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Making use of DFA (Dynamic financial analysis)

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Abstract

Keywords: DFA, dynamic financial analysis, ICA, individual capital assessment, capital allocation, reinsurance pricing, regulatory capital, ratings agency capital, risk management.

This paper gives an overview of the steps and considerations that are required in developing a capital model for an international non-life insurance company. The focus of the paper is on the practical steps required to develop a model rather then a detailed discussion of the theorerical requirements.

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1. Introduction

Over the past few years there has been a drive for insurance companies to build capital models. This has been driven by a number of factors set out below.

Firstly, regulators and rating agencies now consider capital modelling, when incorporated into a holistic enterprise risk management (ERM) framework, essential for a well run insurance company. This has encourage companies to embrace the models to gain competitive advantage through reduced capital requirements (or a higher credit rating for the same level of capital).

Secondly, companies have realised that as well as reducing capital requirements, capital models give senior management, underwriters etc, a tool to better understand the risks in their business, and therefore manage those risks more effectively. This can have direct bottom-line impact on financial results.

Finally, computer speed at a reasonable cost has increased to a level where the important parts of an insurance company can now be sensibly modelled. Even 10 years ago, the computers and software available at the time did not lend itself to running large simulation based models of insurance company, incorporating the level of detail required to do a proper assessment of the loss potential in the tail of a loss distribution.

Capital models themselves come in a variety of forms. There are relatively simple stress and scenario based models that consider the primary impact, and "ripple" impacts, on a company from single event occurring. For small insurance companies, or companies that have simple risks, such models can enable the understanding of risk, and therefore form a suitable basis for the business. For larger companies, or where the interactions of risks is more complicated, simulation based stochastic capital models become vital. These stochastic models can range from relatively simple to extremely complicated.

This paper details the following aspects of capital modelling:

- The need for capital modelling, exploring the requirements from various external stakeholders in capital modelling (regulators and rating agencies), both nationally and internationally;

- Capital modelling project management, considering the approach used to manage the development of a sophisticated capital model, giving ideas on how to achieve genuine business buy-in, and indicating past pit-falls that could be avoided when embarking on a capital modelling project;

- Global implications of capital modelling looking at how the needs of the capital modelling stakeholders (internal and external) differ across the globe;

- Modelling framework, looking at how to consider risk, and also how to analyse the main sources of risk that need to be incorporated within a capital model;

- Technical challenges, considering the technical challenges that a capital modelling team may face when running a capital modelling project;

- Model review, looking at ways that model output can be presented to internal stakeholders to opine upon;

- Using capital models to drive change in the business, focusing on how the "use test" of internal capital models can be satisfied, and the business benefit of having a robust capital model;

- Risk management, looking at how the capital model can help assess risk in the business and form a unified enterprise risk management system within the business.

There are a number of example graphs in this paper, and although these are based around live data, they have been suitably modified to maintain the general trends, but remove any company specific information.

2. The need for capital modelling

2.1. Regulatory perspective

Different regulators have developed (or are developing) different regimes to consider risk within insurance companies. The direction in the development of internal models has been set by the International Association of Insurance Supervisors (IAIS) in their draft paper of 1 July 2007 'Guidance Paper on the use of Internal Models by Insurers' and regulator discussions that preceded this draft.

The key principles set out by the IAIS draft paper include:

i. Where an internal model is used by an insurer, it should be one of its main strategic and **operational decision making tools**. The internal model should integrate the insurer's processes of risk and capital management to assess the risks faced within its business and assist in determining the capital needed, where appropriate, to meet those risks;

ii. An insurer's internal model should be calibrated on the basis of defined modelling criteria which the insurer believes will determine the level of capital appropriate and sufficient to meet its business plan and strategic objectives, ensuring as a minimum, that the insurer can continue to **meet its policyholder liabilities** as they fall due at a confidence level appropriate to the insurer's risk tolerance;

iii. Where a solvency regime allows the use of internal models to determine regulatory capital requirements, the **supervisor should establish appropriate modelling criteria** to be used for that purpose, which would ensure broad consistency between all insurers within the regime;

iv. An insurer's internal model should be **appropriate to the nature, scale and complexity** of its business. In constructing its internal model, an insurer should adopt risk modelling techniques and approaches which are most appropriate to the nature, scale and complexity of the risks incorporated within its risk strategy and business objectives, and which are suitable for use as part of its risk and capital management processes and procedures;

v. An insurer should monitor the performance of its internal model and regularly review and validate the ongoing appropriateness of the model's specifications. As part of its validation process, an insurer should conduct a **'statistical quality test'** which assesses the base quantitative methodology of the internal model. An insurer should consider the model inputs, parameters, assumptions and the appropriateness of the methodology as part of this test process, and ensure that the data used in the model is of sufficient quality and robustness;

vi. As part of its internal validation process, an insurer should conduct a **'calibration test'** to assess the consistency of the output produced by the internal model with the modelling criteria established by the insurer to satisfy its risk strategy and business objectives . Where the insurer also uses its internal model for determining its

regulatory capital requirements, it should recalibrate the model to the modelling criteria specified by the supervisor , where these are different from its own modelling criteria. The insurer should then conduct a further calibration test to confirm the validity of the model outputs for this purpose;

vii. In order to successfully validate its internal models for use as part of risk and capital management, an insurer should conduct a **'use test'** to ensure that the internal model, its methodologies and results, are fully embedded into the risk strategy and operational processes of the insurer. The insurer's board and senior management should have overall control of and responsibility for the construction and use of the internal model for risk management purposes, and ensure that they have sufficient understanding of the model's construction, outputs and limitations, in particular its consequences for risk and capital management decisions;

viii. Where an insurer calculates its regulatory capital requirements using an internal model, the use of the internal model for that purpose should be subject to prior **approval by the supervisor**. In reviewing an insurer's internal model, the supervisor should ensure that it remains fit for purpose in changing circumstances against the criteria of the 'statistical quality test', 'calibration test', and 'use test', and that the model has robust governance and internal controls in place;

ix. The **supervisor should ensure that it has access to the necessary skills, competencies, and resources** in order to enable it to adequately assess the use of an insurer's internal model for regulatory purposes. As part of its assessment the supervisor may consider reviews conducted by relevant external specialists. In such instances, the supervisor would have ultimate responsibility for approving the use of the insurer's internal model for regulatory capital purposes;

x. An insurer should provide information on its internal models for both **supervisory reporting and public disclosure**. The information should include details of how the model is embedded within the insurer's governance and operational processes and risk management strategy, as well as information on the risks assessed by the model and the capital assessment derived from its operation. The supervisor should have the power to require an insurer to report information necessary for supervisory review and ongoing approval of an internal model, where appropriate. The supervisor should consider the appropriate level of public disclosure having due regard to any proprietary or confidential information.

This section details the requirements from a number of regulators across the globe, focusing on areas where the authors have experience in those jurisdictions.

2.1.1. APRA

The Australian Prudential Regulatory Authority (APRA) was one of the first regulators to encourage companies to develop capital models for their business. In July 2002, APRA implemented Prudential Standard GPS 110 – Capital Adequacy for General Insurers which requires insurers to select one of two methods to determine their Minimum Capital Requirement. This required insurers to either develop an APRA approved in-house model (known as the Internal Model Based Method) or use a formulaic method (Prescribed Method).

APRA have also detailed what the approval process needs to cover. The use of the Internal Model Based Method (IMB) requires APRA's approval and the Treasurer's agreement. APRA's approval is subject to a comprehensive model review process including

- completion of a detailed questionnaire about the model and accompanying risk control environment; and

- one or more on-site visits to discuss the detail of the model, risk management systems, and surrounding organisational structure and controls.

APRA must be satisfied that the insurer's methodology for capital assessment is suitably rigorous and broadly consistent with comparable segments of the industry, that the model is well designed, the analysis and assumptions used are sound, and that the results of applying the model are reasonable from a prudential viewpoint.

APRA also requires the insurer to inform APRA in advance of any material changes to the model or surrounding controls, and provide any information necessary. Once the IMB method has been adopted, an insurer must continue to use that method until APRA revokes model approval. This can be instigated by APRA or by request from the insurer.

The approach of having a "fall-back" capital assessment (the Prescribed Method MCR) is beneficial to the Australian insurance industry, although, since it is not fully reflective of the specific circumstances of the insurance company, it is of limited use for purposes other than regulatory capital setting.

The MCR is built up from 4 main components:

- outstandings claims risk – factors are applied to net claims reserves;

- premium liability risk – factors are applied to expected premium liabilities in respect to unearned premium;

- investment risk including concentration of investments and derivatives;

- capital for an insurers maximum event retention (MER).

The requirements are detailed in APRA's Prudential Standard GPS 110.

Using the MCR means that insurers do not have to invest the resources required to build a capital model, and have it approved by APRA. However, this does not necessarily benefit the insurance industry in Australia, since capital models can be used for more than just assessing capital requirements. The lack of a requirement to build an internal capital model (which could be based around a relatively simple stress and scenario approach) means that there are few companies that actually have an approved capital model.

2.1.2. FSA

The FSA, the UK financial services regulator, has adopted a slightly different regime, requiring companies to have a process to assess their minimum capital requirements, the Individual Capital Assessment (ICA).

The ICA is a self assessed capital requirement, with the following features;

- 99.5% Value at Risk measure;
- Single additional year of future underwriting in addition to an opening balance sheet;
- All risks run-off to ultimate (or a suitable risk premium at the end of the first financial year to commute off the liabilities which is the direction being undertaken in Solvency II as described below).

These requirements are detailed in the FSA Handbook.

Since the ICA is a company assessed requirement, there is an approval process led by the FSA. This results in the Individual Capital Guidance (ICG), which gets signed-off by a panel of FSA experts. It is important to note that it is a single capital requirement that gets agreed, and as such it is not an endorsement of the actual capital model underlying it.

Backing up the ICA assessment is the Enhanced Capital Model (ECR), a formulaic model developed by the FSA and Watson Wyatt, that forms a benchmark for the capital required by a large, well diversified UK domestic insurance company. The ECR is set out in the FSA's Integrated Prudential Sourcebook. Very simplistically, the ECR model is built up by adding three components:

- Asset capital requirement – Factors are applied to the assets held within the insurance company, e.g. 3.5% of the value of bonds, and 16% of the value of equities
- Reserving capital requirement – Factors are applied to the net claim reserves (including both outstanding claims and unearned premium reserves), e.g. 9% of motor reserves and 14% of liability reserves.
- Premium capital requirement – Factors are applied to the net written premium for the past year, e.g. 10% of motor premiums and 14% of liability premiums.

The ECR can be calculated from the information contained within the statutory insurance returns, and is therefore can be calculated by anyone with sufficient interest, time and knowledge of the FSA returns.

2.1.3. Europe (Solvency II)

Europe has been considering a revised solvency regime for a number of years, with the process due to be introduced in 2012 (recently extended from 2010). The current proposals for Solvency II suggest a similar regime to Australia, with an approved capital model being used as the primary capital assessment, but a fallback position of a formulaic method if the company does not have a model (or the model is not approved by the local regulator). The specifics of the regime are:

- 99.5% Value at Risk measure;
- Single additional year of future underwriting;
- Risks considered only over a single financial year (ie year end balance sheet to the projected year-end balance sheet in the following year).

There will be a formal process for companies to obtain approval of their capital model by the local regulators, although the specifics of this are not available at the time of writing.

2.1.4. USA

There are a variety of regulars in the United States as each state is regulated separately with some overall coordination being given by the National Association of Insurance Commissions (NAIC). The NAIC has voluntary membership from each state. There is currently no proposal that the authors are aware, to introduce company based capital assessments by any of the regulators.

2.1.5. Summary

A number of regulators across the globe seem to be converging on a process for assessing capital requirements in insurance companies. This seems to be based around companies building, and gaining approval for, their own capital model, with a back-up of a formulaic capital model (which is still used as a benchmark even for companies with an approved internal model). The approval process seems to be converging around a set of principles that the capital model must satisfy. These principles tend to include not only the quality and functionality of the model, but also the "usage" of the model within the company for purposes other than pure capital assessment. Such usage tests are commonly discussed, although they have not been well defined by any regulator, although over time there will be greater clarity as capital modelling becomes part of the process from both a company and a regulatory point of view.

This trend is generally following the direction that has been set by banking regulators.

2.2. Rating agency perspective

Rating agencies have also become more pro-active in the field of capital modelling, although they are currently a number of steps behind the regulators. The following section details the current state of play regarding regulators.

