverage can extend for many years, and thus there can be significant premium liabilities at the financial reporting date. The financial results of these lines can be highly dependent on economic forces such as inflation, interest rates, and unemployment, with significant correlation between classes of business. As such, these lines of business can be subject to aggregation of losses driven by high frequency related to economic or other circumstances. While the claim liabilities and margins for adverse deviations may be estimated using traditional, deterministic approaches, stochastic modeling of the premium liabilities and their associated margins for adverse deviations may be more appropriate for these lines of insurance.

**Long-tail lines of business**

The distribution of unpaid liabilities for long-tail lines of business may be quite volatile and be subject to external forces such as inflation, both economic and social, judicial changes, and regulatory changes. Stochastic analyses of loss development factors and/or frequency and severity may be valuable to the actuary estimating claim and premium liabilities.

## 8. THREE P&C PRODUCT EXAMPLES

In order to compare the risk margin approaches on a consistent basis, the IAA Risk Margin Report presents a set of assumptions that covers a spectrum of insurance products. The following table summarizes the assumptions used by the RMWG of the IAA for three P&C insurance products.

| | **Sample Lines of Business** | | |
|---|---|---|---|
| | **Product A** | **Product B** | **Product C** |
| 1. Notional Coverage Type | Automobile Third Party Liability | General Liability "Risky Liability" | Catastrophe Coverage |
| 2. $\gamma$ (gamma) (Measure of Skewness) | 0.4 | 0.8 | 8 |
| 3. Coefficient of Variation (CV) | 13.3% | 26.1% | 151.3% |
| 4. Settlement pattern | medium | longer | medium |
| 5. Risk distribution | Normal Power | Normal Power | Lognormal |

The skewness, CV, and payment pattern are discussed in detail in Appendix C of the IAA Risk Margin Report. The risk distributions for the automobile third party liability (TPL) and general liability products are compound Poisson models represented by the normal power approximation with the selected skewness and CV. For these two lines, the normal power approximations are very similar to lognormal distributions with the selected CVs.

The RMWG notes that the risk distributions and settlement patterns used in the IAA Risk Margin Report are illustrative, as are the notional coverage descriptions. There is a range of variation

within each coverage, and there are coverages with characteristics that fall outside the range of these illustrations. In particular, a substantial portion of P&C premiums is for business with similar risk characteristics to Products A and B (personal and commercial property, respectively) but with a short settlement pattern. These short-tail lines, however, contribute a much smaller proportion of total liabilities.

The next two sections of the educational note refer to these three product examples.

## 9. QUANTILE APPROACHES

Establishing which statistical measurement is most appropriate for the determination of margins for adverse deviations based on stochastic techniques is an important decision. The difference between the selected measurement and the mean result (with explicit margin for adverse deviations applied to all non-stochastic variables) establishes the dollar provision for adverse deviations for the scenario tested assumptions.

This section discusses quantile approaches for the determination of margins for adverse deviations based on stochastic techniques. Specifically, the approaches addressed are

multiples of the standard deviation,

percentile or confidence levels, also known as Value at Risk or VaR, and

CTE, also known as Tail Value at Risk or TVaR.

These methods are among those suggested in the IAA Risk Margin Report[6] and by the IASB (2007 Discussion Paper Part II Appendix F9, page 36-37).

### Multiples of Standard Deviation[7]

Simplicity and practicality are the two most often cited advantages of using a multiple of the standard deviation as a basis for determining the margin for adverse deviations.

### Percentile or Confidence Levels

The use of confidence levels is currently the most common quantile method applied. Risk margin methods based on confidence levels express uncertainty in terms of the extra amount that must be added to the expected value so that the probability that the actual outcome will be less than the amount of the liability (including the risk margin) over the selected time period equals the target level of confidence. This level is also sometimes called the value at risk (VaR).

In Australia, general insurance (i.e., P&C insurance) is regulated by the Australian Prudential Regulation Authority (APRA) under the *Insurance Act* of 1973. Prudential Standard GPS 310 requires that provisions for insurance liabilities must include a risk margin[8] above the central

[6] Note that the IAA Risk Margin Report presents three other methods that are not included in this educational note: cost of capital methods, discount methods, and conservative assumptions in the current estimate producing implicit risk margins.

[7] Although multiples of the second and higher moments of the risk distribution are identified as a type of approach that might be used to establish a value for risk margins, the IAA Risk Margin Report does not expand on this approach. Instead it notes that, "Variance, semi-variance or higher moment methods are not illustrated here, as there is currently no literature on their practical applications in determining risk margins for liabilities."

