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ALM in a Solvency II World

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Abstract

Global insurance groups are increasingly using large-scale, group-wide internal asset-liability models to inform their economic capital measurement, capital management, group-wide capital allocation, product pricing and discussions with rating agencies.

With the advent of Solvency II, these models will soon be the de facto standard for regulatory capital adequacy measurement and reporting across a large number of global insurers. Several Australian subsidiaries controlled by European parents are likely to be directly impacted by these requirements.

The sophistication of these models has grown exponentially as industry wrestles with the increasing demands of management, regulators, rating agencies and other stakeholders.

The paper considers recent developments in the design of these models as well as the key challenges involved in their application.

Benefits as well as the potential risks and pitfalls will be highlighted using a worked example applied to a hypothetical insurance company. The example should generate an interesting discussion on the usefulness of these techniques and methods for Australian actuaries

Keywords: ALM, Asset liability management, Solvency II, risk based capital, capital management

1 Introduction

A sea change in the asset liability management of insurers has been sweeping through the global life insurance industry over the past decade. The use of static, deterministic models and pre-specified tests for mismatch risks has and will increasingly be replaced by relatively complex dynamic stochastic models of an insurers business. These models can typically be characterised by several key distinguishing features:

- They will typically involve a holistic model of an entire Insurance Group balance sheet.

- They may well involve the stochastic projection of assets and liabilities over some future time horizon, on a "realistic" basis.

- The models will typically attempt to take account of all significant quantifiable risks to the entity, including some potentially awkward and unquantifiable risks, potentially even allowing for "unknown unknowns" (to quote the former US Secretary of Defence).

- The valuation of assets and liabilities will typically be carried out in a market-consistent manner, often utilising complex stochastic methods and simulation techniques to carry out the valuation.

- The models will take into account management decision-making and risk mitigation actions, potentially formalising and quantifying the potentially nebulous actuarial concepts of discretion and policyholder reasonable expectations.

- The modelling of capital fungibility[1] and all forms of diversification between business units and operating entities will be central to the model.

One of the most significant movements into this space is the ongoing Solvency II regulations under development by the European Commission. Solvency II will formalise and expand on previous risk-based capital regulatory environments, and provide a regulatory platform for insurers to make use of their complex internal models to determine regulatory capital requirements.

The purpose of this paper is two-fold. Firstly, it aims to stimulate some thought and discussion on the potential issues raised by the draft Solvency II regulations and the knock-on impact on ALM modelling and risk management for Australian actuaries, both directly within the Australian insurance space and more generally within the wider actuarial field. Secondly, it aims to illustrate via some example modelling the practical implications and limitations of such methods.

Before we continue, it is worth noting that the concepts and methods discussed in this paper are not solely restricted to Life Insurers. General insurers are also adopting such Group-wide economic capital modelling methodologies to measure and manage aggregate risks across their entire business. Indeed, the intended adoption by APRA of internal models for solvency capital purposes is a significant step in formalising the role of such methodologies for Australian general insurers. Considered more broadly, there are clear and emerging practical applications to a much wider range of corporate financial risks, from traditional actuarial fields, for example the

[1] By fungibility we refer to the generally accepted usage of the term, i.e. the ability to freely move capital from one operating entity, fund or business unit to another.

management of defined benefit pension funds in the US and Europe, to issues much closer to home, for instance the corporate balance sheet liquidity risks and complex financing arrangements which have epitomised much of the recent global sub-prime and credit crisis.

Finally, we caution on the blind adoption of models as the final say in managing risks and capital within the life insurance industry. As demonstrated all too often in the recent past, blind devotion to the results and implications of any model is no replacement for the judgement and experience of skilled risk professionals.

2 Summary of Solvency II

By way of background, we provide a brief overview of the regulatory environment proposed under the draft Solvency II regulatory guidelines. The Solvency II framework is currently a moving target, with the draft framework scheduled for implementation by end 2011. The project is currently at its fourth quantitative consultation stage (termed QIS4), with feedback on the results of the implementation from pan-European insurance participants later in 2008. The position described below is based on our understanding of the latest draft EU framework and the technical specifications of QIS4.

2.1 Overview

Solvency II is the catchy tagline for the economic risk-based regulation of insurers currently under development in Europe. The new framework aims to introduce a unified, consistent economic risk-based supervision framework across all EU insurers. The development is spread over two regimes: the draft regulatory framework and legislative environment are the responsibility of the European Commission, while guidance on the practical techniques, calibration and actuarial guidance for capital quantification falls under the remit of CEIOPS (Committee of European Insurance and Occupational Pensions Supervisors).

Solvency II is based on a three-pillar structure, largely in line with the Basel 2 banking framework:

- *Pillar 1 - Quantitative capital requirement*: This covers basic capital requirements including minimum capital requirement (MCR) and solvency capital requirement (SCR)

- *Pillar 2 - Qualitative capital requirement*: This covers the requirements for governance and risk management of insurers, as well as for the effective supervision of insurers.

- *Pillar 3 - Market discipline*: This covers the transparency and disclosure requirements, to support risk-based supervision through market mechanisms

Solvency II is expected to be implemented in 2011 by the European Commission. It is a "total balance sheet" regime where all risks and their interactions affecting the net asset position of an insurance group are to be considered. The broad intention is to capture the economic risks of an insurance business by considering a market-consistent, "exit-value" position of the insurance business. In other words, capital is required to be held to ensure that the entity retains enough capital to allow it to meet its obligations, with a specified level of certainty over a one year period, and remain sufficiently well capitalised at the level that a willing market participant (e.g. another insurer) would pay to relieve it of its obligations at the end of the period.

2.2 Capital requirements

Capital requirements under Solvency II follow a two-tiered structure. Building blocks of the capital requirements under Solvency II are represented by the following diagram.

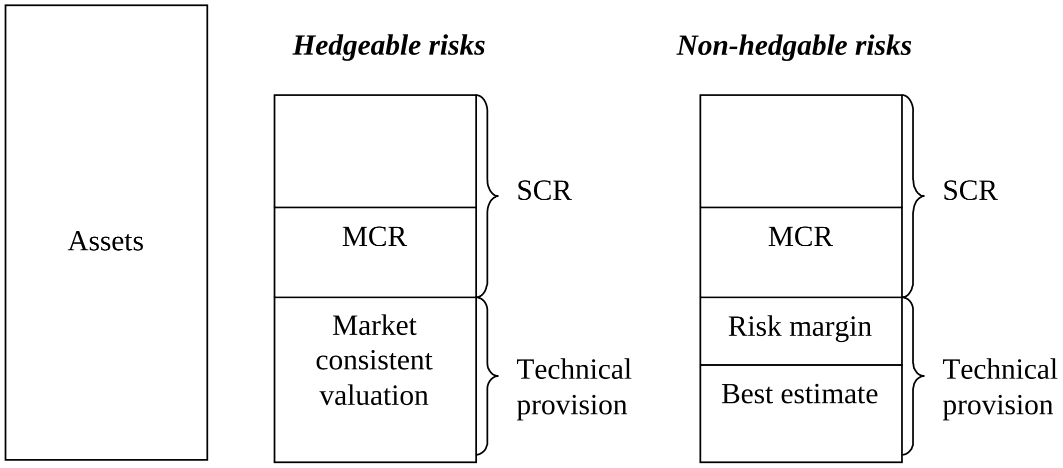

Figure 1: Solvency II Balance Sheet

Each of the main elements of the liability requirements are considered in the following sections.

2.2.1 Technical provisions

Distinction is made between market-hedgeable risks and non-hedgeable risks. In general, it would be expected that the vast majority of insurance risks are not purely hedgeable market risks, or are only partially hedgeable.

For hedgeable risks, the technical provision is the market-consistent value of that liability, i.e. the cost of hedging the liability in the market.

For non-hedgeable risks, the technical provision is comprised of a best estimate component and a risk margin component:

- Best estimate component: calculated using the best estimate of expected future cashflows and discounted using a risk free yield curve, or an equivalent risk-neutral or deflator valuation method for market-contingent cashflows and liabilities.

  It is worth noting that such best estimates of future cashflows can (and should) be negative in some circumstances – for instance under a unit-linked contract the market-consistent value of the liability will typically be less than the face value of units, where an excess of future charges over expenses is expected. This contrasts to the more traditional valuation approach used in solvency calculations of adopting a minimum of a current termination value in any liability valuation.

- Risk margin component: calculated using a "cost of capital" approach. The risk margin is calculated by determining the cost of providing an amount of shareholder funds equal to the SCR necessary to support the insurance obligations over the lifetime of the obligations. Under QIS4, the cost of capital used to calculate the risk margin is 6% above the risk free interest rate. In other words, the cost of capital required for future years is booked on the liability side as the risk margin. This can be considered to be the "cost of risk", i.e. the economic cost to the insurer of underwriting this risk.

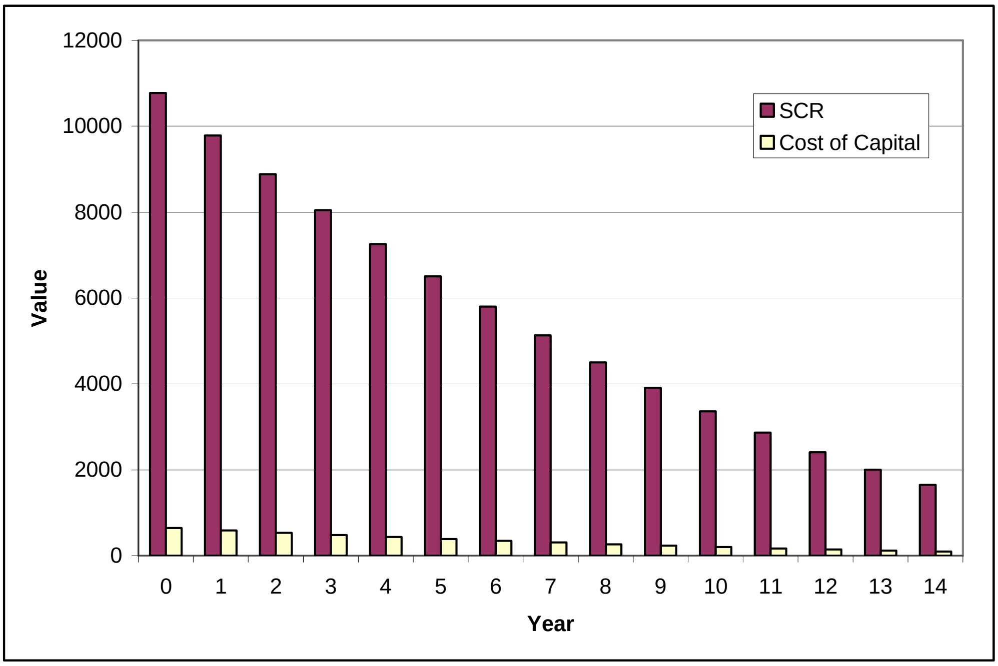

Figure 2: SCR and Cost of Capital Amounts

In practice, the calculation of the risk margin requires the projection of insurance, operational risk and reinsurer default solvency capital requirements over each future time period for a given liability segment. This is a potentially messy and circular process. We discuss this further when considering some example Solvency II modelling in section 5.