2.2.1. Standard and Poor's

Standard and Poor's (S&P) have adopted capital modelling as one of the eight pillars of review when they are considering the rating to apply to an insurance company. The exact model review will vary between companies, but they have noted[1] that the following areas will be considered:

- Risk Quantum
- General Risk Levels
- Specific Risk Levels
- Specific Risk Exposures
- Diversification Benefits
- Model Robustness
- Model Execution
- Model Usage
- Sensitivity Testing
- Usage of EC Results by Standard & Poor's

Of particular interest is their model usage requirements, which are:

"For an insurer to be considered for our EC (economic capital) review, they will usually have demonstrated that they are using economic capital (or some other universal risk model) as a strategic tool - i.e.: they will need to pass a 'use test'. Such uses would include the allocation of EC to subsidiaries, lines of business and individual contracts and performance reporting and management incentive schemes based on such allocations, reinsurance/securitization optimization, investment and financing strategy optimization. Differing uses imply very different sets of assumptions and time frames. It will be important to our considerations that

[1] "Request For Comment: Economic Capital Review Process For Insurers", Standard and Poors (2007)

the insurer be aware of these distinctions and can give a reasonable discussion of why their modelling approaches are appropriate to their usage."

As well as incorporating capital modelling as part of their rating review, Standard and Poor's have also developed their own risk-based factor model. This considers a number of key inputs from technical accounts and balance sheets, including premiums, claims and assets, the latter being split into type of asset, duration of bonds and credit quality of corporate bond issuers. They also include factors that apply to the reinsurance recoveries, based on the rating of the debtor and the duration of the debt.

S&P have their own standard model in addition to the ability to use a capital model. From a non-life perspective, the standard S&P model incorporates:

- Asset credit risk (e.g. corporate bonds, and reinsurance debt)
- Asset market risk
- Reinsurance credit risk
- Property/Casualty premium risk (by line of business)
- Property/Casualty reserve risk

Each item in each of these categories (e.g. market value of assets, volume of business, reserves, …) is allocated a factor based on what the target rating level is (AAA, AA, A, BBB). These are then summed to get a total capital requirement for the specific target grading, albeit that this is only indicative and is only one input to the overall ratings methodology.

2.2.2. A.M.Best

A.M.Best have developed their own capital model, which they have called the Best's Capital Adequacy Ratio (BCAR). This tried to incorporate the company's specific risk characteristics, and has changed over time to incorporate factors such as exposure growth, the insurance cycle and catastrophe and terrorism stress tests. The BCAR is calculated as the ratio between an insurer's adjusted surplus relative to the required capital, where capital is calculated based upon:

- B1 – Fixed income securities
- B2 – Equity securities
- B3 – Interest risk
- B4 – Credit risk

- B5 – Claims and loss adjustment expenses
- B6 – Net written premiums
- B7 – Business risk

The total net required capital is then calculated as the sum of these risk categories less a covariance adjustment to reflect the fact that all of these risks do not manifest themselves at once.

2.2.3. Fitch

Fitch have gone down a different route, and developed their own internal capital model, PRISM. This is a fully stochastic Monte-Carlo simulation model that[2]:

- Offers one common platform to evaluate insurers globally with a sophisticated, stochastic methodology
- Allows comparability of capital quality across countries and between life and non-life insurers
- Uses country-specific data for insurance risk parameterization
- Can be adapted to more closely reflect an insurer's unique financial profile
- Is powered by a realistic, economically based stochastic engine using accepted actuarial techniques and modern financial theory
- Uses hundreds of risk curves, thousands of scenarios and billions of calculations
- Integrates and analyzes risk on a fully aggregated basis
- Allows recognition of reasonable, economic risk diversification

Although it is based around market level information, Fitch have indicated that they will adapt the specifics of the model to reflect better the actual risk characteristics of a specific insurance/reinsurance company. This removes the burden on companies to develop their own risk sensitive modelling capabilities, and in this respect it differs from most of the other regulatory and rating agency environments.

Fitch also has a model based on standard generic factors for each risk type.

[2] Fitch (2007) http://www.fitchratings.com/Prism/

3. Capital modelling project management

Building a full capital model of a company is a resource consuming exercise. Firstly, the model has to be built, data collected, parameters assessed, models run, reviews carried out and finally communicating the outputs to senior management, regulators and rating agencies (and possibly the parent Group as well). Proper project management is vital to manage this resource; without it, the potential for over-spend, over-run or an unsuitable model are significantly increased. The three key stages of a capital modelling project are detailed below.

3.1. Before planning the project

Before the project even starts, it is important to get support within the business to develop a capital model. Although regulatory and rating agency approval are one driver for this, there needs to be backing for the project from senior management in order that the resourcing will be available. This is possibly the most important step, since building a capital model for its own sake is unlikely to result in the model passing the "use test", nor is it likely that it will be useful for the business as a whole.

It is important to identify a high profile project sponsor, preferably the CEO, CFO or Chief Actuarial Officer of the company. This will help increase the businesses enthusiasm to participate in the project, and will also enable the project team to overcome potential obstacles through the project's lifetime. Within QBE, the project sponsor for the European capital model was the Chief Actuarial Officer (who is part of the Board Executive), and the project sponsor for the QBE Group capital modelling project is the Chief Executive Officer of the Group.

Once the project sponsor has been identified, approached and brought on-board with the project, a steering committee needs to be formed, which will monitor development of the modelling, make important model direction decisions, and also review high level output from the model. The constituents of the steering committee are important, and a good mix of business skills will help resolve major issues. At the very least, there should be representatives for underwriting, reserving, reinsurance, finance and operations. The European capital model steering committee consists of:

- Chief Actuarial Officer (Chair)
- Chief Executive Officer
- Chief Finance Officer
- Chief Underwriting Officer
- Two operations directors
- Two senior underwriters

As with the project sponsor, the people on the steering committee need to be committed to the success of the project, be able to see the business benefits from having a capital model, and be sufficiently influential within the company that they can help publicise the project.

3.2. Planning the project

Once high level support for a capital modelling project has been obtained (through the sponsor and steering committee), the next step in a successful capital modelling project is to develop a comprehensive plan. The plan will need to incorporate all aspects of the project:

- Project objectives and scope
- Project structure
    - Sponsor
    - Steering committee
    - Modelling committee
    - Modelling team
- Timelines, including realistic milestones
- Expected outputs from the project
- Project resourcing, including people, financials and IT requirements
- Risk to the project's success

3.2.1. Project objectives and scope

Having clear, detailed objectives for the project will help give the modelling team focus on what they are trying to achieve. It will also inform the business as to what they can expect to get from the capital model, which in turn will help embed the model in the business.

3.2.2. Project structures

The project sponsor and project steering committee have already been discussed, and these need to be reflected in the formal project plan. A modelling team, to regularly go through the detailed model development, will assist with meeting the project deadlines, and help support the modelling team in resolving challenging technical questions. Within Europe, the modelling team, consisting of the Chief Actuarial Officer, the modelling team and an external

technical expert, met weekly, which helped monitor the continue development of the capital model.

3.2.3. Timelines

As with any project, setting a timeline for the project will help to successfully develop the capital model. The timeline should be split into a number of high-level milestones, where output at each milestone can be considered by the steering committee. Within QBE, the following milestones were identified and put on a timeline:

- Develop model structure
- Collect data
- Parameterise reserve uncertainty models
- Review reserve uncertainty with business representatives
- Parameterise underwriting uncertainty models
- Review underwriting models with business representatives
- Obtain financial information (such as asset mix)
- Assess operational risk
- Complete main capital assessment
- Carry out stress tests of some of the key drivers of the capital requirements

Clear milestones can be monitored, and resources external to the core modelling team can be lined up (such as underwriters to review the underwriting models).

The milestones need to be realistic, and allow some margins to reflect the potential for delays in the various steps. The first version of the QBE model took:

- A month to build the model structure
- Two months to parameterise reserve and underwriting uncertainty
- Three months to review reserves and underwriting with actuaries , underwriters and other subject matter experts.

Part of the reason for the (relatively) quick delivery of a fully stochastic capital model for around $4bn of business was the support of the project steering committee and other senior managers within the business. There was a regulatory imperative to complete the project (driven through the FSA and Lloyd's of London), but there was also a desire to use the model for purposes other than regulatory capital setting. The clear reason help push the project into the business and get the necessary resources on where required.

It is interesting to note the weightings of the development of the first QBE capital model; half of the time was used to develop the model, and half to reviewing the model. The review is particularly important since it helps embed the model, getting business experts involved early on, as well as providing a key quality control for the model assumptions. The additional support also helps achieve regulatory sign-off, since it is a clear demonstration that the model has been accepted by the business.

3.2.4. Expected outputs

Defining the outputs from the capital modelling project will enable stakeholders to know what they can expect from the model. The main outputs will depend on the objectives of the project, and will likely include a model suitable to assess the capital required by the business. However, other outputs should also be highlighted, such as tools for assessing the effectiveness of reinsurance programmes or the allocation of capital down to line of business.

The types of outputs are covered later in this paper in the section modelling framework.

3.2.5. Project resourcing

Getting the correct level of human resourcing for the capital modelling project is important. If there is too little resource, then the project is unlikely to be deliver its outputs. If there is too much resource, then the team members will feel less motivated in their jobs, as well as there being an obvious additional cost to the company. Some companies have large teams dedicated to capital modelling, whereas in some companies it is only part of the workload for a single individual. For the European model, QBE had three people fully dedicated to setting up, parameterising and reviewing the model. This is a relatively small team, but it helped maintain focus and enabled the project manager to keep strong control over the capital model development.

Extending the model to the QBE Group has meant that there is a need for extra resources. Five more people are now included in the core modelling team, two from Australia, two from America and one from Asia Pacific (these being the main operating divisions of QBE). This brings the main modelling team to eight people, to build, parameterise, review and maintain the capital model for a $14 billion business. Again this relatively small team means that the capital model is dynamic, and not controlled by internal process and project bureaucracy. However, it does increase the "key staff" risk to the overall project since there is less sharing of knowledge across the business.

IT resourcing is relatively simple; a number of fast computers that are capable of running the sophisticated stochastic models required to assess capital. The cost of the IT requirements are easy to assess, as is the cost of any software required to build the capital model in.

There are other financial costs associated with capital modelling. There may be a requirement for the project manager to visit different parts of the world to assist modelling teams on the ground. There may also be a requirement for people in the modelling team to travel to see underwriters that are in a different country. Finally, there may be training costs associated with staff development, such as training them to handle review meetings, give presentations, or learn about technical aspects of capital modelling.

3.2.6. Risks

The final part of the project outline needs to be consideration of risks to non-delivery of the project objectives. Capital modelling projects have a number of risks associated with them, and these need to be controlled as with any other project.

An example of the types of risks that would be apparent in this type of project include:

- The project does not deliver its anticipated output. This is the main risk facing the DFA project, and will be managed by the regular review meetings by the DFA Steering Committee.

- The project does not meet its deadlines. The deadlines detailed above are fairly tight, and there is little margin for over-run given the regulators interest in the project. The project team will review progress against timetable in detail, and the Steering Committee will also regularly review the progress at a higher level. This will help minimise this risk.

- The business does not support the DFA project and vice versa. Any model will only be as good as its parameters, and the only way to improve them is for the people who understand the business to pass comment on the model. In particular, getting underwriter feedback on the class parameterisation within the model is a key stage to ensure model credibility. Once the model is built, there is a requirement by the regulators to 'embed' the model within business processes rather than just using it for capital assessment.

- The DFA model does not satisfy the regulators. DFA methodology is in its infancy, and there is currently no standard or best practice to follow. Therefore, there is the potential for the regulators to disagree with key assumptions in the model, which in their eyes would invalidate the capital assessment. This risk can not be managed in the short term, although the Project Sponsor will arrange regular update meetings with the regulators to keep them informed of progress and the direction that the project is taking.

- The model is produced in isolation of other on-going initiatives within the Group. The use of an appropriately constituted Steering Group and regular dialogue with Risk Management will help minimise this risk.

There needs to be a thorough risk identification process, typically carried out by the project team and the project steering committee. These two groups of people are likely to have very different experiences, and are therefore likely to offer very different perspectives on the project risks.

Once all of the risks have been identified, they need to be entered into the risk register, along with an assessment of their potential impact on the delivery of the capital model.

Following on from the assessment of the potential impact of the risks, there should be a control mechanism, to manage the project risks (some of the control mechanisms have been detailed in the list of risks above). Ideally, all project risks should be fully mitigated, so that there is a zero probability of non-delivery. However, this is not feasible (usually due to resource constraints), and therefore a review mechanism needs to be implemented. This should track the risks within the project, note any changes to their impact, and set up leading indicators for each of the risks.

There are some risks that are inherent in all capital modelling projects. For example:

- Lack of buy-in and support from the business, especially underwriters and senior management (so the model does not drive change in the business)
- Lack of buy-in from regulators and rating agencies (so that the final model does not satisfy their purposes)
- Poor parameterisation of the model (so the model becomes inappropriate for decision making)
- Lack of resources to complete the project (leading to project team being over-worked or the project being implemented behind schedule)
- Dependence on key staff, particularly a concentration of knowledge amongst one or two people on the project

These project risks are discussed below.

3.2.6.1. Lack of internal buy-in

Both personal experience and also discussion with market practitioners have highlighted that lack of buy-in is probably the greatest threat to a capital modelling project; apathy is dangerous if the model is hoping to achieve any sort of positive change in the business.

