

Risk-Based Regulatory Capital for Insurers: A Case Study¹

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Abstract

Regulatory capital requirements for insurers are the focus of the current development of a global framework for insurer solvency assessment. Banks have already adopted risk-based capital requirements under Basel. Australia has introduced insurer capital requirements that are regarded by many as best practice. The regulator of non-life (property and casualty) insurers, the Australian Prudential Regulatory Authority (APRA), recently introduced new prudential standards that allow insurers to choose between a standardised approach, the Prescribed Method, and an advanced modelling approach, the Internal Model Based (IMB) Method, for determining their minimum (regulatory) capital requirement (MCR). This is consistent with the proposals of the International Actuarial Association (IAA). No insurer in Australia has adopted the advanced modelling approach at the date of writing. In this paper we study the issues in determining regulatory capital requirements using advanced modelling by assessing and comparing capital requirements under the two alternative approaches. A Dynamic Financial Analysis (DFA) model is used for this case study. These issues are of current international interest as regulators, insurers and actuaries face the significant issues involved with the introduction of risk-based capital for insurers.

Key words: insurer solvency, standardized solvency assessment, advanced modelling, Dynamic Financial Analysis

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1. Introduction

Capital is defined as the excess of the value of an insurer's assets over the value of their liabilities. In practice, the value of the assets and liabilities is reported using statutory and regulatory requirements. Regulatory requirements are used for solvency assessment. Methods of determining economic capital have become the focus of insurers in recent years. Increasingly regulatory capital requirements for banks and insurers are becoming risk-based to reflect the economic impact of balance sheet risks. Giese (2003) discusses the concept of economic capital along with the recent developments in economic capital models.

However determined, capital provides a buffer that allows insurers to pay claims even when losses exceed expectations or asset returns fall below expectations. As described by the IAA (International Actuarial Association) Insurer Solvency Assessment Working Party (2004) a level of capital provides, amongst other things, a "rainy day fund, so when bad things happen, there is money to cover it."

Cummins (1988) and Butsic (1994) discuss the need for regulation in insurance. Butsic (1994) argues that if markets were perfectly efficient, capital regulation would not be necessary. Insurers could determine their own level of capital and market forces would price premiums depending upon the riskiness of an insurer becoming insolvent. Fully informed consumers would diversify their insurance policies across insurers taking into account the risk of insurer default. Taylor (1995) and Sherris (2003) use economy wide models to explore equilibrium insurance pricing and capitalisation. Sherris (2003) shows that in a complete and frictionless market model the level of capital will be reflected in the market price of premiums for insurance and there is no unique optimal level of capital for an insurer.

In reality the complete and perfect markets assumptions do not hold. There is asymmetry in information between consumers and insurers and the costs of insurer insolvency can be significant. Insurers do not report their level of default risk even though this is often assessed by rating agencies. For this form of market failure, as described by Frank & Bernanke (2001), an efficient way for insurers to demonstrate financial soundness is to meet regulated levels of capital prescribed for all insurers. This regulatory capital serves as protection for consumers against the adverse effects of insurer insolvency.

The IAA Insurer Solvency Assessment Working Party has developed a global framework for risk-based capital for insurers. In their working paper, "A Global Framework for Insurer Solvency Assessment" (2004), the working party advocates two methodologies for regulatory capital determination. These are the Standard Approach and the Advanced Approach. The Standard Approach applies industry wide risk factor charges to the calculation of the insurer's capital requirement. The Advanced Approach allows insurers to use a dynamic financial analysis (DFA) model to calculate their capital requirement, better reflecting the insurer's risks.

Banks have been increasingly moving to the use of internal models for capital requirements under Basel. Insurers in a number of countries will be faced with similar requirements as regulators adopt a more risk-based capital approach to regulation. Against this background, the issues in implementing risk-based capital are of significant interest to insurers and actuaries at an international level.

1.1 Capital Regulation in Australia

The Australian Prudential Regulation Authority (APRA) is the primary capital regulator of non-life (property and casualty) insurers in Australia. APRA reviewed its approach to regulating non-life insurance companies and recently released a new set of Prudential Standards. These Standards contain a new methodology for determining a non-life insurer's minimum capital requirement. The new capital requirements more closely match regulatory capital to an insurer's risk profile, otherwise known as risk-based capital.ⁱ

Non-life insurers are able to calculate the minimum capital required in one of two ways.

*“An insurer may choose one of two methods for determining its **Minimum Capital Requirement (MCR)**. Insurers with sufficient resources are encouraged to develop an in-house capital measurement model to calculate the MCR (this is referred to as the **Internal Model Based (IMB) Method**). Use of this method will, however, be conditional on APRA's and the Treasurer's prior approval and will require insurers to satisfy a range of qualitative and quantitative criteria. Insurers that do not use the IMB Method must use the **Prescribed Method**.”ⁱⁱ*

APRA's Prescribed Method is in line with the Standard Approach of the IAA Insurer Solvency Assessment Working Party's, while the IMB Method is in line with the Advanced Approach. The solvency benchmark for the new APRA standards is a maximum probability of insolvency in a one-year time horizon of 0.5%.

The IAA Insurer Solvency Assessment Working Party considers that the Prescribed Method should produce a more conservative (higher) value for the minimum capital requirement as it should determine a minimum level applicable to all insurers licensed to conduct business. The IMB Method should produce a lower minimum capital requirement but would only be available as a capital calculation methodology to larger, more technically able insurers with effective risk management programs.

1.2 The Purpose of this Study

This paper presents the results of a case study of the assessment of regulatory capital for non-life insurers in Australia. The case study highlights the issues involved in determining the capital requirements advocated by the IAA Insurer Solvency Assessment Working Party, and in particular demonstrates the challenges of the Internal Model Based approach for insurers. It also highlights shortcomings of the Prescribed Method. The comparative levels of capital required under the Prescribed Method and the IMB Method are important for insurers considering the use of internal model based methods. Insurers using either method should meet minimum levels of capital that ensure a consistent probability of insolvency across different insurers.

The study aims to compare the MCRs under the two methodologies.ⁱⁱⁱ In order to do this we use techniques that insurers would use in practice. The approach used is as follows. A model of a typical, large non-life insurer with five business lines – domestic motor, household, fire & industry specific risk (ISR), public liability and compulsory third party (CTP) insurance – is developed. A dynamic financial analysis (DFA) model is used for the IMB Method capital requirement and this is compared to capital levels calculated under the Prescribed Method. The DFA model is used to

allocate capital to each of the risks considered using a method adopted by practitioners. The model insurer's business mix, asset mix and business size are changed to examine the effect on capital requirements.

This paper begins with a description of the model, which is based on a typical best practice DFA model. We use current techniques that insurers would be expected to use for this purpose. The aim is not to develop new models but to apply those that are currently available for this purpose.

The results from the analysis are presented and conclusions drawn. The main results of the analysis are as follows. Based on the liability volatility assumptions developed by leading industry consultants, the IMB Method was found to produce a higher MCR than the Prescribed Method. From the insurer's perspective this indicates a possible incentive to use the Prescribed Method in practice. It was also found that the Prescribed Method capital requirements were inadequate to ensure a ruin probability in one-year of less than 0.5% for the entire general insurance industry. This illustrates the difficulty in developing Prescribed Method requirements that reflect insurer differences. Finally, the liability volatility assumptions have a significant impact on the results produced by the internal model. These assumptions require further investigation since there is no consensus on insurance liability volatility assumptions suitable for capital requirements. This is an important area for future research.

From an international perspective this study identifies challenges for risk-based capital requirements in insurance. Prescribed Methods, although easier to apply, are more difficult to develop than would seem, especially if consistent treatment of different insurers is important. On the other hand, implementing internal model based capital requirements requires that the issue of the calibration of models and consistency in assumptions used for different classes of business be properly addressed. An internal model can deal with the many interactions between the assets and liabilities and many of the most important risks but this will only be the case if the models are based on a sound estimation of risks from actual data. This is an area that requires attention before regulators can use this approach with the confidence that is necessary for such an important aspect of insurer risk management.

2. The DFA Model^{iv}

2.1 Choice of DFA Model

This study uses a DFA model to determine the capital requirement under the IMB Method. The DFA model used was developed using Prophet, a DFA software package produced by Trowbridge Consulting. The Prophet DFA model is used by several large non-life insurers in Australia for internal management purposes. Other DFA software packages commonly used in the Australian non-life insurance industry include Igloo (developed by The Quantum Group), Moses (developed by Classic Solutions) and TASPC (developed by Tillinghast Towers-Perrin Consulting). Although these various software packages have different features, we do not expect significant differences in the results from using a different DFA software package based on the simplified assumptions used in the model.