2.2.2 Minimum Capital Requirement (MCR)

MCR serves as the threshold for ultimate supervisory intervention and is intended to be lower than the SCR, simple to calculate, and comparable between insurers.

To date the calculation of the MCR has been one of the more contentious calculations in gaining acceptance of the method. CEIOPS has advised that the MCR should be calculated in a more simple and robust manner than the SCR, and should also include an absolute floor. There is a trade-off between simplicity and risk-sensitivity and the MCR is intended to be optimised for simplicity.

Most recent guidance suggests that the MCR may use a modular factor-based approach considering market risk and underwriting risk. It addresses the main risk modules of the SCR in a simplified way and should follow the same one-year horizon as SCR but with a lower level of confidence. Under the QIS4 specification, the MCR for a life insurer is calculated as:

$$MCR_{Life} = \max\left\{\alpha_{WP\_guaranteed} TP_{WP\_guaranteed} + \alpha_{WP\_bonus} TP_{WP\_bonus};\ \gamma TP_{WP\_guaranteed}\right\}$$
$$+ \sum_{i\{non-WP\}} \alpha_i TP_i + 0.25 \cdot Exp*_{ul} + \sum_j \beta_j CAR_j$$

where

$\alpha_{WP\_guaranteed}$ = factor applying to guaranteed with profit benefits[2]

[2] The terms with profit and participating business are taken to mean the same thing here. With profit is by far the more commonly used term throughout Europe, and is used throughout the Solvency II and CEIOPS drafted documents.

α_{WP_bonus} = factor applying to non-guaranteed with profit benefits

$TP_{WP\_guaranteed}$ = Technical Provisions (net best estimate) for guaranteed benefits relating to with-profits contracts

TP_{WP_bonus} = technical provisions (net best estimate) for discretionary bonuses relating to with-profits contracts

$Exp*_{ul}$ = the amount of last year's net administrative expenses in respect of non-retail unit-linked business and management of group pension funds where the policyholder takes the investment risk only.

$\alpha_i TP_i$ = technical Provision multiplied by a factor, separated into different business classes and risk drivers.

$\beta_j CAR_j$ = capital-at-risk multiplied by a factor, separated by outstanding claims of the contract. Capital-at-risk is define as the sum of amounts currently payable on death or disability, less technical provisions (where they are positive)

Under QIS4, the MCR is subject to a floor of 20% of the SCR, and a ceiling of 50% of the SCR, with the Life MCR subject to an absolute floor of €2 million.

2.2.3 Solvency Capital Requirement (SCR)

The SCR corresponds to the economic capital an insurer needs to hold to limit the probability of ruin to 0.5% pa. This probability of ruin is measured relative to the Technical Provisions of the insurer, i.e. it is the amount of capital an insurer would need to exceed the best estimate liabilities plus a risk margin in 1 year's time, with 99.5% confidence. In other words, it is the capital needed in a stress scenario in order to ensure liabilities can be passed on to a third party who could either hedge or hold capital provisions to meet the liability risks.

The SCR is intended to cover all risks that an insurer faces over the next 12 months, and to reflect the true risk profile of the undertaking allowing for all quantifiable risks, as well as the net impact of risk mitigation techniques. It is calculated using Value-at-risk techniques in one of two ways: either in accordance with standard formulae, or using an internal model.

The basic SCR specifies the following risk modules. For those interested, the parameters suggested for the standardised formulae stresses as set out in QIS4 are contained in Appendix A.

1. Market risk, split into

   - Interest Rate risk
   - Spread risk
   - Equity risk
   - Asset concentration risk
   - Exchange rate risk
   - Property risk

2. Counterparty default risk; and

3. Life risk, covering the following sub-risks:

   - Mortality risk
   - Longevity risk
   - Disability risk
   - Lapse risk

- Expense risk
- Catastrophe risk
- Revision risk

Most of these are self-explanatory. Revision risk relates to the unexpected revision of benefit amounts under annuity-type liabilities, for instance Workers Compensation-style benefits, which in some jurisdictions are considered life business. For other general insurance lines of business, additional modules specify the calculation of capital charges for general and health risks.

Under the standard formulae approach, capital charges are calculated for each of the SCR components in accordance with a series of instantaneous stresses to each of the various risk drivers in isolation. The capital charge is generally the change in net asset value following the stress. A correlation matrix is used to combine and reduce the capital charges for the various risks, which allows for the diversification of risks. The SCR will take account of any risk mitigation techniques and management actions applied by the insurer, e.g. reinsurance, securitisation, investment strategies etc. In particular the risk-mitigating effect of future profit sharing is explicitly allowed for in the calculation of capital charges.

There is also an Operational Risk capital charge calculated as the lower of 30% of the basic SCR, or 3% of premium plus 0.3% of Reserves. This is simply added to the basic SCR - no allowance for any diversification between Op risks and other risks are permitted.

2.3 Internal Models

Of particular interest here is the potential for the use of internal models. The use of internal models to calculate capital requirements, rather than the standard formulae approach, should be familiar to many Australian actuaries. APRA has this year initiated a process of allowing general insurers to apply to have their internal models used as the basis for calculation of regulatory capital requirements. The Solvency II approach is similar, but extends across all insurance sectors.

Internal models have been typically classified into “partial” and “full” models, reflecting the scope of their modelling relative to risk categories of the insurer. It is questionable just how acceptable partial models will be in a Solvency II world. The potential for insurers to cherry-pick the risks they model in an attempt to minimise capital requirements will undoubtedly be a key focus of local regulators, and a significant barrier to acceptance of internal models over the standard formulae.

There are several key reasons for using internal models to calculate Solvency II capital requirements.

- Firstly, the standardised approach will most likely be calibrated conservatively. This suggests that internal models may produce lower capital requirements, after allowing for insurer-specific risks.

- Secondly, the methodology and assumptions adopted by the standard formulae are necessarily broad. No single set of assumptions is likely to successfully cover the enormous breadth of risks and interactions between those risks across an entire industry. It is notable that, with the exception of underwriting risks, insurers’ are generally expected under QIS4 to use the standard set of assumptions whenever they calculate their SCR capital requirements. If the final regime tends towards the same model, the use of an internal model will be the key method of exercising significant discretion in the calibration of insurers’ capital requirements. Contrast this to the Capital Adequacy regime in Australia, which retains significant discretion in the margins applied to determine capital requirements.

There are several key tests and standards which insurers' will need to pass in order to adapt their internal models for capital purposes. These include:

- A "Use Test". This tests how well the model is integrated into the wider ERM framework within the insurer. The logic being that, for a model to truly reflect the capital requirements of the business, it should heavily influence the parts of the business it purports to model. Integration of ALM models into corporate structure, risk-based capital management and allocation, product pricing, investment strategy, reinsurance programmes and almost any other realm of actuarial involvement is demanded.

- A statistical quality test. This tests how well the internal model meets actuarial and statistical methodology standards, as well as testing that data is accurate, complete and appropriate. The draft directive also specifically mentions that all payments to policyholders and beneficiaries (whether contractually guaranteed or not) should be allowed for within the modelling, as well as permitting assumptions about future management actions.

- Calibration Standards. This permits internal models to be set up with alternative time horizons or risk measures, provided the calculation of the SCR can be shown to provide an "equivalent level of protection" to the one-year, 99.5% VaR requirement. For instance, an insurer may wish to model the run off of an annuity book over the life of the book rather than a one-year period, and calculate capital required to fund the annuity cashflows at some lower level of confidence. In practice it is unclear how this would be demonstrated in practice. The likely result is that very few (if any) insurers would deviate from the standard risk metric.

- Documentation standards. Insurers should set out in detail the design and operational details of the model, as well as providing a detailed theoretical outline of the theory, assumptions and mathematical and empirical basis underlying the models.

3 Comparison with the current Australian approach

Overall, the Solvency II structure has some striking similarities to the current Australian structure:

- MCR is the "hard floor" on capital similar to the Solvency requirement under LPS 2.04, a trigger below which insurers' authorisation will ultimately be under threat.

- SCR is intended as the capital buffer needed to meet policyholder obligations with a certain probability, above the market-consistent value of liabilities. The aggregate amount of capital needed can be viewed as similar to Capital Adequacy requirements under LPS 3.04, the trigger for closer regulatory intervention.

On the other hand, there are many differences between Solvency II and the current Australian approach:

3.1 Risk Targets

Australian solvency requirements are to hold sufficient capital to meet contractual policyholder liabilities in a stressed environment, with a given level of certainty; Capital Adequacy requirements require the insurer to hold sufficient capital to meet all benefits, whether guaranteed or discretionary, at a given, generally stronger, level of confidence. This contrasts with the Solvency II requirements. There, insurers are required to hold capital to provide a certain probability of being able to fund policyholder expectations in a stressed environment, by ensuring market-consistent liabilities can be passed on to a third party. This can be considered holding capital to fund an "exit value" of liabilities rather than a "runoff" of contractual obligations.

3.2 Probability of Insolvency

Australian Cap Ad requirements require capital to be held at the 99.75% level over 1 year, i.e. holding capital against a 1 in 400 year event. At first glance this appears to be deeper into the tails of the distributions than Solvency II's 99.5% 1-year probability, i.e. a 1 in 200 year event. The difference in the risk target above (i.e. funding contractual obligations vs. policyholder expectations) means the Australian standards are not necessarily stronger.

3.3 Use of Internal Models

Solvency II appears to actively encourage the adoption of internal models into the business by implying the potential to reduce regulatory capital requirements. While the use of some partial internal models is implied for some lines of business under Australian capital requirements, the presence of a large-scale, holistic model of the business to determine capital remains in the initial stages of approval for general insurers only at present.