There are a number of reasons why stakeholders do not buy-in to the capital modelling process.

Capital modelling represents a step-change in the way that business considers risk, and there may be a lack of understanding by some stakeholders. For example, more traditional underwriters typically struggle to understand the mathematics of what a capital model is doing, and therefore feel alienated by the process. This can be remedied by a proper communications plan at the start of the project. By explaining what the capital model is, and where the stakeholders will have involvement with the project, the perceived threat will

reduce. If nothing else, letting an underwriter know that they do not have to understand the theoretical niceties of a copula will assist in the process.

Another way to improve buy-in is to focus on the non-regulatory reasons for having a capital model. Most people will become apathetic if they are told that they have to do something for purely regulatory reasons. A much better reason, and indeed something that is pushed by regulators themselves, is that projects should have a genuine business benefit, for example the ability to better understand their reinsurance protections, and possibilities to improve the protection for the same spend, or have the same protection for a reduced spend. By focusing on the uses of capital models other than capital adequacy testing, buy-in is likely to be increased.

The final pointer on improving business buy-in is the support of the project steering committee. If the senior management on the committee are engaged in the business, then their reports are also more likely to want to be engaged as well. It is also very useful to have at least one senior underwriter on the steering committee, since this will help demonstrate that the model has a business focus, and as mentioned above, is not purely regulatory focused.

3.2.6.2. Lack of external egagement

Just as there can be a lack of internal engagement, lack of interest and engagement by regulators and rating agencies can reduce the impact that the capital model has. This is likely to be less of an issue in today's environment, since it is these external influences that are pushing for companies to have capital modelling capabilities. However it is still important that they buy-in to a company's capital model so that it can be "approved", either formally or informally.

The best way of controlling this risk is the same way as controlling internal buy-in risk, i.e. clear communication and involvement. External parties should be informed that the project is happening at the project initiation stage, so that they can help offer any a steer on some required features of the model. They should also be regularly updated with the project's progress, and education meetings should be conducted so that they are fully au fait with how the model approaches the key risks.

One of the key deliverables from the project should be a report on the key modelling decisions that have been made and the main assumptions in the model. This should be formally submitted to regulators and rating-agencies, so that they can see the deliverables from the project and what it is being used for in the business. If the external parties are only made aware of this at the end of the project, then they will not have planned their resources for any review of the modelling work that they have to do.

3.2.6.3. Poor parameterisation

"Garbage in, garbage out" is a commonly used adage, and it is very apt for capital models. They require on lots of assumptions, and if most of these are poorly parameterised, then the output from the model will be meaningless. This risk can be controlled through a proper business review of the main modelling assumptions. For example, a capital modeller is unlikely to fully understand what is happening in the market, although they understand the

historic statistics. An underwriter may be unable to properly parameterise a capital model, although they do understand what the main outputs should look like. These two parties need to work together so that the underwriters business knowledge is embedded in the statistics behind the capital model, and this can be done through the parameter review process.

3.2.6.4. Lack of resources

Resourcing a capital modelling project is difficult, and requires individuals with appropriate technical skills that are able to communicate effectively with the business.

3.2.6.5. Key-staff dependence

Capital modelling teams are usually relatively small teams (a few main people pulling together the strands of the work), and therefore there is a strong key-man dependence on these individuals.

3.3. Project implementation

With a properly planned project, the implementation of the capital model should be simple. Well defined milestones mean that the project can be tracked, in order to assess whether it is likely to deliver on time. Project risks can be continually re-scoped, and controlled, as they arise through the development.

One area that has not been mentioned is the management of some of the stakeholders of a capital modelling project.

The key internal stakeholders are managed through the steering committee, although it is important that the modelling team make the effort to extend publicity as far as possible. During the development phase of the QBE capital model, the modelling team held one hour meetings with most of the underwriting teams within the business. This gave them warning that their input would be needed at the review stage, and also helped publicise the fringe benefits of having a capital model, such as the extra information that underwriters could use to fine-tune their reinsurance.

External stakeholders should also be brought on-board at an early stage. It is much easier to include them on the capital modelling journey, rather than hand them a thousand page report at the end of the project, for which they do not have the necessary resources (or enthusiasm) to review, and hopefully approve. With the European model, QBE held a number of meetings with our two UK regulators; Lloyd's of London and the FSA. These had a collaborative tone, with the process and ideas being incorporated into the QBE capital model being shared to get consensus that the general approach was sound. The meetings also helped QBE since we were able to obtain input from people who have seen a wide variety of capital modelling approaches, and could help improve the QBE approach.

4. Global implications of capital modelling

The needs of internal and external stakeholders of capital models differ across the globe. For example, UK companies have a regulatory need for a well calibrated capital model, whereas it is optional for Australian companies. The global implications of a capital model need careful consideration to ensure that all of the different needs are satisfied.

4.1. Project structure

Before considering what the different needs are across the globe, the project management side of global capital modelling will be considered.

There are three main approaches to building a cross-border capital model; the centralised approach, the decentralised approach and a hybrid of the two.

4.1.1. Centralised approach

A centralised approach is based around all of the work being carried out as part of a central Group function. They build the models, own the assumptions and sell the results to senior management and external stakeholders.

Such an approach is the easiest to control across a group. All countries are modelling using exactly the same process, and the people involved are the same, so there is consistency across the globe. There are also reduced resource requirements, since the people involved in the project are likely to be familiar with the inner workings of the model.

Unfortunately, this approach has the major drawback that buy-in from the regional entities may be low, and this may be detrimental to satisfying any global "use test" requirements set up by regulators and rating agencies. There is also a concentration of knowledge in one area, which may increase the key-man risk of the project.

4.1.2. Decentralised approach

A decentralised approach is the opposite the centralised approach, with all of the model building, parameterising and selling being carried out by the divisions. In such circumstances, the group act as aggregators, taking the divisional level models and combining them to produce a picture of risk across the whole group.

A decentralised model is likely to be a much better approach, since it negates the major drawback of a centralised model; the lack of buy-in from the regional divisions. The people doing the work are the people that best understand the underlying risk profile of the business, so the model output should be a better reflection of the risk.

Control is a major issue with such an approach. The lack of consistency across the globe makes amalgamating results complicated, for example, correlations across countries are much more difficult to model properly. There is also a strong possibility that risk will be understated within certain areas since the modellers have a vested interested in making their

part of the group look better than other areas, and therefore there may be unintentional (or sometimes intentional) biases creeping into the model.

The other issue with a decentralised approach is maintaining momentum and enthusiasm of the remote teams to ensure that Group capital modelling requirements are satisfied to timetable. This requires additional support, for example weekly telephone calls as a minimum, to ensure that the project remains on track and that the remote staff are suitably engaged in the process. For the project manager this can be problematic due to time zone differences, in particular coordinating a combined teleconference between Australia, Europe and the USA will inevitably impede on one persons sleep.

4.1.3. Hybrid approach

As with most things in a capital modelling project, a comprise of the two extremes is likely to be the best approach. The centralised model is good because there is consistency across the globe, and therefore regional biases are likely to be reduced. However, the work needs to be done regionally in order to get better buy-in for the model, and to get some of the fringe benefits that a capital model can offer. The potential for bias in the model can be reduced by having someone in the group that is ultimately responsible for the parameterisation, thereby ensuring that the model is reflective of the risks each in geographical area.

4.2. Communication

Communication between the group project manager and the divisions is vital for the success of a global capital model. Each part of the world needs to be engaged in the process since it would be very easy for someone to consider a group capital model as a group compliance requirement, which would reduce the usefulness of having a robust capital model that they could use for other purposes. Any problems need to be resolved quickly so that people overseas remain motivated and supported in their work.

There should also be regular dialogue between all parts of the world simultaneously. With modern communications media, this is much easier, although inevitably there will be one part of the world that will have to endure teleconferencing at an unsociable hour (the timings could be rotated so that there is not one part of the globe that is being consistently imposed upon). These discussions help motive everyone since they help show each country how their work is fitting in with the bigger picture. They also offer a good forum to swap experiences and ideas, which is an important developmental part of the meeting.

4.3. Model usage

Different parts of the globe will use their part of the capital model for different purposes. Each country's usage needs to be considered up front, so that the design of the model can be made flexible enough to satisfy these needs. This will also help engage each country in the global process, since there would otherwise be a tendency for countries to feel left out unless they are in the same geographical location as where the group model is being developed.

The reasons for the model usage will depend on the particular regulatory regime and interest of senior management. For example, smaller countries are likely to be more interested in

using the capital model to assist with their planning, and less interested in modelling some of their reinsurance programmes since they are not sufficiently large to have meaningful loss experience, and are buying the coverage as sleep-easy cover.

Model usage is discussed further in section 7.

5. Modelling frameworks

This section considers some of the finer detail of the modelling framework, and deliberately avoids consideration of specific modelling platforms.

For any capital model, there are three key decisions that influence the modelling framework:

- Risk measure
- Risk tolerance
- Time horizon

5.1. Risk measure

The first decision to make is what type of risk measure should be used. Following is a consideration of some of the more commonly used risk measures.

5.1.1. Value at Risk (VaR)

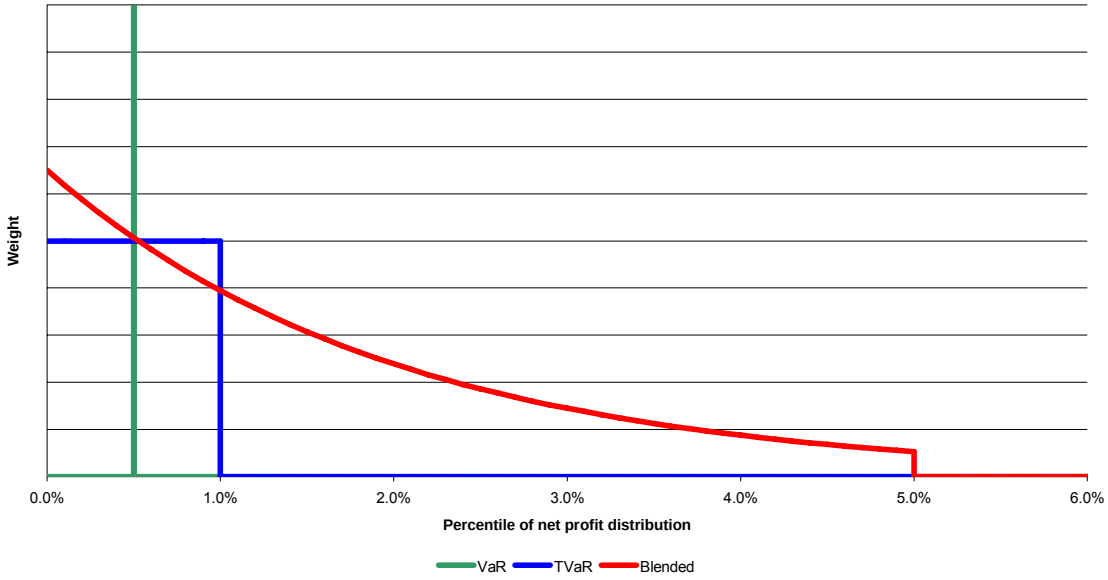
The most common risk measure used in capital modelling is value at risk, which only considers a single point on the probability distribution. For example, it may consider the amount of capital required in order to remain solvent in 199 out of 200 scenarios, so if the company held that amount of capital, then it would have a probability of insolvency of 0.5%.

5.1.2. Tail Value at Risk (TVaR)

Tail value at risk is an extension to the VaR that considers the entire tail of a distribution. It considers the average value beyond a specified percentile. As an example, if a company were to hold capital equal to the 99% TVaR, then it would have sufficient capital to cover its expected shortfall for the worst 1 in 100 years. Note that for any fixed percentile, TVaR will be at least as great as the equivalent VaR.

5.1.3. Blended risk measure

VaR and TVaR can be considered as special cases of blended risk measures. These apply weights to the entire net profit distribution in order to arrive at a capital assessment. VaR is a spike, and TVaR is a straight line weighting. The following graph shows these, along with another possible risk measure.



The alternative risk measure applies the weighting to the worst 5% of scenarios, with an increasing weight as the losses accumulate (representing the fact that capital is really needed for the worst outcomes, rather than the more common outcomes). Such a blended approach has a number of advantages over the simpler VaR and TVaR risk measures, although there is additional complexity in choosing the weighting function. For example, senior management may want to be able to combine classes of business in a risk sensitive way, but not focus on the really extreme outcomes from the capital model, where they have less faith in the predictive capabilities at a class-by-class level. By using a suitably selected weighting function that applies larger weights to, say, the 10^{th} to 50^{th} percentiles, the capital model would become more useful for their purpose.

5.1.4. Requirements of different users

5.1.4.1. Regulators

Regulators tend to use the VaR risk measure, and this helps satisfy their needs to promote confidence in the insurance market. They do not want insurance companies to enter liquidation, and a suitably defined VaR risk measure links directly into this. However, it is arguable whether it actually helps policyholders, since it only considers the amount of capital required to remain just solvent, and does not consider what surplus there would be for policyholders were such a scenario to arise. Therefore, although VaR is the most commonly used regulator risk measure, TVaR is arguably a more appropriate one.

