A Framework for Assessing Risk Margins

Prepared by the Risk Margins Taskforce (Karl Marshall, Scott Collings, Matt Hodson & Conor O'Dowd)

This is the final version of a draft paper that was presented to the Institute of Actuaries of Australia 16th General Insurance Seminar 9-12 November 2008, Coolum, Australia. The changes between this and the draft are minimal and reflect our view that the fundamental principles and techniques discussed in the draft remain appropriate.

Contents

Abstract

The main purpose of this paper is to propose a comprehensive framework for assessing insurance liability risk margins and to provide practical advice on how to implement it. The key sources of uncertainty are examined and the main quantitative approaches to analysing uncertainty discussed, including commentary on the advantages and disadvantages of each approach. The framework recognises, however, that quantitative analysis of historical data cannot alone capture adequately all aspects of future uncertainty. There will always be a need for judgement to be applied and in many situations such considerations will dominate the risk margin assessment. The application of judgement, however, is arguably the most difficult aspect of any attempt to estimate future uncertainty and assess appropriate risk margins. Our paper examines the key judgmental aspects and introduces a structured approach to combining these qualitative considerations with the results of any available quantitative analysis.

Keywords: framework, risk margins, uncertainty, APRA, independent risk, systemic risk.

1. Introduction

1.1. Preamble

General Insurance actuaries in Australia have, for many years, been analysing the uncertainty involved in the claim process with a view to assessing appropriate risk margins for inclusion in insurance liabilities. The approaches adopted to date range from those that involve little analysis of the underlying claim portfolio to those that involve significant analysis of the uncertainty using a wide range of information and techniques, including stochastic modelling.

The Risk Margins Taskforce was created to provide GI actuaries in Australia with support and guidance in the assessment of risk margins. In particular, it was felt that actuaries would benefit greatly from a stronger awareness of the key considerations when analysing uncertainty and the tools at their disposal when undertaking such analysis. A better equipped actuarial profession could feel more confident that key stakeholders, including APRA, insurance company boards, senior management and auditors, better understand the nature of and feel more comfortable with the quality and consistency of actuarial advice in this area.

The main purpose of this paper is to propose a comprehensive framework for assessing insurance liability risk margins and to provide practical advice on how to implement it. The key sources of uncertainty are examined and a combination of quantitative and qualitative approaches to their measurement explored.

1.2. Current approaches to assessing risk margins

In preparation for a presentation to the 2006 Reserving Seminar of the Institute of Actuaries of Australia (IAAust), the Taskforce canvassed a number of actuaries and APRA to gain a better understanding of the range of approaches used in Australia to assess risk margins. This information was supplemented with feedback from the *2006 General Insurance Claims Reserving and Risk Margins Survey*, the results of which were presented at the same seminar.

Although there appear to be a wide range of approaches used by Australian actuaries in the assessment of risk margins it is fair to say that most of the differences relate to the analysis and investigations conducted to parameterise a generally adopted risk margin calculation methodology, rather than the calculation methodology itself. The calculation methodology can be generalised as follows:

- *Coefficients of variation (CoVs)* are determined for individual valuation portfolios or groupings of portfolios, where these groupings include insurance classes made up of relatively homogeneous risks.
- A *correlation matrix* is populated with assumed *correlation coefficients* reflecting the expected correlations between valuation portfolios or groupings of portfolios.
- CoVs and correlation matrices are determined separately for outstanding claim liabilities and premium liabilities and further assumptions made about the correlation between these two components of the insurance liabilities.
- A statistical distribution is selected and combined with the adopted CoVs and correlation coefficients to determine the aggregate risk margin at a particular probability of adequacy.

The approaches used to determine CoVs vary significantly. The least sophisticated approaches involve deriving CoVs using either or both of two papers, *Research and Data Analysis Relevant to the Development of Standards and Guidelines on Liability Valuation for General Insurance* by Bateup and Reed (the Tillinghast paper) and *APRA Risk Margin Analysis* by Collings and White (the Trowbridge paper), both prepared at the end of 2001 (collectively these papers are referred to as the 2001 papers). These approaches often ignore the individual characteristics of the valuation portfolio for which risk margins are being assessed, deferring instead to the characteristics of the portfolios analysed by the authors of the two papers.

More sophisticated approaches include some form of quantitative analysis (stochastic or otherwise) supplemented by a qualitative assessment of the sources of uncertainty not captured by quantitative techniques. One such approach is discussed in the paper, *A Framework for Estimating Uncertainty in Insurance Claims Cost* by O'Dowd, Smith and Hardy, prepared for the IAAust's XVth General Insurance Seminar which was held in October 2005 (the PwC paper).

Anyone who has read the PwC paper will appreciate the similarities between the framework proposed in that paper to the framework discussed in this paper. **The Taskforce is collectively of the view that the PwC paper has significant merit and the concepts advocated by the authors of that paper have played a prominent role in the development of the framework discussed in this paper. We would encourage readers of this paper to read the PwC paper to ensure a more complete understanding of some of the concepts discussed.**

The most common approach to populating the correlation matrix with correlation coefficients is via the deployment of actuarial judgement. Usually the key risks that are considered to cause valuation portfolios to be correlated are considered in turn and the correlation between classes categorised as high, medium or low with each category having associated correlation coefficient values. The techniques deployed in the assessment of correlations range from those that are quite basic and heavily influenced by the benchmark correlation matrices discussed in the 2001 papers to those that take a more methodical approach to analysing the contribution to correlation from each key risk.

It is more the exception than the norm to include a quantitative analysis of past experience in the assessment of correlation effects. The main reason for this is that most quantitative techniques require a significant amount of data, time and cost to produce results that are sufficiently credible and intuitively justifiable. It is more common to see such techniques deployed when assessing more extreme probabilities of adequacy, i.e. well in excess of 90%, rather than probabilities of adequacy around the 75% level.

Generally, the most common distribution adopted to determine the aggregate risk margin at a particular probability of adequacy is the LogNormal distribution. The Normal distribution is also used by some actuaries, particularly at lower probabilities of adequacy where it can generate a risk margin that is higher than a heavier tailed distribution, such as the LogNormal distribution. It is uncommon for actuaries to test the adopted distribution against past experience or, taking a step further, derive a distributional form that explains the shape of the distribution of future claim cost outcomes based on past experience and/or future expectations.

The general risk margins approach adopted by most actuaries is often referred to as a *bolt-on* approach in that separate analyses are conducted to estimate the central estimate of insurance liabilities and the risk margins. The term bolt-on is also generally used to refer to any approach that does not involve the development of a single unified distribution of the entire distribution of possible future claim cost outcomes.

Judgement pervades both the central estimate assessment process and the risk margin assessment process. Also, well fitting models are those that adequately reflect past sources of uncertainty only. For these reasons, it is impossible to develop a purely quantitative model, fitted to the past data, that accurately represents the range of possible future claim cost outcomes. Rather, an approach that advocates internal consistency between the assessment of the central estimate and the sources of future uncertainty around that central estimate is important. The framework discussed in this paper is one such approach. This transparent framework combines quantitative and qualitative analysis, both of which are conducted giving full consideration to the central estimate assessment.

1.3. Practical framework for assessing risk margins

A number of key stakeholders, including Appointed Actuaries, APRA and auditors, have expressed some concern that the wide range of approaches adopted in practice to assess risk margins might lead to significant inconsistencies in the final outcomes, whether those be for regulatory or financial reporting purposes. Actuaries working in this area have also asked for guidance to help them when they are faced with analysing uncertainty. Finally, APRA have indicated that they would like to see more documentary justification of the risk margins adopted by some insurance companies.

With all of this in mind, we have prepared this paper to provide a comprehensive framework for assessing insurance liability risk margins and to provide practical advice on how to use this framework. There are a number of parts to our framework including the provision of guidance and further information on the tools, both quantitative and qualitative, that an actuary may deploy when analysing the uncertainty associated with insurance liabilities. We have included or referred to practical examples of how to deploy parts of the framework.

The proposed framework recognises that quantitative analysis of historical data cannot alone capture adequately all possible sources of future uncertainty. There will always be a need for judgement to be applied and in many situations such considerations will dominate the risk margin assessment. The application of judgement, however, is arguably the most difficult aspect of any attempt to estimate future uncertainty and assess appropriate risk margins. Our paper examines the key judgmental aspects and introduces a structured approach to combining these qualitative considerations with the results of any available quantitative analysis.

In preparing this paper the Taskforce has mainly considered, as a surrounding context, the current risk margin environment in Australia, in particular the percentile, or quantile, approach to determining margins for uncertainty. Having said this, we are aware that international developments, including proposed changes to International Financial Reporting Standards, are likely to overtake us in the not too distant future. We are of the view that the main aspects of our proposed framework can be readily adopted, altered or enhanced to complement analysis of uncertainty in the evolving wider international context.

The framework discussed in this paper can also be considered in the broader context of quantifying the uncertainty associated with reserve risk and underwriting risk for stochastic capital modelling (often referred to as *Dynamic Financial Analysis* or *Internal Capital Modelling*) purposes. In fact, when parameterising these components of a DFA model, one should draw on any analysis conducted for risk margin purposes and expand the framework to encapsulate those aspects of the parameterisation not captured by an analysis conducted specifically for risk margin purposes.

It is not proposed that this risk margin framework will have the prescriptive nature of a professional standard. Nevertheless, it is hoped that the structure and educational benefits it provides will encourage all actuaries to critically examine their current risk margin methodologies and to take from the framework those insights that are helpful to them in their particular situation. Inevitably, each actuary estimating risk margins will need to make their own judgements and this will be driven by their own knowledge and experience. The proposed framework does not attempt to usurp that process. Ultimately this framework is about enabling the profession and stakeholders to feel more confident in the quality and overall consistency of risk margins advice in future.

This is not a paper on stochastic reserving. Nor is it intended to provide all of the answers. Rather, its aim is to equip actuaries to ask the right questions and then proceed to answer these in a methodical and rigorous manner.

1.4. Structure of this paper

In **Section 2**, we present a framework which takes a methodical and rigorous approach to examining each of the key sources of uncertainty and provides a practical and user-friendly platform to help actuaries determine appropriate and justifiable risk margins for their insurance liability valuation portfolios.

Sections 3 and 4 discuss the assessment of independent risk and systemic risk, respectively, providing more practical guidance and considerations for the assessment of these sources of risk with a view to determining risk margins.

The framework is summarised in Table 1. The sections of the paper that address each step are also shown.

Table 1: Summary of risk margin analysis framework

Step	Framework component	Description	Section of paper
1	Portfolio preparation	Determine valuation portfolios, claim groups and techniques to deploy for each claim group	Section 2.3
2	Independent risk analysis	Conduct quantitative analysis, conduct benchmarking where appropriate, conduct retrospective analysis for stable periods	Sections 2.4 and 3
3	Internal systemic risk analysis	Apply balanced scorecard approach to objectively score central estimate valuation methodologies. Conduct analysis to determine appropriate CoVs to map to scores.	Sections 2.5 and 4
4	External systemic risk analysis	Identify, categorise and quantify potential future external sources of systemic risk	Sections 2.5 and 4
5	Analysis of correlation effects	Select correlation coefficients beween valuation classes and between outstanding claim and premium liabilities for internal systemic risk and for each external systemic risk category.	Sections 2.5
6	Consolidation of analysis	Consolidate CoVs and correlation coefficients. Independence assumed between three sources of uncertainty.	Section 2.6
7	Additional analysis	Conduct sensitivity testing, scenario testing, internal and external benchmarking and hindsight analysis.	Section 2.7
8	Documentation	Document the analysis and judgement relating to each step of the framework	Section 2.8
9	Review	Conduct annual reviews of key assumptions in the context of emerging experience. Full deployment of the framework at least every three years, including active interactions with business unit management.	Section 2.8

2. The proposed framework

2.1. Introduction to framework

The proposed framework provides a practical and robust platform that requires a combination of quantitative and qualitative techniques to be deployed to examine the uncertainty associated with assessing insurance liabilities with a view to determining risk margins.