3.4 Allowance for group-wide diversification benefits & capital fungibility

Solvency II allows credit to be taken for both diversification by risk type and geographically across business units within a group. The standard formulae explicitly allow for credit for simple risk diversification benefits, while internal models will invariably be applied to recognise greater allowance for diversification within an insurance group. Allowance for this level of diversification is easier to justify, quantify and ensure consistency in a regulatory environment spanning 27 member countries than the single country jurisdiction of the Australian environment.

4 ALM Internal Modelling Best Practice

As large-scale global insurers have enhanced their modelling capability in recent years, best practice is being identified in a number of areas of internal economic capital modelling for insurers. Nonetheless, in other areas, best practice is yet to emerge.

4.1 Data Integrity

Control, collation and storage of data for use by insurance models remains a significant issue. Representations made as part of Solvency II suggest that some of the significant costs involved in the development of Basel II compliant risk management systems for banks will need to be replicated for insurers – namely the rigorous IT-led systems to collate, organise, access and verify all forms of internal data. This will potentially require data warehousing systems, a costly and demanding level of expenditure in an industry where legacy IT systems and numerous costly admin system migrations remain rife. It is notable that the UK financial regulator, which has used insurers' internal models as part of their capital requirement regime for some time, has previously indicated that none of the insurers' submissions to date would meet the demanding data requirements of the Solvency II regime.

4.2 Embedding of Models Into Business

The integration of ALM models into the business, in line with the "Use Test" required under Solvency II, is an area of best practice which is still evolving. As evidenced by the significant push towards Enterprise Risk Management (ERM) skills within the profession globally, significant progress has been made in "book-knowledge"; arguably far less has been made in practice. Significant efforts to obtain Board approval, ownership and buy-in to modelling has allowed significant inroads to be made for some insurers, yet significant political issues and the sheer cost and complexity of true integration make this one of the more demanding elements of internal model best practice.

4.3 Economic & Insurance Risk Scenario Generation

The use of commercially available Economic Scenario Generators to project economic variables (interest rates, credit spreads, FX rates, asset returns & income and other economic indicators, often in multiple currencies) in a real-world context has been widespread in internal models. In many instances risk-neutral or deflator models sourced from the same providers are also used to value contingent liabilities. While some internally developed models are in place, the use of third parties' models has generally been accepted within the insurance sector given the development time and expertise needed, ongoing calibration and documentation burden, and ease of auditability which third party vendors have typically provided. The presence of independent calibrations has also proven popular with insurers' desire to demonstrate integrity to regulators and auditors alike.

On the downside, the lack of transparency and time required to gain comfort in the underlying models used has proven a cost to insurers adopting such models. Where sufficient in-house quantitative expertise exists, the development of economic modelling internally has been possible.

Far less well developed is best practice in modelling non-economic variables, such as mortality or persistency experience. Difficulties here include the need to model both short-term experience and changes in expectations over time within a model, and ensuring consistency with both insurer-specific risk profiles and independently generated economic scenarios. The body of academic and actuarial research into such models has improved in recent times (due in part to the ongoing attempts to market mortality derivatives), although their practical usage remains relatively limited within insurers internal models. Some more notable implementations are in place in partial models concerned with specific lines of business (e.g. stochastic longevity risk models incorporated into annuity book models).

4.4 Market-Consistent Valuation of Assets & Liabilities

For most insurance liabilities, a market consistent liability valuation is in principle simply a case of discounting best estimate future cashflows at the relevant risk free rate, and then adding any necessary risk margin. However for some liabilities with benefits contingent on market risks this approach is insufficient. An example illustrates this:

Suppose we have a conventional endowment contract, paying a sum assured plus bonuses at maturity, plus some potential terminal bonuses. The underlying assets backing the policy are based on some set of investments, including equity-style investments. It has been noted for some time that the typical treatment of such a liability (valuing the guaranteed element only, plus potentially some future additions to this guarantee via future regular bonuses) falls short in representing the economic liability, where we also have to contend with the discretionary terminal bonus element. In practice the economic liability is closer to paying out the underlying asset share with a minimum floor on the liability. The liability becomes an asset share plus a put option on the asset share[3], rather than a guaranteed-only liability backed by the asset share, the classical approach taken where we choose not to value the discretionary terminal bonus component. This introduces important consequences for both ALM risk management and modelling.

To value the put option liability, a simple discounting of cashflows no longer suffices. Option pricing methods must be used, and will typically be complicated by an asset strategy which varies over time (usually in a way which depends on the solvency of the insurer, in turn influenced by market conditions), path dependencies in the level of future bonus rate additions granted, regular premiums, and other complications associated with the specific features of the type of contract, particularly the impact of policyholders' reasonable expectations on any discretionary elements.

Global insurers have invested significantly in the past few years in developing complex market-consistent, Monte-Carlo simulation models to value such liabilities. Typically this is a highly complex task in itself, requiring pricing models capable of simulating multiple asset classes over multiple time periods in a variety of currencies, all within an arbitrage free framework. Such models will be calibrated to replicate the prices of traded market instruments best reflecting the nature of the liability being values, such as equity options, or interest rate caps or swaptions. Significant issues need to be addressed in terms of producing a calibration which extrapolates the (often scanty) market-implied data onto the valuation of considerably longer-dated insurance liabilities.

4.5 Model Calibration & Sensitivity Testing

The complexity of any "full" internal model can be quite staggering. The importance of thoroughly documented, rationally argued and back-tested model calibrations

[3] Equivalently, this can be considered as a guaranteed liability plus a call option on the underlying asset share. Economically, the valuation, problems and issues are the same.

cannot be overemphasised. Of equal importance is the requirement to ensure that any model calibration is more than just a fit to historic data. Over-reliance on historic data-implied model inferences has gazumped many an unwary model user in recent times, as the litany of "unforeseen" circumstances claimed by introspective model-dependent financial firms to be apparent "10 sigma" events demonstrates.

Particularly crucial in terms of internal capital modelling are deep understandings of model-implied tail correlations. The significance of diversification benefits claimed by many insurers' modelling inevitably needs to be subject to a critical assessment of just how jointly "extreme" the scenarios giving rise to aggregate capital requirements genuinely are. It is worth pointing out that tail correlations inevitably depend on both the model construction and the calibration of the models

4.6 Projection of Derivatives & Complex Financial Instruments

The complexity of asset holdings held on many insurers balance sheet has grown enormously over recent years. The internal models of large-scale insurers are now having to cope with the demands of projecting and valuing complex derivative positions, non-traditional assets such as alternatives, commodities and Mortgage and Asset-Backed securities. The interactions between such assets, traditional asset classes underlying the derivatives and the impact of asset-contingent liability values lends itself well to the complex models in use.

4.7 Dynamic Management Actions and Hedging Programs

One of the key benefits of using internal models is their ability to capture dynamism and management behaviours operating in a non-linear, solvency-dependent way. For example, an implemented dynamic hedging program might involve the implementation of a set of rules altering the underlying asset strategy of a book of business given certain triggers, e.g. varying levels of solvency coverage. Identifying and modelling these rules will drastically alter the risk structure of an insurer, and their effect often can't adequately be captured using a simpler, deterministic set of stress tests to identify risk-based capital requirements. Some interesting examples of this have been witnessed in German insurance markets, where modelling has uncovered major issues with structures driven by historic book values and policyholder expectations which led to the development of products with dynamically increasing duration mismatches.

4.8 Multiple Time Period Projections & Nested Simulations

A stochastic asset-liability model projecting the future balance sheet position of the insurer is likely to be the main component of any internal model. Given the comments above regarding the use of Monte-Carlo simulation techniques to value a liability at a given point in time, projecting this value over some stochastic future period of time presents some particular difficulties. In theory, to do this would require a nested simulation model, with the (outer) simulations projecting the real-world position of the insurer over time, and then performs a further simulation at each point simply to value the liabilities and assets, e.g:

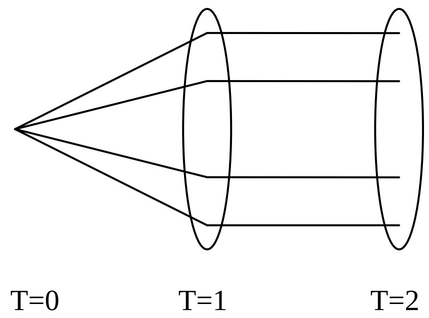

Figure 3: Nodes of Stochastic Simulation

Each line here represents a possible sample path in our stochastic projection. At each "node" of the stochastic projection above, the insurer needs to value their complex path-dependent liabilities, also by simulation. An insurer may wish to have (say) 50,000 sample paths of their capital projection, and require a further 10,000 to value the liability at each node. That's a lot of simulations, which even with modern computing power provides an obstructive computational burden.

The solution is to use one of a number of techniques to reduce the scale of the problem, either using closed-from approximations to the projected liability value at each node (which can capture the non-linear behaviour of the liability valuation over time), or alternative "smarter" techniques (such as Least Squares Monte Carlo) developed within the quantitative finance literature to deal with the problem of embedded options within derivative contracts. Note that solutions to these problems are still in their infancy within insurance models, with best practice yet to emerge.

5 Case Study – A Sample Model Office Stochastic ALM model

To illustrate some of the issues and techniques surrounding the use of large-scale ALM models within a Solvency II context, we consider a sample asset liability model. This has the following key features:

- The model projects assets and liabilities on an existing book of business over a variable time horizon and model timestep. In our case we consider annual projections over a 5 year period, in annual timesteps.

- The model allows for the stochastic projection of assets and liabilities, their value, cashflows and regulatory valuation for capital purposes. In this example, we have used 10,000 scenarios produced by the Barrie & Hibbert ESG[4] to project key economic and market risk variables within a real-world set of scenarios. This provides us with term structures of nominal and real interest rates, inflation experience, risk-free and credit-risky bond portfolio returns (including default risk and credit transition behaviour) and FX rates, plus income and returns on several key asset classes (equities, property & alternative assets). Appendix C details the key assumptions involved in the calibration of the asset model.

