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Determining a Catastrophe Risk Profile

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Appendices

1 Introduction

NZ insurers need to understand their exposure to catastrophes, their Catastrophe Risk Profile (‘CRP’). There are many areas in which the CRP plays an important role, areas including:

- Solvency calculations
- Financial Condition Report
- Negotiation and purchase of catastrophe programmes
- Assessing economic capital

A similar analysis is also useful in a macro context for governments to assess the impacts of catastrophes, including social, economic and financial impacts.

1.1 Extreme Event Exposure

In respect to the solvency calculations for a non-life insurance business, there is a requirement for the insurer to estimate their Extreme Event Exposure (‘EEE’). For insurers with property exposures, in respect of earthquake events, this is the projected total of losses, calibrated to a 1 in 1000 return period.

This is a difficult amount to assess, as the events in question are, by definition, very rare and very large. Hence there is limited historical and/or scientific evidence on which to base estimates of the impact of future events on current exposures. Nevertheless, it is incumbent on an insurer to determine the EEE and for the Appointed Actuary (‘AA’) to attest to it, as part of the solvency return. Clearly this is an issue that the insurer and the AA must discuss in order to reach a suitable value.

The Solvency Standard does not specify how the EEE should be determined, although there is an unstated implication that catastrophe models will be used.

There are a number of concerns with using catastrophe models for this purpose, not least that they are very complex and can return highly uncertain results, especially at the extreme tails.

1.2 Catastrophe Working Party

As a consequence of these concerns, the New Zealand Society of Actuaries has commissioned a working party to investigate the derivation of the EEE and to propose alternative methods in which the RBNZ may require the EEE to be determined.

The terms of reference for the Catastrophe Working party are reproduced in Appendix A.

1.3 Catastrophe Risk Profile definition

The catastrophe risk profile of a company is an understanding of the financial impacts from the occurrence of natural perils. It may be represented in many ways, some of the more common are:

- Exceedance probability curves
- Value at Risk
- Tail value at risk tables

1.4 Purpose / Scope

This Catastrophe Working Party has recognised that the Solvency Standard is silent on how the insurer must determine the EEE. Similarly, an insurer may determine their CRP in any fashion they like.

However, the insurer must be able to demonstrate that they believe that the EEE corresponds to a 1 in 1000 year return period.

The purpose of this paper is to provide discussion points on methods that an insurer may use to determine their CRP and how they may gain assurance that the EEE is based on a 1 in 1000 year return period.

The paper also presents alternative approaches the RBNZ could adopt in determining the EEE for the Catastrophe Risk Capital Charge in the Non-Life Solvency Standard.

1.5 Structure

The paper is set out in the following manner:

- The relevant sections from the solvency standard have been summarised
- The principles one should follow in determining a CRP
- A description of what catastrophe models are, why they are used and what their limitations are
- Alternatives to using catastrophe models
- The questions that an AA should ask themselves when choosing amongst the options
- A suggested framework for determining a CRP and ways in which you may get comfort that the EEE is regulatory compliant
- Suggested alternative methods for the RBNZ to require the EEE calculation.
- A brief literature review of Association of British Insurers’ publications relevant to modelling catastrophes

2 Solvency Standard

As noted in the previous section, an insurer's CRP has multiple purposes. However for this paper, and in keeping with our terms of reference, the main focus is on its use in calculating the Catastrophe Risk Capital charge ("CRCC") under the Reserve Bank of New Zealand ("RBNZ") Non-Life Insurance Solvency Standard.

2.1 Catastrophe Risk Capital Charge ("CRCC")

The CRCC has been included in full in Appendix B, however a summary is:

The CRCC is:

- Intended to provide protection against a defined extreme event exposure ("EEE");
- Calculated as the net cost (after reinsurance recoverables) of the EEE plus the cost of one reinstatement of the full catastrophe reinsurance programme.

The EEE is defined as the highest expected total insurance losses from one of the following events;

- A major Wellington earthquake;
- A major non-Wellington earthquake;
- A major non-earthquake event.

Each of these events are set at specific loss return periods;

- For earthquake events, the minimum required loss return period is 1 in 500 transitioning to a maximum calibration of 1 in 1000 years by circa 2017;
- For non-earthquake events the loss return period is 1 in 250.