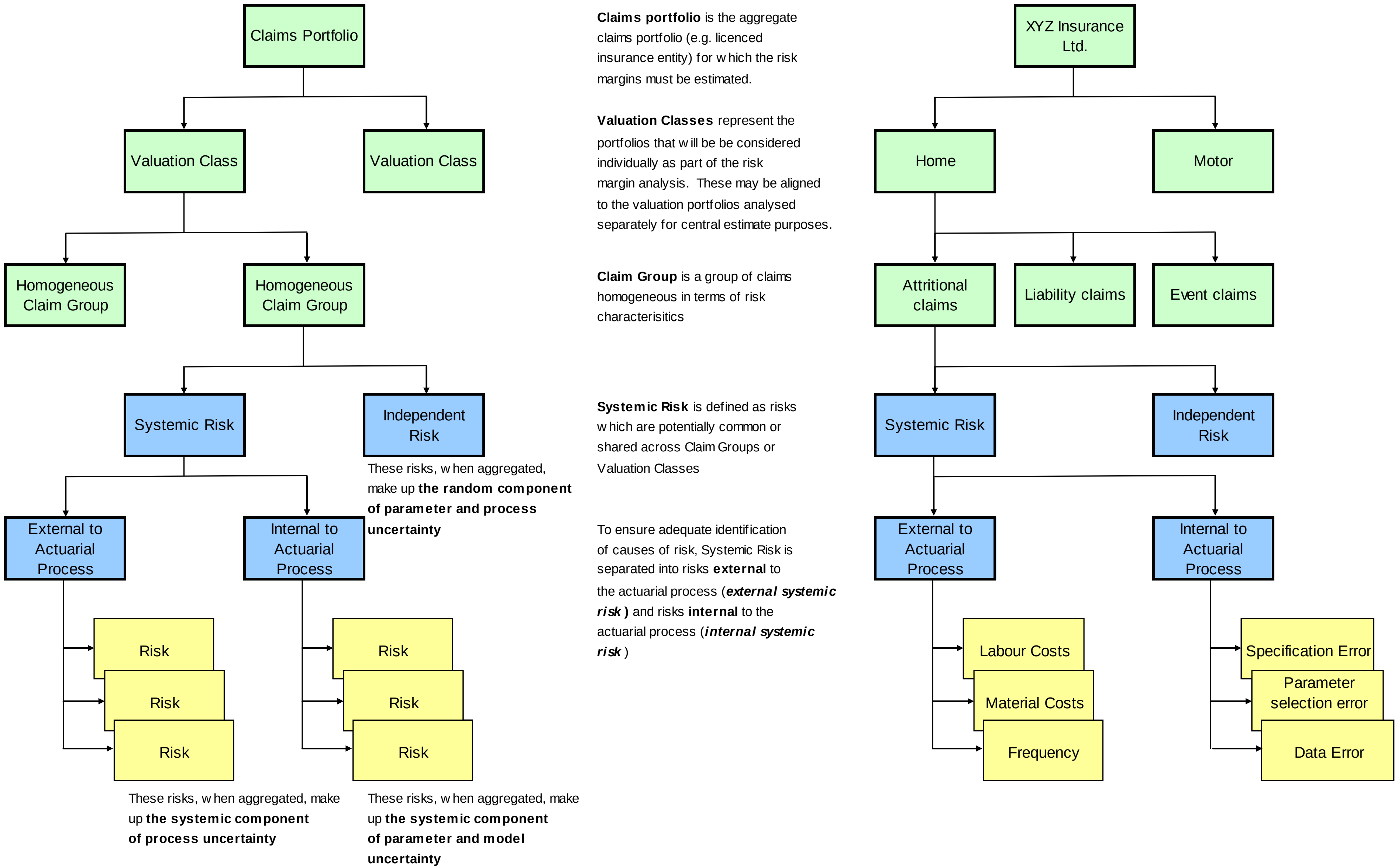
Quantitative techniques alone are insufficient to enable a complete assessment of the various sources of uncertainty. These techniques must be supplemented by qualitative analysis to ensure that all sources of uncertainty are captured. It is common practice for Australian actuaries to adjust the results obtained using quantitative techniques to allow for their known weaknesses. However, this is not always done in a rigorous manner, nor is there much consistency across the profession.

The framework is designed to introduce more rigour and consistency to the risk margin assessment process by encouraging actuaries to examine their own portfolios using a step-by-step process that requires them to ask a number of questions in the context of these portfolios. This will enable judgemental aspects of the process to be better reasoned, justified and documented and ultimately provide more structure in the application and combination of both quantitative and qualitative processes.

It is not expected that all of the techniques discussed in this paper will be used in practice for all valuation portfolios. Rather, if an actuary proceeds through the step-by-step process using techniques suited to their own portfolios, understanding the strengths and weaknesses of these techniques and asking the right questions along the way, they can only be more comfortable that the risk margins adopted are appropriate.

The framework revolves around quantifying the contribution to uncertainty from each of the main sources of uncertainty and is graphically represented in Figure 1 below.

Figure 1: Framework for determining insurance liability risk margins



2.2. Sources of uncertainty

The sources of uncertainty are the cornerstones of the framework. The framework itself has been designed to ensure alignment between the analysis and the techniques deployed with the key sources of uncertainty, ensuring a complete measurement of uncertainty.

At the highest level, the sources of uncertainty can be categorised as belonging to either the *systemic risk* source or the *independent risk* source.

Systemic risk represents those risks that are potentially common across valuation classes or claim groups. Systemic risks arise from two sources:

- Risks internal to the insurance liability valuation process, collectively referred to in this paper as *internal systemic risk*. This source of uncertainty encapsulates the extent to which the adopted actuarial valuation approach is an imperfect representation of a complex real life process. Model structure and adequacy, model parameterisation and data accuracy are all aspects of internal systemic risk. This source of uncertainty is alternatively referred to as *model specification risk*.
- Risks external to the actuarial modelling process, collectively referred to in this paper as *external systemic risk*. Even if the valuation model is an appropriate representation of reality, as it exists today, future systemic trends in claim cost outcomes that are external to the modelling process may result in actual experience differing from that expected based on the current environment and trends.

Independent risk represents those risks arising due to the randomness inherent in the insurance process. Independent risk also arises from two sources:

- The random component of *parameter risk*, representing the extent to which the randomness associated with the insurance process compromises the ability to select appropriate parameters in the valuation models.
- The random component of *process risk* being the pure effect of the randomness associated with the insurance process. Even if the valuation model was perfectly calibrated to reflect expected future outcomes, the volatility associated with the insurance process is likely to result in differences from the perfect expected outcomes.

In the detailed discussion of the framework below, quantitative and/or qualitative techniques are considered and aligned to the assessment and measurement of the internal and external sources of systemic risk and independent risk, the latter incorporating both parameter and process risk.

The nature of traditional quantitative modelling techniques, e.g. bootstrapping and stochastic chain ladder, are such that they are best suited to analysing sources of independent risk and past episodes of external systemic risk. However, they are inadequate alone to capture internal systemic risk or external systemic risk, to the extent that this latter differs from the past. For both systemic risk sources, traditional quantitative modelling techniques must be supplemented by other analysis, both quantitative and qualitative.

2.3. Preparing the claims portfolio for analysis

Before commencing any analysis one must prepare the *claims portfolio* for analysis. The claims portfolio would normally represent the aggregate insurance entity or aggregation of insurance entities for which the risk margin analysis is being conducted.

The claims portfolio should be split into appropriate *valuation classes*. A number of factors will impact how the valuation classes are selected.

An important consideration is whether the valuation portfolio split adopted to determine central estimates of insurance liabilities, or outstanding claim liabilities and premium liabilities where the split is different, should be adopted for risk margin analysis purposes. This would be preferable as it allows the risk margin analysis to be conducted in the context of the central estimate analysis and quantitative and qualitative analysis to be aligned with the key valuation drivers observed as part of the central estimate valuation. One of the attractions of the framework is that each of the sources of uncertainty being analysed can be aligned with the central estimate analysis and appropriate decisions around volatility made in the context of that analysis.

It may not be possible or particularly insightful, however, to conduct quantitative analysis at the same granular level as used for central estimate valuation purposes. The central estimate valuation portfolios may be too small for credible analysis or the valuation portfolio allocation may be at a more granular level than makes practical sense. For example, a large insurer may split its motor and home portfolios by state, product and claim type, resulting in a large number of individual central estimate valuation portfolios. The task of conducting quantitative analysis at the same granular level may be significant, costly and, considering the level of qualitative analysis that will be deployed as part of the assessment, unlikely to materially improve the final outcome. In such cases, quantitative analysis may be conducted on aggregated valuation classes and the results then allocated down, in an appropriate manner, to the valuation classes that are considered appropriate for the deployment of the framework.

In the end, the choice of valuation classes for risk margins analysis purposes will come down to a balance between the practical benefits gained from a higher level portfolio allocation and the potential additional benefit and insights gained from a more granular allocation. When making this decision consideration should be given to the need to retain as much consistency as possible between the central estimate methodology and basis and the risk margin analysis.

Once the claims portfolio has been allocated into risk margin valuation classes, consideration should be given to whether any valuation classes would benefit from a further allocation. For certain portfolios, it will be apparent that different groups of claims are materially more or less uncertain than others and should be treated separately for risk margin analysis purposes. Within each of these *claim groups* there is an element of homogeneity but between claim groups behaviour is expected to be different.

A good example of a valuation class that would normally require further segregation is a home portfolio. These portfolios are normally materially exposed to claims arising from natural peril events. The patterns of development for event claims often differ materially from those for non-event claims. Separate analysis of event and non-event claims will usually provide valuable insights into the past contribution to uncertainty from each of these claim sources with a view to making appropriate assumptions regarding future uncertainty. Also, home liability claims typically behave quite differently from other home claims and should be considered for separate analysis.

Again, a pragmatic view should be taken when considering whether groups of claims are homogeneous, a view that balances the benefits against the practicalities and cost.

For certain valuation portfolios, e.g. those with little historical data, it may not be possible to deploy all components of the framework. However, we do consider it important to consider each component in the context of each valuation portfolio as this will ensure that appropriate questions are asked as part of the analysis.

2.4. Analysing independent risk sources

Many approaches used in practice by actuaries to analyse uncertainty and assess risk margins have an element of quantitative analysis conducted using stochastic (or other) modelling techniques. Often, but not always, adjustments are made to the results from this modelling, reflecting an appreciation that it has not fully encapsulated all sources of uncertainty.

There are a number of reasons why stochastic modelling techniques do not enable a complete analysis of all sources of uncertainty:

- A good stochastic model will fit the past data well and, in doing so, *fit away* most past systemic episodes of risk external to the valuation process, leaving behind largely random sources of uncertainty. Some techniques, e.g Generalised Linear Modelling (GLM), offer more flexibility in fitting to the past experience than others, e.g. Mack method.
- Where it has not been possible to fit away all past systemic episodes of risk or where no attempt has been made to do so, the outcome of the analysis may be substantially affected by these episodes. Consideration then needs to be given to whether past episodes of systemic risk are reasonably representative of what one can expect in the future. For some portfolios this will be a very significant assumption, based solely on judgemental considerations.
- Even where one is comfortable that a model adequately reflects the volatility expected in the future from both independent and systemic sources external to the actuarial valuation process, the model is highly unlikely to incorporate uncertainty arising from sources internal to the actuarial valuation process, i.e. internal systemic risk.