- Additional simple stochastic models developed by the author for mortality experience, mortality expectations, persistency experience and expense experience supplement the economic scenarios. The key assumptions of note are that we assume different (albeit highly correlated) sources of uncertainty for mortality and longevity risks, with decorrelation of risks at alternative ages. For simplicity, both mortality experience and lapse risks are assumed to be independent of market risks, with mortality expectations updating in line with mortality experience over time[5]. Appendix B provides further details of the models and calibration adopted.

- Given the focus on understanding ALM risks, capital management and the impact of regulatory capital requirements, we limit the projection to a current book of in-force business. Naturally if we were interested in understanding the projected actual capital consumption and risk profile of the company over time, we would need to include new business over our projection horizon.

- Within each stochastic simulation we consider the projected assets and liabilities of the book, in addition to the regulatory solvency requirements of the book. Regulatory solvency requirements are considered for the current draft Solvency II standard formula requirements. These have been based on the formulae and methodology set out in the most recent CEIOPS SII consultancy phase, QIS4, summarised in Appendix A. In terms of internal capital modelling, we consider the net position of assets less technical provisions as the key measure of solvency.

- For simplicity, all taxes are ignored. For the purposes of understanding our high-level ALM principles this is not a significant complication worth considering in detail here. Needless to say, tax considerations do provide significant practical and theoretical complexities in practice, particularly where we are interested in calculating “market values” for complex, market-contingent insurance liabilities.

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[4] The Barrie & Hibbert ESG is a commercially available economic scenario generator for both risk neutral pricing and real-world simulation. Its use in our examples reflects its wide use in such modelling in Europe and the US.

[5] Best practice in this instance would have some linkage, especially for certain products, between lapses, morbidity and possibly for mortality catastrophes.

It is worth noting that the intention of this section of the paper is not to comment on the specific calibration of the Solvency II and APRA capital charges. Given the preliminary nature of the QIS4 calibration, this would be a premature step. Instead, we focus on the impact of the calculation methods and the sensitivities and nature of the projected capital position of our modelled insurer.

We have selected below products to consider that are common across many jurisdictions around the world, rather than choosing Australian-specific products.

5.1 Sample Policy 1 – Conventional Endowment

We start by considering first of all a participating pure endowment contract. For simplicity the contract is assumed to be a paid-up contract, paying a sum assured plus bonuses on death or maturity, with the potential for terminal bonuses on maturity. We assume that the asset share[6] of the contract is payable on surrender. The following single contract is considered.

Maturity (Years)	Sum Assured	Attaching Bonus	Asset Share (VSA)
5	30,000	3,000	30,000

Table 4: Endowment Assurance Liability Profile

For simplicity we assume that compound bonuses are granted at the best-estimate rate of 2% pa. Once again for simplicity this is assumed to be constant. A more realistic model would allow this to vary in line with the solvency position of the fund, although in this short-term example the valuation effect of not doing so is small.

Assets of the fund are invested in a mix of equities and bonds, in the following proportions.

Asset Type	Holding
Cash	10.00%
Equity	30.00%
Bond	60.00%

Table 5: Asset mix for assets backing Endowment Assurance business

Bonds are assumed to be invested in a variety of government bonds, with an aggregate duration of 4 years at outset, approximately equal to the duration of the portfolio, after allowing for lapses and mortality.

First off, we consider the initial balance sheet of the book. Under the basis set out in Appendices A, B and C the initial balance sheet is as follows:

[6] Asset share is defined here as the accumulation of premiums less expenses and risk charges at the earning rate of the underlying fund.

Initial Balance Sheet		
		Solvency II
		$
Assets	Asset Value	31,307
Liabilities	Asset Share	30,000
	Put Option Value	231
	Risk Margin	423
	Tech Provisions	30,653
	Net Assets	653
	SCR	653
	Free Capital	0

Figure 6: Initial Capital Balance Sheet of Endowment Book

The SCR calculated under Solvency II here is based on the standard SCR formulae, and not on our model.

The technical provisions under the endowment contracts are made up of two elements: the asset share of the underlying contract, plus the value of any additional payments required on maturity or death should the guaranteed sum assured plus bonus bite, referred to above as the "Put Value". This value is calculated assuming a 20% implied equity volatility, and zero volatility in respect of the matching bond assets. As a writer of a put option, we are "long" implied volatility in our market-consistent Solvency II balance sheet. Therefore uncertainty in this volatility will also be a risk factor we should allow for. For the time being we ignore this risk, although it certainly would be allowed for in a full internal model.

We consider the capital position of the fund over the 5 years remaining of the contract in terms of our internal model. We do so by considering the capital position in our projected scenarios. Figure 7 shows the net assets of the fund at the end of each policy year under Solvency II assumptions, in each of our model simulations.

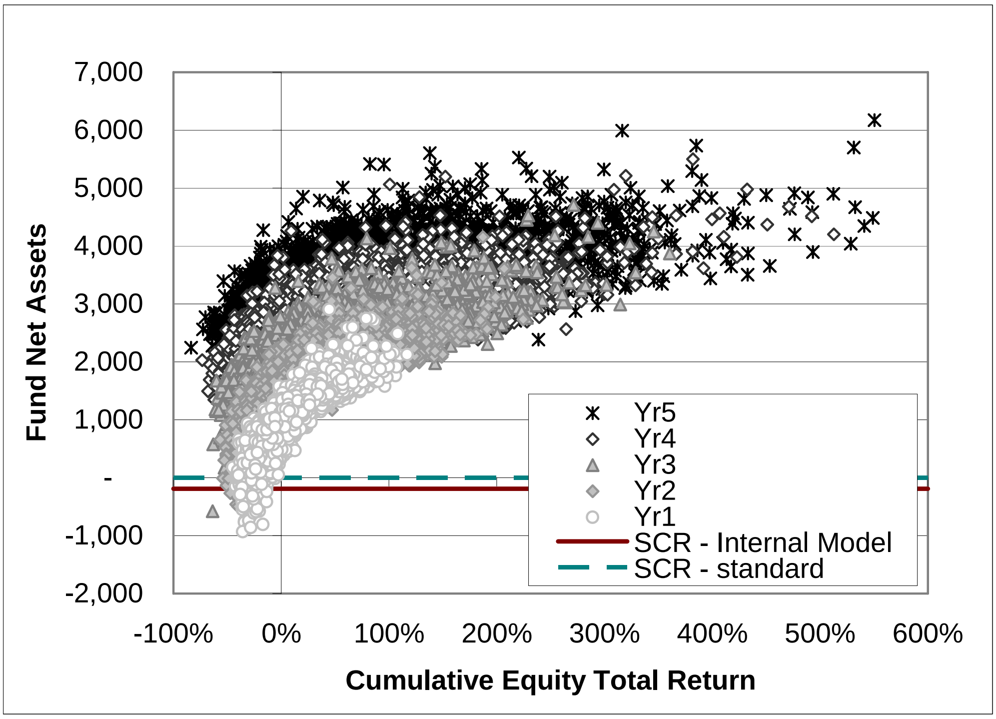

Figure 7: Projected Net Asset position, Solvency II

In the above, the horizontal lines represent the capital requirements under the simulation model, calculated as the 99.5% of the end Yr 1 capital, discounted back to time 0 at the earned return on the fund, and the standard formulae capital requirement. The internal model capital requirements are $190 greater than the standard SCR of $653

In our simplistic example, the standard formulae capital requirements are actually higher than the model implied results. This is a combination of several elements:

- The calibration of the key internal model elements is slightly more conservative than the standard formulae: 99.5% of equity returns is -35%, 1Y yield fall is -53%, 10Y 35% of starting yields in our ESG scenarios. Each of these is marginally larger than the equivalent QIS4 standard stress test (32%, 51% and 34% respectively).

- The non-linear impact of the optionality in the equity returns, in combination with the other risk drivers, leads to a higher impact when modeled explicitly, rather than via a simple stress test.

- There is additional diversification built into the internal model e.g. diversification along the yield curve (the standard formulae shocks are a single curve scenario), and between risk drivers.

- Our simple model made no allowance for long-term changes in lapse expectations – uncertainty in persistency was assumed to be time diversifiable. This is an important assumption in this case, and illustrates the importance (and difficulty) of allowing for a reasonable model of policyholder behaviour within a complex stochastic model.

- Our internal model makes no explicit allowance for Operational Risk (although this contribution of the overall SCR is actually small).

It should be noted that this is just a single example. The Solvency II calibration includes some allowances for diversification benefits, which are likely to mitigate these impacts over a more diverse book of business.

Finally, it can be seen that the capital position becomes more positive in all simulations. This is a result of the emergence over time of risk premia from our equity assets, and the relative caution in the diversification benefits assumed under Solvency II, relative to the internal model calibration.

We can also consider the drivers of the changes in capital requirements. In particular, we consider the distribution of the elements that contribute to the total Solvency II technical provisions. The distributions at the end of each of the first 4 years in the liability components are shown in the chart below, with various percentiles of the component elements shown in decreasing shades of colour.