[8] GPS 310, Section 77 states that, "The valuation of insurance liabilities for each class of business must comprise:… (c) risk margins that relate to the inherent uncertainty in the central estimate values for **outstanding claim liabilities and premium liabilities**." Allowance for diversification or reinsurance or both can be made in determining the risk margin."

estimate value of those liabilities. The risk margins are calculated for each class of business and the aggregate of those risk margins must be greater than

> the margin that would give the provision a 75% level of sufficiency to meet the insurance liabilities, or
>
> one half of the estimated standard deviation of the insurance liabilities of the insurer.

Singapore and South Africa also require that claim liabilities include a minimum provision for adverse deviations based on a 75% confidence level. While these three countries have set a 75% confidence level threshold in their respective insurance legislation, it is important to note that there is currently no generally accepted method (from a regulatory, accounting, or actuarial perspective) for determining an appropriate quantile for the purpose of determining risk margins.

**CTE**

The CTE is a conditional expected value based on downside risk and can be defined as the average of outcomes that exceed a specified value such as the Qth percentile. CTE(Q%) is calculated as the weighted-average of the highest (100-Q)% of the results from stochastic simulation. For example, a $75^{th}$ percentile CTE result is the mean result of the 25% highest cost scenarios. By way of comparison, CTE(0%) is, by definition, equal to the overall mean result since it is the average of all scenarios.

For life insurance, the Standards of Practice (paragraph 2320.51) state that

> "If the selection of scenarios is stochastic, then the actuary would adopt a scenario whose policy liabilities are within the range defined by
>
> > the average of the policy liabilities which are above the $60^{th}$ percentile of the range of policy liabilities for the selected scenarios, and
> >
> > the corresponding average for the $80^{th}$ percentile."

Thus, the Standards of Practice for life insurers require that margins for adverse deviations be between CTE(60%) and CTE (80%).

The 2001 Research Paper states that,

> "Setting the liabilities [for life insurers] in excess of CTE(80%) would not normally be an acceptable practice as the resulting coverage would be excessive and inconsistent with GAAP. Provision for more catastrophic, implausible or unknown events is done through required capital, which would normally be established at a much higher CTE%."

Unlike life insurance, there is no specific statistical measurement or percentile mandated by the Standards of Practice for P&C insurance. The examples prepared by the RMWG of the IAA, indicate that a range of CTE(60%) to CTE(80%) is likely too high for many traditional P&C lines of insurance.

**Three P&C Product Examples**

In the IAA Risk Margin Report, the risk margins for the three sample products are first presented as the number of standard deviations above the mean required to reach the selected confidence level and then as a percentage of the discounted current estimate. Recall that Product A is representative of automobile third party liability, Product B of "risky" general liability, and Product C of catastrophe coverage.

**Table 9.1 Risk Margins at Selected Confidence Levels**
**Number of Standard Deviations[9]**

| Product | γ (gamma) | Number of Standard Deviations Above the Mean Required to Reach Selected Level of Confidence | | | | |
|---|---|---|---|---|---|---|
| | | Confidence Level | | | CTE | |
| | | 65% | 75% | 90% | 40% | 75% |
| A | 0.4 | 0.33 | 0.64 | 1.32 | 0.63 | 1.33 |
| B | 0.8 | 0.27 | 0.60 | 1.37 | 0.62 | 1.30 |
| C | 8.0 | (0.11) | 0.10 | 0.81 | 0.38 | 1.08 |

**Table 9.2 Risk Margins at Selected Confidence Levels**
**Risk Margin as % of Discounted Current Estimates**

| Product | γ (gamma) | Percent of Discounted Current Estimate | | | | |
|---|---|---|---|---|---|---|
| | | Confidence Level | | | CTE | |
| | | 65% | 75% | 90% | 40% | 75% |
| A | 0.4 | 4.4% | 8.5% | 17.6% | 8.4% | 17.6% |
| B | 0.8 | 7.1% | 15.7% | 35.7% | 16.2% | 33.9% |
| C | 8.0 | -16.0% | 15.1% | 123.2% | 51.7% | 164.6% |

The risk margins illustrated in Tables 9.1 and 9.2 assume that the risk would be measured separately for each line of business based on the experience of the reporting entity alone.

Comparing the number of standard deviations to confidence levels,

If the risk distribution is normal, the number of standard deviations to achieve a particular confidence level would be constant between products.