The framework proposes the use of one or more stochastic modelling techniques to analyse independent sources of risk and to inform on past episodes of systemic risk external to the actuarial valuation process. There are a number of approaches that may be used to analyse independent sources of risk, including:

- Mack method;
- Bootstrapping;
- Stochastic Chain Ladder;
- Generalised Linear Modelling (GLM) techniques; and
- Bayesian techniques.

Although these techniques can be used for both outstanding claim liabilities and premium liabilities, it is possible and practically helpful to analyse independent risk as it pertains to premium liabilities using techniques specifically designed for this purpose.

The analysis of independent risk is an art in itself and actuaries will only become comfortable in this area with practical experience of working through the main issues on their own valuation portfolios. A range of stochastic techniques may be used and decisions made on the strengths and weaknesses of each approach in the context of the past experience. It may be possible to refine the modelling to focus on certain past periods with limited past episodes of systemic risk, thus largely isolating past independent risk and examining the extent to which it has impacted past volatility.

Finally, we do consider it useful to supplement any analysis of independent risk for a particular valuation portfolio with internal and external benchmarking. Benchmarking is discussed in section 2.7. The main source of external benchmarking in this regard would be the 2001 Tillinghast paper which identified the independent risk component in its overall uncertainty benchmarks. For some portfolios, benchmarking may be the only way to obtain some view of the contribution from independent risk once all other avenues have been exhausted.

2.5. Analysing systemic risk sources

The framework proposes separate analysis of internal systemic risk and external systemic risk. Qualitative approaches are proposed for this purpose. Two approaches are discussed in Section 4 of the paper, one designed to analyse internal systemic risk and the other designed to analyse external systemic risk. Introductions to these approaches are given in this sub-section. Both techniques have been designed to allow judgement to be deployed in a robust, transparent and consistent manner, giving due consideration to each of the key contributors to the two sources of systemic risk.

Internal systemic risk

Internal systemic risk refers to the uncertainty arising from the actuarial valuation models used being an imperfect representation of the insurance process as it pertains to insurance liabilities. Valuation models are designed to predict future claim cost outcomes based largely on an examination of the key predictors of claim cost, and trends in these predictors, as these have been observed in the past claim experience.

When assessing the uncertainty associated with the insurance liabilities it is important to subject the valuation methodology to objective scrutiny to assess the extent to which the quality of the insurance liability estimate may be compromised by inadequacies in the valuation process. The need to be objective as part of this process is important. Human nature is such that it is easy to become overly defensive of the modelling approach adopted for central estimate purposes. Objective comparisons and scoring of the adopted valuation methodology against best practice, irrespective of whether such best practice is possible in the context of the portfolio being analysed, is crucial to forming an appropriate view of the contribution of internal systemic risk to uncertainty.

We consider there to be three main sources of internal systemic risk. These are:

- *Specification error* **-** the error that can arise from an inability to build a model that is fully representative of the underlying insurance process. The process is likely to be too complicated to be replicated in any actuarial valuation model. Also, the information available may be such that the underlying process cannot be fully understood and the model structure is simplified as a consequence.
- *Parameter selection error* **-** the error that can arise because the model is unable to adequately measure all predictors of claim cost outcomes or trends in these predictors. Again the insurance process is such that there can be a large number of claim cost drivers that would be difficult to fully capture in an actuarial valuation model.
- *Data error* **-** the error that can arise due to poor data or unavailability of data required to conduct a credible valuation. Data error also relates to inadequate knowledge of the portfolio being analysed, including pricing, underwriting and claims management processes and strategies.

One approach to analysing internal systemic risk is discussed in detail in section 4 of the paper. This involves developing a balanced scorecard to objectively assess the model specification against a set of criteria designed to rank aspects of the modelling from worst to best practice. For each of the sources of internal systemic risk, risk indicators are developed and then scored against the adopted criteria. The scores are then aggregated for each valuation class and mapped to a quantitative measure (CoV) of the variation arising from internal systemic risk.

There are a number of subjective decisions that are required to be made as part of this process. These include the risk indicators, the measurement and scoring criteria, the importance (or weight) afforded to each risk indicator and the CoVs that map to each score from the balanced scorecard. Quantitative techniques may be used to inform aspects of these decisions.

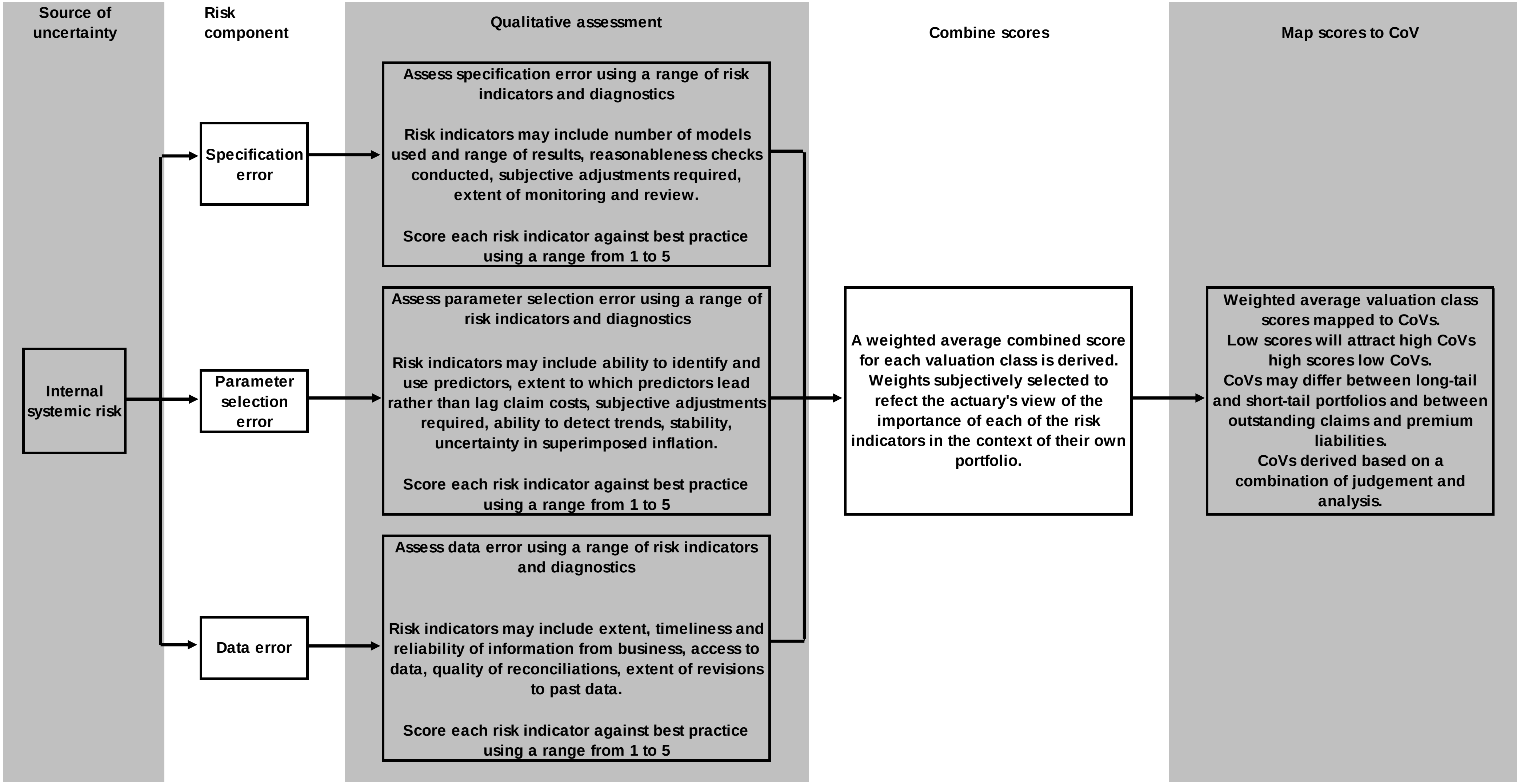
Development and deployment of a balanced scorecard approach to measuring internal systemic risk is a blend of art and science. Actuaries unfamiliar with the approach will need time to develop the skills required:

- to draw out all of the risk indicators;
- objectively score them against best practice; and
- map them to a CoV in the context of their own valuation classes.

Section 4 of the paper provides some thoughts and tools that may be used as part of such an exercise. However, it is fully expected that new techniques will emerge as experience develops and the writers of this paper welcome and encourage future contributions to the development of actuarial thinking in this area.

The analysis of internal systemic risk is summarised in Figure 2 below.

Figure 2: Internal systemic risk – systemic risk internal to the actuarial valuation process



External Systemic Risk

All of the standard quantitative modelling techniques analyse the volatility inherent in the past claim experience. As such, they can only be used to inform on the uncertainty arising from past episodes of external systemic risk. To use these techniques in isolation would require an assumption that the contribution to volatility from future external systemic risk is expected to be similar to that experienced in the past. It is quite possible, and for some valuation classes likely, that future external systemic risk will exhibit significantly different characteristics from actual past episodes.

It is, therefore, important to identify each of the main potential sources of external systemic risk and, for each of these sources, quantify their impact on the overall volatility of the insurance liabilities. The main external systemic risks for any valuation class can be categorised as belonging to a number of *risk categories*. These include:

- *Economic and social risks* – normal inflation and other social and environmental trends
- *Legislative, political risks and claim inflation risks* – relates to known or unknown changes to legislative or political environment within which each valuation portfolio currently operates and shifts or trends in the level of claim settlements (this risk category encapsulates most systemic trends normally referred to as superimposed inflation)
- *Claim management process change risk* – changes to the processes relating to claim reporting, payment, finalisation or estimation
- *Expense risk* – the uncertainty associated with the cost of managing the run off of the insurance liabilities or the cost of maintaining the unexpired risk until the date of loss
- *Event risk* – the uncertainty associated with claim costs arising from events, either natural peril events or man-made events
- *Latent claim risk* – the uncertainty associated with claims that may arise from a particular source, a source that is currently not considered to be covered
- *Recovery risk* – the uncertainty associated with recoveries, either reinsurance or non-reinsurance

Each of these risk categories will normally have been considered as part of the central estimate valuation of outstanding claim or premium liabilities. There is, therefore, a strong case for conducting the analysis of external systemic risk in conjunction with the central estimate valuation, thereby ensuring that both parts of the valuation take a consistent and complete view of all systemic risk categories.

A critical step in any valuation process is the interaction between the valuation actuary and business unit management. This is required to ensure that the valuation actuary has an appropriate level of understanding of all aspects of the insurance process, particularly as this relates to the valuation of insurance liabilities. These interactions will normally incorporate discussions about all aspects of the portfolio management process, including underwriting and risk selection, pricing, claims management, expense management, emerging portfolio trends and the environment within which the portfolio operates. It would be of great benefit to the valuation process, and not particularly onerous, to extend discussions to consider the main potential external systemic risks that may impact the portfolio. This information can then be used to inform both the central estimate valuation and in the identification and quantification of risks associated with each external systemic risk category.

For most valuation classes, the risk identification and categorisation process will identify a small number of systemic risks and categories that account for the majority of the uncertainty. For property classes, for example, *event risk* is likely to dominate the volatility of the premium liabilities whereas for long-tail portfolios *legislative, political and claims inflation risks* are likely to be the key contributors to the volatility for both outstanding claim and premium liabilities.

When analysing external systemic risk it is useful to rank each of the risk categories in descending order in terms of expected impact on insurance liability uncertainty. This ranking can then be used to guide the effort to be expended on quantifying the risks associated with each risk category. More time and effort would be spent on quantifying the uncertainty associated with material risk categories.

Section 4 of the paper discusses the assessment of external systemic risk in more detail and includes some examples of potential sources of systemic risk within each risk category.

Correlation effects

At this point in the deployment of the framework, an actuary will have derived CoVs for independent risk, internal systemic risk and for each source of external systemic risk in each systemic risk category. The next step requires making allowance for the fact that each of these sources of risk is not fully correlated either within valuation classes or between valuation classes.