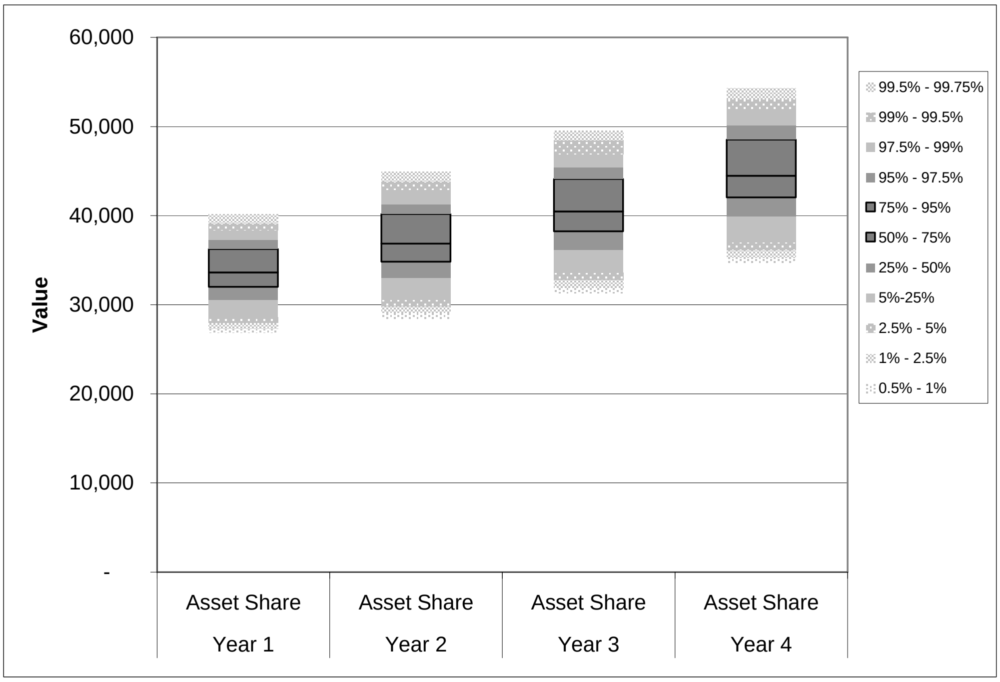

Figure 8: Distribution of Solvency II tech provision components – Asset Share

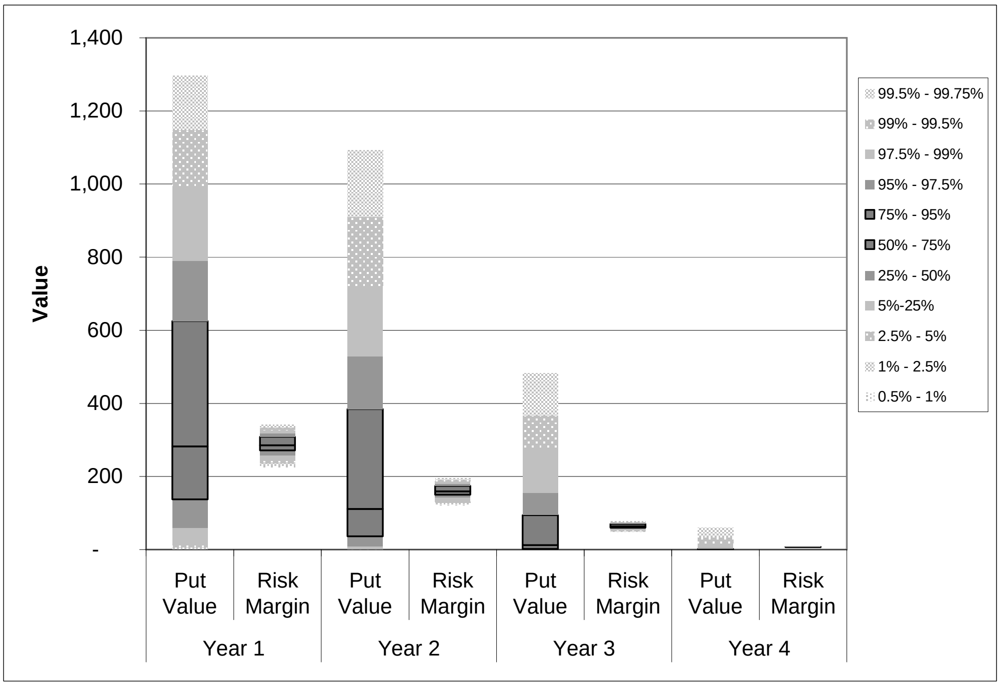

Figure 9: Distribution of Solvency II tech provision components – Put Option & Risk Margin

The charts above illustrate several things:

- Firstly, for this contract the risk margins are not significant contributors to either the size or the variability of the technical provisions.

- Secondly, the risk margins and put options both decrease towards zero at maturity. This is a result of the reducing risk as maturity approaches, and the fact that the guarantees are increasingly in-the-money.

- Third, the Put Option decreases in importance (in terms of the magnitude of the contribution to total Technical Provisions) over time as the time value of the option decreases. This can be seen by the decreasing median option value relative to the increasing median Asset Share liability.

Finally, we plot the net asset position at a one-year time horizon relative to the key risk drivers here – value of the put option, short-term interest rates and equity returns.

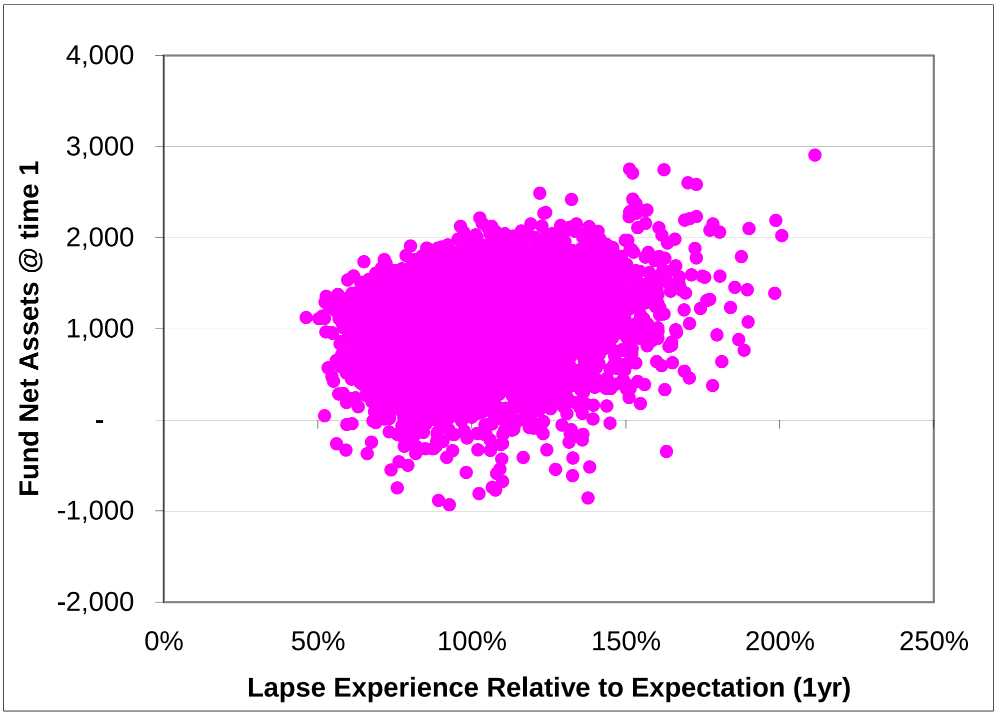

Figure 10: 1-year Net Assets relative to lapse experience

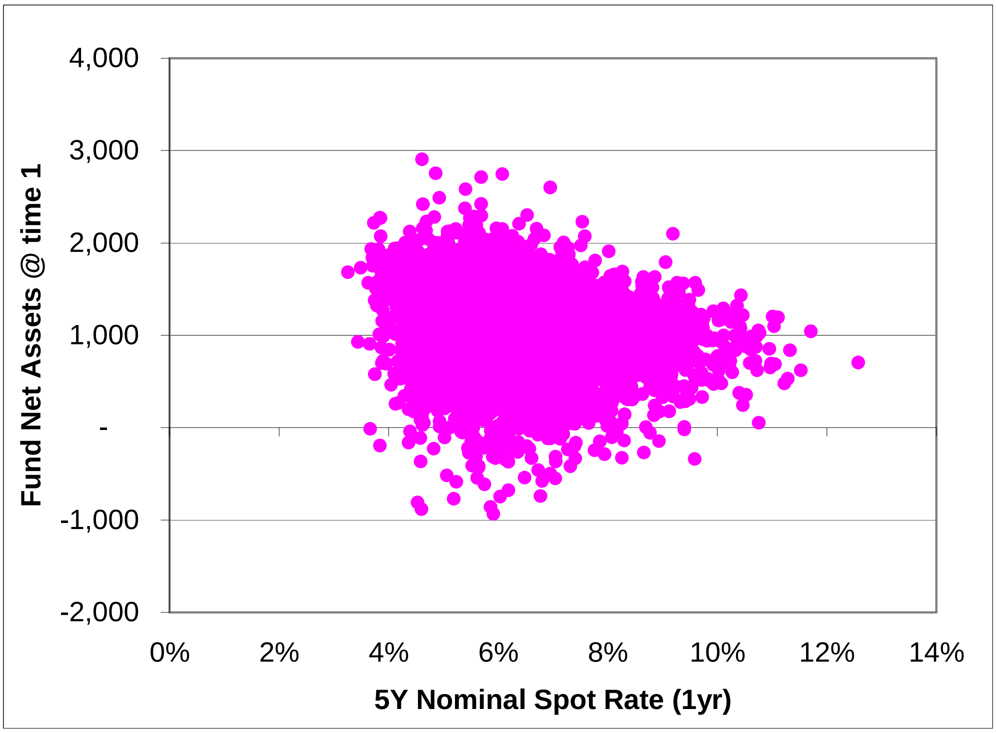

Figure 11: 1-year Net Assets relative to 5Y Interest Rates

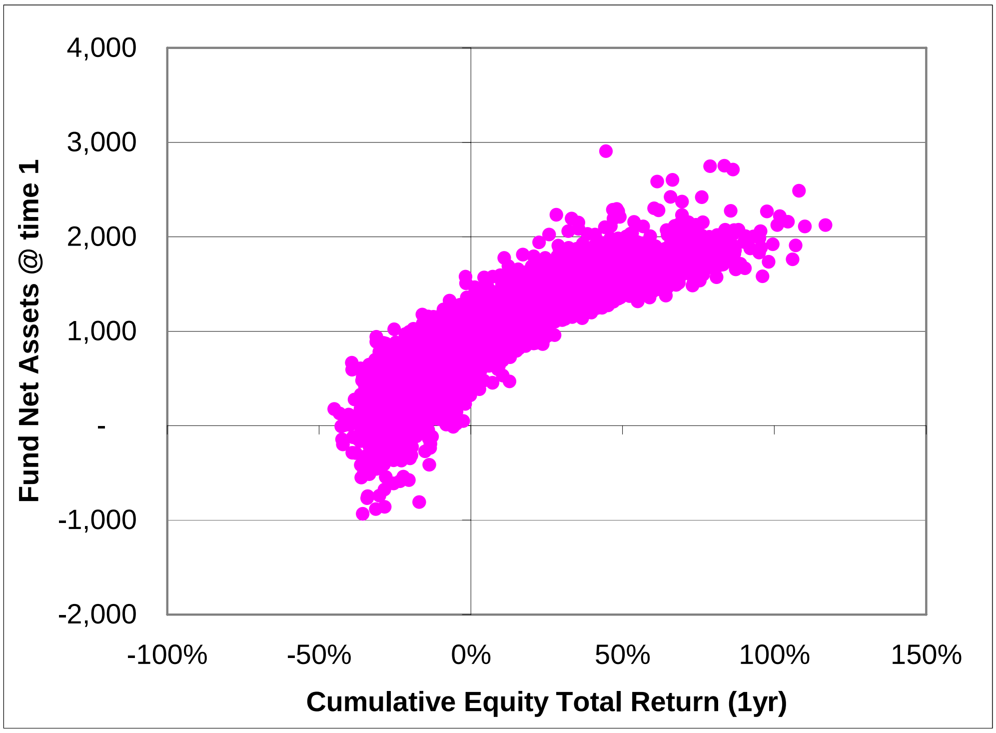

Figure 12: 1-year Net Assets relative to Equity Returns

We can see from the above that lapse experience turns out to be a weak driver of the net capital position after 1 year, as exhibited by the relatively "flat" net asset position relative to lapse experience. This is not unexpected, as the assumed payment of asset share on surrender should ensure the company is relatively indifferent to lapses, in terms of its net capital position. A small residual exposure to low lapse experience remains, given the capital requirements associated with the maturity guarantees.