The AA must review the basis of the CRCC. If the AA believes that the EEE is not reflected in the CRCC then they must recommend an alternative method which must be agreed by the RBNZ and used by the insurer.

2.2 There is no requirement to use Catastrophe Risk Models

For the purposes of this paper there is one aspect of the CRCC worth highlighting. There is no requirement within the non-life solvency standard to use catastrophe risk models. However our terms of reference ("ToR") require us to investigate alternative methods of calculating the CRCC which do not rely on catastrophe risk models. Hence we have struggled with this apparent anomaly – how do we propose an alternative to catastrophe risk models when there is no requirement to use catastrophe risk models?

We have resolved this issue by noting that while catastrophe risk models are the defacto standard, they are highly complex and are most volatile at the extreme tails. It may be that alternative approaches can be used to replace or complement catastrophe risk models.

As a result, we have looked at alternative methods or approaches to catastrophe risk models that an AA could adopt in meeting the existing solvency requirements. This does not exactly meet the ToR however we nevertheless believe it is a useful question, and the solutions posed will be helpful to an AA in meeting their requirements.

However, we know that in practice most insurers are using catastrophe risk models to calculate the CRCC. This is because catastrophe risk models have been designed to estimate losses at specific return periods, and so naturally produce information which is consistent with the solvency requirements. Another reason is that catastrophe risk models are also commonly used in setting an insurer's catastrophe risk programme. As such using catastrophe risk models to calculate the CRCC naturally produces an answer which is consistent with an insurers catastrophe reinsurance programme.

3 Principles of a catastrophe risk profile

3.1 Why the need for principles?

It is widely appreciated in the actuarial community that models are simplifications of reality; nevertheless we should have some principles that a model should meet in order for actuaries and other stakeholders in the model to have confidence in the model, the modelling process, and in particular the model output.

In this section, 'model' refers to any approach that is used to assess the CRP for an insurer and is not restricted to catastrophe risk models.

3.2 What are the principles?[1]

- The model should reflect the risk profile of the business being modelled
  - Holistic thinking about the risks that could afflict the business with catastrophic consequences needs to be considered well before beginning selecting a model.
  - A key element of this thinking includes collecting and analysing information about the business' exposures (location, financial value, function, criticality, etc) in tandem with identifying potential perils.
- The model should be valid, rigorous and well-documented
  - The small size of the New Zealand insurance market often means fewer resources are devoted to developing catastrophe models on a regular basis – such as undertaking scientific investigations to include less-understood perils like tsunami. Nevertheless, the model should incorporate the latest available data and information, such as earthquake zones, building vulnerability curves, etc.
  - There are numerous reasons for a model to be well-documented – particularly for convincing auditors, regulators and other oversight bodies of its validity.
- The model should allow for all the significant features of the business
  - Every business is unique, and there may be features that impact the modelling of the catastrophic risk profile. An example could be an insurer subject to regulation or legislation around implementing stronger risk mitigation measures for some or all exposures. Using vulnerability models based upon market averages would not be valid for these exposures.
- The model should have appropriate input parameters and parameter values
  - The input parameters should at the very least include the key drivers of risk – such as maximum shaking from earthquake, flood zone, building type, etc.

[1] Principles sourced from ActEd 'CA1' material

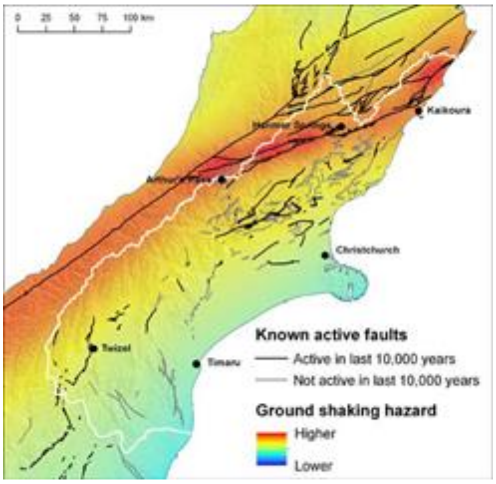

Figure 1 Key input for modelling earthquake risk - a seismic hazard map (for Canterbury in this example). Source: ecan.govt.nz

- The parameters which have the greatest materiality and sensitivity should be given the greatest attention when collecting data and making expert judgements.