At this stage, it is worth commenting that we do not consider or discuss any quantitative methods to assessing correlation effects as part of this paper. The main reasons for this are as follows:

- Available techniques tend to be technically complex and often require a substantial amount of data. The time and effort required to learn, implement and appropriately adjust these techniques may outweigh the benefits gained.
- These techniques will yield correlations that are heavily influenced by the correlations, if any, experienced in past data. Correlations associated with external systemic risk sources may differ materially from correlations associated with past episodes of systemic risk.
- Also, it is difficult, if not impossible, to separate the past correlation effects between independent risk and systemic risk or to identify the pure effect of each past systemic risk.
- Internal systemic risk cannot be modelled using standard correlation modelling techniques.
- Even if modelling of correlation effects were practical, they are unlikely to yield results that could be aligned to the outcomes of the framework discussed above in relation to independent risk, internal systemic risk and external systemic risk.

Having said this, it is not our intention to entirely rule out quantitative analysis of past correlation effects. Such analysis may provide useful insights that can help in the assessment of potential future correlation effects.

The framework can be readily extended to incorporate an appropriate allowance for correlation effects. This extension follows the spirit of the framework discussed so far and requires that correlation effects be considered in the context of each source of uncertainty and/or risk category. Again, reliance is placed on an actuary's own judgement but the actuary is encouraged to deploy their judgement in a robust and transparent manner in the context of each of the risks affecting their valuation classes.

Correlation effects can be considered in the context of each source of uncertainty. The key considerations are discussed below.

- Independent risk – as suggested by the name, this source of uncertainty can be assumed to be uncorrelated with any other source of uncertainty, either within a particular valuation class or between valuation classes.
- Internal systemic risk – this source of uncertainty can be assumed to be uncorrelated with independent risk, as discussed above, and with each potential external systemic source of risk, either within a particular valuation class or between valuation classes. Internal systemic risk contributes to correlation effects through correlation of this source of uncertainty between valuation classes or between outstanding claim and premium liabilities.
    - The *same actuary effect* and the use of template or valuation models across different valuation classes are key considerations for correlation effects between valuation classes.
    - Linkages between the premium liability methodology and outcomes from the outstanding claim valuation are key considerations for correlation effects between outstanding claim and premium liabilities.
- External systemic risk – it is reasonable to assume that the contribution to uncertainty from each risk category is uncorrelated with independent risk, internal systemic risk and with the contribution to uncertainty from each other risk category, either within a particular valuation class or between valuation classes. Correlation effects will arise from correlations between classes or between outstanding claim and premium liabilities from risks categorised as belonging to similar risk categories, e.g. claims inflation risk across long-tail portfolios or event risk across property and motor portfolios.

It is possible that external systemic risk categories may be partially correlated either within or between valuation classes. If this is the case, the correlated risk categories may be aggregated into broader categories that are not correlated with other risk categories.

For practical purpose, the correlation relationship between any two sources of uncertainty or risk categories can be considered to belong to one of a finite number of assumed correlation bands. For example, five correlation bands may be defined as *nil*, *low*, *medium*, *high* and *full* correlation. For quantification purposes one might allocate correlation coefficients of 25%, 50% and 75%, respectively, to the low, medium and high correlation bands. Having any more than five categories is likely to result in spurious accuracy attaching to what is already a largely subjective process.

The PwC paper describes a useful way of considering and assessing correlation effects. A root dummy variable, which can be considered to be the root source of correlations within a risk category, is created. Dummy variables may also be set up for groupings of valuation classes that belong to the same class of business, e.g. separate valuations may be conducted by state within a worker's compensation class of business. A hierarchical structure can then be constructed for each systemic risk category containing correlations between the following components:

- premium liabilities and outstanding claim liabilities for a particular valuation class;
- outstanding claim liabilities for individual valuation classes and the relevant class of business dummy variables; and
- class of business dummy variables and root dummy variables.

The implied correlations, both within valuation classes or classes of business and between valuation classes, can then be assessed.

2.6. Consolidation of analysis into risk margin calculation

Once an actuary has progressed through the analysis discussed above they will have the following assumptions that need to be consolidated and converted into a risk margin for the whole claims portfolio:

- CoVs in respect of independent risk for each valuation portfolio, separately for outstanding claim and premium liabilities
- CoVs in respect of internal systemic risk for each valuation portfolio, separately for outstanding claim and premium liabilities
- CoVs in respect of each potential external systemic risk category, separately for outstanding claim and premium liabilities
- Correlation coefficients between each source of uncertainty, risk category, valuation portfolio and outstanding claim/premium liability combination.

For practical purposes, we propose that a simple linear correlation dependency structure be adopted to allow for the various correlation effects. Correlation matrices are created for each of the three sources of uncertainty described in section 2.2 above. As discussed above, independent risk, internal systemic risk and external systemic risk are all assumed to be uncorrelated. As such, the contribution from each source of uncertainty to the total CoV, after correlation effects, can be calculated individually and then combined.

We consider a simple linear correlation dependency structure to be reasonable for the assessment of risk margins associated with probabilities of adequacy of up to at least 90%. Where one is faced with requirements for extreme probabilities of adequacy, e.g. for portfolios in run off or when parameterising reserve risk for DFA modelling purposes, it is recommended that other dependency structures be considered.

An example of the consolidation and risk margin calculation for an example insurer, Insurer ABC, which underwrites three classes of business, Motor, Home and CTP is shown in Figure 3 below.

Figure 3: Claims portfolio CoV and risk margin calculation for Insurer ABC

A: Proportion of insurance liabilities

Class	Proportion of insurance liabilities (weights) Outstanding claims	Premium liabilities
Motor	5%	25%
Home	5%	25%
CTP	30%	10%
Total	40%	60%

B: Independent risk

Class	Independent risk Outstanding claims CoV	Premium liabilities CoV	Insurance liabilities CoV
Motor	7.0%	5.0%	1.3%
Home	6.0%	5.0%	4.3%
CTP	6.0%	15.0%	5.9%
Total	4.6%	3.9%	3.0%

C: Internal systemic risk

Class	Internal systemic risk Outstanding claims CoV	Premium liabilities CoV	Insurance liabilities CoV
Motor	5.5%	5.0%	4.9%
Home	5.5%	5.0%	4.9%
CTP	9.5%	8.0%	8.7%
Total	7.6%	4.2%	4.9%

Internal systemic risk correlation matrix

	Motor OSC	Motor PL	Home OSC	Home PL	CTP OSC	CTP PL
Motor OSC	100%	75%	50%	50%	25%	25%
Motor PL	75%	100%	50%	50%	25%	25%
Home OSC	50%	50%	100%	75%	25%	25%
Home PL	50%	50%	75%	100%	25%	25%
CTP OSC	25%	25%	25%	25%	100%	75%
CTP PL	25%	25%	25%	25%	75%	100%

D: External systemic risk

External systemic risk - coefficients of variation by risk category

	social, etc, risk	Legislative, political and claims inflation risk	Claim process risk	Expense risk	Event risk	Latent claim risk	Recovery risk	All risk categories
Motor OSC	1.0%	0.5%	2.0%	1.0%	1.0%	0.0%	3.0%	4.0%
Motor PL	2.0%	0.5%	2.0%	2.0%	3.0%	0.0%	5.0%	6.8%
Home OSC	1.0%	1.0%	2.0%	1.0%	2.0%	0.5%	0.5%	3.4%
Home PL	2.0%	1.0%	2.0%	2.0%	15.0%	0.5%	1.0%	15.5%
CTP OSC	3.0%	10.0%	4.0%	2.0%	0.0%	0.5%	1.0%	11.4%
CTP PL	4.0%	12.0%	4.0%	3.0%	1.0%	0.5%	2.0%	13.8%

External systemic risk - risk category correlations

Risk category	*Correlations adopted*
Economic, social and environmental risk	Nil between CTP and other, 25% PL/25% OSC between motor and home, 50% between OSC and PL within classes
Legislative, political and claims inflation risk	Nil between CTP and other, 25% PL/25% OSC between motor and home, 50% between OSC and PL within classes
Claim management process risk	25% between classes, 50% between OSC and PL within classes
Expense risk	25% between classes, 50% between OSC and PL within classes
Event risk	Nil between CTP and other, 50% PL/25% OSC between motor and home, 50% between OSC and PL within classes
Latent claim risk	Nil between classes, 50% between OSC and PL within classes
Recovery risk	Nil between classes, 50% between OSC and PL within classes

Class	External systemic risk Outstanding claims CoV	Premium liabilities CoV	Insurance liabilities CoV
Motor	4.0%	6.8%	6.0%
Home	3.4%	15.5%	13.1%
CTP	11.4%	13.8%	10.7%
Total	8.6%	8.0%	6.5%

E: Consolidated CoVs

Class	All sources of uncertainty Outstanding claims CoV	Premium liabilities CoV	Insurance liabilities CoV
Motor	9.8%	9.8%	7.9%
Home	8.8%	17.0%	14.6%
CTP	16.0%	21.9%	15.0%
Total	12.4%	9.9%	8.7%

F: Risk margins

Required probability of adequacy **75%**

Class	Risk margins - Normal distribution Outstanding claims	Premium liabilities	Insurance liabilities	Risk margins - LogNormal distribution Outstanding claims CoV	Premium liabilities CoV	Insurance liabilities CoV
Motor	6.6%	6.6%	5.3%	6.3%	6.3%	5.1%
Home	5.9%	11.5%	9.9%	5.7%	10.5%	9.2%
CTP	10.8%	14.8%	10.1%	9.9%	13.0%	9.4%
Total	8.4%	6.7%	5.8%	7.9%	6.3%	5.6%

The following comments are made to help in the interpretation of the example in Figure 3.

- The CoVs and correlation coefficients used and risk margins derived are indicative only. The emphasis is on demonstrating how consolidation could work in practice, rather than proposing appropriate risk margins or underlying assumptions.
- Part A gives the percentage breakdown of the total net central estimate of insurance liabilities by valuation portfolio and between outstanding claim and premium liabilities. There is no need to use actual dollar amounts in the calculation. The percentage breakdown (or weights) will suffice. For simplicity, for this example all homogeneous claim groups have been combined within the valuation classes.
- Part B shows the CoVs adopted in respect of independent risk for outstanding claim and premium liabilities following a combination of quantitative modelling and benchmarking. The insurance liability CoVs by valuation portfolio and the insurance liability, outstanding claim liability and premium liability CoVs for all valuation portfolios combined have been derived assuming independence (or nil correlation) between valuation portfolios and between outstanding claims and premium liabilities.
- Part C shows the CoVs and correlation coefficients (in correlation matrix form) adopted for outstanding claim and premium liabilities in respect of internal systemic risk. These CoVs and correlation coefficients have been derived following a qualitative analysis of internal systemic risk using a balanced scorecard approach. The insurance liability CoVs by valuation portfolio and the insurance liability, outstanding claim liability and premium liability CoVs for all valuation portfolios combined have been derived using the assumed correlations between valuation portfolios and between outstanding claim and premium liabilities. When creating any correlation matrix it is important to include a check that the matrix is positive definite.
- The first table in Part D shows the CoVs adopted in respect of each external systemic risk category. The second table summarises the adopted correlation coefficients in respect of external systemic risk. The implementation of these correlations is conducted using seven correlation matrices, one for each external systemic risk category. Each of these matrices is 6x6, similar to the correlation matrix shown in Part C for internal systemic risk. With an assumption of independence between risk categories there is no need to create a larger 42x42 matrix with a row and column representing each risk category, valuation portfolio and outstanding claim/premium liability combination. The CoVs and correlation coefficients shown in these two tables have been derived following a qualitative analysis of potential external systemic sources of risk. The third table in Part D shows the aggregate CoVs in respect of external systemic risk, derived for each valuation portfolio and for all valuation portfolios combined in respect of outstanding claim liabilities, premium liabilities and insurance liabilities.
- Part E consolidates the CoVs from each of the three sources of uncertainty, derived in Parts B to D. The key assumption underlying the derivation of consolidated CoVs is that there is independence between each of the sources of uncertainty.
- Part F converts the consolidated CoVs into risk margins assuming a required probability of adequacy of 75%. Two statistical distributions have been adopted as representative of the underlying distribution of insurance liabilities: the Normal distribution and the LogNormal distribution. At lower probabilities of adequacy, including 75%, the Normal distribution delivers a higher risk margin,

irrespective of the consolidated CoV. At higher probabilities of adequacy, including 90%, the LogNormal distribution can give a higher result, where the consolidated CoV is not too high. For particularly high CoVs, the LogNormal distribution can generate risk margins that appear unreasonable. For example, for a 75% probability of adequacy the risk margin percentage does not increase much above 25% and actually reduces as the CoV increases above 75%. Another way of looking at this is that LogNormal risk margins can reduce quite significantly as a percentage of the CoV as the latter increases whereas Normal risk margins remain unchanged as a percentage of the CoV.