The Prophet DFA model calibrated for this study uses typical assumptions for this purpose. It was not developed to meet the requirements for approval by APRA and

the Treasurer for use in the IMB Method. The Prophet model is broadly representative of current industry best practice in general insurance DFA modelling.

2.2 Description of the Prophet DFA Model

The Prophet DFA model consists of an economic model and an insurance model. The key interaction between the two models is inflation, which affects both the asset returns in the economic model and the claims and expenses in the insurance model. We describe the main features of the DFA model for completeness. Other models will differ in details but are broadly similar to the model described here.

2.2.1 The Economic Model

Prophet uses The Smith Model (TSM) to model the economic environment. TSM is a proprietary economic model that forecasts a range of economic variables including bond yields, equity returns, property returns, inflation and the exchange rate. The key features of the model are that TSM ensures that all initial prices and projections are arbitrage-free and that markets are efficient. Historical data is used to calibrate TSM to derive the necessary parameters for the projections, including the risk premium and covariance matrix parameters that ensure efficiency in markets. For further details on TSM see www.thesmithmodel.com. We should emphasise that we are not advocating the use of any particular model or software. Our aim is to use typical software and assumptions as would be used by an insurer in order to assess the impact of capital requirements and to draw conclusions about the alternate approaches.

2.2.2 The Insurance Model

The insurance model is disaggregated into separate models for each of the business lines' liabilities. Assets, liabilities not relating to a specific line, and interactions between business lines are modelled at the insurer entity level.

Opening Financial Position

The opening financial position for the insurer is an input and covers the details of the insurer's liabilities and assets. From this opening position projections are simulated for the insurer's asset returns, claims for each business line, expenses and reinsurance recoveries.

Asset Returns

Asset returns are projected based on the assumed asset allocation and the simulations from the economic model.

Claims

There are four stochastic claims processes in the model: run-off claims (outstanding claims); new attritional losses; new large claims; and new catastrophe claims. Attritional and large claims are modelled separately for each business line, while catastrophe claims are modelled by the catastrophe event.

Run-off claims

The opening value for the outstanding claims reserve equals the expected discounted value of the inflated run-off claims. The expected run-off claims are input into the model in the form of a run-off triangle. For each accident year the run-off claims are assumed to follow a lognormal distribution with a variance parameter for each business line and each accident year inputted into the model. Formulae are provided in Appendix 1.1 for details of the run-off claims model.

External factors that affect the run-off claims are inflation and superimposed inflation. The inflation level is derived from the economic model, while superimposed inflation is modelled as a stochastic two-state process. The superimposed inflation process consists of a normal superimposed inflation state and a high superimposed inflation state, with a transition probability matrix determining the movement between these two states. The process is described in Appendix 1.5.

New Attritional Losses

Ultimate attritional losses from new claims are assumed to follow a lognormal distribution, with a specified payment pattern. Inflation and superimposed inflation are also included. Correlations between business lines are modelled by a specified correlation matrix that is inputted in the model. More information for the attritional loss model is given in Appendix 1.2.

New Large Claims

A collective risk model is used to model large claims. The frequency of claims is modelled as a Poisson process and a lognormal distribution is used to model large claims severity as, for example, in Klugman, Panjer & Willmot (1998). Details for the large claims model are given in Appendix 1.3. The assumptions for the large claims payment pattern, inflation and superimposed inflation are identical to those used in the modelling of attritional claims.

New Catastrophe Claims

Catastrophe claims are modelled based upon similar principles to the collective risk model with some modifications. Four catastrophe types are modelled separately. For each catastrophe, a Poisson frequency process was used to model the number of catastrophe events per year and an empirical distribution was used to model the claim severity from the event. For each event, there is a primary and a secondary severity process modelled, with the primary process being larger than the secondary process. The key difference between the modelling of large and catastrophe claims is that catastrophes are considered as events and are not specific to any business line. Further details are in Appendix 1.4 for the catastrophe model.

It is assumed that all claims from catastrophes are paid in the year in which they were incurred.

Expenses

There are three categories of expenses in the model: acquisition expense; commission; and claims handling expense. Acquisition expense and commission are expressed as a fixed percentage of premiums. Claims handling expense is a fixed percentage of claims. Expenses vary across business lines.

Reinsurance

The model allows for individual excess of loss (XoL) reinsurance to cover large claims and catastrophe reinsurance to cover catastrophes. Proportional reinsurance is not explicitly modelled so in effect attritional claims can be viewed to be net of proportional cover. For both reinsurance contracts there is a cost of cover, a deductible amount, an upper limit and a specified number of reinstatements for the contract.

2.3 Key Interactions and Correlations in the Prophet DFA Model

An important aspect of DFA modelling is accounting for the many interactions and correlations between variables in the model. It is particularly important when considering the tail-end of the distribution of insurance outcomes given that extreme losses are often driven by several variables behaving unfavourably. For example, a one in two hundred year loss for an insurer could occur when both a catastrophe event causes very high insurance claims and at the same time asset markets under perform. In the Prophet DFA model there are four key interactions that are modelled: between assets and liabilities; claims and expenses; attritional claims across business lines; and between catastrophe claims across business lines.

Relationship between Assets and Liabilities

Inflation is the central driver of the relationship between assets and liabilities. Consumer Price Index (CPI) and Average Weekly Earnings (AWE) inflation are projected by TSM. Inflation impacts asset returns as TSM assumes markets are efficient and incorporates a risk premium and covariance matrix to relate inflation with other asset prices. The impact of TSM's projected inflation on liabilities is through claims inflation in the insurance model.

Relationship between Claims and Expenses

Claims handling expenses are modelled as a fixed percentage of claims. Thus, claims handling expenses are perfectly correlated with claims incurred.

Relationship between Attritional Claims across Business Lines

A correlation matrix is specified to model the relationship between the attritional claims of different business lines. Appendix 1.6 gives the correlation matrix used for the DFA study base case.

Relationship between Catastrophe Claims across Business Lines

Since catastrophes are modelled as events that can impact multiple business lines there exists a correlation between catastrophe claims across different business lines. For business lines that are impacted by either the primary or secondary severity distribution of a given catastrophe event, there will be perfect correlation between claims from that catastrophe event. In the case where one line is impacted by the primary severity distribution and another is impacted by the secondary severity distribution, there will be a positive correlation (but less than one). Lines that are not affected by a given catastrophe event, will have zero correlation with lines that are affected.

Modelling of dependence in insurance is a topic of current research. We have not included more detailed models of dependence in this case study. We aimed to use current industry practice which is currently largely based on correlations. Even using correlations is problematic since there is no current agreement on the assumptions to use.

3. DFA Model Assumptions

3.1 Data Sources

The data used to create the model insurer came from the following sources:

- APRA's June 2002 Selected Statistics on the General Insurance Industry (APRA statistics).

- Tillinghast’s report “Research and Data Analysis Relevant to the Development of Standards and Guidelines on Liability Valuation for General Insurance” (Tillinghast report).
- Trowbridge’s report “APRA Risk Margin Analysis” (Trowbridge report).
- Allianz Australia Insurance Limited (Allianz).
- Promina Insurance Australia Limited (Promina).
- Insurance Australia Group Limited (IAG).

The model insurer created is not representative of any of the insurers that provided data for the study. Full details of the model assumptions are provided in Sutherland-Wong (2003) and available from the authors on request. Brief details are provided in Appendix 1.

3.2 Data used for Model Insurer

Number of Business Lines

Five business lines were included. This was considered large enough for an in depth analysis without over complicating the analysis. To ensure a broad mix of business lines, two of the five were chosen to be short tail, two long tail and one of intermediate policy duration. The largest business lines from the APRA statistics (by gross written premium) for each of these categories were chosen. These were: Short Tail - Domestic Motor and Household; Intermediate - Fire & ISR and Long Tail - Public Liability and CTP.

Size of Business Lines

The business size was set so that the model insurer had a 10% market share from the APRA statistics (by gross written premiums) in each business line.

Expected Claims

The expected claims for each line of business were set to a level to produce an expected after-tax return of 15% on capital based on an assumed capital level of 1.5 times the MCR calculated under the Prescribed Method. The payment pattern, premium assumptions and inflation assumptions were used to solve for the expected claims for each business line to meet this target.