- The model should be communicable and the output verifiable
  - The actuary should be able to explain to all stakeholders the purpose of the model, what it models, what it does not model, the model output - and an indication of the uncertainty in each of these areas.
- The model should not be overly complex or time-consuming to run
  - The 80/20 rule should be applied – focus on modelling the most material business areas and perils to a level judged appropriate by the actuary; otherwise the subsequent aspects of the process (interpreting output, considering risk mitigation measures, etc) may not be given the attention required.
- The model should be capable of development and refinement
  - Ideally, incremental improvements should be made rather than step-changes resulting in high volatility in EE estimates due to model updates.
- The model should be capable of being implemented in a range of ways
  - The ability to run sensitivity checks by varying the input parameter values.
  - To utilise the model in other areas of the business that would benefit from understanding all or part of the process to create the business' catastrophe risk profile, such as asset management or treasury functions.

4 Using catastrophe models

4.1 Evolution of catastrophe models

'Catastrophe risk model' is the common name that refers to the modelling of natural perils.

As computing power has increased, it has enabled the modelling of highly complex natural disaster events along with their impacts on insurable structures.

Prior to this, insurers used a combination of scenario modelling and risk factor models. These are still used by insurers instead of or to complement catastrophe models.

In different parts of the world, different perils are of concern and this is reflected in the catastrophe models that exist. In the USA, wind models are very important; while Australia has a range of models including flood, fire, and storm.

In New Zealand, we understand that the only commercially produced catastrophe models are in respect of earthquake hazards as the other natural perils are far less severe in comparison.

In the remainder of this paper, catastrophe models will refer to earthquake models unless otherwise noted.

4.2 What are Catastrophe models

Catastrophe models typically have four component sub-models

- Exposure model. Detailed data on the risks.
- Hazard model. Simulating the natural peril and its impact on the exposures
- Vulnerability model. Modelling the physical damage to each exposure from an event
- Financial model. Estimating the loss to the insurer after applying coverage terms, deductibles and limits.

4.3 Why are they used

Catastrophe models are used because they can provide the most granular representation of how a natural peril can generate financial losses.

There is currently the computing power to simulate hundreds of thousands of earthquake events, how these propagate through the earth and affect the structural integrity of different types of domestic and commercial properties.

They are necessarily complex because catastrophes are complex. However, this increasing complexity of models makes them heavily reliant on the reliability of many parameters that must be input - see 4.4 below.

4.3.1 Information used

Many current models allow the user to input the insurer's exposures property by property with as much detail as is known about each risk. This may include the exact location of the residence, its construction type, age of the dwelling, number of levels and other relevant data. If information is unknown, a model typically defaults to industry average figures (which are clearly less accurate).

In New Zealand the earthquake library is generally provided by GNS and may consist of 500,000 different earthquake events. Each event will be modelled to propagate out from the epicentre and the soil / rock composition and the incidence of water features can be taken into account in the estimation of the shaking force and direction at each location.

The hazard and exposure models will then be combined to estimate the impact on each structure. The influence of building codes may be incorporated to infer how a structure responds to the quakes. This will lead to an assessment for each structure which will imply a ground up cost.

Finally, the costs will have the relevant excess, policy conditions and EQC recoveries applied for each property to be aggregated to arrive at the insurer's estimated liability.

4.4 Shortcomings

Catastrophe models are at the apex of understanding catastrophes' impacts, surpassing factor based and scenario models. However, like all complex tools they can be misunderstood and misused with disastrous consequences.