Since the risk distributions for these contracts are not normal, the number of standard deviations from the mean to achieve a particular level of confidence decreases as the risk distribution becomes more skewed. For example, Table 9.1 shows that the number of standard deviations from the mean to achieve the 65% and 75% confidence levels decreases as the risk distribution becomes more skewed (i.e., reading down the column).

Conversely, in order to have the risk margin at the same multiple of the standard deviation for all contract types, the confidence level would be larger for distributions with more skewness.

Using a risk margin equal to a fixed number of standard deviations produces positive risk margins, even for highly skewed distributions.

In both tables above, for the extreme case (Product C), the risk margin for the 65% confidence level is negative, meaning that the 65% confidence level is lower, not higher

[9] Simulation analysis was conducted to reproduce the findings in the IAA Risk Margin Report. All findings were verified except the number of standard deviations at CTE(40%) and CTE(75%) for Product C. The values in Table 9.1 reflect the calculations prepared on behalf of the PCFRC and not those contained in the IAA Risk Margin Report.

than the mean of the distribution. This shows that at least for certain extreme distributions, use of confidence levels without some adjustment may not give appropriate risk measures. In Australia, for example, supervisory risk margins for general insurance are based on a 75% confidence level, subject to a minimum of one-half standard deviation.

Using CTE rather than confidence levels produces risk margins that are consistent with confidence level risk margins for the less skewed distributions, but does not decrease or produce negative risk margins with increasing skewness, even for the most skewed distributions.

Comparing the CTE to number of standard deviations, we note that if the standard deviation is considered as a risk measure, the results for the less skewed products are consistent with confidence level and CTE. For example, the 75% confidence level corresponds to approximately 0.65 standard deviation above the mean for products A and B. However, for the very risky product C, the CTE risk measures require a margin equal to more standard deviations than less skewed products. The CTE is therefore more risk sensitive than the number of standard deviations and may be a better risk measure for risks with skewness at the extreme end. Ultimately, it can be said that the number of standard deviations may be a more consistent measure for expressing profitability, while CTE is more relevant to measure security.

**Evaluation of Quantile Methods**

In evaluating the various methods for developing risk margins, the IAA Risk Margin Report suggests that two aspects of insurance liabilities be considered to measure risk margin,

time – the rate at which risk is released over time (i.e., settlement pattern), and

shape – the risk distribution of possible outcomes around the mean value, at the reporting date, over a specified time horizon.

The IAA paper applies the term quantile methods to a group of methods that rely only on the *shape* aspect of risk. In the examples, shape was measured variously by standard deviation, confidence levels (VaR or percentiles), and CTE. For each of these shape measurement statistics, the method requires one parameter, number of standard deviations (e.g., 0.6), the confidence level (e.g., 75%), or the CTE level (e.g., 40%), respectively.

Comparing the three quantile methods illustrated in section 9, it is observed that within the range of most contracts the risk margin based on confidence levels does not increase with increasing skewness of the product risk distribution. Increasing margins with increasing skewness is a property that is considered desirable in a risk margin. In the examples, the CTE and standard deviation measures did behave as desired in that respect.

Products with longer settlement times tend to have riskier shapes than products with shorter settlement times, but there is no direct relationship between time and risk as measured by the quantile methods, according to the IAA paper. The IAA paper continues with the comment,

> "A quantile method will have the same risk margin for a set of obligations that settles over five years as for a set of obligations that settle over two years, if both sets of obligations have the same shape parameter. For example, unpaid claims for a short tail liability product and for excess property product might each have a distribution of settlement amounts described by a log normal distribution with coefficient of variation of, say, 20%. While the property unpaid claims will settle over two years and the liability unpaid claims might settle over five years, both will have the same quantile based risk margins. This assumes the quantile method

> is applied in the usual fashion. Applying an approach that varies with time would solve that issue."

The addition of a measurement for parameter uncertainty is one possible enhancement to a stochastic analysis for the purpose of reflecting the time consideration. For longer-tail lines, there is generally an expectation of greater uncertainty, for example in the older development factors and/or tail factor. A greater degree of parameter uncertainty for liability than for the excess property (referring to the IAA example above) would lead to a greater margin for adverse deviations for liability using quantile approaches.

**Practical Issues and Partial Solutions of Quantile Approaches**

**Selection of Confidence Level or CTE Level**

While practice has developed in some countries, no theory or practice has yet developed to determine what confidence or CTE level relates directly to P&C insurance for the purpose of determining margins for adverse deviations.