Interest rates are also a relatively small contributor, again not unexpected given the (almost) duration matched position assumed.

Of more interest is the relative exposure to equities, which clearly drive much of the change in net assets. Unsurprisingly the Solvency II exposure is heavily dependent on equity returns, given the assumed optionality within the Solvency II position. Note that this effect is relatively small, and remains confined to the most extreme scenarios, where the non-linearity of the option begins to become more apparent.

We finally consider a similar chart, this time showing the end-year capital position relative to the value of the Solvency II put option.

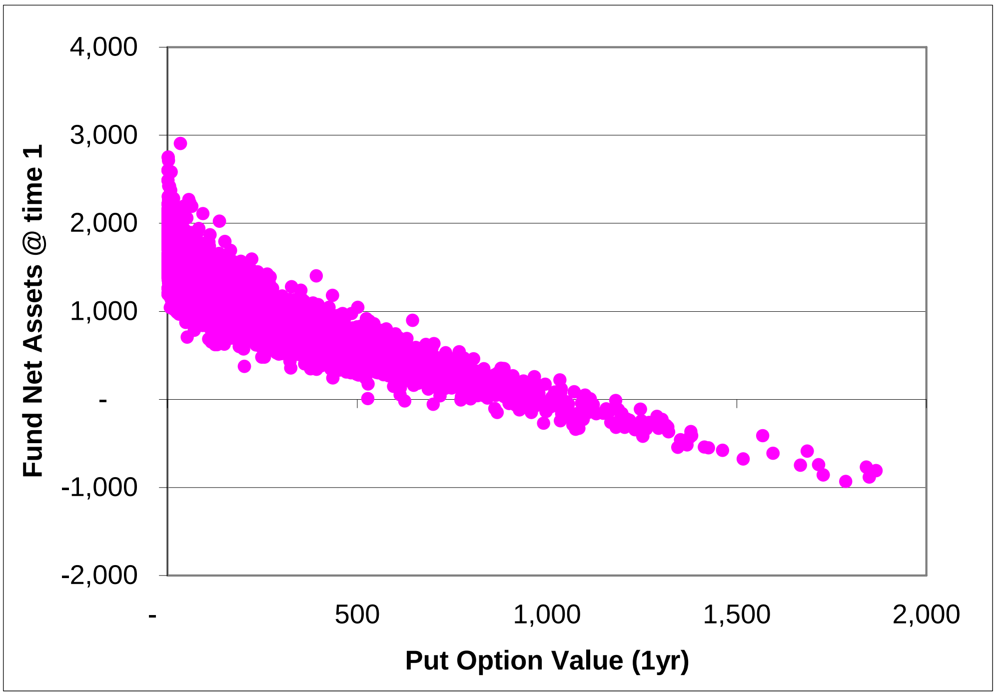

Figure 13: 1-year Net Assets relative to SII Put Option value

Unsurprisingly, the optionality and non-linearity exhibited by the Solvency II liability is a strong driver of capital in the model. A more sophisticated, simulation-based valuation approach is necessary to deal properly with our non-modelled issues of path dependence and dynamism in bonus rates, although our simple approach here captures much of the dynamic. Regardless of this, we can clearly observe the stronger impact on free capital in situations where the option value is larger.

5.2 Sample Policy 2 – Unit Linked Fund

We turn our attention to another example, this time a unit-linked policy. Again, for simplicity we consider a single contract, this time a 5 year unit-linked contract. We choose the 5 year term purely to illustrate the progression of capital over time, not to be representative of the typical duration of such contracts.

Maturity (Years)	Unit Value	Annual Premium	Management Fee[7]	Annual Expenses
5	100,000	1,200	1%	$500 fixed + 0.1% Inv Mgt Expense + 0.2% Renewal Expense

Table 14: Unit Linked Liability Profile

The contract has the following initial balance sheet and underlying asset mix. As before, we assume no hypothecation within the fund, and set the initial asset amount equal to the Solvency II standard formulae capital requirement.

Asset Type	Holding
Cash	5.00%
Equity	30.00%
Property	20.00%
Alternative Assets	15.00%
Overseas Equity	10.00%
Risk Free Nominal Bond	10.00%
AA Bond	10.00%

Table 15: Asset mix for assets backing Endowment Assurance business

Initial Balance Sheet

		Solvency II
		$
Assets	Asset Value	100,922
Liabilities	BE Liability Value	98,577
	Risk Margin	160
	Tech Provisions	98,736
	Net Assets	2,185
	SCR	2,185
	Free Capital	0

Figure 16: Initial Capital Balance Sheet of Unit Linked Book

We see that the liability value of the unit-linked policy under Solvency II is actually less than the unit value of $100,000. This is a result of using a "realistic" economic balance sheet approach. The present value of the excess future charges over expenses is essentially booked on the realistic balance sheet as an asset. The relatively large SCR is primarily a result of the charge made to cover lapse risk, where the lapse scenarios no longer provide for this excess of charges over expenses. Like Solvency II, the Cap Ad capital requirement also allows for the excess of future charges over expenses, but is subject to a minimum of the unit value. We might commonly expect to see a minimum of the Solvency capital requirement biting in this case.

[7] The management fee is assumed to be net of trail commission.

Firstly, we consider the Solvency II net assets in each modeled scenario, at each time horizon:

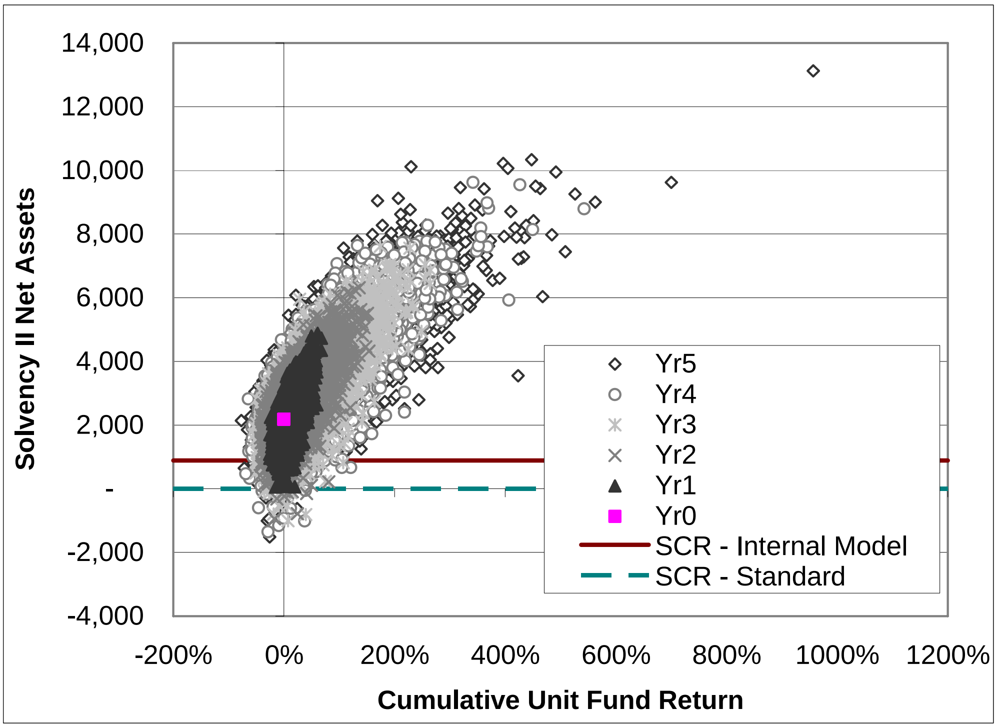

Figure 17: Projected Solvency II Net Assets vs Unit Linked fund return

We can see that the net asset position under the Solvency II book is never actually negative in the first year in our simulations; the internal model capital requirement is \$1,303 compared to \$2156 under the standard formulae, \$882 less than the standard formulae. The Solvency II regime capital requirement appears significantly stronger than our model suggests.

Also of note is the impact that the unit fund return has over time. We see that the net asset position "flattens" relative to the fund return over time. This suggests that the one-year driver of this return is not perhaps the same as the longer term behaviour. Why should this be the case? The approach of allowing the net expected future charges to be considered an asset turns out to be the main cause. In the first year this excess "asset" effectively earns the return on the unit fund. In reality these excesses are only earned over time, and are subject to considerable uncertainty (e.g. funding costs via uncertain future interest rates, lapse and expense experience, and expense inflation). This uncertainty dilutes the assumed initial asset return assumed to be earned on the excess charges.

We also consider the drivers of the capital position, and whether this has any impact on the management of capital within the fund.