Care should be taken with the following:

- Exposure Model. How you treat the data, and in particular unknown data can be quite material.
- Hazard model. It is difficult to model and set parameters to measure the effects of large earthquake events and other catastrophe risks. In recent years, the North American wind models were revised and had significant effects on reinsurance purchasing decisions and rating agency requirements. Large events such as the Great Tohoku Earthquake in Japan were greater than were previously thought possible in the region, thus requiring changes to the probabilistic event sets. Therefore, despite consideration of unknown faults in the models, new events on previously unknown faults can also change our probabilistic event sets.
- Vulnerability model. Assessing the vulnerability of a well-known stock of risks (with current building standards) is difficult. Assessing this with imperfect data and across differing building codes/regulations is harder. Vulnerability curves are often revised after significant events occur, as each event results in significant additional data points for consideration. • It takes time and expense to assess and account for new evidence of hazard events and potential

damage. These changes may take years to incorporate, leaving model users to make judgmental adjustments in the interim.

- Non-modelled. Some known factors are considered too difficult to model (e.g., liquefiable land or the impact of weakening/damage on damage if there are multiple events) and are not reflected in catastrophe models. Companies often have their own views of adjustments and model tweaks based on underwriter or modeller insight.
- Multiple events. Catastrophe models do not typically allow for multiple (or prior) events. It is assumed that the housing stock resilience is at ‘100%’.
- Unknown. Potential black swan events may always exist

Further to the point above regarding the hazard model, catastrophe models may propagate earthquake events using the Gutenberg–Richter law which notes that there is a common logarithmic relationship between the relative magnitudes of earthquakes and the expected frequency. The consequence of this law is that there is expected to be ten times as many magnitude 5 earthquakes as there are magnitude 6 quakes. If the maximum earthquake magnitude assumption is revised, it impacts not only the largest event but also the frequency of all smaller events. This flows through to the intensity of events affecting an insurer’s exposures.

4.5 Other issues

In addition to the above, users of catastrophe models should be aware of the following.

- Model changes. Catastrophe modelling firms update their models from time to time. This can have large impacts on the results that are produced.
- Spurious accuracy. Catastrophe models are highly complex and professionally designed. There can be a tendency to simply accept what is produced without enough interrogation.
- Dangerous. Insurers may base their business plans on the results of a catastrophe model. It is important therefore that the decision makers understand what is being produced.
- Uncertainty in coverage. This has been rectified to some degree in New Zealand with domestic property on a sum insured basis but is still difficult to assess with the interaction with EQC and multiple caps, gaps in coverage etc,
- The more time that has passed since the last event, the less we can be certain of how an event will impact on modern buildings under new building codes.

5 Alternative to catastrophe models

In this section we propose some alternative approaches to catastrophe risk models produced by catastrophe modelling vendors.

5.1 Factor based approach

This approach uses fairly simple rules of thumb to estimate the cost of an EEE. For example it might apply a simple percentage to a region's exposure.

The difficulty with this approach is demonstrating consistency with the required return periods. This could perhaps be overcome by calibrating the percentages against actual events (e.g. the Canterbury earthquakes) where there is a reasonable understanding of the return period.

5.2 Scenarios

This approach requires developing specific catastrophe scenarios and an associated financial impact. So an example may be an earthquake in Wellington or a Tsunami in Tauranga.

This approach would be particularly useful for those insurers whose largest exposures are outside Wellington, and therefore probably not captured within catastrophe models.

It is not a simple task to define catastrophe scenarios, calculate their impact and associate them with a specific return period. The Association of British Insurers has written a very good paper on the topic, title "Non-Modelled Risks". A brief synopsis can be found in Section 9.2.

5.3 Past events

This approach uses known past events to determine the EEE. So for example an insurer could adopt the expected losses from Canterbury Earthquakes calibrated to the required return period.

5.4 In-house models

This approach uses catastrophe models developed in-house by an insurer rather than those developed by catastrophe model software providers.

Given the complexity of catastrophe models this would be a significant undertaking for any insurer. Perhaps the most likely application is for catastrophes and regions not covered by the current catastrophe model software (e.g. Tauranga).

5.5 Industry models

This approach uses catastrophe models developed through industry collaboration. Given the small size of NZ insurance companies this is probably a more likely option than the development of in-house models.

The Oasis Loss Modelling Framework (http://www.oasislmf.org) is an example of this. This is a not-for-profit organisation which has been established with the aim of sharing catastrophe models amongst participants. http://www.oasislmf.org.