**Different Confidence Levels for Different Products or During Claims Runoff**

As shown in the three product examples, it might be appropriate to use different confidence levels for different products. Note that an appropriate methodology to develop a specific level of overall confidence has not yet been developed and it is unclear whether it may exist. Varying the levels chosen by product emphasizes this difficulty. In addition, having different confidence levels by product may make it more difficult to achieve consistency.

During the course of claim runoff, the risk distribution may become wider and increasingly skewed; that is, there are fewer claims and the remaining claims may be larger. As a result, as with differences by product, different confidence intervals by claim runoff year may be necessary to maintain a consistent risk margin for a growing or declining portfolio.

While different confidence levels may be required for different products and years at different levels of maturity, a constant CTE level or a multiple of standard deviations approach might better achieve the desired simplicity.

**Sources of Risk Distributions and Treatment of Extreme Events**

The examples shown previously are based on theoretical distributions. In practice, risk distributions may be partly based on methods such as curve fitting and stochastic modeling.

One difficulty with these techniques is that there is usually insufficient or no information on the effect of extreme events. Among the approaches to address this problem are the use of

- weighted averages of possible scenarios of relevant extreme events (usually those not reflected routinely or at all in the available data), and
- judgmental analysis of particular operational or risk issues (e.g., new claims or underwriting systems or procedures).

In addition, the examples assume that estimates of the probabilities of all outcomes are available. In practice, a complete distribution may not be necessary. For example, there are statistical methods for estimating moments from the data without a deeper knowledge about the complete risk distribution. Also, it may be sufficient to identify the severity of events only at specified probability levels. Stress and scenario testing might be used to provide information regarding the events at the required levels of probability.

Moreover, the risk distribution needs to include provision for the possibility that the underlying model is incorrect in some respects. For example, in estimating expected property insurance outcomes, the assumption that extreme weather conditions are becoming more common may be appropriate. There are some techniques for addressing such risks, but this area remains a matter for ongoing research.

Nonetheless, the degree of potential unreliability of models, particularly for extreme events, even with the mitigation strategies noted above, remains significant, since quantifying this risk can be complicated.

Professional judgment and regulatory, accounting, and professional guidance may be required to determine the appropriate approach.

## 10. COMPARISON OF RISK MARGIN METHODS

This section of the educational note first presents a summary of observations regarding the various methods for determining margins for adverse deviations. The observations are followed by a comparison of the methods from a quantitative perspective and then from a qualitative perspective. The qualitative review includes a comparison of each method to the desirable characteristics of risk margins identified by the IAIS and the IAA.

### Summary Observations

In the quantile family of methods, CTE approaches are theoretically more sound than confidence level approaches, with the differences being significant for products with more skewed risk distributions. Regulatory oversight or actuarial practice would apply higher confidence levels for products with risk distributions that are more highly skewed.

Explicit assumptions are best considered as useful approximations for implementing a quantile method. Consistency among insurance products and between insurance and other industries is challenging using a purely explicit assumption approach.

### Quantitative Comparison

Quantitative comparisons of the methods show that

for Product A, a CTE(40%) is similar to the 75% confidence level,

Product B shows very different results for the 65% and 75% confidence levels. Similar to Product A, the 75% confidence level is close to the CTE(40%).

for Product C, the range of possible risk margins is very wide. Use of the CTE measure or multiple of standard deviations in the quantile method avoids the negative risk margins that would be calculated using confidence levels.

The following table compares the examples from the methods described in section 9.

**Table 10.1 Comparison of Risk Margins from Different Methodologies**

| Risk Margin Approach | Product A | Product B | Product C |
|---|---|---|---|
| 1. 0.5 standard deviations | 6.7% | 13.1% | 75.7% |
| 2. 1.0 standard deviations | 13.3% | 26.1% | 151.3% |
| 3. 65% confidence | 4.4% | 7.1% | -16.0% |
| 4. 75% confidence | 8.5% | 15.7% | 15.1% |
| 5. 90% confidence | 17.6% | 35.7% | 123.2% |
| 6. 40% CTE | 8.4% | 16.2% | 51.7% |
| 7. 75% CTE | 17.6% | 33.9% | 164.6% |
| | | | |
| Notional Coverage Type | automobile third party liability | general liability "risky liability" | catastrophe coverage |

It is interesting to compare the indicated risk margins in the above table to the range of margins set out in subsection 2260 for deterministic analyses. For product A (automobile third party liability), all risk margin approaches result in a margin for adverse deviations that is within the 2.5% to 20% range. For product B (general liability "risky liability), three of the approaches exceed the 20% high margin: 1.0 standard deviation, 90% confidence, and 75% CTE. For product C (catastrophe coverage), only the 75% confidence produces a margin for adverse deviations that is within the range specified in subsection 2260 for claims development.