5.1.4.2. Rating agencies

Rating agencies also tend to focus on VaR risk measures, and this fits in naturally with their workings. They issue ratings to insurance companies, and also provide historic default studies that show the proportion of companies with a given rating that defaulted within a specified timescale. By understanding and managing VaR capital, rating agencies can provide a clear link between capital and the probability of defaulting on their obligations (even if there is only a partial default).

5.1.4.3. Policyholders

Policyholders ultimately want to have their claims paid if a company were to become insolvent. Therefore, VaR is not an effective method to manage insurance companies from their perspective. It is too weak since it does not consider the tail of the distribution, and it is this amount that ultimately decides what amount of their claims will be paid if a company were to default. Because of this weakness, if companies were managed through TVaR, then this would satisfy the needs of policyholders better.

5.1.4.4. Shareholders

Shareholders are interested short-term and long-term profit from their insurance investments. If the company were to default on its obligations, then they are unlikely to receive their capital investment back since their investment has the lowest ranking of all of the company's obligations. Therefore, the natural risk measure for shareholders to use is VaR, since this assesses the probability that they will lose their investment.

5.1.4.5. Senior management

VaR is a natural risk measure for senior management to use. It is (relatively) easy to understand, and reflects the probability that they will continue to have a company to run. Senior management are ultimately responsible to the shareholders, and although they have a fiduciary duty to run the company in a fit and proper manner, if there was a series of circumstances that lead to the company becoming insolvent, they will not be overly concerned with the actual level of insolvency that occurs. Senior management are the only party that would have a real interest in the blended method. They could choose a suitable weighting function to give a risk measure that assists then in answering specific questions about their business.

5.2. Risk tolerance

The risk tolerance and risk measure are closely related decisions. For example, a company may wish to go for a lower risk tolerance (e.g. 99% rather than 99.5%), with a stronger risk measure (TVaR rather than VaR). It is also possible to express different risk tolerances for different risk measures that will given an equivalent amount of capital out of the model.

Sometimes the risk tolerance and risk measure will be defined by a stakeholder. For example, regulators often say that companies must hold capital equal to that required by a BBB rated company (which in turn is usually expressed as a 0.5% VaR). Standard and Poor's have published[3] that they use the following probability of defaults in their assessments:

- 'AAA' - 99.9%
- 'AA' - 99.7%

[3] "Request For Comment: Economic Capital Review Process For Insurers", Standard and Poors (2007)

- 'A' - 99.4%
- 'BBB' - 97.2%

This area is an important area in which to get a board to focus. Boards are often not used to being able to espouse their risk appetite in percentiles. Boards often need to be taken through a range of scenarios to assist in getting a better indication of their risk appetite. Examples of the types of scenarios needed for discussion include:

- reference to ratings agencies rating levels and the implied default levels;
- implications for pricing of various levels of capital while still maintaining return on equity targets;
- examples of the types of natural catastrophes that the company would be able to withstand (obviously based on educated guesswork before the model is completed).

5.3. Time horizon

The time horizon, although a simple concept, is easy to misintpret, and needs to be carefully defined. When a company has a one year model, this will almost always mean that it incorporates an extra year of premium income into its capital model. The complexity comes with what happens at the end of the first projected financial year. Some models will completely ignore the position after one financial year, and this will tend to give a relatively modest level of capital requirement, since risks, particularly for longer-tailed liability business, does not manifest itself for a number of years. Other models will build in a risk margin to the reserves at the end of the first projected year, and although this will increase the capital requirements, it is still likely to be insufficient to actually run-off the business. Finally, some companies will consider what happens to the additional year, as well as the existing business, at ultimate. This is the strongest definition of a single year model, and consistent with the standard expected by the FSA in the UK. However, Solvency II consider the middle definition of one year, i.e. the financial position of the company at the end of the year, with a suitable risk margin on the reserves. APRA is yet to issue guidance on the proposed timeframe to consider for the model.

In summary the main options to consider are:

- whether to include the opening balance sheet in the model;
- the number of new years of business to be incorporated into a model;
- whether the business should be modelled until the next balance date or until it is materially run off.

The authors opinion is that a comprehensive model should include the opening balance sheet and be modelled until run off. The alternatives to our preferred options produce models that

underestimate the level of required capital. The number of years of new business that need to be considered is more difficult. In times of higher profitability a three year model will produce a lower capital requirement, and from a prudential perspective, the expected profitability from the second and third year are a weak source of capital, and therefore we consider a single year of new business the most appropriate basis. However, in times of lower profitability, a three year will produce a higher capital requirement, and in this case, we have no clear view on whether the single year or multi-year model should be used, since this will depend on the exact nature of investigation being carried out. If models are developed with multi-year capabilities, then further light can be shed on the one/three year option for senior management to make a more fully informed decision.

5.4. Model structure

Once the three key decisions discussed above have been decided being:

i) risk measure;

ii) risk tolerance;

iii) time horizon.

the next stage of building a capital model is to decide upon the actual structure. The fundamentals of a capital model can be simplified to producing stochastic business plans. Anything that can cause variability in a business plan should be reflected in the capital model. Indeed, a clear link between the planning process and the capital modelling process is (arguably) a necessary condition for the capital model to be useful to the business. If it is not clearly linked to the expected shape of the future business, then its outputs are pretty meaningless.

All paramaterisation of the model should ensure that the mean of the distributions matches the business plans for the company. This is based on business plans being the average outcome for the following year. If business plans are more or less optimistic then the calibration should be modified.

Following is consideration of some of the key risks that a well calibrated capital model needs to consider.

5.4.1. Underwriting risk

In some regards, underwriting risk is the easy risk for insurance companies to incorporate into their capital model. People, in particular senior management, are familiar with the risks that business they are currently writing faces, and underwriters are familiar with considering the uncertainty around business they are about to write.

5.4.1.1. Premium income

Premiums can be either simply parameterised, or extra complexity can be added (if it is appropriate).

At very least, the rating cycle should be removed from the premium calculation since it is will give a better reflection of the risk within the new business component. The rating cycle should be modelled sperately. There are two elements to the rating cycle. Firstly, the average rating environment, and secondly the variability around this expected cycle. There are some complicated models for rating cycles, that enable correlations between lines of business cycles to be easily incorporated. They are based around auto-regressive time-series models, typically AR2 models that refer back to the previous years rating cycle and also the year preceding this. Such models have the following parameterisation:

$$C_t = \mu + \alpha(C_{t-1} - \mu) + \beta(C_{t-1} - C_{t-2}) + \sigma^2$$

In this parameterisation, the four parameters ($\mu, \alpha, \beta, \sigma$) can be interpreted as the mean of the cycle, the mean reversion of the cycle, the momentum in the cycle, and lastly the variability of the cycle around this formula. Such a parameterisation fits well to various market level cycles, and although company level cycles are more variable, they still work fairly well. The correlations are driven through the cycles by fitting a market cycle using an AR2 parameterisation, and then including a component of the company level cycle in the class of business cycle, which changes the parameterisation to:

$$C_t = \mu + \alpha(C_{t-1} - \mu) + \beta(C_{t-1} - C_{t-2}) + \gamma(C_{t,Company} - \mu_{Company}) + \sigma^2$$

Once the rating cycle has been stripped out the premium calculations and modelled separetely, then the capital model can be further refined by splitting the premiums between renewal business and new business. Such a complexity does not necessarily add any additional quality to the model, although if the business planning process includes such a split, then it does help align the capital model with the planning model.

Premium income typically has the following variables influencing the level of premiums which can be made stochastic:

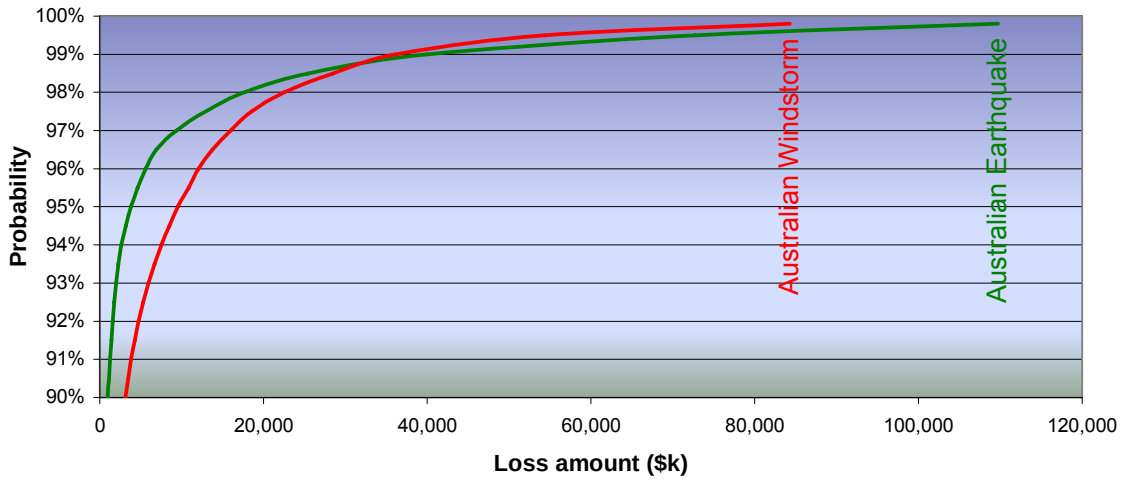
- rate changes
- inflation
- volume of business (changes in exposure)
- rating cycle (which also has correlations with other areas – see section on correlations below)

5.4.1.2. Claims

As a minimum, claims should be split into their three constituent components; attritional, large and catastrophy orientated. Each of these three elements behave differently from the others, and therefore need to be considered separately. The exact definition of attritional, large and catastrophe are open to interpretation, and will depend on the business being written and the reinsurance protections that are being brought. The threshold for a large claim should be below the reinsurance retention, but should be sufficiently large such that the fitted distribution is a good match for the type of claims that could occur.

For reporting purposes, it is useful to have a company-wide definition of large and catastrophe claims that apply across all parts of the business, so that the various elements can be combined to see how much money the company has set against the three components. There is an argument that attritional can be controlled by the company, and that the actual large and catastrophe events should be compared against the provisions made by the company.

Catastrophe events are commonly generated from proprietary catastrophe models. Such models show a set of possible events, with an estimate of the frequency of the event, the exposure to the event, and the mean and standard deviation of a loss from this type of event. Claims can then be simulated from the event loss table using standard methods (for example the secondary uncertainty simulation method discussed by RMS), and correlations between classes can be easily incorporated. Following is a graphical representation of what the output from a catastrophe model looks like:



This is typical of most catastrophe losses, where the windstorm tends to give more severe losses in the main part of the distribution (below the 99th percentile in this case), but then the earthquake losses become more significant (above the 99th percentile).

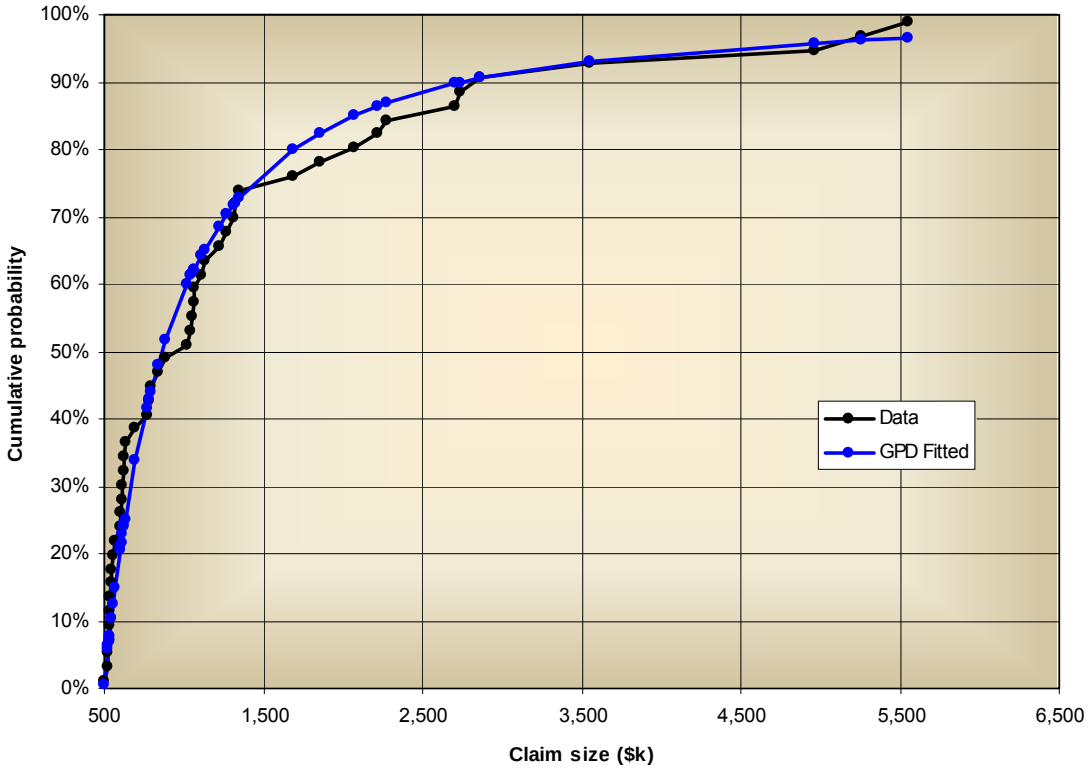
Individual large claims tend to develop differently from smaller claims, and are also likely to be subject to an outwards reinsurance program. Therefore, they need to be split out as one

component of the underwriting model. Methods for carrying out large loss analysis are well documented within actuarial literature, and typically follow:

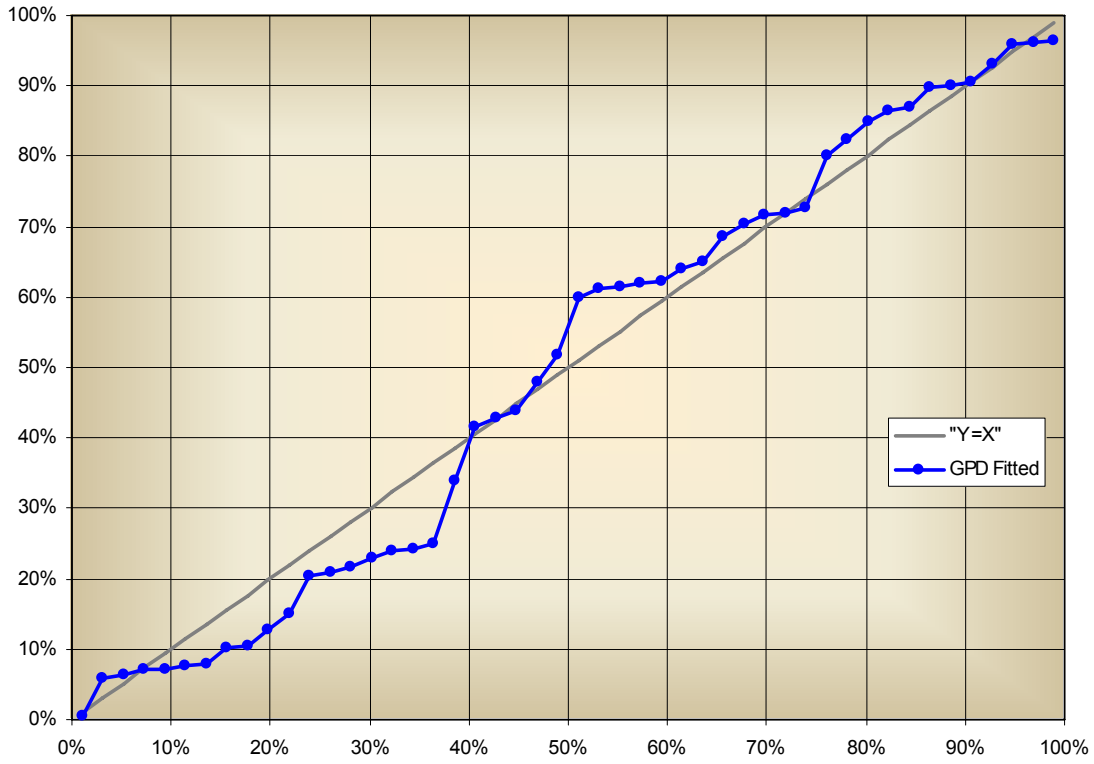
- Inflation of individual historic large claims
- Apply IBNER factors to develop individual claims to their ultimate expected value
- Select a threshold and fit a severity model using weighted least squares or maximum likelihood.
- Project a triangulation of the number of claims in excess of the threshold to assess the ultimate expected number of large claims
- Assess the frequency distribution (this may be a Poisson distribution using the average claims frequency, or could be the negative binomial distribution using the variability of the ultimate number of claims).

The specific large-loss model needs to be considered carefully, since we are looking for a distribution that has a thick tail. In the authors experience, most capital models use a variety of the Pareto family of large loss curves, with the Generalised Pareto A (GPD) distribution being the most commonly used one. These curves have very long tails, which make them more suited for capital modelling where we are trying to assess what happens in the tail.

When considering large claim severity fitting, there are a number of key diagnostics that can be considered to assess the goodness-of-fit for the model. Following is an example of a cumulative probability plot, which is the usual method to visually check the quality of the model:



In this example, the model seems to fit quite well to the claims in excess of $500k. This is demonstrated by the closeness of the blue line to the black line. However, the cumulative probability plot can be misleading and makes it difficult to spots parts of the curve where there is systematic over or under estimate of the claim amount (i.e. where the gradients of the two lines differ). To resolve this, the P-P plot is a much better graphical representation of the goodness-of-fit:



The PP graph is more difficult to interpret, but gives a clearer indication of goodness-of-fit. Each point on the graph is a single point of data. Its "x" value is the quantile that the point represents within the data (i.e. if there are 10 data points, then each point will be separated by 10% on the x-axis). The "y" value is the quantile of that particular claim amount on the fitted claim distribution. If the fit is perfect match for the data, then the blue line would be along the y=x line, i.e. the grey line. Departures from this represents a deterioration in the quality in the fit.

For this particular example, the fitted curve re-iterates the model is a fairly good fit to the data, although it suggests that there is a systematic under-fit for the data below the 40th percentile (which look at the cumulative probability graph above, is around $600k). There it may be better to re-select the threshold to be above $600k.

Attritional losses are the remaining component of the claims, and these should be a balancing item between the planned loss amount, and the value of claims arising from the catastrophe

and large claims element. The variability can also be assessed by calculating the "as-if attritional loss ratio" for each historic year, which considers the premiums excluding the rating cycle, and the historic claims less the inflated large losses and catastrophe losses that are considered in the proceeding two elements. A distribution can then be used such as the gamma distribution or the log-normal distribution, which is not symmetric, but does not necessarily have a thick tail (since this is picked up through the large loss and catastrophe components).

As well as simulating the loss variabilities, an important component of the underwriting risk in a capital model is caused by correlations between classes. For example, superimposed inflation is likely to impact on a number of classes of business at the same time. Such loss correlations need to be included within the capital model, since it would otherwise any conclusions coming out of the model would be not be realistic (e.g. capital would be understated). The correlations can be generated through two main methods. Firstly, there could be a correlation driver, such as inflation, which feeds into the model. Individual shock events can also be incorporated using a correlation driver, for example if an aviation loss event is simulated, then there are losses to the aviation hull and aviation liability classes. The second method is to use statistical correlations, such as copulas. These are an easier method to incorporate correlations since the exact driver for the correlation does not have to be specified. Unfortunately, there is never sufficient data to parameterise such dependency structures properly, so judgement parameterisation is required (albeit that this can be checked through a thorough underwriting review process).

Once the gross claim models have been parameterised, including dependencies between classes, the second part of the claims analysis is to put them through the outwards reinsurance programmes. In some circumstances, the finer detail of some reinsurance programmes can not be implemented within the capital model and sometimes these have to be ignored (subject to them not being material omissions). However, all material reinsurance structures should be incorporated to have a meaningful capital model. The level of modelling of the reinsurance structures is a matter for judgement. Where reinsurance is modelled the stochastic analysis can be used to assist in undertaking reinsurance pricing analysis.

5.4.1.3. Expenses

The third element of the underwriting model is expenses. Some of these are variable, and can be linked to other elements in the underwriting model. For example, commission is directly linked to the gross premium, and claims handling expenses are likely to link to the gross claims amount. Other expenses could be fixed, such as the premises costs, and these can be included as a single fixed expenditure during the year. If the capital model is allowing for risks to ultimate, then the full run-off expenses should be incorporated into the underwriting risk model. Again each of these elements can be made stochastic.

5.4.2. Reserving risk

Reserve risk modelling has been well researched by actuaries across the globe. Some of these methods, such as Mack, only give summary statistics of the reserve variability, and as such are not directly suitable for capital modelling purposes unless an underlying distribution (such as the log-normal) is also assumed. Other methods, such as bootstrapping give the full distribution of reserve run-off to incorporated into the model. There is a great deal of

literature devoted to exploring this and the many other methods and is well documented in other actuarial papers so will not be repeated here.

The treatment of reinsurance recoverables can be problematic. To do a full analysis, one would need to:

- Develop individual historic claims for IBNER
- Simulate IBNR claims on past years, and develop them to ultimate
- Put the actual historic claims and the new IBNR claims through the past reinsurance programmes

Such an analysis is possible, but requires a large number of assumptions to get the full cash flow projection of the claims. Instead, practitioners often use a fixed gross-to-net ratio, based on the full reserving exercise. Although this is only an approximation, whether it is prudent or optimistic will depend on the exact circumstances. For example, it could be the case that claims that are just under the reinsurance retention level will deteriorate on the gross basis, but would not deteriorate on a net basis, in which case the gross-net ratio should reduce as the gross claims increase. On the flip side of this, it may be the case that claims are close to the top of the reinsurance protection, or there is almost a horizontal exhaustion of the past reinsurance protections, in which case the ratio should increase as the claims increase.

Following similar reasoning to the underwriting risk, there should be correlations between the reserve variability of different classes of business. Again, these could be incorporated through a correlation driver (such as inflation), or through statistical correlations (such as copulas). Such correlations are unlikely to be parameterised through data since there is usually insufficient information, so they will have to be checked through a review of divisional totals, where a number of classes of business are aggregated to check the combined output for reasonableness.

5.4.3. Credit risk

There are a number of sources of credit risk to an insurance company, since there are a number of external parties that are debtors on the balance sheet.

5.4.3.1. Reinsurance credit risk

The most common source of credit risk is external reinsurers, since this is typically one of the larger debtors on the balance sheet. Reinsurance credit risk is usually incorporated by considering the credit quality of the different reinsurers on an insurer's balance sheet. Then default factors are applied to the various recoverables, for example the Standard and Poor's default probabilities. When using these, a duration of the recoverables will have to be assessed, since the probability of default for a reinsurer increases over time. One way of calculating this is to project the triangulation of reinsurance recoverables. A loss-given-default assumption will also have to be selected, and again information on this assumption can be sought from rating agency literature or from history. History, as well as the rating

agency publications, suggest a 50% loss-given-default assumption, with a 30% standard deviation.

The above considers the default applying to a single reinsurer, although in reality most reinsurers will be likely to be exposed to the same type of event that would cause the insolvency of a specific reinsurer. Such potential for contagion of reinsurance default means that tail correlations should be applied between the default risks of the different reinsures on a company's books.

There are more sophisticated ways to consider credit risk, such as using ratings transitions of the reinsurers across the time-horizon of the projection period. This is important to assess the levels of bad-debt reserves that should be incorporated on the balance sheet, but has a secondary impact on the capital assessment since once the reinsurance recoveries have run-off, the important consideration is whether they were paid, rather than whether they were paid by a lower rated reinsurer.

5.4.3.2. Broker/agency credit risk

The next largest debtor on the balance sheet is likely to be broker and agent balances. These are less risky than the reinsurance asset since they are much shorter-term, and are often held in protected (eg trust) accounts. However, there have been incidences of brokers defaulting on their balances, and the insurance company having to continue to honour the policy – depending upon the local insurance law of that country. Credit risk on broker balances can be allowed for in a similar way to that of reinsurers, although the duration selected for the default probability will need to be much lower.

5.4.4. Asset (market) risk

There has been a trend over time for most non-life insurance companies now trying to avoid too much investment risk through investing in high quality corporate bonds and/or government bonds. Even though these are secure, their market value is dependant on the prevailing yield curve. Since the yield curve is uncertain, it follows that the market value of the bonds are volatile and should be modelled stochastically.

Investment risk needs to be incorporated into the capital model in order to build the holistic picture of the risk in the balance sheet. There are a number of proprietary asset models that are supplied by investment banks and actuarial consultants. Some of these have a backing in the actuarial literature, the most famous asset model probably being that developed by Wilkie. These can be linked directly into most capital models since they give simulations of a bond/cash/equity index.

Care needs to be taken when selecting an asset model to integrate into the capital model, and consideration needs to be given to:

- Ensuring fat-tailed distributions are incorporated into the various indices;

- Consistency between the different indices, for example during a high inflationary scenario, there should also be a high cash rate (since the real return on cash remains relatively constant);

- Consistency between different currencies (if applicable).

Since the asset models are mostly proprietary, no further discussion is considered within this paper. A full description is available from the many providers of asset models.

5.4.5. Liquidity risk

Liquidity risk tends to be an immaterial risk for non-life insurance companies, since they typically hold very liquid assets. However, in the event of a natural catastrophe, there could be a liquidity crunch, so there should be some allowance made for liquidity issues. To do so, the short-term cash flows need to be considered within the model, so, for example, a cost associated with a short-term overdraft facility could be incorporated whenever there is negative cash flows simulated.