6 Selecting the approach

An AA should consider the following questions when deciding which approach(es) should be used to determine the catastrophe risk profile of a particular insurer. These questions derive from the principles of a good model (discussed in Section 3.2).

6.1 Questions to consider

- Principle: Reflect the risk profile of the business being modelled
  - Does the model cover all areas where the material exposures are located?
  - Does the model cover all of the perils of concern to the company?

Figure 2 Perils modelled by RMS, by region. Source: www.rms.com

- Principle: Be valid, rigorous and well-documented
  - Valid - how often is the model updated, including the latest science, building knowledge and other key elements?
  - Could key-person risk or model-dependency become a problem? How easy is it to apply some oversight to the entire process? What happens if the key-person is unavailable.
- Principle: Allow for all the significant features of the business
  - Law of averages - does the model rely upon a substantial portfolio of relatively homogenous exposures.
  - Can it cater for bespoke risks.
  - How flexible is the model to adapt for the particular company - both now and in the future?

Figure 3 Housing - a relatively homogenous exposure. Source: www.sanfrancisco.travel

Figure 4 Hydro dam – example of a heterogeneous exposure that cannot be analysed on a 'portfolio basis'. Source: www.tvnz.co.nz

- Principle: Have appropriate input parameters and parameter values
  - How data-hungry is the model? What credibility attaches to the various inputs that are required.
- Principle: Be communicable and the output verifiable
  - Comparability - is the model, or at least the modelling technique, used elsewhere in the market?
  - Transparency - can the model output be readily reviewed with confidence by a competent person?
- Principle: Not be overly complex or time-consuming to run
  - Proportionality - will the resources vested in determining the catastrophe risk profile be proportionate to the company's societal impact (e.g. insurer with large market share, captive belonging to a public utility)
- Principle: Be capable of development and refinement
  - Process - does the modelling process provide significant learning outcomes (over and above the model outputs)?
  - Is the company vulnerable to step-changes in model changes, or can it move gradually to accommodate improvements in modelling?
- Principle: Be capable of being modified in a range of ways
  - Ease of sensitivity checking.
  - Could the model (specific or general) be applied in other business functions?

7 Framework for determining your CRP

The framework below assumes that the insurer will currently have an approach on how to assess their catastrophe risk. This will likely produce either as point estimate or a profile.

Given that the catastrophe modelling will influence many business decisions, including catastrophe programme purchase, and that it will be used as an input into the Solvency Return, how can the AA gain assurance that the profile is accurate.

This is very difficult, even at the less frequent return periods but especially so at return periods of 1 in 500 or more. Described in this section are a number of possible approaches with a critique of when they may be appropriate.

7.1 Ratification of approach

7.1.1 Understanding of models

The first step is to understand the process by which catastrophes are modelled. Whether it be a catastrophe model, risk factors approach, scenario testing or some other process, there are some questions that need to be addressed. These were addressed in Section 4.4.

7.1.2 Trending

Historical stability of the CRP is an important feature. In principle, the CRP (if accurate) should not move erratically as it can significantly impact capital requirements and solvency assessments.

However, there have been some significant changes in catastrophe models (e.g. RMS v11) that had material impacts on insurance companies in the U.S. It is presumed that the NZ specific models will be updated following the Canterbury earthquakes.

How could a company manage these changes?

One way is to recognise that the CRP produced by a catastrophe model is a distribution. There will be a mean CRP and there will be confidence intervals above and below. Companies may state that their adopted CRP shall lie within a range around the mean (e.g. between 40% and 60% of the modelled CRP. This will allow the insurer some time to manage the impacts of change within a reasonable range.

7.1.3 Calibration

It is always useful to calibrate the CRP. This could be carried out in a number of ways, two of which are described below.

Past events

In New Zealand, we have recently had some extreme earthquake events in Christchurch. Although there is some debate as to the exact return period of the various events, there is little doubt that the impact was very rare and almost certainly greater than a 1 in 1000 year return period.

This can be used then to test how the existing modelling approach performs against a known extreme outcome.

Multiple models

Using multiple models is a common method to ratify the results of the chosen CRP.