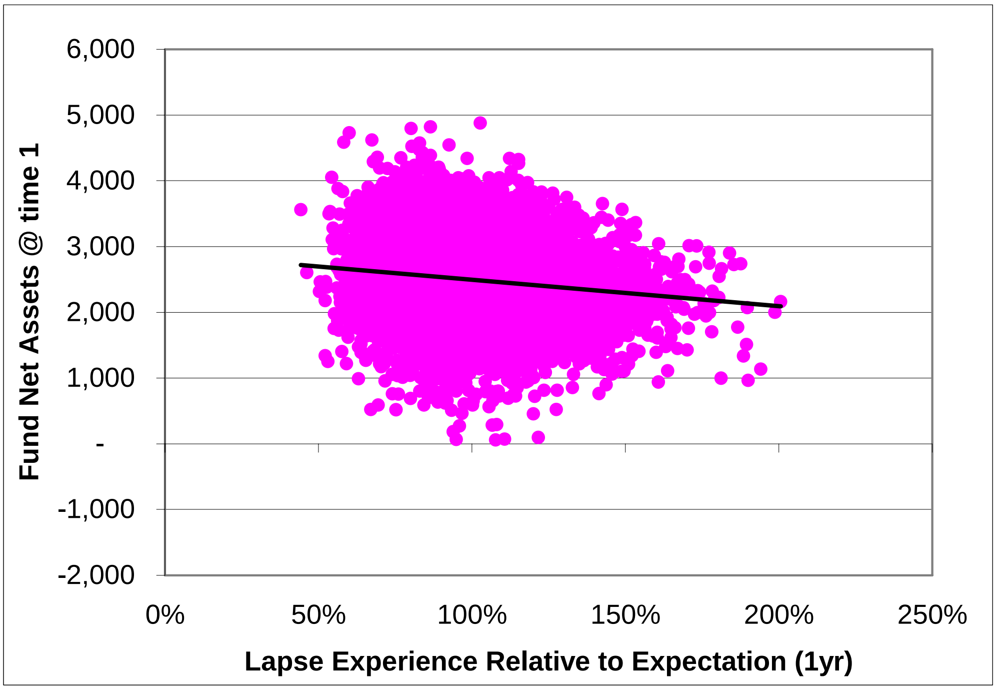

Figure 18: 1-year Net Assets relative to Lapse experience

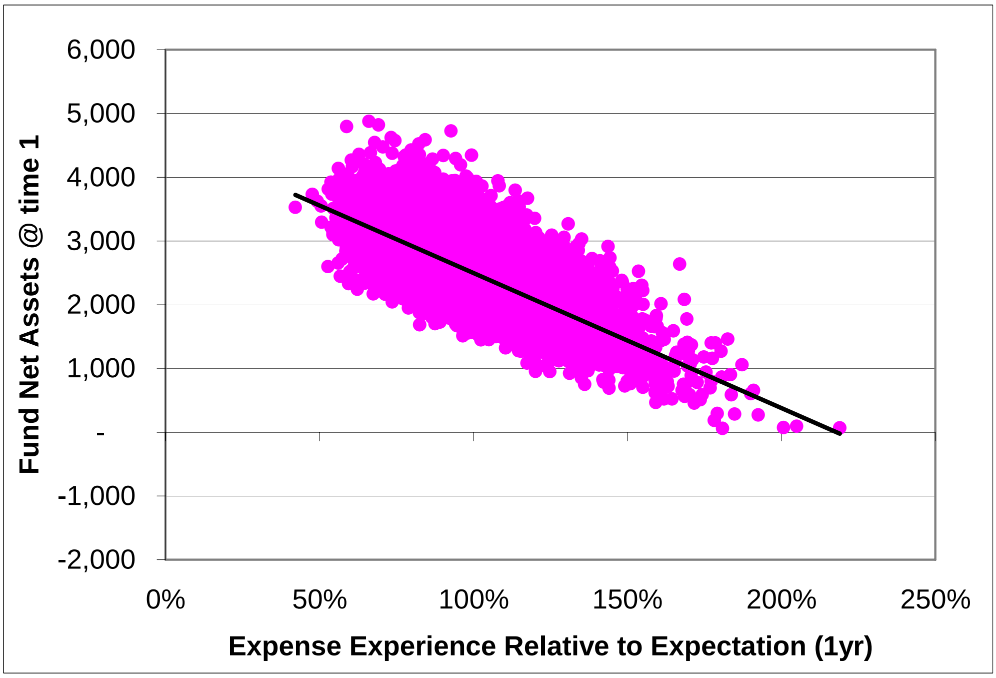

Figure 19: 1-year Net Assets relative to Expense Experience

We saw previously the strong exposure to the unit fund return over time, unsurprising given the fixed nature of our assumed expenses and fund return-dependent charges. Booking the future excess of assets over liabilities creates a small exposure to lapse risks (note this will be unhedgeable), plus in our case an assumed exposure to asset risks on this additional excess assets. Not that in general this will not be observed within Cap Ad, due to the frequent biting of the Solvency & MTV minima for unit linked business.

Adopting a differential investment strategy for these excess Solvency II assets over technical provisions (or removing the assets from the fund) would remove the fund risk to shareholder capital. Of course, in practice this would never be possible – future charge "assets" are in effect locked up in the unit fund of the policyholder. A short holding of the unit fund assets equal to this excess capital, if held within shareholder funds, would effectively reduce shareholder exposure to falls in the value of the unit fund (and hence the future charge amounts).

We also see that, in this case, we are strongly exposed to increases in expense costs – no surprise whatsoever given the fixed nature of expenses and lack of direct linkage to income from unit fund management charges. We have not done so here, but Solvency II allows an assumption that future unit charges can be increased from year 2 on to cover 75% of such expense increases – a key risk mitigation impact which will immediately reduce this exposure to expense risks, assuming a firm can justify that this would be in line with actual practice and reasonable expectations.

While initially looking somewhat peculiar, in practice theses elements will make little difference to the practical management of the capital in the business. This is reassuring, given the low-risk nature of this business.

5.3 Comparison with Australian Capital Requirements

In order to avoid muddying the above analysis, we haven't explicitly modelled the Australian capital requirements next to the Solvency II requirements. As such our sole comments are qualitative, and subject to some caveats.

In the above examples, we would expect the Cap Ad capital requirements to behave very similarly to Solvency II capital regime. The broad principles (allowing for any significant optionality, allowance for the impact of future excesses of charges over expenses, etc.) are largely similar. The resilience reserve tests, assuming that the embedded optionality has been sufficiently allowed for in the liability valuation, should provide similar levels of stresses to the standard Solvency formulae.

This is subject to certain limitations and differences in approach. For instance, under unit linked contracts the Cap Ad requirement will invariably be limited to the Solvency requirement, and its minima of the unit fund plus a 0.35% margin for operational risks. This is a common limiting factor on capital requirements in Australia, which implicitly requires capital to be held assuming the immediate surrender of all policies. The Solvency II regulations appear to be more concerned with achieving a realistic, economic balance sheet approach, and so do not appear to have been designed with such considerations in mind.

This should come as no surprise; Solvency II has been, in part, modelled on the Australian capital regime, and provides further evidence of the strong position of Australian actuaries to exert influence and expertise where Solvency II issues might start to affect them. We comment on this again later.

5.4 Further examples

Time constraints prevent us considering a possibly more interesting and relevant example, that of Term life policies. The current Australian regulatory environment essentially requires the full DAC under such contracts to be booked as a liability. This is potentially very similar to the above unit-linked example, which under a Solvency II-type realistic balance sheet regime, would most likely require a significantly lower lapse charge (as 100% lapses are unlikely to be considered under such a regime). We leave this additional consideration for future analysis.

We have also done little to comment on the impact of diversification benefits both at a group level (primarily geographic diversifications) and between different funds and lines of business. The total balance sheet regime of Solvency II ultimately allows credit for such diversifications, and internal models will no doubt be used to press regulators to make greater allowances for such diversification than standard formulae allow. Again, our modelling structure does allow us to consider such features, but we defer this for further study.

6 Implications of Solvency II on Australian Actuaries

We address one final question: what impact will Solvency II have on ALM for Australian insurers and actuaries?

One trivially obvious answer to this is "none" – Solvency II principles and methodologies apply and have been developed in Europe for the life insurance liabilities represented in Europe, not in Australia. Our basic analysis above suggests that, for a couple of relatively simple liability classes shown, such approaches do not create large differences in the management of the capital position of the business. While there are some Australian arms of European insurance groups who will potentially need to contend with some of the modelling capabilities demanded by their parent group to satisfy Solvency II, most will be of sufficiently small size in relation to their parents to be waived the onerous requirements of building Solvency II compliant models.

Of course this isn't a very deep answer. In practice, the wider ramifications will to be felt across the global insurance landscape. In particular we may well observe:

- The adoption of Solvency II style regulations across different regulatory regimes. For Australian actuaries working in Asia, the impact of Solvency II will already be high on the agenda. Some Asian countries with significant European insurance groups present in the local market (complete with European-style products) have indicated an eagerness to adopt a Solvency II style regulatory regime. Given the onerous task of adopting such a regime and the scarcity of experience in doing so, there will inevitably be a demand for Australian actuarial expertise in helping insurers progress towards such a radical change in regulatory requirements.

- A growing demand for "global best practice" in ALM and ERM methodologies. To date, this has certainly been observed as one driver behind insurers' investment in adopting increasingly sophisticated modelling techniques. This has been driven by several "market" sources. Industry groups such as the CRO forum group of 13 leading European insurers have been vocal in their support of a Solvency II framework, particularly where this would allow greater credit for capital benefits via geographic and business unit diversification effects. Credit rating agencies have also been placing increasing weight on the results of internal ALM models and ERM frameworks in their assessment of insurance group credentials.

- An increasing trend towards more complex options and guarantees within products. In particular the anticipated rise of variable annuity-style guarantees, with complex interactions between life and investment market risks, will require the use of some of the more complex valuation methods described earlier, and the knock-on effects on capital modelling and management that accompany the adoption of such models.

While the direct impact of Solvency II may well be limited, Australian actuaries are exceptionally well placed to both influence the direction, and provide key actuarial skills, to the global changes in insurance company ALM which will inevitably proliferate following the adoption of Solvency II.

7 Final Thoughts

It will come as no surprise to a reader of this paper that we consider the continued development and use of complex internal models within insurers as an exciting and increasingly prevalent development in the management of a life insurers' business. However, as the previous simple examples illustrate, for simple classes of business such as those above, there should be minimal impact on the measurement and management of most forms of Australian business, given the relatively straightforward, linear nature of most of the risks run.

One important caveat should be stressed: complex models are no substitute for the professional judgement that experienced risk managers provide. Such models are only as good as the extent to which actuarial judgement, suitable parameterisation, robust data sources and a healthy dose of scepticism can provide. A prime example of this is the ongoing impact of the sub-prime crisis engulfing global financial markets. It is arguable that hundreds of millions of dollars spent on complex Basel II compliant models, calibrated to a limited amount of historical data, coupled with an apparent loss of focus on the nature of the potential risks being run, has contributed to a situation where models failed to spot the likelihood and ultimate impact that a drying up of market liquidity and the knock-on effect on credit spreads would have on balance sheets.