Claims Volatility

The volatility assumption used for each business line determines the insurance outcome at the 99.5th percentile and therefore directly impacts the MCR. Rather than using individual insurer data for these assumptions, we used statistics that were more representative of the broader Australian general insurance industry.

The Tillinghast and Trowbridge reports both include estimates of the coefficients of variation (CVs) of the insurance liabilities of the Australian general insurance industry. However, the reported CVs in these reports were vastly different, with the Tillinghast numbers being generally twice as large as the Trowbridge numbers. Appendix 1.1 provides details of CVs used in this DFA case study.

Thomson (2003) outlines the initial risk margins that insurers have adopted since the new standards came in force from July 2002. He reports that for short tail lines, insurers were generally aligned with the lower Trowbridge numbers, and for long tail lines the numbers were consistently lower than the Tillinghast report. However, there

was a great deal of variation in the risk margins adopted within each business line suggesting that there is no real consensus among the industry on the appropriate level for risk margins. It would generally be in the interest of insurers to adopt lower risk margins in order to report a lower liability value and also a lower capital requirement.

The Tillinghast numbers were used in the analysis as they represented a more conservative view of variability in the industry. The Trowbridge numbers were used as an alternative scenario in the analysis to determine the impact of these assumptions.

Payment Pattern

The payment pattern data was derived from typical insurer data.

Asset Mix

The asset mix for the model insurer was representative of the industry average investment mix. Details are given in Appendix 1.7.

Reinsurance

The reinsurance for each business line was based upon typical insurer data. For the long tail lines, individual XoL contracts were designed to cover most of the large claims. For the short tail lines (including fire & ISR), catastrophe XoL contracts were designed to set the maximum event retention (MER) of the insurer to equal \$15 million.

Superimposed Inflation

The superimposed inflation parameters were estimated from typical insurer data. The parameter details are found in Appendix 1.5.

4. Assessment of the DFA model

The model was designed to broadly represent best practice in applying DFA models to capital analysis and to be consistent with the way that practitioners would model the business lines. The parameters of the model were set to capture the features of a typical insurer. The model can also be assessed against APRA's Guidance Note GGN 110.2, which sets out the qualitative and quantitative requirements for an internal model. The key quantitative risks that an internal model must capture, as specified by the Guidance Note, fall under the broad categories of investment risk, insurance risk, credit risk and operational risk.

TSM is used in Prophet to capture the dynamics of the economic market and the subsequent impact on an insurer's investment portfolio. While no stochastic asset model currently available is perfect, TSM is representative of best practice in economic forecasting and assessment of investment risk.

The Guidance Note specifies a range of risks relating to the insurance business that need to be included in the model. These risks include outstanding claims risk, premium risk, loss projection risk, concentration risk and expense risk. Prophet allows for these risks using the assumed variability in its three claims processes; attritional, large and catastrophe claims. Attritional claims are assumed to follow a lognormal distribution. This assumption is common industry practice for modelling claims. The lognormal assumption can be inadequate for capturing the true variability in claims processes, particularly when analysing the tail-end of the distribution of claims.

Modelling dependencies between business lines with a standard (linear) covariance assumption may not adequately capture the dependence in tail outcomes. Although not commonly used in industry practice, copulas are an increasingly useful method of measuring tail dependencies. Venter (2001) and Embrechts, McNeil & Straumann (2000) provide a good coverage of the use of copulas in modelling tail dependencies in insurance.

The Prophet DFA model does attempt to capture the variability in claims at the tail-end of the distribution by including separate models for large claims and catastrophe claims. Dependencies between business lines in these tail outcomes are in part captured by the impact of catastrophe events on multiple business lines. In fact the catastrophe model has a similarity to frailty models used to construct copulas. How well the model captures the tail risk in practice is an empirical issue that needs further research.

Concentration risk is a component of loss projection risk, relating to the uncertainty of the impact of catastrophic events. This risk is accounted for by the catastrophe model. The XoL catastrophe reinsurance assumptions in the model limit the impact of concentration risk.

Expense risk is accounted for since claims handling expenses are expressed as a percentage of claims incurred. Although some unexpected expense increases may be independent of the amount of claims, there is normally a significant level of correlation between claims and claims handling expenses. Assuming expenses and claims are perfectly correlated results in a conservative allowance for the expense risk of the insurer, since under circumstances in the tail when claims are higher than expected, so too will be claims handling expenses.

Like all businesses, insurers face the credit risk that parties who owe money to them may default. For an insurer, the key sources of credit risk arise from their investment assets, premium receivables and reinsurance recoveries. Credit risk relating to investment assets is implicitly covered in The Smith Model. The Prophet DFA model calibrated in this study does not account for the risk of default in premiums or reinsurance owed. Thus, the MCR calculated by the IMB Method using the Prophet DFA model will not include a charge for these risks. To compensate for this, in calculating the total MCR for the IMB Method, the charge from the Prescribed Method for outstanding premiums and reinsurance recoveries is included.

Guidance Note GGN 110.2 highlights operational risk as a quantitative risk that should be included in an insurer's capital measurement. However, operational risk is a particularly difficult risk to quantify and is an area of ongoing research in both insurance and banking. APRA's Prudential Standards include a Guidance Note for operational risk, GGN 220.5, which outlines the qualitative measures an insurer should pursue to manage operational risk but does not provide any guidance on how to quantify the risk for capital calculation.

The Prophet DFA model calibrated in this study does not account for operational risk. There is no well-accepted model nor sufficient data and analysis to properly assess insurer operational risk. The Prescribed Method does not have a charge for operational risk. The Basel Committee's Working Paper on the Regulatory Treatment of Operational Risk (2001) reports that operational risk should make up 12% of a

bank's minimum required capital. Giese (2003) uses a survey of banks and non-life insurers to report that on average banks allocate approximately 30% of their capital to operational risk, while non-life insurers allocate approximately 16%. However, in the absence of an agreed approach to allocating capital to operational risk for non-life insurers, it was decided that no additional charge would be made. Given the comparative nature of this study, this assumption does not impact on the conclusions drawn or the significance of the results.

5. Methodology

A model insurer was created to be representative of a typical large non-life insurer operating in Australia. The Prophet DFA model was used to project future insurance outcomes under different assumptions. Six thousand (6000) simulations were performed for each set of assumptions and used to estimate the required capital to ensure a ruin probability over a one-year horizon of 0.5%. The number of simulations was determined so that the standard error of the capital requirement estimate was small enough to be reliable. The capital requirement calculated by the Prophet DFA model was then compared to the MCR under the Prescribed Method for the model insurer.^v A summary of the Prescribed Method capital charges for Australia is provided in Appendix 2.

The following five different sets of assumptions were examined to assess the impact of different assumptions and different types of insurer. Since the assumptions for the liability volatilities currently used differ significantly, it was important to examine the impact of these differences. It was also important to consider different types of insurers with different balance sheet structures. In each case, only the model assumption mentioned is changed from the base case.

Alternative Liability Volatility Assumptions

The model was run using the Trowbridge volatility assumptions. This was to indicate the sensitivity of the capital requirements to a change in volatility based on an alternative view on the variability of business lines. Since both sets of volatility assumptions have been proposed it is of interest to examine the resulting difference.

Riskier Asset Mix Assumption

The model was run with the insurer having a significantly higher proportion of investment assets in equities. This was designed to indicate the MCR required for insurers in the industry holding significant levels of riskier assets. This also allows a comparison of the significance of the investment capital charge for the IMB and Prescribed Methods.

Short Tail Insurer Assumption

The insurer was assumed to only sell short tail business lines. Assets and liabilities were scaled back to reflect the smaller overall insurer size, while all other assumptions remained unchanged. Since some insurers have predominantly short tail business this will identify the significance of the short tail capital charge for the comparison between the IMB and Prescribed Methods.

Long Tail Insurer Assumption

The insurer was assumed to only sell long tail business lines. Assets and liabilities were scaled back to reflect the smaller overall insurer size, while all other

assumptions remained unchanged. This will identify the significance of the long tail capital charge.

Smaller Insurer Assumption

In this case the insurer was assumed to have premiums equal to 2.5% of the gross written premiums from the APRA statistics. The liability variability assumptions were adjusted according to the Tillinghast report to account for the smaller business size. Assets and liabilities were also scaled back and all other assumptions remained unchanged.

In order to compare the IMB and Prescribed Methods it is necessary to allocate the MCR to lines of business. To do this we use a technique adopted by practitioners. Myers & Read (2001) have proposed an allocation of capital to lines of business based on marginal changes in business mix. Sherris (2004) shows that, under the assumptions of complete and frictionless markets, there is no unique capital allocation to line of business unless an assumption about rates of return or surplus ratios is also made. In this case study we have set the liability parameters to generate a constant rate of return across lines of business.