This could be as a result of blending models – see Section 7.2 for more details or from using different type of models, for example, catastrophe models and factor models.

Note that the various models need not be catastrophe models nor do they all need to be included in the decision making process.

7.1.4 Sensitivity analysis

Sensitivity analysis can be an invaluable method to understand how the modelled results can be affected by changes in key assumptions.

7.1.5 Professional Judgement

Experience and expertise play a critical part in the AA's determination of a suitable EEE value. Hence simple and quick estimates may be made to provide additional confidence in the results calculated from the more detailed approaches.

7.2 Model blending

Model blending typically refers to the process whereby multiple catastrophe models are combined to produce a more informed result. It is not a risk free process and does not bypass the necessity of understanding each of the individual models. Blending two inadequate models or assumptions does not make an adequate model.

Described below are different ways in which models may be combined (adapted from ABI's Industry Good Practice for Catastrophe Modelling).

- Simple weights, common approach- this can use a weighted average of model outputs, although it assumes that the underlying models are calibrated to the same extent at the stage of model output. The choice of weights is based on high level assumptions, rather than model detail, and weights can be applied to the output severity distributions or the frequency distributions
- Simple weights, alternative approach- this is based on event loss table data and applies weights to the event rates. Simulation methods can be used to take account of models with year loss tables. This approach preserves event sets with physical events and footprints, and is a probability-weighted model that can enable correlation between portfolios
- Model decomposition - this approach weights different components of models differently, which can help with sensitivity testing of specific components and take advantage of the perceived specific strengths of different models. A blended model run might include per portfolio or country marginals, such as a blend of models with other adjustments and loss calibration, correlations between countries, and clustering variable weight blending - this isolates a component of a model and applies a distribution of weights. For example, a revised event rate distribution that gives model A the same event relationship as model B, and can be based on vintage of data, and new research
- 'Shoehorning' refers to the need to incorporate output from two or more models in an accumulation or dynamic financial analysis platform, based on the format of output from one model. It takes account of grouping across different models appropriate for different portfolios, where the portfolios cannot all be run in the same model

Multi model approaches can reduce the impact of model change however it can make any change more complex. And it requires understanding the strengths and weaknesses of each model to most effectively blend.