- Both distributions are used in practice by actuaries with the LogNormal distribution more common for higher probabilities of adequacy and the Normal distribution, for the reasons discussed above, often given consideration at the 75% probability of adequacy. The right-tailed nature of the distribution of insurance liabilities perhaps lends itself more to a right-skewed distribution such as LogNormal. However, it does have its practical issues at lower probabilities of adequacy as discussed above. Considering the level of judgement required in the application of the framework, spending a substantial amount of time deliberating over the form of the distribution is unlikely to be of much value. An actuary should adopt a distribution that is appropriate in the context of their own claims portfolio, including the consolidated CoV assessed and probability of adequacy required. One might not be so comfortable to adopt a LogNormal or Normal distribution without further justification if the purpose of the analysis is to derive risk margins with very high probabilities of adequacy (i.e. 99.5% for portfolios in run off) or when parameterising reserve risk in a DFA modelling context.
- A spreadsheet tool has been created to do the calculation required for the consolidation shown in Figure 3. This tool has been provided as an attachment to this paper to help readers understand the key formulae underpinning the consolidation. Obviously, this tool may also be adapted for use in the deployment of the framework discussed in this paper.

2.7. Additional analysis

There are a number of areas of additional analysis that may be conducted to give an actuary further comfort regarding the outcomes from the deployment of the framework described above. These include sensitivity analysis, scenario testing, benchmarking and hindsight analysis, each of which is discussed below.

Sensitivity testing

The framework requires a substantial amount of actuarial judgement in its application. Judgement is required in all aspects of the analysis, irrespective of whether quantitative or qualitative methods have been used to assess the volatility associated with a particular source of uncertainty.

Valuable insights into the sensitivity of the final outcomes to key assumptions can be gained by varying each of the key assumptions. It is recommended that, as part of the analysis, the CoVs and correlation coefficients adopted for independent risk, internal systemic risk and each external systemic risk category be flexed and the impact on the valuation class and claims portfolio risk margins examined.

Following such an analysis, one might review certain key assumptions, particularly those that have a substantial impact on the final outcome, with a view to gaining additional comfort that the adopted assumptions are reasonable and justifiable.

As a demonstration of sensitivity testing in practice changes have been made to certain key assumptions adopted for the example in Figure 3.

- If the independent risk CoVs by valuation portfolio for outstanding claim and premium liabilities are reduced by 50%, the risk margin for the whole claims portfolio (based on the LogNormal distribution) reduces from 5.6% to 5.4%. Alternatively, doubling these CoVs increases the risk margin to 6.5%.
- If the internal systemic risk CoVs by valuation portfolio for outstanding claim and premium liabilities are increased by 50%, the risk margin for the whole claims portfolio increases from 5.6% to 6.6%. Alternatively, increasing the correlation coefficients to give full correlation across all combinations increases the risk margin to 6.3%.
- If the CoVs for the legislative, political and claims inflation systemic risk category for CTP (outstanding claims and premium liabilities) are reduced by 50%, the risk margin for the whole claims portfolio reduces from 5.6% to 5.2%. Doubling the CoV for the event systemic risk category for Home premium liabilities increases the risk margin to 7.0%. Finally, assuming full correlation, within all valuation classes and systemic risk categories, between outstanding claim and premium liabilities increases the risk margin to 5.8%.

Scenario testing

It is often insightful to tie the risk margin outcomes back to a set of valuation outcomes by strengthening some of the key assumptions adopted for central estimate purposes to align the outstanding claim liabilities and premium liabilities with the provisions assessed including risk margins. Various different assumption scenarios may be tested and valuation outcomes, including projected ultimate claim frequencies, average claim sizes, loss ratios, etc, compared for each scenario against the central estimate basis.

These (risk margin inclusive) valuation outcomes can be considered in the context of the emerging experience and what is known about the portfolio. Also, the basis changes required to deliver these outcomes can be considered in the context of the emerging experience.

Internal benchmarking

As part of the CoV selection process, the proposed CoVs should be subjected to a range of internal checks. For each source of uncertainty individually the adopted CoVs should be compared between valuation classes, particularly similar valuation classes, for outstanding claim liabilities, premium liabilities and insurance liabilities. Comparisons should also be made between outstanding claim and premium liability CoVs within classes.

For independent risk, there are two main dimensions that should be considered in the context of internal benchmarking: portfolio size and length of claim run off. The *law of large numbers* implies that the larger the portfolio, the lower the volatility arising from random effects. Also, the longer a portfolio takes to run off, the more time there is for random effects to have an impact. These considerations have a number of implications for independent risk CoV selection, including:

- Outstanding claim liability CoVs for short-tail portfolios are likely to be lower than for similar sized long-tail portfolio and substantially lower than much smaller long-tailed portfolios.
- Premium liability CoVs for long-tail portfolios would normally be higher than outstanding claim liability CoVs for the same portfolios. This is due more to the law of large numbers than any material differences in the length of the run off. The extent of the difference will depend on the size of the premium liability and outstanding claim liability with the difference being more for small portfolios which will have higher independent risk components than for large portfolios which will have smaller independent risk components.
- Premium liability CoVs for short-tail portfolios would normally be lower than outstanding claim liability CoVs for the same portfolios, assuming the same independent risk profile between outstanding claim and premium liabilities. This is due mainly to the law of large numbers. The independent risk profiles may not, however, be similar. Event risk, where material, is likely to mean that the independent risk profile of premium liabilities and outstanding claim liabilities are different. This is likely to offset the benefit that premium liabilities gain from their greater size and in any event make benchmarking problematic.

For internal systemic risk, the CoVs can be compared in the context of each valuation class. If template models are used for similar portfolios, particularly classes with homogeneous claim groups, then one would expect CoVs to be similar between classes. Also, the underlying process and the key drivers of this process are likely to be more complicated in long-tail portfolios than most short-tail portfolios. If similar valuation methodologies are applied for both short- and long-tail classes then one would expect higher internal systemic risk CoVs for the long-tail portfolios.

The main sources of external systemic risk are likely to be much more significant for long-tail portfolios with the exception of event risk for property and, to a lesser extent, motor classes and liability risk for home classes.

External benchmarking

External benchmarking refers to the use of the Tillinghast and Trowbridge 2001 papers or APRA’s November 2008 General Insurance Risk Margins Industry Report to benchmark CoVs and/or risk margins derived as part of a risk margins analysis.

APRA have indicated that a large number of actuaries rely, to varying extents, on the analysis presented in the 2001 papers in the selection of their own risk margin assumptions. This reliance ranges from those actuaries who conduct thorough analyses on their own portfolios and then benchmark the adopted risk margins with those derived from the 2001 papers to those actuaries that derive risk margins solely from the 2001 papers with little or no consideration of the reasonableness of this approach in the context of their own portfolios. The latter approach was certainly not one of the original intentions of the authors of the 2001 papers. The former approach is more consistent with the expectations of the authors.

It is not our intention to dismiss external benchmarking out of hand. Rather, we consider that this form of benchmarking has some merit when combined with a thorough analysis of a particular claims portfolio. Benchmarking will be of some benefit where there is little information available for analysis purposes, particularly for the analysis of independent risk. More generally, the use of benchmarking should be as a sanity check rather than as the entire basis of the risk margin assessment. In any deployment of benchmarking, the differences between the benchmark portfolio(s) and the claims portfolio being analysed must be considered and factored into the analysis.

The use of the Tillinghast paper in the assessment of independent risk is discussed in section 2.4 above. Before using the Tillinghast paper, however, an actuary needs to be aware of the following issues:

- The assumptions required to derive the independent component of the CoV were derived based on an analysis conducted during 2001. The independent CoVs depend on the size of the outstanding claim or premium liabilities. Inflation between 2001 and the effective date of the current valuation should be backed out of the outstanding claim and premium liabilities before calculating the independent CoV. If this is not done then the independent CoV will be understated.
- The premium liability risk margin should be calculated by applying a multiple to the outstanding claim risk margin for an outstanding claim liability **that is the same size as the premium liability**, not for the actual outstanding claim liability, irrespective of whether this is lower or higher than the premium liability.

Hindsight analysis

Hindsight analysis involves comparing past estimates of outstanding claim liabilities and premium liabilities against the latest view of the equivalent liabilities. Movements can be analysed and converted to a coefficient of variation reflective of the actual volatility observed in the past. This volatility contains a combination of past instances of independent risk, internal systemic risk and external systemic risk. Care needs to be taken in the interpretation of any hindsight analysis as the models may have changed (improved) since previous valuations were conducted. Also, future external sources of systemic risk may differ materially from past such episodes of systemic risk.

Hindsight analysis is particularly useful for short-tail valuations where there is little serial correlation between consecutive valuations. Hindsight analysis is somewhat less valuable for long-tail portfolios where there is usually significant serial correlation between consecutive valuations.

The reader is referred to the 2005 paper *An Empirical Approach to Insurance Liability Prediction Error With Application to APRA Risk Margin Determination* by Andrew Houltram for a thorough discussion of the benefits and practicalities associated with hindsight estimation.

Another form of hindsight analysis, which we will refer to as *mechanical hindsight analysis*, is one that takes a mechanical approach to estimating the outstanding claims and premium liabilities, systematically removing the most recent claims experience. An example of such an approach is as follows:

- Apply a chain ladder method on a triangulation of cumulative claim payments based on a triangulation of data at the valuation date.

- The adopted payment development factors should be calculated using an objective approach, e.g. the average of the actual experience over the last three years.
- The outstanding claim payments derived using all data to the valuation date is referred to as the 'current' estimate.
- Remove a diagonal of payment data one at a time and apply the same method objectively to derive outstanding claim payments at past valuation dates.
- Compare each of the past estimates of outstanding claim payments with the current estimate, for the equivalent accident periods and ensuring that relevant payments made between valuation dates are added to the current estimate of outstanding claim payments.
- The method can be extended to incorporate a mechanical projection of premium liabilities at each valuation date. Premium liability volatility and past levels of correlation between outstanding claim and premium liabilities can be examined.

Mechanical hindsight analysis may be used to analyse:

- independent risk, by focusing the analysis on periods where there was a degree of stability in the experience with few or no systemic trends;
- internal systemic risk, by applying this technique using a range of actuarial methods (preferably those used for central estimate valuation purpose) and observing the differences in volatility outcomes; and
- all past sources of uncertainty, by applying the approach across all past periods.

The latter is a mechanical variant of the hindsight analysis described in the first three paragraphs of this sub-section.