A numerical estimation procedure was used to allocate capital to line of business. The procedure was as follows:

Step 1: The size of business line 1 was reduced by 1%.

Step 2: The marginal change in the MCR was calculated, and this amount was allocated to business line 1.

Step 3: Steps 1 to 2 were repeated for business lines 2 to 5.

Step 4: Steps 1 to 3 were repeated 100 times until all the business line sizes were reduced to zero and the MCR was reduced to zero.

The capital allocated to each line was calculated as the sum of all of the marginal capital allocations for each line of business. Using a 1% reduction each time was sufficiently small so that the capital allocation was found to be independent of which line was reduced first.

The capital allocated to each line of business is such that, as an additional small amount of each liability is added, the overall insurer one-year ruin probability is maintained. This is equivalent to using the ruin probability for the total company as a risk measure when determining capital allocation. In other words, the capital allocated to each line of business is such that for the insurer the overall ruin probability is constant.

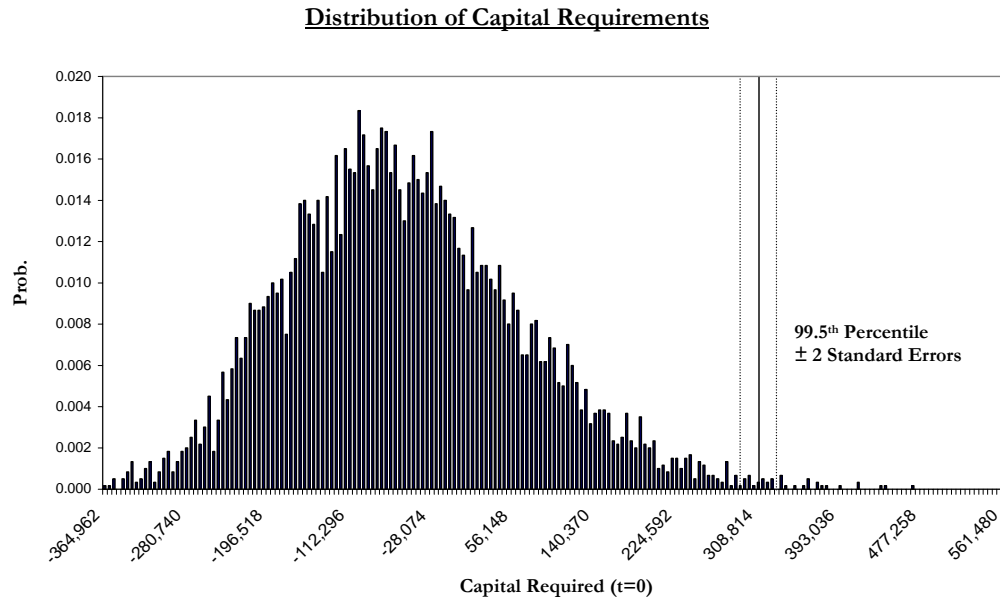
6. Capital Requirements and Model Results

6.1 Model Insurer – Base Case

The model was run for the base case assumptions. The Prophet DFA model produced a distribution of insurance outcomes. For each of these outcomes, the amount of assets in excess of the technical reserves required at the start of the year to ensure that the insurer's assets are equal to their liabilities at the end of the year was determined.

This represents a distribution of capital requirements. The Prophet MCR was determined as the 99.5th percentile of this distribution of capital requirements. By taking this capital requirement, the probability that total assets will exceed liabilities at the end of the year will be 99.5%, using the same simulations. This value was \$309.4M with a standard error of \$10.9M. The standard error was calculated using the Maritz-Jarrett method. Details of the method for computing the standard error are in Wilcox (1997). The distribution of capital requirements is shown in Figure 1.

Figure 1:
Distribution of Base Case Prophet Capital Requirements



The results of the determination of the MCR by both the internal model and the Prescribed Method are given in Table 1. Since the Prophet DFA model does not make an allowance for credit risk, the overall MCR for the model insurer was determined as the sum of the internal model capital requirement plus the credit risk capital charge from the Prescribed Method. This capital requirement is the MCR calculated under the IMB Method and is shown in Table 1.

Table 1
Base Case MCR Comparison between IMB Method and Prescribed Method

Minimum Capital Requirement (MCR)		Base Case S'000
<i>IMB Method</i>	Prophet MCR	309,396
	+ Adjustment for Credit Risk	28,705
	TOTAL	338,101
<i>Prescribed Method</i>	TOTAL	233,323
	<i>Std Error IMB</i>	10,912

The MCR calculated by the IMB Method was found to be significantly larger than the MCR under the Prescribed Method. The MCR calculated by the IMB Method represents the risk-based level of capital required to ensure a ruin probability in one-

year of 0.5%. The Prescribed Method is found to produce a capital requirement insufficient to ensure a probability of ruin over a one-year time horizon of 0.5%.

To understand each method's treatment of the various risks we break down each of the MCRs by line of business and by risk type. The capital charge components that make-up the Prescribed Method's MCR are presented in Table 2.

Table 2:
Components of the Base Case Prescribed Method's MCR

Prescribed Method MCR						
Capital Charge	Motor \$'000	Home \$'000	Fire & ISR \$'000	Public Liability \$'000	CTP \$'000	ENTITY \$'000
Investment Risk						36,687
Credit Risk						28,705
Outstanding Claims Liability	5,314	2,381	3,740	10,188	69,667	91,290
Premium Liability	20,696	9,192	8,335	6,160	17,258	61,641
Concentration Risk						15,000
TOTAL						233,323

Under the Prescribed Method, the total capital charges relating to liability risks (outstanding claims, premium and concentration risk) equal \$167.9M. The long tail business lines account for 61.5% of this charge, while the short tail lines (including fire & ISR) account for 38.5% of the charge.^{vi}

The Prophet internal model capital requirement was allocated to individual business lines using the numerical approach set out earlier. The resulting allocation is shown in Table 3.

For the MCR calculated by the IMB Method, long tail lines account for 67.4% of capital while short tail lines (including fire & ISR) account for 32.6%. Although this allocation gives a slightly higher capital weighting to long tail lines than the Prescribed Method, the differences are small.

Table 3
Base Case Allocation of IMB Method's MCR to Business Lines

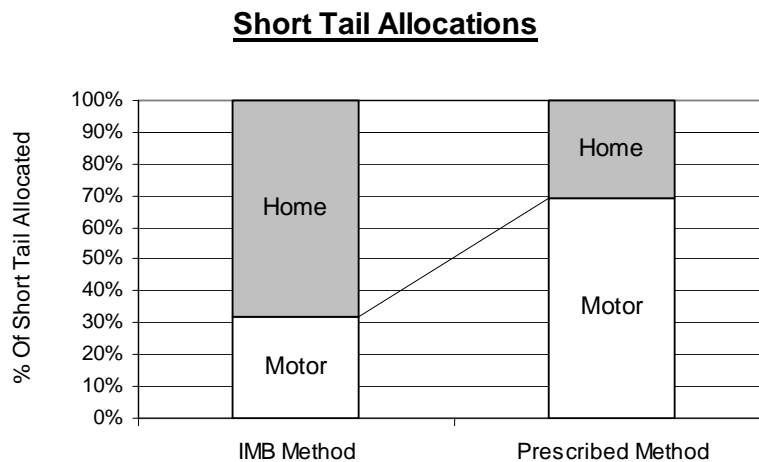
IMB Method MCR – Base case

Business Line	Capital Allocated \$'000	% of total
Motor	28,291	9.1%
Home	60,965	19.7%
Fire & ISR	11,550	3.7%
Public Liability	7,266	2.3%
CTP	201,323	65.1%
	309,396	100%

There are however significant differences in capital allocations at an individual line level for household (home), public liability and CTP insurance. The Prescribed Method allocates the same percentage charge to both household and motor insurance. Since the model insurer has approximately half the level of household insurance as motor insurance, the Prescribed Method capital charge is approximately half. However, the allocation of the MCR calculated by the IMB Method to the household line is more than double the capital allocated to the motor line. This is driven largely by the significantly higher CV for household insurance based on the Tillinghast report assumptions (33% CV for household compared with 22% for motor). The difference between the capital allocations under the two methods is illustrated in Figure 2.