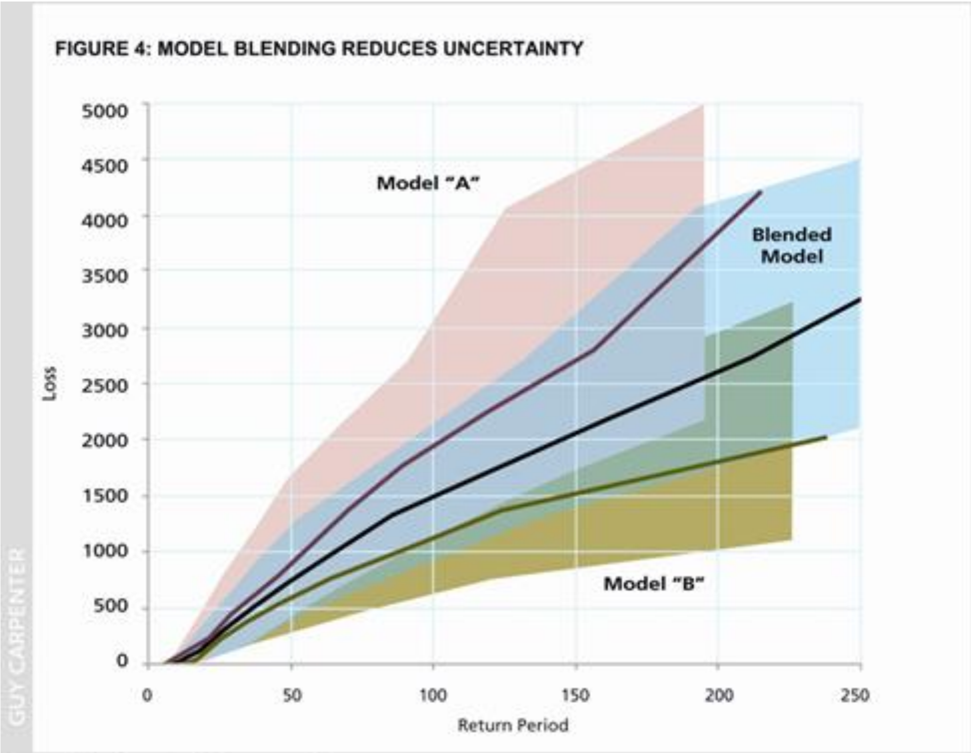

FIGURE 4: MODEL BLENDING REDUCES UNCERTAINTY

Source: Guy Carpenter & Company, LLC

7.3 Case studies

Example 1 – multiple catastrophe model

Insurer A is a large multi-line non-life insurance company. They run catastrophe models from three different catastrophe model vendors and three profiles are obtained.

The actuaries interrogate the providers of each model to understand the differences and what is excluded from each.

Insurer A then blends the three profiles using judgement to create a modified profile for the company.

Example 2 – catastrophe model and risk factor model

Insurer B is a smaller non-life insurance company. It uses a combination of catastrophe models and risk factors to inform its catastrophe risk profile.

Every second year it undertakes comprehensive catastrophe modelling from a catastrophe modelling provider to re-calibrate its profile. At these times it updates its risk factors which can be applied less granularly to its portfolio.

In the intervening periods, it uses its risk factor model to infer its CRP.

8 Alternatives for calculating CRCC

The main focus of this paper has been on the question:

What are alternative methods or approaches to Cat Risk Models that an AA could adopt in meeting the existing solvency requirements?

This section considers a slightly different question being:

What are alternative approaches that the RBNZ could adopt in setting the CRCC that would result in less reliance on cat risk models (or none at all)?

There is an important distinction between those questions. The answers to the first question helps AA's consider what options are available to them right now. The answers to the second question present possible options for changing a significant component of the solvency standard and so would clearly require RBNZ acceptance. The second question is arguably a more significant one as it implies an industry-wide mandated change.

In the table on the following pages we consider other possible approaches that could be adopted to determining a CRCC. Not surprisingly, these options are similar to those we have outlined in Section 5. Essentially they are all different methods of estimating the insurance costs of a catastrophe and so equally applicable in determining a CRP for an insurer, or as a method for determining a CRCC. We have also suggested the pros and cons of each method.

Option	Description	Pros	Cons
Existing Non-Life Solvency Standard	Specific scenarios set to a minimum loss-return period. The requirement to calibrate against specific loss-return periods results in Cat models being commonly used to calculate the requirement.	• Broadly fits to current insurer catastrophe reinsurance programmes • Cat models are the most scientific assessment of risk – is there anything better? • Existing approach	• Lack of consistency amongst insurers – potential for “model shopping” • Use of return periods is considered problematic – arguably spurious accuracy relative to known issues with these models • Potential for large changes in capital requirements as models are updated • Generally focused on earthquakes and less on other extreme events • Use of cat models results in a lower level of transparency
Factor based approach	Relatively simple factors applied to a measure e.g. percentage of premium, percentage of sum insured. A slightly more complex version of this could be a simple estimation of Probable Maximum Losses (PML) based on the cost of the Canterbury earthquake events. This approach was proposed by the NZ Society of Actuaries in a submission to the RBNZ on the non-life solvency standard. The specific factors would perhaps be derived using Cat models.	• Simple and easily applied • Transparent • Consistent between insurers • Stable and predictable levels of capital	• Too simple? Will it produce a reasonably accurate level of capital? • Not a granular risk based-approach - potentially produces capital distortions and a mis-pricing of risk; • May discourage insurers from better understanding their catastrophe risk and also discourage further development of cat models
Scenario based approach	Realistic extreme scenarios specified	• Removes the need for return	• Is likely to still require the use of