5.4.6. Operational risk

Operational risk assessment is still in its infancy, although this is not a reason to exclude it from the capital model. Most companies consider their control environment through an operational risk register, that incorporates a judgementally assessed frequency and severity for all of the key risks that the company faces, alongside other softer risk management issues, such as the controls, and their effectiveness, that help reduce the impact of the risk. Such a risk register can be used as the basis for the operational risk assessment within the capital model, although it would need to be backed up by a robust operational risk scenario analysis.

To use the risk register for assessing operational risk, each risk needs to be considered to assess whether:

- It is included elsewhere within the capital model. As an example, reserve deterioration risk would likely fall into this category.

- It is partially included within the capital model. For example, delegated underwriting tends to be riskier than primary underwriting, and some of this risk will be manifest in the historic data. However, there is a residual risk in excess of that in the historic data, so part of the risk register may be incorporated into the capital model

- The risk is not included within the capital model at all, for example IT risk would have been unlikely to have been considered already.

The frequency and severity bandings could then be used to simulate operational risk losses from the risks remaining on the risk register. Some of these risks would not cause an actual loss to the company, but may rather affect the future profit potential for the business. In such circumstances, it is arguable that the risk does not need to be incorporated into the capital model, since loss of future business does not actually affect the capital required by the

business. Note that the exact distributional assumptions used will depend on the specific risks since some will have much longer tails than others.

Given that the operational risk assessment detailed above is "pseudo-mathematics", it is important to validate this component of the model (although arguably it is important to validate all of the risk components of the capital model). This can be done by the risk management function putting together operational risk scenarios that consider the impact that a specified event would have on the company, including all ripple-effects that the event would have. Examples of such scenarios could include:

- Action by a competition regulator due to pricing collusion.
- Over-run or non-delivery of major IT projects
- Cost, and loss of money, arising from the loss of key staff within the business.

Over the next few years, the development of operational loss databases are likely to become more prevalent (there is already a large database managed through the ABI insurance trade-association in the UK). When these have meaningful levels of data, then standard actuarial techniques could be applied to the data to develop a more refined operational risk model. However, it is important to note that such databases will never have events that have brought down insurance companies, since by definition if an insurance company were to become insolvent, they are unlikely to continue subscribing to the database and therefore the loss event is unlikely to be captured. Therefore, such databases need to be incorporated carefully in order that the full range of operational risk losses that the insurance company is exposed to are incorporated within the capital model.

5.4.7. Group risk

Group risk is an interesting risk category, and there is a strong argument that it should be negative. If being part of a group were not beneficial from a capital point of view, then the company should be split into its separate subsidiaries since this would be more beneficial to the owners (shareholders) of the parent company. However, regulators (and probably rating agencies) would want to include capital to allow for the circumstances where other elements of the group pull on the resources of the company. Such risk could be incorporated in a similar fashion to that discussed for operational risk assessment.

5.4.8. Correlations between risk categories

A number of the risk categories are naturally linked, and such linkages need to be incorporated within the capital model alongside the intra-risk category risks. Examples of linkages include:

- Inflation linking together underwriting risk , reserving risk and market risk;

- Links between the underwriting losses experienced by the company and the reinsurance credit risk since the company's reinsurers are likely to follow the fortunes of the primary insurer;

- Reserve variability between classes;

- Rate movements between classes;

- Attritional loss variability between classes;

- Large loss frequency between classes;

- Natural catastrophe losses between classes;

- Between reserve variability and attritional variability;

- Inflationary link between reserves and loss volatility;

- Default risk between reinsurers;

- Overall default risk of reinsurers and natural catastrophe losses;

- All asset returns, inflation and exchange rates;

There are a number of other linkages that could be included, but materiality on the output must be a key driver of the complexity that is incorporated within the modelling framework.

5.5. Poor quality data

Capital modelling, as with most analytical models, suffers from "garbage in, garbage out". To do the work fully requires vast quantities of good quality data, and typically this does not existing within most companies. Therefore, compromises have to be made.

If the data is just poor, then parameterisation of the model can take place, although a more thorough review of the output with an appropriately skilled individual would become more important.

If there is no data (such as for a new class of business), then similar classes of business could be used, otherwise market statistics may be the only direction to go. There are a number of good quality market information sources, such as country-wide regulatory return.

6. Model review

Once the various parts of the capital model have been assessed, they need to be reviewed by the relevant business experts:

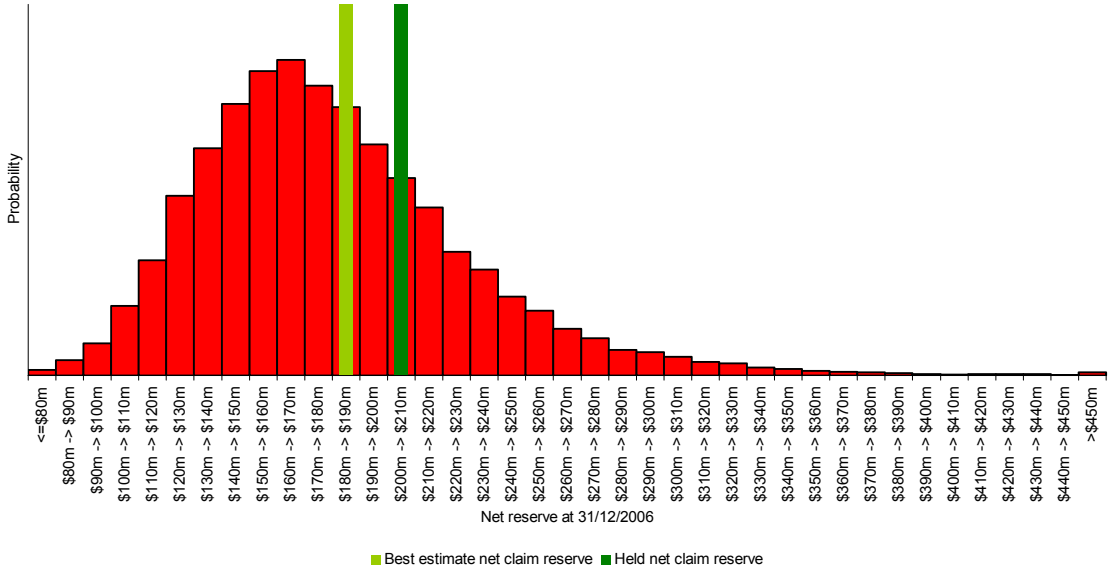
- Underwriters and pricing actuaries for underwriting risk;
- Reserving actuaries and underwriters for reserving risk;
- Reinsurance function and security committee for credit risk;
- Investment function for market risk;
- Risk management for operational risk and group risk;
- Senior management and Board for overall reasonableness of the aggregate capital model.

These reviews can be carried out using a variety of outputs, such as feedback questionnaires and graphical representations. Following are some examples of how such reviews could be conducted.

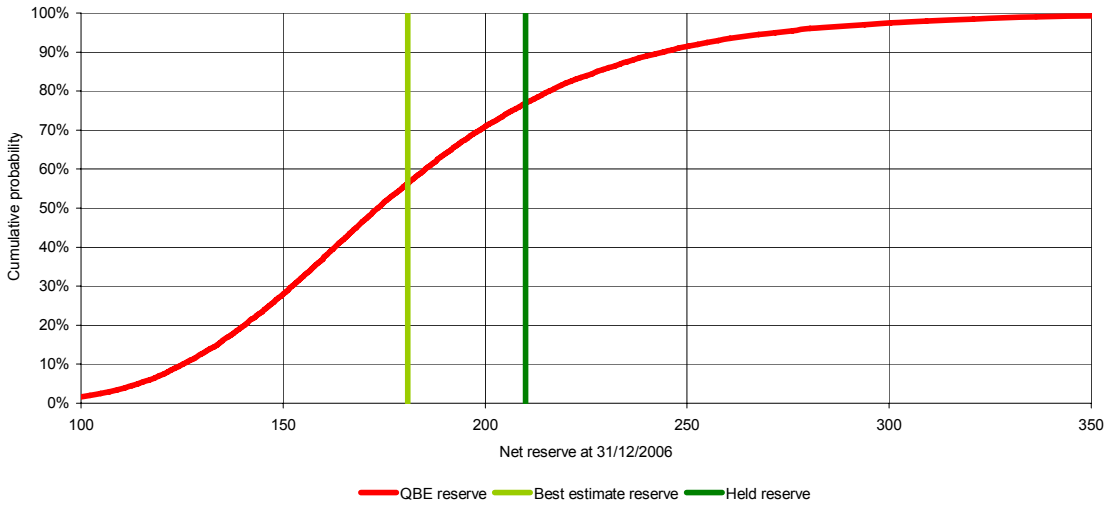
The model review process is important, since it gives ownership of the model assumptions to the parts of the business that properly understands the impact of those risks. Where possible, the assumptions feeding into the capital model should be derived from that that are already used within the business, for example there may be pricing variability assumptions that can be directly linked into the model. Such use of the business's data means that the central modelling team are not relying on the data to incorporate within the capital model, but rather are using (arguably) better quality information that other business decisions are being based upon. The additional benefit is that the business should be able to better understand how their input is affecting the capital model, and therefore buy-into the process better.

6.1. Probability graphs

The most common way to consider the model outputs is to produce a discrete or cumulative probability graph of the output, such as the following (which considers reserve risk)



These graphs are well known by most numerate people, although from a purist point of view, they do not show the reader much about the distribution. It is difficult to calculate the area under the graph, so the reader cannot easily assess the exceedance probabilities. Therefore, a more meaningful graph to include is the cumulative probability graph, such as the one illustrated below:



This graph, although it does not look as interesting as the discrete probability graph, shows more information on the underlying distribution. For example, it can be seen in this example that the company is reserved at just over the seventy-fifth percentile, and that the best estimate reserves (the mean) is roughly at the fifty-fifth percentile, demonstrating that the distribution of reserving outcomes is skewed to having deteriorations rather than having releases (which is common for most insurance statistics).

With a small amount of explanation, the cumulative probability graphs can become easily understandable by even the least numerate person. However, care needs to be taken to explain the graphs in terms that the reader will understand, for example using return periods rather than probabilities when talking to a treaty underwriter.

The best way to review these graphs is to pick out a few percentiles of the distribution. The authors have found that asking for commentary on the mean, the 25^{th} and 75^{th} percentiles and also the 99^{th} percentile have been most useful, since these help calibrate the middle part of the distribution that is important for day-to-day management, as well as the tail of the distribution that is more important for capital modelling, but is also more difficult to opine upon. Such feedback could be sought using a questionnaire that picks up these key statistics from the graphs, and then explains them in simple English, such as:

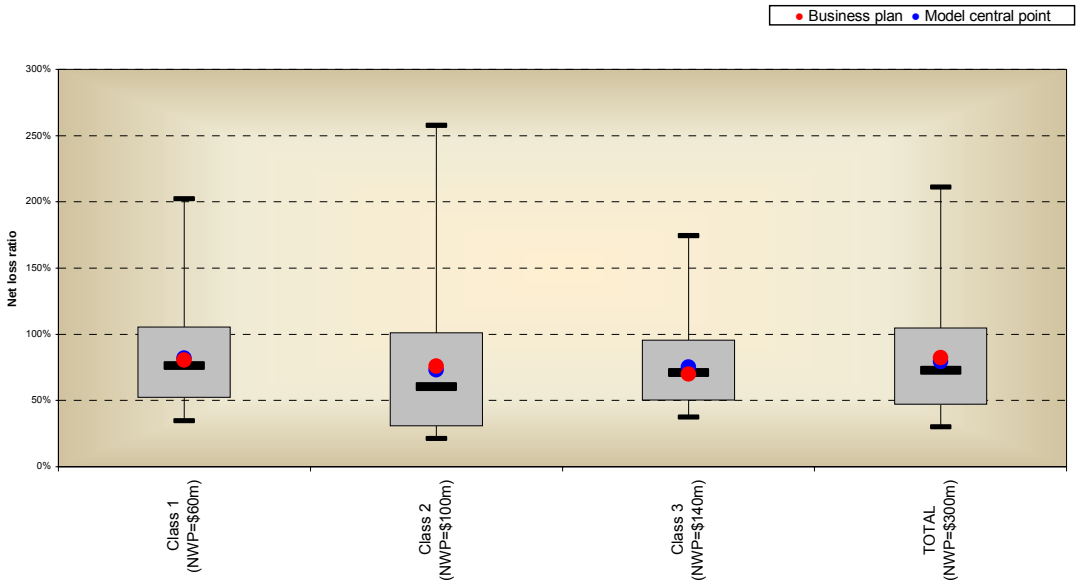
- Is $180m your best estimate reserve?

- Do you think there is a 1 in 4 chance that the held reserves will not be sufficient to cover the ultimate claims amount?

- Do you believe that a worst case scenario for reserve deteriorations is $180m above the best estimate (or $160m above the held reserves)? What events would cause such a deterioration?