In considering these allocations of capital it is worth emphasising that we are comparing a Prescribed Method with a method that was designed to ensure an equal expected rate of return to capital across lines of business. These differences will only be of real significance if company management were to use these results in their business strategy or decision making. In practice, these allocations are used for a variety of purposes including pricing as well as decisions about which lines of business to grow and to limit.

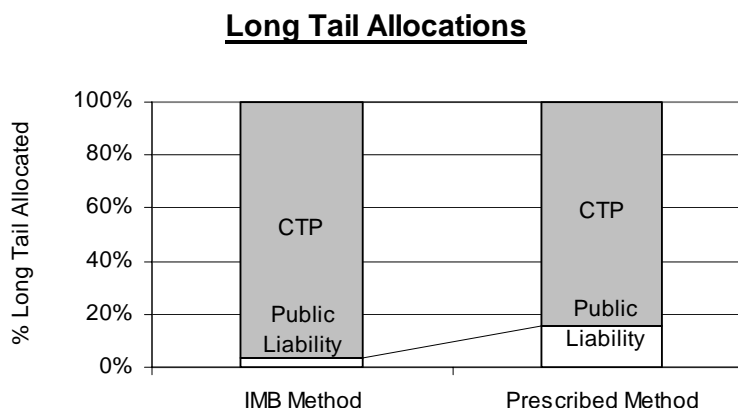
Figure 2
Relative Short Tail Capital Allocations



For public liability and CTP insurance the Prescribed Method gives the same allocation of capital charge percentages to each of these lines so that the difference in the Prescribed Method capital charged for the model insurer is due to the relative sizes of the business lines (51.8% of capital is allocated to CTP with 9.7% allocated to public liability). For the internal model allocation the capital allocated to CTP is much higher (65.1%) and for public liability it is much smaller (2.3%). Figure 3 illustrates the differences between the capital allocations under the two methods for the long tail lines. The difference in this case is driven largely by the diversification effects from each line. Public liability insurance has a moderate correlation (35%) with CTP and zero correlation with all other business lines. This results in the public liability line providing large diversification benefits to the model insurer. CTP on the other hand is assumed to have a 50% correlation with motor insurance so the diversification benefits to the model insurer are diminished and a higher level of capital is therefore

allocated to this line. The Prescribed Method has difficulty handling correlations between lines of business and differences in insurer business mixes. This is a strength of the internal model, although the assumptions underlying the correlations between business lines need to be considered carefully.

Figure 3:
Relative Long Tail Capital Allocations



6.2 Alternative Assumptions

Table 4 summarises the results from the alternative assumptions. The table shows the capital requirements from the IMB and Prescribed Methods for the base case and for each of the alternative assumptions.

Table 4
Summary of MCR Comparisons for Alternative Assumptions

Comparisons for All Scenarios

		Base Case	Trow-bridge CVs	80% Equities	Short Tail Only	Long Tail Only	Small Insurer
		\$'000	\$'000	\$'000	\$'000	\$'000	\$'000
<i>IMB Method</i>	Prophet	309,396	94,586	370,414	209,196	228,828	139,951
	Credit Risk	28,705	28,705	28,705	10,745	12,513	5,577
	TOTAL	338,101	123,291	399,119	219,941	241,341	145,528
Std Error IMB		10,912	3,469	13,517	5,221	9,056	5,413
<i>Prescribed Method</i>	Investment Risk	36,391	36,391	85,366	9,157	22,656	9,098
	Credit Risk	28,705	28,705	28,705	10,745	12,513	5,577
	OSC Liability	91,290	88,237	91,290	7,890	80,999	28,808
	Premium Liability	61,641	59,415	61,641	30,885	23,789	15,876
	Concentration Risk	15,000	15,000	15,000	15,000	0	15,000
TOTAL		233,027	227,749	282,001	73,677	139,956	74,359

6.2.1 Alternative Volatility Assumptions

Adopting the lower CVs from the Trowbridge report dramatically reduces the MCR calculated under the IMB Method by \$214.8M. The internal model results are extremely sensitive to the volatility assumptions for the insurance liabilities. An insurer who uses the Trowbridge CVs for the volatility of their business will require

an MCR under the IMB Method that is significantly lower than the MCR calculated under the Prescribed Method. Without an extensive study of liability volatility to validate these assumptions, it is open to insurers who can use the internal model approach to adopt volatility assumptions in line with these levels.

6.2.2 Riskier Asset Mix

As expected, the MCR under both the IMB and Prescribed Methods increase when the insurer's proportion of invested assets in equities is increased to 80%. However, there is a difference in increase for each method. Under the IMB Method, the MCR increases by \$61.0M while under the Prescribed Method the increase was much less at only \$49.0M. The capital charge for equities in the Prescribed Method may not be sufficient to allow for the impact of these securities on ruin probabilities.^{vii} Since asset risk, especially asset mismatch risk, is a major risk run by insurers, a Prescribed Method should not encourage insurers to adopt a riskier investment strategy. The above result suggests that the Prescribed Method in Australia may have an incentive for insurers to invest in equities.

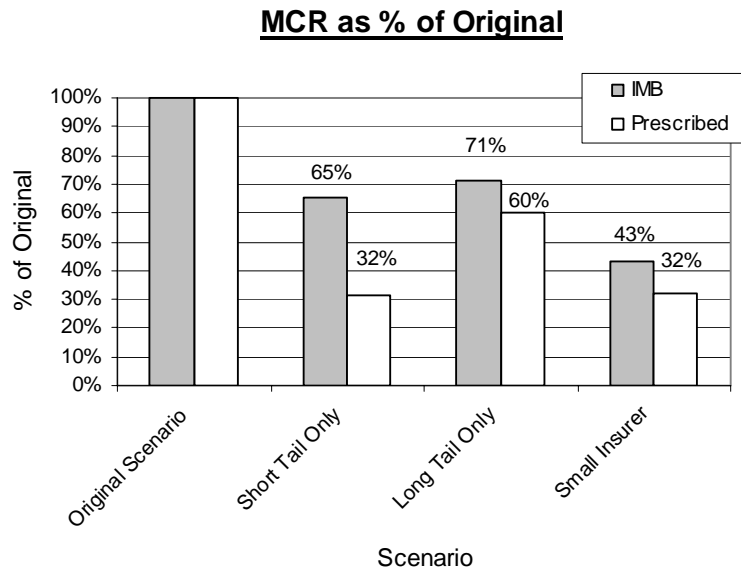
It is interesting to note that had the Trowbridge CV assumptions been used, then changing the asset mix from 20% equities to 80% equities would have increased the MCR by a greater amount of \$83.7M. The reason for the larger increase under the Trowbridge assumptions is related to the relative size of the various risks and their impact on ruin probability. The Trowbridge assumptions have lower insurance liability volatility, so that fewer of the outcomes at the 99.5th percentile of the capital required distribution are due to high claims costs. Instead, the outcomes at the 99.5th percentile are more often due to low asset returns. This leads to a higher proportion of the overall capital under the IMB Method being attributed to asset risk when insurer liability volatility assumptions are lower. This in turn creates a greater disparity between the Prescribed Method's and IMB Method's charges for asset risk.

6.2.3 Short Tail Insurer

Removing the long tail lines from the insurer reduces the overall insurer's size along with the MCR. Under the IMB Method the MCR reduces by \$118.2M while under the Prescribed Method the reduction is significantly larger at \$159.3M. The internal model allocates more capital to each of the insurer's liabilities than is charged by the Prescribed Method. So, rather than comparing absolute changes in MCR, it is more interesting to compare the relative changes. The same will hold for the long tail and small insurer scenarios.

Figure 4 illustrates the MCRs under the different assumptions relative to the base case.

Figure 4
Alternative Assumptions MCRs as a Percentage of the Base Case



For the short tail insurer, the IMB Method has a reduction in its MCR of 65% of its original size, while under the Prescribed Method the MCR reduces to 32% of its original size. The internal model is allocating a greater amount of capital to a purely short tail insurer compared to the Prescribed Method. The reasons for this highlight some further shortcomings of the Prescribed Method. By reducing the number of lines of business, diversification benefits are lost. This is accounted for in the IMB Method but not by the Prescribed Method, which has constant capital charges independent of the business mix. The result is that the capital calculated under the IMB Method is higher than under the Prescribed Method.

The short tail capital charges (relative to other capital charges) under the Prescribed Method may also charge less for the risk of those lines than the internal model. This would be consistent with Collings' (2001) finding that as an insurer increases its business mix with short tail lines^{viii}, it will have a relatively larger capital increase under the IMB Method than the Prescribed Method.