A more critical viewing of the risks involved, their interdependencies and a better appreciation that "unknown unknowns" that are out there, would have benefited a vast number of undoubtedly clever financial institutions. It is also worth recognising the impact that potentially simpler methods, such as scenario testing, could have made to the recognition, measurement and management of these risks.

The big challenge for ALM in a Solvency II world is to retain this focus whilst taking advantage of the quantitative advances that undoubtedly can be achieved via more sophisticated modelling of a life company's business.

Appendix A: QIS4 standard formulae SCR parameters

The following parameters have been assumed in the standard SCR calculations. These are based on the parameters set out in the latest QIS4 technical specifications. Each capital charge is fundamentally calculated by stressing asset values and Technical Provisions in the stated scenario, with the capital charge equal to the stressed net asset value.

- Mortality shock: permanent 10% increase in mortality rates for each age

- Longevity shock: permanent 25% decrease in mortality rates for each age

- Disability shock: increase of 35% in disability rates for the next year, together with a permanent 25% increase (over best estimate) in disability rates at each age in following years

- Lapse shock: For policies where surrender value exceeds technical provision, the greater of 50% increase in lapse rate, or 30% of [surrender value – technical provisions] across those policies. For policies where surrender value is lower than technical provision, a 50% reduction in lapse rates.

- Expense shock: 10% increase over best estimate expense assumption and 1% increase over expense inflation. For policies with adjustable loadings, 75% of these additional expenses can be recovered from year 2 by increasing fees and charges.

- Catastrophe shock: An absolute 1.5 per mille increase in the rate of mortality over the next year, plus an absolute increase in morbidity inception experience of 1.5 per mille over the following year, with 1/3 each of the increases remaining sick for 6, 12 and 24 months, respectively. Note that for the modelling above we used the simplified formula of 0.15% of capital at risk for any products with benefits dependent on mortality or disability. Capital at risk is defined here as lump sum insured plus annualised benefit payments multiplied by an annuity factor for the expected duration of benefits, less Technical Provisions.

- Interest rate shocks: the larger of the change in net asset value from the following proportional changes in spot interest rates, varying by term:

Interest Rate Term (Years)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20+
Up Scenario	0.94	0.77	0.69	0.62	0.56	0.52	0.49	0.46	0.44	0.42	0.42	0.42	0.42	0.42	0.42	0.41	0.40	0.39	0.38	0.37
Down Scenario	-0.51	-0.47	-0.44	-0.42	-0.40	-0.38	-0.37	-0.35	-0.34	-0.34	-0.34	-0.34	-0.34	-0.34	-0.34	-0.33	-0.33	-0.32	-0.31	-0.31

e.g. If 5 year rate is x%, "Up" scenario stressed rate is x * (1 + 0.56)%

- Equity shock: instantaneous shock of -32% to equity value for global equity shocks, -45% for emerging markets, non-listed equities and alternative investments
- Property shock: instantaneous shock of -20% to property value
- Currency shock: change in net asset value resulting from immediate 20% rise or fall in value of all currencies relative to local currency
- Spread risk: A capital charge equal to $\sum_i MV_i \times m(dur_i) \times F(rating_i)$ where MV_i is the market value prior to the shock of credit risky asset i, *m(dur)* is a function of the modified duration of the asset, and *F(rating)* is a function of the credit rating of the exposure. Under QIS4 the functions *m* and *F* are set as:

Rating	F(Rating)
AAA	0.25%
AA	0.25%
A	1.03%
BBB	1.25%
BB	3.39%
B	5.60%
CCC	11.20%
Unrated	2.00%

Rating	m(dur)
BB	Max(Min(dur, 8),1)
B	Max(Min(dur, 6),1)
CCC	Max(Min(dur, 4),1)
Otherwise	Max(dur,1)

- The various risk charges are aggregated using a simple correlation matrix approach, with risks aggregated using the formulae:

$$SCR_{Agg} = \sqrt{\sum_{r,c} Corr_{r,c} \times SCR_r \times SCR_c}$$

No attempt is made in the standard formulae to allow for any non-linearity of risks or non-constant correlations. The following correlation matrices are used to aggregate risk charges within and between the various risk modules.

Aggregate Capital Charges:

	Market	Default	Life	Health	General
Market	1				
Default	0.25	1			
Life	0.25	0.25	1		
Health	0.25	0.25	0.25	1	
General	0.25	0.5	0	0.25	1

Market Risk Charges:

	Interest	Equity	Property	Spread	Concentration	FX
Interest	1					
Equity	0	1				
Property	0.5	0.75	1			
Spread	0.25	0.25	0.25	1		
Concentration	0	0	0	0	1	
FX	0.25	0.25	0.25	0.25	0	1

Equity Risks

	Global	Other
Global	1	
Other	0.75	1

Life Underwriting Risks

	Mortality	Longevity	Disability	Lapse	Expense	Revision	Cat
Mortality	1						
Longevity	-0.25	1					
Disability	0.5	0	1				
Lapse	0	0.25	0	1			
Expense	0.25	0.25	0.5	0.5	1		
Revision	0	0.25	0	0	0.25	1	
Cat	0	0	0	0	0	0	1

Appendix B: Model Methodology & Assumptions

In constructing our internal model, assets and liabilities are projected and valued using a combination of the Solvency II parameters set out in Appendix A, the Economic Scenarios described in Appendix C, and some additional stochastic elements added. In particular, the following components were used to allow for the impact of non-economic risks:

Mortality

For the purposes of our modelling, we have assumed best estimate mortality follows 70% of IA95-97 (ultimate, 2yr select) with mortality improvements as per the LPS2.04 solvency standard improvement factors.

Stochastic mortality experience and expectations are allowed for by assuming that proportional mortality improvements follow a simple lognormal model. This is intended as a simple descriptive model, rather than a sophisticated description of true mortality uncertainty. Mortality rates deviate from the best-estimate rates according to a factor F(x), so that

$$q_x(t) = E[q_x(t)] \times F(x)$$

Where $q_x(t)$ is the actual mortality rate at time t for a life aged x,

$E[q_x(t)]$ is the best estimate mortality rate at time t for a life aged x, and

$F(x)$ is a function of two correlated geometric Brownian motions, representing uncertainty at two distinct ages, chosen here to be ages 40 & 70.

Mortality expectations are updated to fully incorporate all fluctuations in experience, so that the revised expectation at all future times t+1 is $\hat{E}[q_x(t+1)]$

$$\hat{E}[q_x(t+1)] = E[q_x(t+1)] \times F(x)$$

i.e. the mortality expectations are updated in line with the ratio of actual experience to expectations over a given time period.

The model has been calibrated assuming a proportional volatility of mortality rates of 4% p.a., and a correlation of 90% between improvement factors at ages 40 and 70, with F(x) linearly interpolated between ages, and extrapolated according to a function of the form:

$$F(x-1) = F(x) * \left[1 + \left(\frac{F(x)}{F(x+1)} - 1\right) \times C\right] \text{ for x < 40}$$

$$F(x+1) = F(x) * \left[1 + \left(\frac{F(x)}{F(x-1)} - 1\right) \times C\right] \text{ for x > 70}$$

For a constant decay factor C. We set C = 0.98 here, to provide a smooth function for shocks somewhere between linear extrapolation and an assumption of a constant extrapolation of the improvement factors.

Lapse Experience

Best estimate lapse rates for endowments are assumed to be 5% pa, for unit linked contracts we assume 15% in the first 2 years, then 10% thereafter.

Lapse experience is assumed to be lognormally distributed, with proportional volatility of rates of 10% per annum. Expected lapse rates are assumed to not be affected by historic experience, i.e. no updating of expectations is assumed to take place following the observed lapse experience. It should be noted that this model provides significantly lower levels of capital requirements than an assumption in Solvency II or Australian capital calculations that adverse lapse experience is either permanent, or large and immediate. Again, the model is not intended to provide an accurate model of genuine lapse behaviour, merely to illustrate the potential impact of Solvency II style capital calculations within an internal model relative to current Australian capital requirements.

Expense Experience

Fixed expenses are assumed to follow a geometric Brownian motion, with proportional volatility of 10% per annum, in addition to an inflationary increase component. Real expense inflation is assumed to be 1% per annum in addition to price inflation.

In the two examples given, we assume expenses as follows:

Type	Expense
Fixed annual expenses per policy	$500
Investment Expenses as proportion of FUM	0.1%
Renewal Expenses as a proportion of premium	0.2%

Asset & Net Cashflow Reinvestment

The model assumes that net cashflows are reinvested or deducted in line with the initial asset portfolio proportions. Bonds are assumed to be held until maturity, at which point any proceeds are reinvested in line with the remaining asset holdings.

Appendix C: Economic Scenario Modelling

The economic scenarios used in the modelling are based on the commercially available economic scenario generator provided by Barrie & Hibbert Ltd. The following variables are modelled, along with some key model outputs/calibration targets. All calibrations are as at 1 January 2008.

Economic Variable	Model Assumed	Key Calibration Targets/Results
Nominal interest rates (AUD & USD)	2-factor lognormal Hull-White	Initial rates calibrated to government bond yields $5^{th}/95^{th}$ percentile of 1-year AUD rate distribution over 1 year: 4.2% / 9.9% $5^{th}/95^{th}$ percentile of 10-year AUD rate distribution over 1 year: 4.7% / 7.8%
Real interest rates (AUD & USD)	2-factor Vasicek	Initial rates calibrated to government index-linked bond yields & inflation expectations
Inflation (AUD & USD)	Derived from interest rate models	$5^{th}/95^{th}$ percentile of AUD price inflation distribution over 1 year: 2.0% / 4.2%
Equity total returns & dividend yields	Multifactor lognormal model with stochastic volatility	Arithmetic excess mean return 4% pa Annualised volatility of log return 20%
Property total returns & rental yields	Multifactor lognormal model with constant volatility	Arithmetic excess mean return 3% pa Annualised volatility of log return 15%
Alternative asset returns & income yields	Lognormal model with constant volatility	Arithmetic excess mean return 2% pa Annualised volatility of log return 10%
FX rates	Purchasing power parity model	Annualised volatility of real FX rate: 11%
Credit Spreads	Extended Jarrow-Lando-Turnbull	$5^{th}/95^{th}$ percentile of AUD AA 7Y spot spread: 0.9% / 2.6%

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