2.8. Documentation and regularity

Documentation

APRA have indicated that a wide range of approaches have been taken by actuaries in the documentation of risk margins analysis. Documentation ranges from that which provides a thorough discussion of approach and justification for the assumptions underpinning the adopted risk margins to that which provides very little commentary or justification.

Documentation of actuarial judgement is not necessarily an easy task. However, we believe that the framework offers actuaries an opportunity to document their analysis and key judgemental decisions in a complete and robust manner, aligned to the key steps in the framework.

Regularity and review

A full application of each step of the framework is a substantial and comprehensive undertaking. We do not consider that the framework need be applied in its entirety each time an actuary conducts a central estimate valuation of insurance liabilities.

We consider a full application of the framework at less regular intervals to be reasonable and appropriate. At the very least, however, a full application should be applied every three years. These extensive reviews should incorporate all of the steps of the framework discussed above and summarised in Table 1. They will also involve significant interaction with business unit management.

At more regular intervals, aligned to the times when central estimate valuations of insurance liabilities are conducted, a less comprehensive review of the key assumptions adopted as part of the previous full application will suffice. The key assumptions should be examined in the context of:

- any emerging trends;
- emerging systemic risks; and
- changes to valuation methodologies.

Changes to key assumptions would only be considered where there is reasonable justification for doing so, i.e. where the previous assumptions are no longer deemed appropriate. Another way of thinking of these regular reviews are as monitoring exercises where key assumptions derived from the previous full framework application are monitored against emerging experience and developing knowledge and adjusted where justified.

If new portfolios emerge in the period between full applications of the framework, one should consider applying the key steps within the framework to those portfolios.

The successful deployment of this framework will require significant interaction with business unit management. The process may benefit from a feedback and communication loop, enabling the business to provide their views on the outcomes of the analysis. This will reduce the possibility that lots of assumptions, which all make sense individually, contribute to an overall outcome that does not make sense. This communication loop may incorporate the demonstration of scenarios that would give rise to the outcome assessed at the selected probability of adequacy.

3. Independent risk assessment

Independent risk reflects the contribution to the uncertainty associated with the actual claim cost outcome from random effects. This source of risk has two components: the random component of parameter risk and the random component of process risk. It is not normally particularly enlightening or beneficial to split independent risk between these two components. Having said this, some quantitative modelling techniques do allow the split to be assessed as part of their normal application.

There are a number of approaches that may be used to analyse independent sources of risk, including::

- Mack method;
- Bootstrapping;
- Stochastic Chain Ladder;
- Generalised Linear Modelling (GLM) techniques; and
- Bayesian techniques

The bibliography includes references to a number of papers that describe these techniques.

The techniques vary in their capacity to enable actuaries to identify past levels of independent risk. In the application of most of these techniques, one is attempting to fit a model to past systemic episodes and trends and to analyse the residual volatility once these episodes and trends have been fitted away. The better the model fit is the more likely that the residual volatility observed reflects random effects alone.

An actuary faced with the task of assessing independent risk will need to decide upon which techniques to use for each of their valuation classes. This decision should consider the extent to which the independent risk for a particular valuation class is material to the overall claim portfolio risk margin, the contribution to uncertainty from internal systemic risk and external systemic risk and the cost and effort associated with applying the techniques. Where the cost and effort outweighs the potential benefit then a simpler approach, perhaps incorporating benchmarking, may be considered.

For some valuation portfolios, the data available may be too limited or volatile to enable a credible split between past episodes of systemic risk and past independent risk. In these cases, actuaries may consider using a model that does not attempt to fit away the past systemic risk and supplement this analysis with additional allowances for external systemic risk, to the extent that this is considered to differ from past systemic risk, and internal systemic risk, which cannot be modelled using standard quantitative modelling techniques.

Independent risk assessment for outstanding claim liabilities

Any of the techniques mentioned above can be used in the assessment of past independent risk for outstanding claim purposes. Some of the techniques offer more flexibility in terms of fitting to past systemic episodes and trends.

Consideration should be given to aligning the methodology adopted to analyse uncertainty with that used for central estimate purposes. For example, if the PPCI method plays an important role in the central estimate assessment and bootstrapping is the preferred approach to analysing uncertainty then the PPCI method should be bootstrapped. This will ensure that past volatility is examined and conclusions drawn in an environment that is internally consistent.

GLM techniques can be used to model individual claims or aggregate claims. These techniques are used for reserving purposes to identify the key factors that have contributed to past claim cost outcomes. Combined with a range of useful statistical diagnostics, these techniques are well placed to support the analysis of independent risk.

Bootstrapping techniques offer less flexibility than GLM techniques but can be adapted to help in the assessment of random effects. For example, if past periods that have been largely unaffected by systemic episodes can be identified then the bootstrap residuals can be calculated for these stable periods and used as part of the bootstrapping process. Plots of residuals by accident period, development period and experience period can be used to identify periods that have been affected by past systemic episodes.

Independent risk assessment for premium liabilities

The bootstrapping, GLM and Bayesian approaches may also be used for the purpose of analysing the volatility in past claim experience for the purpose of assessing the independent risk component for premium liabilities.

However, it is possible to use simpler techniques to analyse the past volatility of key components of the premium liabilities. Consider a valuation class where the central estimate of the claim cost component of the premium liabilities is assessed by combining a projected claim frequency and average claim size. The adopted claim frequency and average claim size has been selected following an analysis of output from the outstanding claim valuation supplemented by portfolio level pricing analysis.

For some valuation classes, it can be a relatively straightforward exercise to remove the impact of past systemic episodes (including seasonality) from observed claim frequencies and determine the claim frequency CoV in respect of past residual volatility. Similarly, past average claim sizes can be adjusted to remove past inflation, including both standard and superimposed, and other past systemic episodes (again including seasonality) and a CoV in respect of past residual volatility derived.

Where a loss ratio approach to projecting premium liabilities is used, allowance should be made for systemic shifts in past premium levels as well as claim costs.

Often large claims are extracted for separate analysis. Again, observations can be made as to the aspects of past experience that represent systemic episodes and those that are purely random.

The process of identifying and isolating past systemic episodes can only be enhanced if an actuary has a strong understanding of the possible systemic sources of risk for a particular portfolio. The role that product and claim management can play in improving this understanding should not be underestimated. This is discussed further in section 4.

4. Systemic risk assessment

4.1. Internal systemic risk

Internal systemic risk refers to the uncertainty arising from the actuarial valuation models used being an imperfect representation of the insurance process as it pertains to insurance liabilities.

As discussed in section 2.5, we consider there to be three main sources of internal systemic risk. These are:

- *Specification error* - the error that can arise from an inability to build a model that is fully representative of the underlying insurance process.
- *Parameter selection error* - the error that can arise because the model is unable to measure all predictors of claim cost outcomes or trends in these predictors.
- *Data error* - the error that can arise due to poor data, unavailability of data and/or inadequate knowledge of the portfolio being analysed.

When an actuary conducts an assessment of outstanding claim or premium liabilities, there are a wide range and variety of approaches and methodologies that are available. The merits of each approach will be considered in the context of the valuation classes being assessed. The characteristics of each class and the level of information available, including granularity of data, will all play a role in the decision around which approach to use.

Although care will normally be taken to ensure that the approach adopted is appropriate for the valuation class being assessed, models are likely to represent a simplified view of the insurance process. Models also range in their capacity to identify underlying trends in the claims experience. Standard triangulations methods will normally analyse predictors (e.g. claim payments, reports, finalisations, case estimates) that have been aggregated to a reasonably high level or lag rather than lead the underlying drivers of the insurance process.

In light of this, any analysis of uncertainty would be incomplete without an objective assessment of the adequacy of the modelling infrastructure and its ability to reflect and predict the underlying insurance process. In this section of our paper, we propose one approach, involving the development of a balanced scorecard, which may be used as part of such an assessment.

One other point worth making before we walk through the balanced scorecard approach in detail is that the assessment of internal systemic risk must be conducted in the context of the actual approach used to assess the central estimate of outstanding claim and premium liabilities. The strengths and weakness associated with that approach will be considered and scored with a view to determining an appropriate allowance in risk margins for internal systemic risk. Consistency between the central estimate and risk margin assessments are one outcome of a robust assessment of internal systemic risk.

The balanced scorecard was discussed in section 2.5 and presented diagrammatically in Figure 2. In summary the approach involves:

- For each of the specification, parameter and data risk components, conduct a qualitative assessment of the modelling infrastructure, considering a range of risk indicators and scoring these indicators on a scale of 1 to 5 (where 5 represents best practice).

- Apply weights to each risk indicator, reflecting its relative importance to the overall modelling infrastructure, and calculate a weighted average score representing an objective view of the quality of the modelling infrastructure for each valuation class.
- Calibrate the weighted average score derived to a CoV in respect of internal systemic risk. The development of appropriate CoVs will likely involve a substantial amount of judgement, perhaps supplemented by quantitative analysis.

In a paper entitled *Asbestos Liabilities & the New Risk Margins Framework*, prepared by Brett Riley and Bruce Watson, the authors describe an alternative approach to assessing the level of internal systemic risk. This approach specifies High and Low scenarios that 'represent the end points of what might be considered a reasonable range of central estimates based on alternative interpretations of all available information'. The approach advocated by Messrs Riley and Watson certainly has merit and represents a reasonable alternative to the balanced scorecard approach described in this paper. It also has the appeal of being simpler and, therefore, more practical to apply.

Scoring the modelling infrastructure

We would encourage actuaries to develop a balanced scorecard approach that is suited to the characteristics of the valuation classes within their own claims portfolio including risk indicators that are most relevant in the context of these classes. Having said this, we feel that it is useful if we outline potential risk indicators that actuaries may wish to consider and develop for the purpose of their own analysis. Table 2 includes potential risk indicators and some suggested minimum requirements for a high score for each of these indicators. The characteristics that represent a poor score should be readily apparent.

Table 2: Internal systemic risk - Potential risk indicators

Risk component	Potential risk indicators	Requirements for high score
Specification error	Number of independent models used	Many different modelling approaches considered - each approach should add value by considering different dimensions of claims experience
	Extent to which models separately analyse different claim/payment types	Relevant homogeneous claim or payment types modelled separately
	Range of results produced by models	Low variations between different models in terms of past performance - take care that comparisons are appropriate (e.g. PCE vs PPCI for old accident periods for short-tail classes may not be appropriate)
	Checks made on reasonableness of results	Significant reasonableness checks conducted, including reconciliation of movement in liabilities, diagnostic checks on valuation outcomes, acceptance of results by business, expert peer review, benchmarking against industry
	Confidence in assessment of model 'goodness of fit'	Actual vs Extected close, few difficulties in selecting parameters, relevant sensitivities yield small variances in results
	Number and importance of subjective adjustments to factors	Few subjective adjustments, relevant subjective factor sensitivites yield low variances and adjustments regularly monitored and reviewed
	Extent of monitoring and review of model and assumption performance	Model and assumption performance monitored continuously and reviewed regularly
	Ability to detect trends in key claim cost indicators	Models have performed well in detecting trends in the past
	Sophistication and performance of superimposed inflation analysis	Detailed analysis of past sources of superimposed inflation and robust quantification of each past source
	Level of expense analysis to support CHE assumptions	Detailed expense analysis, including how expenses are incurred over the lifetime of claims relating to each claim type
	Ability to model using more granular data, e.g. unit record data	Unit record data is available and used to further analyse and better understand key predictors and trends in these predictors
Parameter selection error	Best predictors have been identified, whether or not they are used	Best predictors have been analysed and identified, including internal and external variables that show strong correlaton with claims experience
	Best predictors are stable over time or change due to process changes	Predictors stable over time, stabilise quickly and respond well to process changes
	Value of predictors used	Predictors are close to best predictors, lead (rather than lag) claim cost outcomes, modelled rather than subjectively allowed for and unimpaired by past systemic events
Data error	Knowledge of past processes affecting predictors	Good and credible knowledge of past processes, including changes to processes
	Extent, timeliness, consistency and reliability of information from business	Regular, complete and pro-active two-way communication between valuation actuary and claims staff/portfolio managers who understand key valuation predictors and how changes may impact or invalidate these
	Data subject of appropriate reconciliations and quality control	Reconciliations against other sources are conducted for all data sources and types, checks are conducted throughout data processing steps, reconciliations against previous valuation conducted, data and differences well understood
	Processes for obtaining and processing data are robust and replicable	No past instances of poor data understanding, no or low potential for miscoding of claim type
	Frequency and severity of past mis-estimation due to revision of data	No past instances of data revision
	Extent of current data issues and possible impact on predictors	No known current data issues

Each of the risk indicators should be considered in the context of both the outstanding claim and premium liabilities. Additional indicators may be considered for premium liabilities, for example whether the outstanding claim liabilities are used as an input to the premium liability assessment or whether credible portfolio level pricing analysis is used as an input to the premium liability assessment.