This means that insurers will have an incentive to write short tail lines if they are using the Prescribed Method. If there is a relative advantage in capital required for short tail lines this may also lead to underpricing of these lines.

6.2.4 Long Tail Insurer

In Figure 4 we note that the MCR calculated by the IMB Method reduces to 71% of its original size, while under the Prescribed Method the MCR reduces to 60% of its original size for the case of a long tail insurer. The internal model allocates a higher level of capital to a purely long tail insurer than the Prescribed Method.

The same two effects as for the short tail insurer appear to apply to the case of the long tail insurer. Once again there is a loss of some diversification benefits for the purely long tail insurer leading to the higher relative MCR under the IMB Method than the Prescribed Method. The long tail capital charges (relative to other capital

charges) under the Prescribed Method charge less for the risk of those lines than the internal model. This is inconsistent with Collings (2001) findings that increasing the business mix with long tail lines^{ix} led to a greater relative MCR under the Prescribed Method than the IMB Method.

However, regardless of the relative impact of long tail lines of business, it is clear that the Prescribed Method can not deal adequately with differences amongst business mix of insurers. Applying the Prescribed Methods will lead to incentives for insurers to change their business mix to optimise their regulatory capital position. Lines of business with too low capital charges will be increased leading to potential price cuts that can not be justified if proper risk allowance were to be made.

6.2.5 Small Insurer

Figure 4 also shows the effect of changing the size of the insurer. In this case the insurer is assumed to reduce to 25% of its original size. Under the Prescribed Method, the MCR reduced by a similar amount to 32% of its original size.^x The percentage capital charges under the Prescribed Method are independent of insurer size. For the IMB Method, while the size of the insurer decreased, the overall volatility of each of the business lines is assumed to increase. This is based on the assumption that smaller business portfolios have greater independent variance and that pooling of insurer risks reduces relative volatility within a class of business. The volatility assumptions in an internal model should depend on the size of the business line, with higher volatility assumed for smaller lines. The overall MCR under the IMB Method reduced to 43% of its original size.

7. Implications For Risk-based Capital Regulation of Insurers

7.1 Dependence of Internal Model Results on Volatility Assumptions

These results show the strong dependence of an internal model's output on the insurance liability's volatility assumptions. Of all the sensitivities performed, the greatest change in MCR resulted from changing from the original Tillinghast insurance liability CVs to the Trowbridge CVs.

Insurers would be expected to prefer to have a lower regulatory capital requirement. Insurers in the industry that have liability volatility similar to the Tillinghast CVs are unlikely to adopt an internal model to calculate their MCR. Insurers that have liability volatility similar to the Trowbridge CVs have an incentive to adopt an internal model to lower their MCR. As yet no insurer in Australia has elected to use an internal model based approach. This may be for a number of reasons. One of these could be that the Prescribed Method produces lower capital requirements than would be required if they were to adopt an internal model. If this were the case then those insurers who use these levels of capital to price their insurance contracts could be undercharging compared to the premium rate required to generate the level of ruin probability considered appropriate by APRA using the internal model approach.

The importance of the assumed CVs in determining an insurer's MCR indicates a clear need for an assessment of the level of volatility across business lines and an understanding as to how this varies across companies. Thomson (2003) commented on APRA's disappointment with the general lack of justification by actuaries in the risk margins they adopted for their first reporting under the new APRA requirements.

It appears that the Australian industry is yet to understand fully the true level of volatility in their insurance business and have yet to reach agreement on best practice in calculating volatility. This is expected to be an important issue for any regulator to address, regardless of country, in the introduction of risk-based regulatory capital requirements.

Issues with the Prescribed Method

Considering the results in Figure 4, it is evident that the Prescribed Method does not prescribe a level of capital that is adequate to ensure a ruin probability of 0.5% for all insurers, regardless of size or mix of business. This is based on the presumption that the internal model used in this study represents an insurer's realistic business situation. The model used has been developed to be close to the realistic situation and reflects industry best practice. The MCR calculated by the internal model should be representative of the actual level of capital required to ensure a ruin probability in one-year of 0.5%. Although the IAA Insurer Solvency Assessment Working Party (2004) state that the Prescribed Method should be conservative to make sure that it is representative of all insurers that conduct business, in the Australian general insurance industry this does not appear to be the case.

An important part of implementing the risk-based capital requirements is the calibration of the Prescribed Method capital charges. APRA calibrated the current capital charges at an industry-wide level so that the total MCR of the industry increased by a factor of 1.4 – 1.5 times the previous level. This was a substantial increase in capital requirements across the industry. The impact of the changes differs between insurers depending on their experience relative to the industry. Insurers with lower volatility experience are effectively treated as the same as those with higher volatility experience. Even if the charges are adequate for the average insurer they may be inadequate for insurers with greater than average volatility. Assuming APRA want to secure an industry-wide solvency requirement of a 0.5% ruin probability in one-year then they will need to increase the Prescribed capital charges for insurance liabilities. Given that the last change in regulatory requirements increased the capital requirement in the industry by around 50%, a further increase is a politically contentious issue.

This is the situation that is likely to face many regulators at an international level when they consider the introduction of these risk-based capital requirements. There are likely to be poorly capitalised insurers that will no longer be able to operate under these more stringent requirements. At the same time capital strong insurers will be expected to meet the requirements. Given the difficult capital situation that has been faced by the insurance industry at an international level, the adoption of risk-based capital for insurers may take longer and require more attention to capital weak insurers than otherwise.

An important issue for the Australian regulator will be to consider the liability capital charges that should be increased and to what extent. Collings (2001) found that short tail lines had a relatively higher capital requirement under the IMB Method compared to the Prescribed Method, and vice versa for long tail lines. While the results from this study are broadly consistent with this, the differences between long tail and short lines are less distinct.

At an individual line level, our internal capital allocation showed that the household line was allocated a significantly larger amount of capital than the motor line. This was driven by the higher CV assumption for household from the Tillinghast report. Differences in household and motor volatility suggest that it is inappropriate for household and motor to have identical capital charges.

Differences in the capital allocations between CTP and public liability were assumed to be driven largely by diversification effects. Smaller insurers and insurers with less diversified business mixes are under charged under the Prescribed Method to a greater extent than larger and well-diversified insurers. This strongly indicates the need to include diversification benefits in the capital requirements, concentration charges for less diversified insurers or varying capital charges based upon business size.

Further sophistication to the Prescribed Method must be weighed up against the benefits of simplicity in the method. However it is clear that using a Prescribed Method that is out of line with the actual risk-based capital requirements will produce incentives for insurers to behave out of line with the economics of the business. This is a critical issue if this approach leads to an incentive for insurers to underprice or grow riskier business lines.

7.3 Investment Risk Capital Charges

Our results demonstrated that the capital required for higher levels of equity investment was greater under the IMB Method than the Prescribed Method. The Prescribed capital charge for equities under the model assumptions is insufficient to cover the risk. This is consistent with the findings of Collings (2001) that the Prescribed Method is less responsive to increases in equity investment than the IMB Method. An adequate charge to cover equity risk at the 99.5th percentile would need to be larger than the current Prescribed charge of 8%,^{xi} particularly for insurers with investment portfolios that are not well diversified.

On the asset side, the Prescribed Method provides little incentive for insurers with a well-diversified investment portfolio. As an example to illustrate this point consider the property investment capital charge. The capital charge for property investment is 10% while the capital charge for listed equity is 8%. For insurers that perceive there to be relatively higher risk-adjusted returns to be gained from equity than property, there is an incentive to overweight their investment in equity. This is despite the fact that there can often be considerable diversification benefits of holding equity and property together. Collings (2001) provides another example by considering the diversification and immunisation benefits of holding appropriate amounts of government bonds and cash. While there is an optimal amount of each of these securities to hold that minimises overall volatility for the insurer, the capital charges under the Prescribed Method do not distinguish between the two asset classes and charge a constant amount of 0.5%.

In order to ensure the MCR under the Prescribed Method provides an industry-wide solvency requirement of a 0.5% ruin probability in one-year, APRA will need to change the investment capital charges. For risky assets such as equity, the current capital charges should be increased. APRA should also provide incentives for insurers to hold well-diversified asset portfolios. This could be achieved by offering diversification discounts or alternatively a more stringent investment concentration charge.^{xii}

7.4 Incentive to Use an Internal Model

The opening section of APRA's capital standards states that APRA encourages insurers with sufficient resources to adopt an internal model for calculation of their MCR. APRA has a desire for insurers to begin to adopt the IMB Method in line with its aim for insurers to more closely match their capital requirements with their individual risk characteristics. The results of the analysis of the capital requirements that we have undertaken indicate that there is no incentive to adopt the IMB Method especially if an insurer has insurance liability CVs in line with the Tillinghast report. The Prescribed Method's capital charges would need to increase to the extent that the internal model would produce a lower MCR. Alternatively there needs to be a much closer examination of the volatility of insurer liabilities and a more careful calibration of the Prescribed Method capital charges.