A selection above the 20% high margin is still possible as mentioned in paragraph 2260.04 of the Standards of Practice, "A selection above this high margin for adverse deviations would be appropriate, however, for unusually high uncertainty". Furthermore, paragraph 2270.03 of the Standards of Practice states, "a selection above the high margin for adverse deviations set out in paragraph 2260.02 may be appropriate when stochastic modeling indicates variability in estimates of policy liabilities that may not be identified using deterministic analysis."

**Qualitative Comparison**

This final section compares the various risk margin approaches described in this educational note (i.e., explicit assumptions, multiple of standard deviation, confidence level, and CTE) with the desirable characteristics identified in section 3.

**Compliance with the Five IAIS Characteristics**

The five characteristics identified by the IAIS, from section 3, are repeated here for convenience.

a. The less that is known about the current estimate and its trend; the higher should be the risk margins.

b. Risks with low frequency and high severity should have higher risk margins than risks with high frequency and low severity.

c. For similar risks, contracts that persist over a longer timeframe should have higher risk margins than those of shorter duration.

d. Risks with a wide probability distribution should have higher risk margins than those risks with a narrower distribution.

e. To the extent that emerging experience reduces uncertainty, risk margins should decrease, and vice versa.

There are two possible interpretations of characteristic c. One interpretation is that

> liabilities that persist over a longer timeframe have increased exposure to risks, and hence will have higher risk margins, than shorter tail liabilities that are otherwise exposed to similar risks. We call this c-1.

Another interpretation is that

> for two sets of liabilities with the same riskiness in their distribution of ultimate settlement values (i.e., having similar risks) the risk margin should be higher for the liabilities that settle over a longer time period. We call this c-2.

For example, unpaid claims for short tail liability coverage and for excess property coverage might each have a distribution of settlement amounts described by a lognormal distribution with a coefficient of variation of 20%. The property unpaid claims will settle in two years; and the liability unpaid claims might settle in five years. From a quantile perspective the two sets of unpaid claims would have the same risk margin, without adjustment or refinement in the modelling process (i.e., adjustment for parameter uncertainty).

An assessment of the methods against these characteristics, which are referred to as the six extended IAIS characteristics, including both c-1 and c-2 follows.

**Explicit Assumptions**

Although explicit assumptions could be constructed in a manner to address the characteristics, they do not necessarily satisfy any of the characteristics. Each product would need its own set of assumptions.

As an implementation approach, explicit assumptions, selected by product, could be made to approximate the percentile method. If the approximation were sufficiently close, the explicit assumption approach would satisfy the characteristics to the same extent as the method it approximates.

**Quantile Methods**

All of the quantile methods fail characteristic c-2. Consider two products that have the same risk distribution for unsettled contract obligations at the reporting date, but have obligations that involve settlement over two different time periods. To comply with characteristic c-2 the margins would be different. However, the risk margins for the two products, based on the number of standard deviations, confidence level, CTE, or any method that relies only on characteristics of the risk distribution, would not be different.

In addition, the confidence level method does not necessarily satisfy characteristics (a), (b), (d) or (e). In section 9, we show that highly skewed distributions (e.g., Product C) can result in negative risk margins, as increasing skewness is accompanied by a decreasing rate of increase in

risk margins. More generally, the examples also show that, as distributions become more dispersed and more skewed, the risk margins implied by a fixed confidence level include fewer standard deviations. This violates the spirit of characteristics (a), (b), (d), and (e).

CTE and methods based on multiples of the standard deviation generally satisfy characteristics (a), (b), (d), and (e) better than do the confidence level method. Table 9 shows that the CTE method and multiples of standard deviation methods are consistent for the more well-behaved products (A and B), but that the use of CTE is more sensitive to increasing risk than is multiples of standard deviation. However, while CTE is more refined in that it can provide a better insight into the tail amounts, its general approach is similar to that of confidence levels.

**Compliance with IAA Desirable Characteristics**

In the following table, we summarize the IAA characteristics (presented in section 3) and present an assessment of whether or not each method meets or can meet the objective.