6.2. Box-whisker plots

Looking at a single probability graph is easy if the reviewer is only reviewing one or two items in the capital model. If they need to consider a number of classes simultaneously, then box-whisker plots are a better way to elicit comments on the relative and absolute levels of variability between classes. Following is a box-whisker plot for the net loss ratio for a number of classes, which gives various pieces of summary information on the model output in a single easy-to-use format.



This is interpreted as:

- The thick line within the box is the median, so half of the time, one would expect the net loss ratio to be below the line, and half of the time above the line.

- The bottom of the box starts at 25% and the top of the box is at 75%. This means that half the time the net loss ratio is within the box, and half of the time the net loss ratio is outside of the box.

- The whiskers are at 0.5% and 99.5%

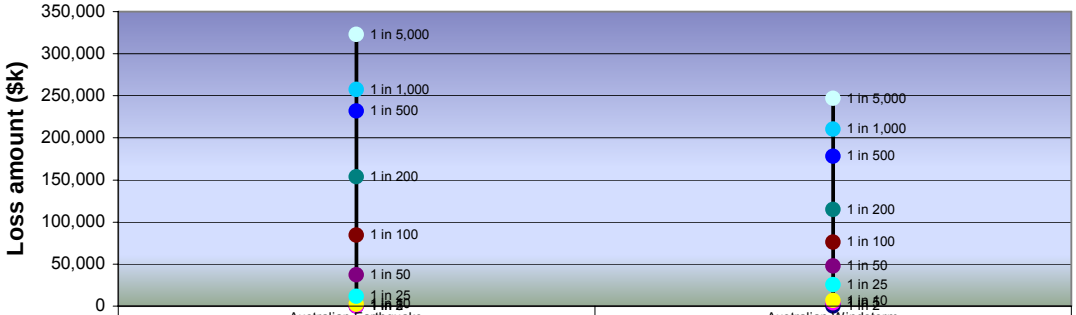
- The red dot is the business plan, which is taken to be the best estimate of the net loss ratio

- The blue dot is the average value of the modelled net loss ratio, so there is a slight disagreement between the model and the plan for class 3.

These graphs allow a quick comparison between classes of business, and with the total also being shown allow the reviewer to see the impact of diversification between the classes of business. The authors have found that these graphs are particularly useful with steering committees and with lead underwriters, who are more interested in relativities and the aggregate position for their particular parts of the business.

6.3. Dot plots

When underwriters, particularly treaty underwriters, are considering the output from a model, dot plots have been found to be useful. These show specific return periods for a number of events on the same graph, as follows:



	Australian Earthquake	Australian Windstorm
1 in 2	0	3
1 in 5	138	3,752
1 in 10	2,072	6,694
1 in 25	11,884	25,496
1 in 50	37,368	47,671
1 in 100	84,301	76,219
1 in 200	153,645	114,690
1 in 500	231,699	177,951
1 in 1,000	257,487	210,170
1 in 5,000	322,939	246,990

The area where these graphs are really useful is when the output from catastrophe models are being reviewed. They are easy to read and interpret, and give statistics (return periods) that underwriters are comfortable with. Extra data can also be incorporated into these graphs, for example if any realistic disaster scenario (RDS) work has been carried out, then this figure could also be included for each of the modelled perils.

7. Using capital models to drive change

7.1. Capital adequacy

The primary use of capital models is to assess the capital required to run a business. This aim, in itself, does not drive much change in the business, other than to focus people's minds on the capital impact of what they are doing. This can lead to changes to the business plan, but this usually arises through using the model for capital allocation rather than capital adequacy.

Capital adequacy levels can then be discussed with ratings agencies, insurance supervisors etc as discussed in section 2 of this paper.

7.2. Capital allocation

Using a capital model for capital allocation purposes can be a major driver of change within the business. If each class of business is allocated an amount of capital, then its return on capital can be assessed, and this could then link into individuals' remunerations. For example, bonus payments could be linked into the return on equity achieved in the preceding year. Such a step could be a major change in the business, since it would focus peoples' minds, in particular underwriters, on the risks inherent in the business they are writing, and these will then be better controlled, in order for them to benefit from additional remuneration.

Using a capital model to have a direct impact on the remuneration strategy of a company is arguably the ultimate demonstration that the model is being used within the business. If senior management had no confidence in the model, then such usage would not be considered, and therefore the fact that it is being used for this purpose demonstrates that there is genuine belief that the model is reasonable.

When doing a capital allocation exercise, there are a number of important considerations that have to be made at the outset of the project, since these could materially alter the output from the exercise. Such considerations are:

- What is the purpose of the capital allocation? If it is to allocate out risk capital, then it should be based around high percentiles on the loss distribution. If it is being used as a planning and strategic input, then it would make more sense to include lower percentiles (e.g. 75^{th} and 90^{th} percentiles) within the capital allocation, since these are the likely departures from the budget for any one class.

- Is the capital being allocated the actual capital held by the company, the theoretical capital that should be held by the company or just a sub-set of the company's capital

- Should reserve risk be included within the capital allocation, i.e. each class of business needs to fund a year of new business as well as the potential that its historic reserves could deteriorate.

- If reserve risk is included, then should it be on a steady-state basis (the level of reserves held is commensurate with the premium being written/earned by that class of business), or should it include the actual reserves backing the business.

- Where a multi-year model is used, how many years of business should be considered for capital allocation purposes.

Beyond these basic philosophical questions, the actual allocation exercise can be politically sensitive within the business. Underwriters have a vested interest in reducing their allocated capital, since this will improve their return on equity, and therefore the model needs to be consistently parameterised across the whole of the business (note that consistent does not mean the same). Underwriters should be given the opportunity to comment on the underwriting models so that they can see the link between their forecast volatility and their capital allocation. Even giving underwriters some control over the process, the output from a capital allocation exercise still needs to be carefully communicated to the business to avoid potential conflicts that could otherwise occur. The process also needs to be ultimately owned by a senior management with no vested interest in any one section of the business, and typically the CEO is the best placed person to own the capital allocation and have the right to veto the model for strategic or tactical reasons.

There are a number of approaches to capital allocation, each of which has its own benefits and drawbacks. Much of this has been discussed in the literature, and the precise approach taken to capital allocation needs to be tailored to the needs of each particular company. Often there will need to be judgemental overlays to the technical allocation arising from the model, for example a strategic decision may be made to reduce the capital allocated to a particular line of business in order to encourage it to grow (and therefore increase the diversification between the risks within that class and reduce overall risk at a class level). There may also need to be judgement overlays where the model is not giving a reasonable result, although in such circumstances it would be better to review the particular parameterisation rather than discarding that particular part of the model output.

7.3. Business planning

One of the natural places for capital allocations to feed into are company business plans. Historically, most companies have consider the insurance profits arising from different lines of business, and used them as the basis for comparing different lines of business. This is obviously flawed since property catastrophe business will almost always be planned to have a lower loss ratio, and therefore higher insurance profit, than motor business due to their different risk characteristics. Including the capital allocation within this process would allow senior management to do proper comparisons of different lines across the whole of their business. This should facilitate more effective planning strategies, only writing business where it achieves a level of return on capital that is aligned with the company's strategy.

7.4. Reinsurance

A well parameterised capital model should incorporate sensible gross and net projections of claim costs and premiums, and therefore proper assessment of the outwards reinsurance protections is a necessary component of the modelling. This component of the full capital model can be extracted to create a smaller reinsurance assessment tool, which is based around

the same underlying parameterisation of the capital model. Different reinsurance structures could then be considered, for example, the risk/reward profile for different retention levels could be properly assessed, and therefore effective decision making can take place. This could be further linked into the capital allocation methodology, so that the capital allocation impact of different reinsurance programmes can be considered.

To carry out a reinsurance benchmarking exercise, the risk and reward both need to be specified, and these are considered below.

7.4.1. Risk

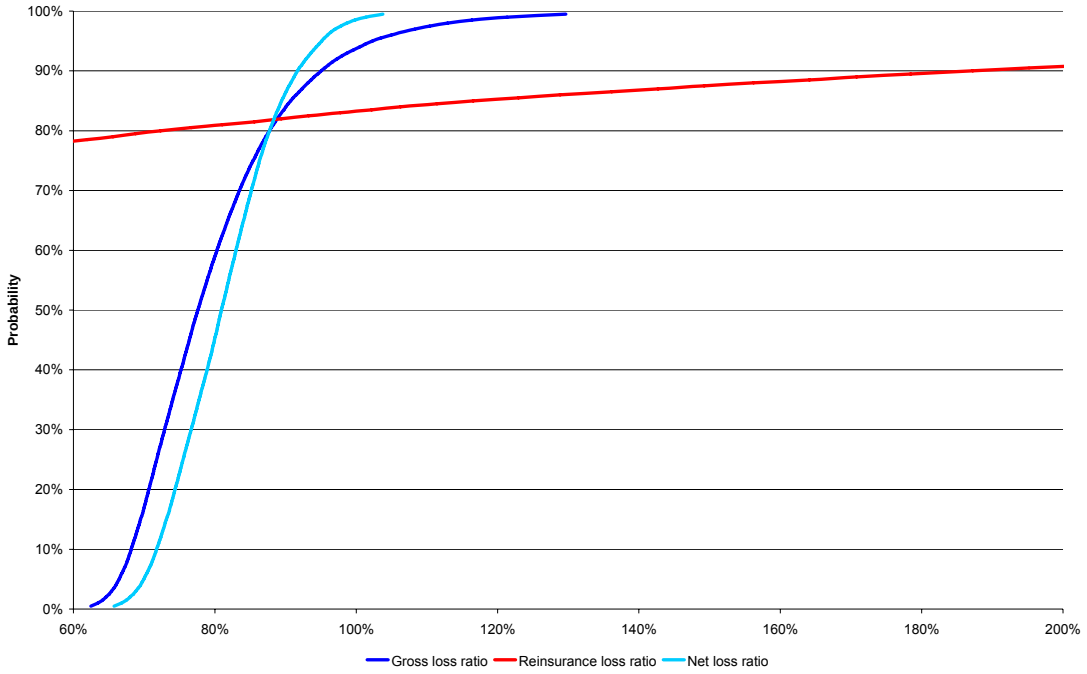
Reinsurance is purchased to protect a portfolio against large adverse developments, and therefore standard deviation is not a very good measure of risk to use for this exercise. The value at risk (e.g. 99%ile net loss ratio) is a better measure, since it considers the large losses, and tail value at risk is a further refinement on this since it allow for all adverse developments in excess of a specified threshold. The definition of risk should also link into what is important for the user of the information. If the user is an underwriter, then they are likely to be more concerned about lower percentiles on the distribution, e.g. 90%ile, since this would have a direct impact on their profit-share. Senior management, however, may be more concerned with much higher percentiles, since this is what is likely to have a more material impact on the business (the 90%ile loss is likely to diversify away when combined with all of the other portfolios within a business).

7.4.2. Reward

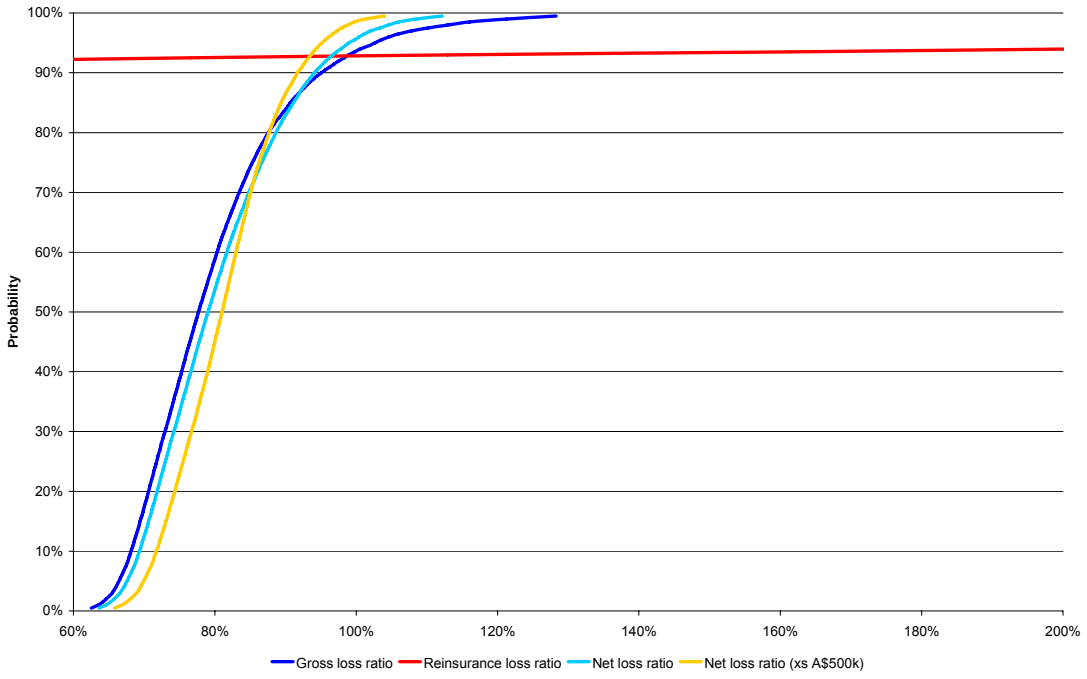
The benefit of buying less reinsurance is that the reinsurance spend is less, and therefore a simple reward measure to use the net written premium for the portfolio. However, this does not capture the fact that the reward measure should incorporate some adjustment of risk to select an optimal strategy. A better reward measure to use would be the expected net insurance profit, since this reflects the reduced reinsurance spend and increase claims cost associated with increasing the retention.