There are other reasons why insurers would not adopt an internal model for the MCR calculation. Even though risk management and measurement techniques in non-life (property and casualty) insurance have vastly improved over the last decade and DFA modelling has become an important part of internal management for many large insurers, developments in these areas are still occurring. The IMB Method requires an internal model with a very high degree of sophistication to adequately address all the material risks of an insurer and their complex interrelationships. There also needs to be the actuarial and risk management human resource skills to ensure proper implementation and interpretation of results. The internal model used in this study was based on simplifying assumptions and the internal model for a real-world insurer would be far more complex. Even with an adequate internal model, the assumptions required in the model need far more careful attention. A greater understanding and consensus of the underlying volatility of insurance liabilities is a major requirement for non-life insurers in order to adopt an internal model for MCR calculation.

Even as actuaries develop the necessary skills and capabilities to adequately implement an internal model for the IMB Method, there will no doubt exist further obstacles from other stakeholders in the general insurance industry. The "black-box" stigma attached to internal models is likely to be an area that actuaries will need to overcome in order to convince general insurance senior management and the regulators to trust the internal model's output for management purposes and MCR calculation.

Industry experts have identified another obstacle to the IMB Method. Financial analysts involved in the trading of general insurance company shares may not have the confidence in the insurer management to rely on them determining their own regulatory capital requirements. Financial analysts may not be willing to rely upon the MCR calculated under the IMB Method.

Differences in approaches to internal modelling may also make it difficult to compare the MCR output from one insurer's internal model with another insurer. Comparison across different insurers is important for regulatory reasons and to avoid opportunistic insurers taking advantage of differences in models. Financial analysts and regulators may prefer to make MCR comparisons based upon the Prescribed Method where the formula is fixed and insurer judgement does not impact the results. This leaves open the need to develop Prescribed Method charges that are more risk-based.

7.5 Further Research

Our results depend to some extent on the degree to which the model and the assumptions used are representative of actual insurers. Our aim has been to use an internal model that broadly represents the insurer's business situation and parameters and assumptions based on industry best practice. We would expect any insurer that used a model similar to the one that we have used for the IMB approach would come to similar conclusions.

In this study, many simplifying assumptions were made in the model's calibration. We are not aware of any comprehensive study that has been completed that examines and assesses the appropriate insurance liability volatility assumptions taking into account actual insurer data and allowing for insurer specific characteristics. This is a critical area of research required for risk-based regulatory capital if internal models are to be used with any confidence.

The modelling of claims correlation is another important area for further research. Dependency models need to be further considered. Brehm (2002) outlines a formal quantitative approach for estimating correlation from data. The Tillinghast and Trowbridge reports' use a much more qualitative approach. Copulas also have great potential for modelling insurance liability dependencies, especially for tail events.

8. Conclusions

The IAA Insurer Solvency Assessment Working Party (2004) has advocated two methods for non-life insurers to calculate their capital requirement – the Standard Approach and the Advanced Approach. In Australia, these dual capital requirements are known as the Prescribed Method and the IMB Method. This study explores the implications of these new capital requirements.

From APRA's perspective, the aim is to meet a regulatory objective of requiring that insurers hold a level of capital to ensure a minimum ruin probability across the industry. It is important that the Prescribed Method adequately charges risks to meet this objective for all non-life insurers licensed to do business in Australia.

This study compared the MCRs calculated under the two methods and analysed the Prescribed Method's capital charges using a model representative of industry best practice. Despite this, simplifying assumptions were made in the model's calibration and there remains a lack of consensus as to the insurance liability volatility assumptions.

However the results of this study have highlighted some significant issues for both regulators and insurers. For the model insurer studied, the MCR calculated under the IMB Method was significantly larger than the MCR under the Prescribed Method. The implication of this result is that despite APRA's desire for insurers to adopt an internal model for MCR calculation, there is an incentive for insurers to use the Prescribed Method to produce a lower MCR. This also highlights the need to develop Prescribed Methods that are as consistent with the underlying risk of the insurer. To do this the need for a diversification allowance is very important.

The results were shown to be highly sensitive to the insurance liability volatility assumptions. However it is arguable that the current capital charge levels in Australia

are too low in order for the Prescribed Method to ensure a ruin probability in one-year of less than 0.5% across the entire general insurance industry. This is likely to be very difficult to achieve. Differences between insurers of different sizes and with different business mixes should at least be considered more carefully in any revision of the Prescribed Method capital charges.

There is a strong case for including either diversification benefits or more stringent concentration charges in the Prescribed Method to address the risk reduction associated with a well diversified business mix and asset portfolio and to give a more consistent treatment of insurers with different characteristics.

The internal model's results rely heavily on its volatility assumptions. There is a major need for a study to be carried out using insurer level data to develop a consensus in the industry as to the level of insurance liability volatility that should be allowed in internal models for capital determination.

We can only conclude that there is much to be done by regulators and insurers if they are to adopt risk-based capital requirements. Some countries have taken a step along this path already. Australia has been one of the first countries to introduce a risk-based regulatory regime for non-life insurers and its experience is no doubt of great interest to insurers, actuaries and regulators internationally. We have analysed the capital requirements with a view to identifying lessons for others. There is still a long way to go before insurers will be in a position to confidently adopt the IMB Method for the MCR calculation even in Australia.

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- Information on The Smith Model (TSM) can be found at www.thesmithmodel.com

Endnotes

- ⁱ For further information on the background to the APRA general insurance reform, refer to Gray (1999), Gray (2001) and IAA Insurer Solvency Assessment Working Party (2004).
- ⁱⁱ APRA's Prudential Standard GPS 110.
- ⁱⁱⁱ Readers are referred to Collings (2001) and IAA Insurer Solvency Working Party (2004) for prior work in this area.
- ^{iv} The model described in this section is of the model calibrated for the purposes of this study.
- ^v See APRA GPS 110 for the insurance and investment risk capital charges.
- ^{vi} The concentration risk charge is allocated only to the short tail and fire & ISR lines.
- ^{vii} This is based on the assumption that TSM is a realistic model of asset returns.
- ^{viii} Collings (2001) used motor insurance as an example of a short tail line.
- ^{ix} Collings (2001) used public liability insurance as an example of a long tail line.
- ^x The MCR under the Prescribed Method did not reduce to 25% of its original size since the risk margins for a smaller insurer are higher and the concentration charge was assumed to remain constant at \$15M.
- ^{xi} 8% is the Prescribed capital charge for listed equity securities.
- ^{xii} The current investment concentration charge only applies to Grades 4 and 5 debt and does not apply to concentrated holdings in other securities.

Appendix 1 Insurance Models

Full details of the DFA model assumptions are available from the authors and are provided in Sutherland-Wong (2003). We provide a brief summary of the main assumptions here.

A1.1 Run-off Claims Model

$$X_{ij}^{RO} \sim \text{Lognormal}(\mu_{ij}, \sigma_{ij}^2)$$

X_{ij}^{RO} – Run-off claims for business line i in accident year j

Volatility of business lines used in base case DFA model based on Tillinghast report.

CVs by Business Line

	Outstanding Claims Liability CV	Premium Liability CV
Motor (Dom)	12.4%	21.7%
Home	18.9%	33.1%
Fire & ISR	18.9%	28.4%
Public Liab	23.7%	29.6%
CTP	21.8%	27.2%

Runoff patterns used in DFA model case study are available from the authors. These were developed from assumed industry run off patterns.