For certain short-tail portfolios, some risk indicators may not be as relevant for premium liability purposes. A large variance in the outstanding claim liabilities, which might only affect the most recent accident periods and have a relatively small impact on the projected ultimate claim frequency or average claim size, may not be material in the context of a premium liability assessment.

Table 3 shows the risk indicator scores which underpin the internal systemic risk CoVs adopted for Insurer ABC in the example in Figure 3 in section 2.6, with a particular focus on outstanding claim liabilities.

Table 3: Internal systemic risk – example balanced scorecard

Risk component	Potential risk indicators	Motor score OSC	Motor weight	Home score OSC	Home weight	CTP score OSC	CTP weight
Specification error	Number of independent models used	4	7	4	7	3	2
	Extent to which models separately analyse different claim/payment types	3	3	4.5	5	2	7
	Range of results produced by models	4	5	4	4	2	2
	Checks made on reasonableness of results	5	5	5	5	4	5
	Confidence in assessment of model 'goodness of fit'	4	5	4	5	2	7
	Number and importance of subjective adjustments to factors	5	3	4	3	3	5
	Extent of monitoring and review of model and assumption performance	4	5	4	5	5	8
	Ability to detect trends in key claim cost indicators	4	4	3	4	3	6
	Sophistication and performance of superimposed inflation analysis		0		0	4	10
	Level of expense analysis to support CHE assumptions	4	4	4	4	2	2
	Ability to model using more granular data, e.g. unit record data	2	2	2	2	5	2
Parameter selection error	Best predictors have been identified, whether or not they are used	4	3	4	5	3	7
	Best predictors are stable over time or change due to process changes	5	5	4	5	2	6
	Value of predictors used	4	5	4	5	3	5
Data error	Knowledge of past processes affecting predictors	4	8	4	8	4	8
	Extent, timeliness, consistency and reliability of information from business	4	5	4	5	4	5
	Data subject of appropriate reconciliations and quality control	4	7	4	7	4	8
	Processes for obtaining and processing data are robust and replicable	5	3	5	3	5	3
	Frequency and severity of past mis-estimation due to revision of data	5	3	3	3	5	5
	Extent of current data issues and possible impact on predictors	4	3	5	3	5	3
Total weighted average score - outstanding claims (OSC)		4.1		4.0		3.5	
Total weighted average score - premium liabilities		4.5		4.5		4.0	

The scores and weights shown in Table 3 are for illustration only and should be taken as a demonstration of concept than as a set of benchmarks that actuaries can use for such portfolios in practice.

The weights allocated to each of the risk indicators are a measure of the importance of that risk indicator, relative to the other risk indicators, in terms of its contribution to overall internal systemic risk. The weights and hence relativities between risk indicators should reflect the particular valuation infrastructure adopted for each valuation class including the relative importance of each risk indicator in the context of that valuation class.

Premium liabilities scored better than outstanding claims in this example due to the extensive use in their assessment of outcomes from the valuation of outstanding claims **and** independent and credible portfolio level pricing analyses conducted recently.

Calibrating scores to CoVs

Once a score representing an objective and qualitative view of the efficacy of the modelling infrastructure has been derived, one needs to determine a CoV that is an appropriate representation of the contribution to outstanding claim and premium liability uncertainty from internal systemic risk. This step is likely to require a significant amount of subjective judgement, supplemented by quantitative analysis.

We suggest that individual actuaries develop a CoV scale which represents their view of the uncertainty associated with internal systemic risk for the full range of possible balanced scorecard outcomes, ranging from worst practice to best practice (or 'perfect') modelling approaches. A large degree of judgement will be required to derive a reasonable range in the context of a particular claims portfolio. The analysis conducted to score the modelling infrastructure together with past model performance should provide invaluable insights into the potential variability associated with a particular modelling approach.

If more than one methodology has been deployed in the past then a hindsight analysis of the actual past performance of each method can be used to assess the relative performance of each method and the extent to which multiple models can improve the performance of the whole modelling infrastructure.

Mechanical hindsight analysis (see section 2.7) may also be used to help in the assessment of internal systemic risk. For example, a mechanical hindsight analysis can be conducted using one method with all claim or payment types aggregated. A further retrospective analysis can be conducted using multiple methods with claim or payment types separated into individual homogeneous groups. The relative difference in performance of the two modelling infrastructures over time may give some insights into the additional uncertainty associated with poor modelling approaches compared to fair or good modelling approaches.

Based on our experience, we would suggest that the minimum CoV associated with a 'perfect' model is unlikely to be much less than 5%. Even a 'perfect' model will not be able to completely replicate the true underlying insurance process or identify every possible predictor of claim cost outcomes.

If you consider a single, aggregated model with limited data or information available to populate the model, significant subjective assumptions required and few identified predictors, CoVs of 20% or above in respect of internal systemic risk are readily justifiable. For such models, it is not infeasible that internal systemic risk could be the main contributor to overall uncertainty.

Table 4 gives CoV scales used in the assessment of risk margins for Insurer ABC as part of the example in Figure 3.

Table 4: Internal systemic risk – example CoV scale

Score from balanced scorecard assessment	Motor CoV	Home CoV	CTP CoV
1.0 to 1.5	17.5%	17.5%	25.0%
1.5 to 2.0	13.0%	13.0%	20.5%
2.0 to 2.5	10.5%	10.5%	17.0%
2.5 to 3.0	8.5%	8.5%	14.0%
3.0 to 3.5	7.0%	7.0%	11.5%
3.5 to 4.0	6.0%	6.0%	9.5%
4.0 to 4.5	5.5%	5.5%	8.0%
4.5 to 5.0	5.0%	5.0%	7.0%

The CoV scale shown in Table 4 is an example only. Actuaries should select CoV scales that are appropriate in the context of their own valuation classes and the modelling infrastructure adopted for each of those valuation classes. Any hindsight analysis deployed to support the selection of appropriate CoVs should be designed to align with the actual valuation methods adopted for the valuation classes being analysed.

Further comments on the CoV scale as presented in Table 4 are:

- The scale is not linear reflecting our view that the marginal improvement in outcomes between fair and good modelling infrastructures is less than the marginal improvement between poor and fair modelling infrastructures.
- The CoVs for CTP, a long-tail portfolio, are higher than those for Motor and Home, both short-tail portfolios. For long-tail portfolios, it is generally more difficult to develop a modelling approach that is representative of the underlying insurance process. Also, key predictors are often less stable for long-tail portfolios and past episodes of systemic risk more likely to impair the ability to fit a good model.
- The scale has been used for both outstanding claim and premium liability purposes. A reasonable 'a priori' assumption is that similar scales can be used for both. Arguments can be made for premium liabilities to have higher or lower CoVs than those applying to outstanding claim liabilities, particularly for poor modelling approaches. For example, the assessment of premium liabilities may include additional uncertainty associated with the estimation of exposure or premium relating to unclosed or contractually bound future business. If this is the case then a loading on top of the outstanding claim liability CoVs may be justifiable. On the other hand, for certain stable short-tail classes, the difference between a simple loss ratio approach and a more thorough frequency/severity approach may not be material in terms of performance in the assessment of premium liabilities but the difference between a single aggregate model and multiple disaggregated models could be material in terms of performance in the assessment of outstanding claim liabilities.

4.2. External systemic risk

External systemic risk refers to the uncertainty arising from non-random risks external to the actuarial modelling process. This uncertainty encapsulates systemic episodes that have not yet occurred but may emerge in the future and those that are emerging in the recent experience but where there is some uncertainty as to how they will develop in future. The risk associated with the actuarial modelling infrastructure potentially being unable to identify emerging risks will be picked up as part of a robust internal systemic risk assessment.

Certain stochastic quantitative approaches may be used to gain insights into past and emerging sources of external systemic risk. These insights, together with those gained from the central estimate analysis, will provide useful intelligence on the type of risks that can emerge in each valuation portfolio, at least the ones that have emerged in the past. However, one cannot readily assume that past experience is a reasonable reflection of the future. A more rigorous approach should consider each of the possible future sources of external systemic risk, using a number of sources of information.

Communication with business experts

Typically actuaries will hold discussions with portfolio and claim management as part of the valuation process. These discussions normally provide valuable insights into emerging trends and possible future sources of external systemic risk. However, the focus is normally on gaining an appropriate level of portfolio understanding to enable an informed assessment of the central estimate of outstanding claim and premium liabilities. Although the information gathered will play a role in the assessment of risk margins, this tends to be more an afterthought than a key focus of discussions.

Discussions can be readily tailored to topics of relevance for both central estimate and risk margin purposes and ensure an appropriate level of focus on both aspects of the valuation process. Business management should be given time to prepare for these meetings to ensure that the valuation actuary gains the maximum possible benefit from them.

From a risk margins perspective, the focus of these meetings should be on the identification of key potential sources of systemic risk, including those that have begun to emerge and those that may emerge in future. Discussions should consider all aspects of the portfolio management process, including underwriting and risk selection, pricing, claims management, expense management, emerging portfolio trends and the environment within which the portfolio operates. Once the key sources of external systemic risk have been identified, they can be categorised for analysis purposes. As well as identifying key risks, the quantification of risk should be another key consideration for business management interactions.

Selection of assumptions

The selection of CoVs for each risk category will involve a combination of quantitative analysis and qualitative judgement. Some risk categories will be more open to quantitative analysis than others. For those categories where such analysis is more difficult, sensitivity analysis, perhaps in conjunction with business management, may shed some light on the range of possible outcomes.

In assessing CoVs in respect of each risk category, it is also important to consider the shape of the entire distribution, to the extent possible. Some risks will demonstrate characteristics that are reflective of a highly skewed distribution and, as such, may not have a material bearing on a 75th percentile risk margin but may be more relevant for higher probabilities of adequacy. An example of such a risk is latent risk where the probability of such risk emerging is very low and certainly lower than 25%. Certain sources of superimposed inflation may also be considered to belong to this category.

In focusing efforts, consideration may be given to ranking individual risks for each valuation class in order of importance, separately for outstanding claim and premium liabilities. For a number of valuation classes it is quite likely that such an exercise will identify a small number of key risks and allow efforts to be focused accordingly. This might also provide justification for excluding certain risk categories that are deemed to be immaterial in terms of their contribution to the overall CoV. A scoring system, developed in conjunction with business experts, may be introduced as a convenient mechanism for ranking individual risks and checking that the contributions from individual risks to the overall CoV for external systemic risk are reasonable.

Each risk category will represent the amalgamation of a number of identified potential sources of risk. In some cases, these individual risks will be correlated and allowance will need to be made for this when combining the risks to determine a CoV for the risk category as a whole. A simple approach, similar to that discussed in section 2.5, may be used to allow for these intra-risk category correlation effects.