**Table 10.2 Comparison of Risk Margins with IAA Desirable Characteristics**

| IAA Desirable Characteristics | Explicit | Deviation | Confidence Level | CTE |
|---|---|---|---|---|
| Consistent methodology for lifetime of contract | achievable | achievable | achievable | achievable |
| Assumptions consistent with current estimates | achievable | achievable | achievable | achievable |
| Consistent with sound pricing practices | not typically used | not typically used | not typically used | not typically used |
| Vary by product based on risk differences by product | yes | yes | yes | yes |
| Easy to calculate | yes | relatively easy | relatively easy | relatively easy |
| Consistently determined between reporting periods | achievable | achievable | achievable | achievable |
| Consistently determined between entities | achievable | difficult without mandated assumptions | difficult without mandated assumptions | difficult without mandated assumptions |
| Facilitate useful disclosure to stakeholders | achievable | achievable | achievable | achievable |
| Provide useful information to users of financial statements | achievable | achievable | achievable | achievable |
| Consistent with regulatory solvency and other objectives | yes | yes | yes | yes |
| Consistent with IASB objectives (i.e., market consistent) | unknown | unknown | unknown | unknown |

All of the methods can be applied based on a consistent methodology for the entire lifetime of the contract. Moreover, to the extent that each of the methods utilizes assumptions relevant to current estimates, they would be implemented in a manner consistent with emerging experience as the experience affects the current estimates.

Within the current Canadian P&C environment, none of the methods is currently used extensively for pricing purposes. The fourth IAA desirable characteristic relates to consistency among classes of business. While, all methods vary by product based on risk differences in the product, the previous section expands on this discussion. A comparison of each method to the IAIS desirable characteristics shows that some methods are more responsive to the variability by product than others.

The fifth IAA desirable characteristic is ease of calculation. We consider the mechanical application of formulas or the use of models that require no judgemental inputs to be "easier" than methods that require judgement in addition to the calculations. Methods that require fewer simulations of future results are also characterized as easier than methods that require more extensive simulations of future results.

The minimum level of likely disclosure would be the amount of risk margin and the basis for deriving that amount. Any approach would allow for the minimum level of disclosure.

For the quantile methods, the methodology chosen and the key parameters in the calculations would be disclosed. Note that it is always a challenge to describe actuarial methods and parameters in a layperson's terms. However, there is no method for which such disclosure would not be possible.

To the extent that market-consistency is required as a principle guiding the measurement or as a tool to enhance consistency based on an external benchmark, there are limitations in the methods presented in this educational note. None of the approaches resolve the issue that there may not be information about how market participants assess the risk to be measured.

## 11. DOCUMENTATION AND REPORTING

The Standards of Practice (subsection 1560) state, "Documentation is an integral part of work that affects the application of nearly all standards... Appropriate documentation describes the course of the work and the actuary's compliance with accepted actuarial practice." Thus, the actuary would document his or her process for determining margins for adverse deviations.

Documentation is important regardless of whether the actuary uses explicit assumptions or stochastic techniques for the determination of margins for adverse deviations. Actuaries following the explicit assumptions approach would document the considerations that were critical in their selection of margins for adverse deviations. Actuaries conducting stochastic analyses would document what components are modeled as random variables as well as the primary assumptions (e.g., selected distributions and parameters). The documentation for both explicit assumptions and stochastic techniques would include support for key decisions made by the actuary.

With respect to reporting, it would normally be in the user's interest to be aware of the margins for adverse deviations selected by the actuary. Accordingly, it seems reasonable that the actuary would consider some disclosure regarding the margins for adverse deviations within the actuarial work product for both internal user and external user reports.

However, this consideration would also take into account the complexity of the concept of margins for adverse deviations, the potential importance of the concept to the user, as well as the sophistication of the user who will be receiving the work product. In some cases, it may be apparent that extensive discussion of the margins for adverse deviations is likely to give rise to misunderstanding and confusion. In other cases, full disclosure of the process and rationale for selecting the margins for adverse deviations may be appropriate.

According to subsection 1820 of the Standards of Practice – Reporting: External User Report,

> 1820.07 "Appropriate description and disclosure in a report strike a balance between too little and too much. Too little disclosure deprives the user of needed information. Too much disclosure may exaggerate the importance of minor matters, imply a diminution of the actuary's responsibility for the work, or make the report hard to read."
>
> 1820.08 "The appropriate criterion for description and disclosure is the question: 'What qualitative and quantitative information best serves the user's understanding and decision-making?'"

It is also important for the actuary to communicate with the insurer's auditors, particularly regarding any significant change, either in the value of margins for adverse deviations or the process for determining such values.