7.4.3. Example outputs

As an example of this, a small model was put together for a motor reinsurance programme. The following graph shows the output from the base model, which includes the existing reinsurance programme in excess of A$500k.



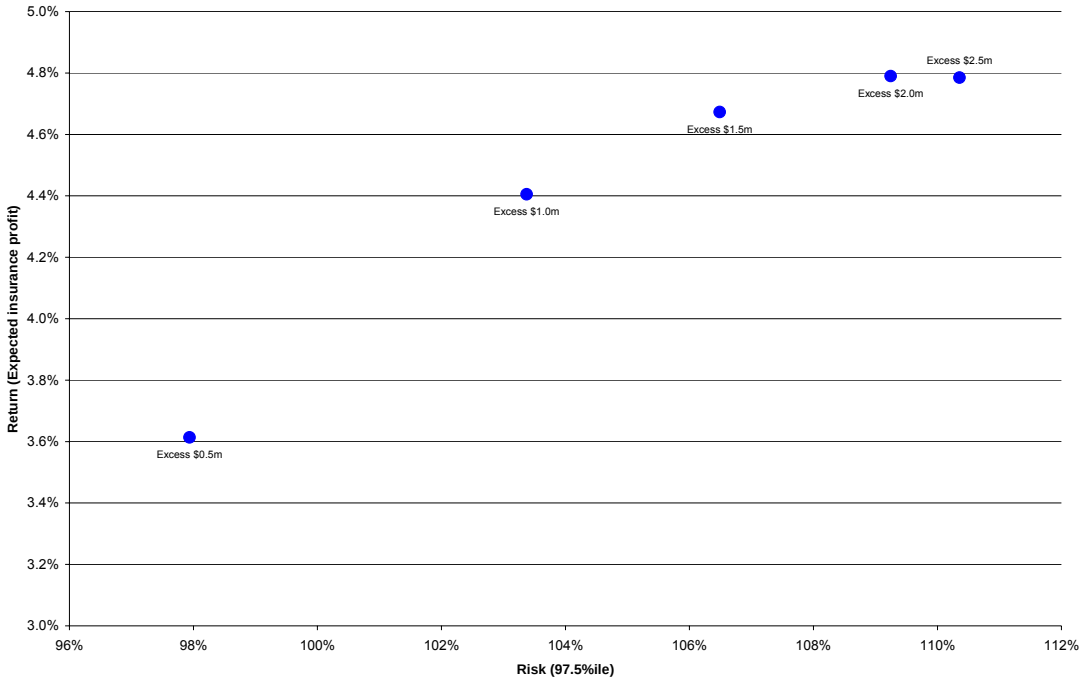
The retention was increased from its existing level (to A$1m) to demonstrate the impact on the portfolio of retaining more risk:



The impact of increasing the retention is an improved net loss ratio 75% of the time (where the orange and light blue lines intersect), but an increase in the net loss ratio in the remaining

1 in 4 years. Whether this is acceptable will depend on the size of the portfolio in the context of the company, and the specific tolerance of risk of the class underwriter. One area to focus on is the increased retention has a significant capital impact (comparing the upper end of the net loss ratio distributions), which demonstrates that reinsurance can be considered as a substitute for capital.

For the purposes of this example, risk could be considered as high percentile on the distribution (e.g. 97.5 percentile), with return being represented by the expected net insurance profit. This gives rise to the following graph for different attachment points on the reinsurance:



This analysis shows that buying reinsurance excess of $2.5m does not affect the expected profitability much, but gives rise to more risk than buying reinsurance excess of $2.0m, this being driven by the relatively low cost of the "sleep-easy" high-level coverage. There is a question for the company as to where it wishes to balance its risk, for example is it acceptable to increase risk by 8% for a 1% increase in expected profitability?

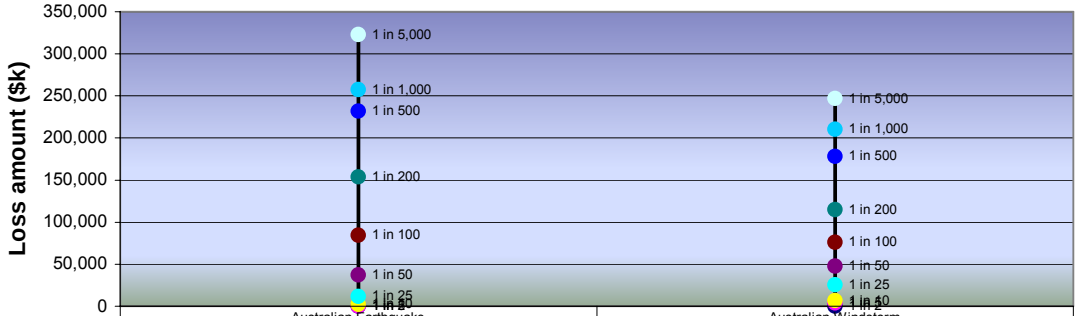
By properly understanding the mechanics of the reinsurance, and using the capital model (or a sub-set of the capital modelling work) to carry out a full analysis, a company should be able to buy more effective protection (i.e. reduced risk) for the same cost, or alternatively reduce the overall reinsurance spend, but still maintain a broadly equivalent risk profile.

As well as benchmarking strategies, the work can be shared with brokers and reinsurers during pricing negotiations, or for the purposes of commuting reinsurances.

7.5. Aggregate (accumulation) monitoring

Traditionally, catastrophe models have concentrated on annualised average losses, and return periods for a single event. Although these are interesting statistics, a more meaningful analysis needs to include return periods for multiple events since natural catastrophe reinsurance typically has limited sideways coverage. The capital model is a natural framework to assess the net aggregate losses from a variety of events. Again, a simplified part of the full capital model could be used to carry out a proper exercise on the net aggregate exposures that a company has to individual catastrophe events (from both natural catastrophes and man-made events). Such a model could be used for two purposes, either to help select an appropriate level of reinsurance protection, or to limit underwriting certain risks where there is currently too much exposure.

In the review discussion above, the concept of a dot-plot was discussed, and this is an effective way of considering aggregate monitoring. Each region/peril can be considered alongside eachother, with the various percentiles being displayed to see where the concentrations of risk are within the business.



	Australian Earthquake	Australian Windstorm
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1 in 500	231,699	177,951
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7.6. Asset allocation

Another area of added-value from capital modelling is to consider strategic asset allocation (this being different from capital allocation). Similar to reinsurance investigations, the entire capital model is unlikely to be necessary to carry out such work, and a stripped down part of the model is likely to be more appropriate. The capital modelling team, the investment division and senior management could then the risk/reward arising from different strategies, and from this, select an asset mix that is optimal for the company's needs.

The link between assets and liabilities is an interesting area, and for non-life insurance business, something that has (arguably) been overstated in the past. For most lines of business, the common link between assets and liabilities is through the use of an inflation measure that is consistent with the investment returns. Such a link, whilst important in the tail of the distributions (where capital is being assessed), does not have such an impact in the main of the distribution (where asset allocation decisions are considered).

This said, there are some lines of business where there are much stronger linkages, for example, losses from creditor business are higher when there is a recession, and during such circumstances, equity returns are depressed. For such business, the link between assets and liabilities is much more important for a sensible asset allocation discussion.

To simplify the discussion on asset allocation, ignore the link between assets and liabilities at the moment. If this is done, there are three main inputs to a strategic asset allocation model:

- Investment return for each main asset class
- Definition of risk
- Definition of return

Each of these is considered below.

7.6.1. Asset models

There are a number of well publicised free asset models, for example the Wilkie (1995) asset model is well publicised within actuarial literature.

There are also a number of proprietary asset models that can be purchased from external vendors. Depending on what the model is being used for, the extra detail that these models supply may be important, but for a number of uses, the simpler freely available models can suffice.

7.6.2. Risk definition

Typically risk is considered as the standard deviation of the overall portfolio, since this is readily understood within the investment markets. Over recent years, better risk measures have started being used, for example VaR and TVaR are now a part of the investment expert's dictionary.

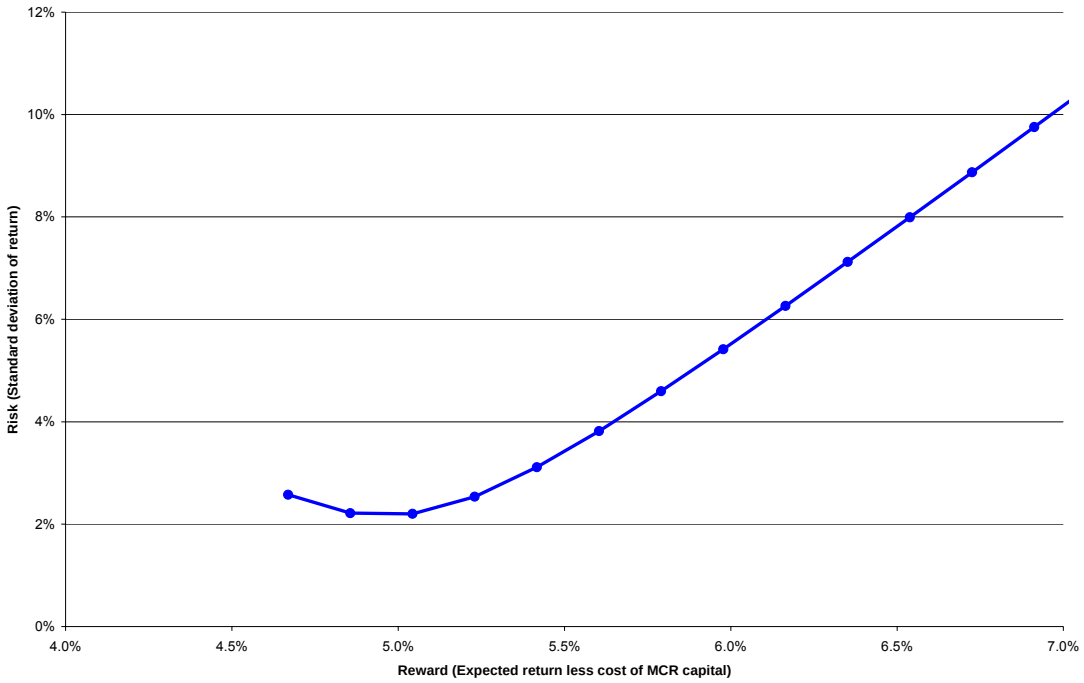
7.6.3. Return definition

The exact measure of return will depend on what is the main statistic of importance to the company. Starting with the basics, the simplest measure of return is the average investment return for the portfolio, including both income and capital gains from the investments.

The simple definition of return can be extended to include the return on capital, or adjusted to reflect the cost of the capital that it incurs. For example, using a return definition of the expected return of the portfolio, less 10% of the MCR for holding that portfolio. This is only a relatively small extra amount of complexity in the calculations, but allows a company to consider the risk of a portfolio against its expected risk-adjusted return, which is a much more meaningful statistic.

Example outputs

A proprietary asset model has been put through an asset allocation tool to find the risk/reward profile for a number of investment strategies. Risk was defined as the standard deviation of the return, and reward was defined as the expected return less the cost of funding the APRA asset MCR. The graph below details the output from this analysis.



Each point along the line, from left to right, reflects a 5% increase in the equity holding of the company, starting from 0% equities (the rest being held in a mixture of cash and bonds). This example shows that by holding 15% equities in their portfolio, the company can expected to make better returns, but with less risk, than holding no equities at all. The reason that this occurs is that the equities and cash risks are not fully correlated with each other, so that the additional volatility from holding additional equities is reduced to reflect the diversification benefit.

By using the asset component of the capital model, the company should be able to improve their overall approach to investment management, and either get additional returns for no extra investment risk, or reduce overall investment risk for the same expected return.

8. Risk management

To date, there has been limited integration of technical capital modelling with the broader risk management of insurance companies. The integration between risk management and capital modelling is increasing quite rapidly as both areas are focussed on the quantification and management of risk. The former tends to focus on issues that can be quantified using standard actuarial techniques, whereas the latter is more focused on the process of assessing individual risk and typically concentrates less on the full quantification of risk. The logical progression of a capital model to integration with risk management, is in order to create a unified enterprise risk management framework that allows senior management to consider risk strategically and holistically across the whole business. Actuaries, armed with their technical modelling capabilities and understanding of risk, are ideally placed to fill this gap, although it requires a change of mindset to do so successfully.