A key consideration when determining risk categories for a particular valuation class is whether there is any correlation between categories. The consolidation of the analysis of external systemic risk is substantially simplified if one can assume that each of the risk categories is independent. Certain risk categories may have to be combined to ensure that this assumption is valid.

In the balance of this section, we explore each of the risk categories discussed in section 2.5 with a view to providing some insights into the types of risk that may be included in each risk category and the analysis that may be conducted to estimate appropriate CoVs for each category.

Economic and social risks

This risk category incorporates a number of potential sources of external systemic risk. These sources include, but are not limited to, levels of standard inflation (AWE and CPI), general economic conditions (unemployment rates, GDP growth, interest rates, asset returns), fuel prices, driving patterns, etc.

Some of these risks can have a material impact on both outstanding claim and premium liabilities. Others are material only for premium liabilities. For example, economic conditions can have a material impact on outstanding claim and premium liabilities for professional lines and builder’s warranty valuation classes. Uncertainty around driving conditions, on the other hand is less relevant for motor outstanding claims than it is for motor premium liabilities.

Uncertainty around AWE and/or CPI will impact all valuation classes. Due to the longer term settlement for long tail classes, AWE uncertainty is somewhat more material for these classes than for short tail valuation classes. Analysis of past levels of AWE and CPI can shed some light on past systemic sources of volatility. Economic commentators often provide insights into the potential sources of volatility.

Any analysis of past levels of inflation should consider the extent to which past volatility is random and the extent to which it has been impacted by systemic events. For the purpose of analysis of systemic sources of risk, we are only interested in the latter. This applies to the analysis of past experience in respect of any systemic event in any risk category.

Potential systemic shifts in claim frequency for short tail valuation portfolios should be included in this risk category.

Legislative, political and claims inflation risk

These risks have been combined, for convenience, into one risk category since they are often correlated. For example, the risks associated with the legislative and political environment are often correlated to the drivers of non-standard claims inflation for long tail valuation classes.

This risk category is likely to be much more material for long tail valuation classes than for short tail classes. For long tail classes, in particular, a number of potentially material risks may be identified and allocated to this risk category. Some of these risks will be correlated and, as such, quantification should make allowance for this correlation.

The analysis conducted to quantify CoVs for this risk category can also be used to justify superimposed inflation assumptions for central estimate valuation purposes. After all, for long tail valuation classes, the risks in this category are normally aggregated and referred to as superimposed inflation for insurance liability valuation purposes. For each risk, one is aiming to form a view of the range of possible impacts on claim cost outcomes. The average of this range, combined across all risks, provides an estimate of superimposed inflation.

Individual actuaries will identify the key risks in this category in the context of their own claims portfolio. As a general guide, for long tail classes, this category would be expected to include some of the following sub-groups of risk:

- Impact of recent legislative amendments, including possibility of erosion of intent of amendments through assessment and threshold erosion, changes in court interpretation, etc.
- Potential for future legislative amendments with retrospective impacts.
- Precedent setting in courts, including impact of judicial decisions perhaps leading to new heads of damage.
- Changes to medical technology costs
- Changes to legal costs
- Systemic shifts in large claim frequency or severity

Typically, actuaries will have access to various forms of analysis relating to the potential impact of a specific series of legislative amendments. This information may include both external and internal analyses, the latter possibly tailored to the specifics of a particular portfolio. When supplemented by discussions with product and claim management, a sound understanding of the range of possible outcomes can be obtained, including the likelihood and potential severity of a particular outcome occurring.

For short tail classes, this risk category includes the risk that claim inflation will increase at a level different from that adopted for central estimate purposes, in addition to that arising from standard inflation (see above) or claim management process risk (see below). Claim cost reduction initiatives would normally be allocated to this category and information is sometimes available as to the range of possible outcomes from such initiatives.

Claim management process change risk

Changes to the claim management process can impact all valuation classes. Typically, however, such changes will have a more material impact on some valuation classes than others. The key here is to work closely with claim managers to gain a sound understanding of the claim management philosophy and the process that underpins that philosophy. Current or future potential changes to process should be identified as part of such discussions.

Analysis of past experience will help identify past systemic episodes that may have been impacted by the claim management process. Discussions with management may help isolate the process changes that contributed to those systemic episodes. Reporting patterns, payment patterns, finalisation and reopening rates and case estimation processes should all be considered as part of these discussions.

Sensitivity testing of key valuation assumptions, which can be useful in the assessment of CoVs for this risk category, is relatively straightforward using traditional triangulation techniques. If such analysis is conducted, sensitivities considered should be aligned with the potential sources of uncertainty identified following discussions with claim management.

Claim management process risk is likely to be more relevant for outstanding claim liabilities than for premium liabilities. For outstanding claim liabilities, particularly for short tail valuation classes, this risk can be material since it impacts the pattern of emergence of credible claim estimates. For premium liabilities, we are more interested in the extent to which changes to claim management processes can impact the magnitude of the claim cost. The impact on claim emergence is normally of secondary importance.

Expense risk

One would generally expect this to be a small contributor to total external systemic risk.

Ideally, one would spend time with product and claim management to understand the key drivers of policy maintenance and claim handling expenses. Armed with a good understanding of these drivers, a valuation actuary can identify the key sources of possible variation relative to the central estimate assumptions. Sensitivity testing around the key drivers, preferably conducted in association with informed business and process experts, and analysis of past expense levels with a view to identifying past systemic effects can be combined to help form a reasonable view as to the range of possible claim cost outcomes. Such an analysis could be conducted in conjunction with any expense analysis conducted for central estimate expense assumptions.

Event claims can have a material impact on the level of claim handling expenses. The larger an event, the smaller the fixed component of the event management cost will be as a percentage of the claim cost. In light of this, the analysis may benefit from including claim handling expenses in respect of event claims with the analysis of event risk itself.

Event risk

Event risk relates to single events which give rise to a large number of claims. This risk is likely to be material for property and, to a lesser extent, motor valuation classes but will be insignificant for most other valuation classes. Event risk also arises in medical malpractice and builders' warranty portfolios where a large number and/or cost of claims can arise from one source, i.e. a single doctor or a single builder.

The approach to assessing event risk will differ materially between outstanding claim and premium liabilities. For outstanding claim liabilities, the approach will be defined by the extent to which there are material outstanding events. If there are, then these should be analysed separately. Discussions with event claim management should be held to understand their expectations as to claim cost outcomes and to identify any specific issues that may influence outcomes. The range of development patterns for previous events may also influence the view on uncertainty.

There is often a wealth of information available to help in the quantification of event risk for premium liabilities, including:

- Past experience in respect of event claims. When analysing past experience, it is important to allow for changes in portfolio size, geographical spread, inflation, policy terms and conditions, reinsurance arrangements, etc. where these are considered to be material. It is not particularly difficult, where sufficient credible past experience is available, to build a relatively simple statistical model with key frequency and severity assumptions based on appropriately adjusted past experience. In fact, modelling of this nature may have been conducted by pricing actuaries or as part of a reinsurance placement and can be adapted for event risk analysis.
- Output from proprietary catastrophe modelling. A number of such models are used in practice, including those developed by RMS, EQE, AIR and Risk Frontiers. Insurers will normally have access to these models through their reinsurance intermediaries who are well placed to provide advice on the range of possible outcomes based on modelled events.
- Reinsurance intermediaries typically also have available models in respect of natural perils, and some man-made perils, that can be used to model perils not covered by proprietary catastrophe models. These, together with the proprietary models, will normally be used by intermediaries in support of an insurer's catastrophe reinsurance program renewal and can be readily extended to provide advice on the uncertainty associated with event risk.

Latent claim risk

Latent claim risk is negligible for most valuation classes. For some, primarily workers compensation and liability classes, the risk can be considered to be material. However, this is one of the most difficult risks to quantify. The probability of these events is low but the impact should they occur could be substantial

Purely in the context of setting risk margins it is unlikely that analysis of latent claims risk warrants a substantial commitment of resources given that it is such a low probability event. However if such risk exposure is significant enough to be a formal component of the central estimate or if the object of the exercise is modelling extreme risks for capital adequacy purposes (using a DFA approach) then a thorough examination of this risk driver is certainly warranted.
.
This risk is the one most likely to be quantified using a large degree of judgement. Discussions with underwriters may help shed some light on some potential sources and give a feel for their likelihood and potential impact. Also, casualty reinsurance underwriters often have a more informed understanding of the potential sources of latent risk claims from their dealings with a number of direct insurers globally. Using all of the information collected, scenarios may be developed to reflect a possible range of scenarios from which reasonable CoVs can be derived.

Recovery risk

This risk category encapsulates systemic uncertainty in relation to reinsurance and non-reinsurance recoveries. This category is likely to be relatively insignificant for most portfolios. One possible exception is motor valuation classes where third party recoveries are often a material consideration.

The focus here should be on systemic events that may lead to different recovery outcomes from those adopted for central estimate purposes.

An analysis of past non-reinsurance recovery rates and patterns will inform on past systemic events. Combined with discussions with claim management around current trends in recovery management and any current or planned future initiatives that may impact recovery levels, one can readily form a view as to the range of possible systemic outcomes.

Reinsurance recoverability is another potential source of external systemic risk that should be considered within this category. The extent to which this is material will depend on the reinsurance arrangements themselves. A material shift in reinsurance market conditions may significantly alter the ability to recover from reinsurers. For example, one or more catastrophic events (on a global scale) or a downturn in asset returns, or a combination of both, may substantially reduce the ability to recover from reinsurers. The probability of such events occurring and materially impacting recoveries is low but the severity, should they happen, could be high. Discussions with reinsurance management are often enlightening and can help in the identification of possible scenarios, the likelihood of them occurring and the quantitative impact should they occur.

Bibliography

Bateup R and Reed I, 2001, *Research and Data Analysis Relevant to the Development of Standards and Guidelines on Liability Valuation for General Insurance*, Proceedings of the 13th General Insurance Seminar, Institute of Actuaries of Australia.

Collings S and White G, 2001, *APRA Risk Margin Analysis*¸ Proceedings of the 13th General Insurance Seminar.

Houltram A, 2003, *Reserving Judgement – Considerations Relevant to Insurance Liability Assessment Under GPS210*, Proceedings of the 14th General Insurance Seminar.

Houltram A, 2005, *An Empirical Approach to Insurance Liability Predicition Error Assessment With Application to APRA Risk Margin Determination*, Proceedings of the 15th General Insurance Seminar.

O'Dowd C, Smith A and Hardy P, 2005, *A Framework for Estimating Uncertainty in Insurance Claims Cost*, Proceedings of the 15th General Insurance Seminar.

Riley B and Watson B, 2009, *Asbestos Liabilities & the New Risk Margins Framework*, Presented to the Institute of Actuaries of Australia 2009 Accident Compensation Seminar.

ROC Working Party, 2008, *Reserving Uncertainty*, Paper for GIRO 2008

Stochastic Reserving Papers

England P.D. and Verrall R.J., 1999, *Analytic and Bootstrap Estimatesof Prediciton Errors in Claims Reservng*, Insurance: Mathematics and Economics 25

England P.D. and Verrall R.J., 2002, *Stochastic Claims Reserving in General Insurance*, British Actuarial Journal 8, Part 3

England P.D. and Verrall R.J., 2006, *Predicitve Distributions of Outstanding Liabilities in General Insurance,* Annals of Actuarial Science 1, Part 2

Kirschner G.S., Kerley C and Isaacs B, *Two Approaches to Calculating Correlated Reserve Indications Across Multiple Lines of Business*

Mack T, 1993, *Measuring the Variability of Chain Ladder Reserve Estimates*

Taylor G and McGuire G, 2005, *Synchronous Bootstrapping of Seemingly Unrelated Regressions*

Verrall R.J., 2004, *A Bayesian Generalized Linear Model for the Bornhuetter-Ferguson Method of Claims Reserving,* North American Actuarial Journal, Volume 8, Number 3