Cumulative Payment Patterns (Uninflated) by Business Line

	Motor (Dom)	Household	Fire & ISR	Public Liability	CTP
Development Period					
1	81%	86%	20%	11%	5%
2	100%	98%	90%	23%	11%
3	100%	99%	95%	37%	24%
4	100%	99%	98%	54%	41%
5	100%	100%	99%	69%	59%
6	100%	100%	100%	81%	73%
7	100%	100%	100%	88%	82%
8	100%	100%	100%	92%	88%
9	100%	100%	100%	95%	93%
10	100%	100%	100%	97%	96%
11	100%	100%	100%	98%	98%
12	100%	100%	100%	99%	99%
13	100%	100%	100%	99%	99%
14	100%	100%	100%	99%	100%
15	100%	100%	100%	100%	100%

A1.2 Attritional Loss Model

Parameters for attritional losses

Attritional Claims Parameters (Lognormal Distribution)

(Claims are a % GEP)

	Motor (dom)	Home	Fire & ISR	Public Liability	CTP
μ	-25.4%	-81.7%	-70.8%	-74.8%	-36.3%
σ	22.4%	30.6%	26.0%	27.0%	20.9%

A1.3 Large Claims Model

$$K_i^L \sim \text{Poisson}(\lambda_i)$$

$$(X_i^L)_k \sim \text{Lognormal}(\mu_i, \sigma_i^2)$$

$$Z_i^L = \sum_{k=1}^{K_i^L} (X_i^L)_k$$

K_i^L – Number of large claims for business line i

$(X_i^L)_k$ – Size of the k^{th} large claim in business line i

Z_i^L – Aggregate large claims for business line i

Large Claims Parameters (Poisson Frequency & Lognormal Severity)

(Claims are \$'000)

	Fire & ISR	Public Liability	CTP
λ	0.53	1.36	1.42
μ	7.72	8.22	8.67
σ	0.46	0.25	0.22

A1.4 Catastrophe Claims Model

$$K_j^C \sim \text{Poisson}(\lambda_j)$$

$$(X_j^C)_k \sim \text{Empirical Distribution}$$

$$(Y_j^C | X_j^C)_k \sim \text{Empirical Distribution}$$

Each business line is assigned a fixed percentage of either the primary severity or the secondary severity for each catastrophe type.

$$(PC_i)_j = P_j^C \times A_i$$

$$(SC_i)_j = S_j^C \times B_i$$

A_i – % of primary severity for business line i

$(PC_i)_j$ – Aggregate primary claims for business line i from catastrophe type j

B_i – % of secondary severity for business line i

$(SC_i)_j$ – Aggregate secondary claims for business line i from catastrophe type j

$$P_j^C = \sum_{k=1}^{K_j^C} (X_j^C)_k$$

$$S_j^C = \sum_{k=1}^{K_j^C} (Y_j^C | X_j^C)_k$$

K_j^C – Number of catastrophe events for catastrophe type j
 $(X_j^C)_k$ – Primary severity of the k^{th} event for catastrophe type j
 $(Y_j^C | X_j^C)_k$ – Secondary severity of the k^{th} event for catastrophe type j
 given that the primary severity was $(X_j^C)_k$
 P_j^C – Aggregate primary severity for catastrophe type j
 S_j^C – Aggregate secondary severity for catastrophe type j

Estimated parameters used in the base case DFA model.

Small Catastrophe Claims Parameters (Poisson Frequency & Empirical Severity)

λ	Mean (% of GEP)	Std. Dev
4.3	0.88%	0.43%

% Impact to Each Business Line

	Motor (dom)	Home	Fire & ISR
% of Primary Severity	50%	100%	190%

Large Catastrophe Claims Parameters (Poisson Frequency & Empirical Severity)

Large Catastrophe Type	λ	Mean (% of GEP)	Std. Dev
1	0.5	24.73%	31.69%
2	0.4	64.35%	82.67%
3	0.3	20.81%	26.73%

% Impact to Each Business Line

Large Catastrophe Type		Motor (dom)	Home	Fire & ISR
1	% of Primary Severity		6%	8%
	% of Secondary Severity	64.6%		
2	% of Primary Severity		9%	8%
	% of Secondary Severity	1.6%		
3	% of Primary Severity		85%	84%
	% of Secondary Severity	33.8%		

A1.5 Superimposed Inflation Model

$$P = \begin{bmatrix} p_{00} & p_{01} \\ p_{10} & p_{11} \end{bmatrix}$$

$$I_N \sim \text{Uniform}(a_N, b_N)$$

$$I_H \sim \text{Uniform}(a_H, b_H)$$

P – Transition Probability Matrix

p_{ij} – Transition probability from state i to state j

I_N – Superimposed inflation rate in the normal state

I_H – Superimposed inflation rate in the high state

Estimated values were:

$$P = \begin{bmatrix} 0.9 & 0.1 \\ 0.2 & 0.8 \end{bmatrix}$$

$$I_N \sim \text{Uniform}(-0.02, 0.04)$$

$$I_H \sim \text{Uniform}(0.05, 0.15)$$

A1.6 Correlation Matrix for Attritional Claims

$$\text{Correlation Matrix} \sim \begin{bmatrix} \rho_{11} & \rho_{12} & \rho_{13} & \rho_{14} & \rho_{15} \\ \rho_{21} & \rho_{22} & \rho_{23} & \rho_{24} & \rho_{25} \\ \rho_{31} & \rho_{32} & \rho_{33} & \rho_{34} & \rho_{35} \\ \rho_{41} & \rho_{42} & \rho_{43} & \rho_{44} & \rho_{45} \\ \rho_{51} & \rho_{52} & \rho_{53} & \rho_{54} & \rho_{55} \end{bmatrix}$$

ρ_{ij} – correlation of attritional claims between business line i and j

The parameter values based on the Tillinghast study were:

	Motor (dom)	Home	Fire & ISR	Public Liability	CTP
Motor (dom)	1.00	0.75	0.40	0.00	0.55
Home	0.75	1.00	0.35	0.00	0.00
Fire & ISR	0.40	0.35	1.00	0.00	0.00
Public Liability	0.00	0.00	0.00	1.00	0.35
CTP	0.55	0.00	0.00	0.35	1.00

A1.7 Asset mix

For the base case the asset mix assumed was

Asset Mix

	Proportion Invested
Cash	15%
Equities	20%
Fixed Interest	55%
Index Bonds	10%
	100%

Appendix 2: Summary of Australian Prescribed Capital Charges

i. Outstanding Claims and Premiums Liability Capital Charges for Direct Insurers

Class of Business	Outstanding Claims Risk Capital Factor	Premiums Liability Risk Capital Factor
Householders Commercial Motor Domestic Motor Travel	9%	13.5%
Fire and ISR Marine and Aviation Consumer Credit Mortgage Other Accident Other	11%	16.5%
CTP Public and Product Liability Professional Indemnity Employers' Liability	15%	22.5%

ii. Investment Capital Charges

Asset	Investment Capital Factor
Cash	0.5%
Debt Obligations of: <ul style="list-style-type: none"> • the Commonwealth Government; • an Australian State or Territory government; or • the national government of a foreign country where: <ul style="list-style-type: none"> – the security has a Grade 1 counterparty rating; or, if not rated, – the long-term, foreign currency counterparty rating of that country is Grade 1. GST receivables (input tax credits) 	0.5%
Any debt obligation that matures or is redeemable in less than one-year with a rating of Grade 1 or 2 Cash management trusts with a rating of Grade 1 or 2	1%
Any other debt obligation (that matures or is redeemable in one-year or more) with a rating of Grade 1 or 2 Reinsurance recoveries, deferred reinsurance expenses and other reinsurance assets due from reinsurers with a counterparty rating of Grade 1 or 2	2%
Unpaid premiums due less than 6 months previously Unclosed business Any other debt obligation with a rating of Grade 3 Reinsurance recoveries, deferred reinsurance expenses and other reinsurance assets due from reinsurers with a counterparty rating of Grade 3	4%
Any other debt obligations with a counterparty rating of Grade 4 Reinsurance recoveries, deferred reinsurance expenses and other reinsurance assets due from reinsurers with a counterparty rating of Grade 4	6%
Any other debt obligations with a counterparty rating of Grade 5 Reinsurance recoveries, deferred reinsurance expenses and other reinsurance assets due from reinsurers with a counterparty rating of Grade 5 Listed equity instruments (including subordinated debt) Units in listed trusts Unpaid premiums due more than 6 months previously	8%
Direct holdings of real estate Unlisted equity instruments (including subordinated debt) Units in unlisted trusts (excluding Cash Management Trusts listed above) Other assets not specified elsewhere in this table	10%
Loans to directors of the insurer or directors of related entities (or a director's spouse) Unsecured loans to employees exceeding \$1,000 Assets under a fixed or floating charge (refer paragraphs 14-15)	100%
Goodwill (including any intangible components of investments in subsidiaries) Other intangible assets Future income tax benefits <i>(Assets in this category are zero weighted because they are deducted from Tier 1 capital when calculating an insurer's capital base – refer GGN 110.1)</i>	0%