Option	Description	Pros	Cons
	in detail e.g. Wellington earthquake of a certain magnitude. This approach was proposed by the Insurance Council of New Zealand in a submission to the RBNZ on the non-life solvency standard.	periods which are considered problematic – more transparent as a result; • Cat models will likely still be used (to some degree) to calibrate the scenarios. However a scenario approach is arguably less "extreme" than the current "loss return" approach. It seems likely that differences between cat models will be greater at the extremes, and so a scenario approach will naturally result in more consistency; • More transparent than return periods – a clear understanding and description of the catastrophe scenario being met by insurers.	cat models. So the perceived shortcomings of those models will still impact this option to some degree (e.g. inconsistency, lack of transparency, large changes in capital). • Will the scenarios be broad enough to cover all insurers extreme event exposures? Will likely require some underpin e.g. consideration of all other risks to the same probability.
RBNZ mandated catastrophe model	This is a version of the scenario based approach but goes further in that it would mandate specific Cat models to be used (e.g. RMS version x) as well as the scenarios to be modelled. This option has never been proposed previously (as far as we are aware). Whilst it may seem unusual for a regulator to be specifying a model, it is not dis-similar to choosing acceptable rating agencies for assessing the quality of assets – that is also a model (of sorts). This method could be underpinned by	• All the pros of the scenario approach but the added benefit of greater consistency amongst insurers – no opportunity for model shopping; • Stability of capital as regulator can manage changes in model versions; • Regulator will develop an in-depth understanding of arguably the biggest risk to the NZ insurance industry;	• Will the scenarios be broad enough to cover all insurers extreme event exposures? • Does the RBNZ have sufficient resources to manage such a process?

Option	Description	Pros	Cons
	an Individual Capital Assessment Requirement – allowing an insurer to hold lesser capital when they can demonstrate that they have a better understanding of their catastrophe exposure.		

In the table below we have scored each option against what we see as the key criteria for a CRCC:

- Risk based – does it reflect the underlying risks?
- Consistency – will it produce a consistent level of capital amongst insurers?
- Transparency – can it be easily understood by users of the information e.g. insurers, AA's, RBNZ?
- Stability – will the required level of capital be stable and predictable, and thus facilitate a robust and competitive insurance sector;
- Effort – how much additional effort would be required to implement this approach above current requirements?

	Criteria					
	Risk-based	Consistency	Transparency	Stability	Effort	Weighted total
Weighting of criteria (out of 5)	5	2	3	2	1	
Options (scored out of 5)						
Existing Non-Life Solvency Standard	4	3	2	2	5	41
Factor based approach	2	5	5	5	4	49
Scenario based approach	4	4	3	3	3	46
RBNZ mandated catastrophe model	4	4	4	4	1	49

9 Further reading

9.1 ABI – Industry Good Practice for Catastrophe Modelling

The purpose of this report is to encourage good practice in the market when modelling catastrophic risk. It is an example of the benefits that come from collaboration between a range of professionals involved in a common activity. The inspiration for the report comes largely from Solvency II regulatory implementation; in particular the need for insurers to assess risk in a structured approach, having appropriate processes in place, and recording evidence that the processes are being followed. The nine chapters of the report can be briefly summarised as follows:

- Governance – senior management must have a sound understanding of a company's risk exposure and its key drivers. The 'use test' requires demonstration that the model is widely used within the business and continues to reflect the risk profile of the business.
- Use of third-party service providers – an outsourcing agreement should be formalised. Importantly, outsourcing does not allow a company to delegate the ownership of the modelling process; responsibility for understanding the model rests with the company.
- Catastrophe modelling documentation – More than one level of documentation is likely to be needed to address the different audiences. The documentation should be consistent with the intended use, materiality and proportionality of the model.
- Use and management of catastrophe models data – the principle focus should be on obtaining accurate, complete and consistent data on the most critical areas of the business.
- Model selection and model change policy – there should be some documented rationale behind the selection or change of a catastrophe model. Regular engagement with third-party providers should highlight any proposed model updates and potential impacts on the view of risk ahead of the model release.
- Options and settings of catastrophe models – choose appropriately to ensure the model is calibrated to the company's view of risk and not the 'industry' view based upon default settings.
- Catastrophe model validation – the challenges of validating third-party catastrophe models is acknowledged; ideally, companies should be provided with enough information about the model to create the required level of confidence in the strengths and weaknesses of the model. Similarly, companies should satisfy themselves that the validation undertaken by third-party vendors around the science of low-frequency, high-impact events is robust and consistent with currently accepted scientific knowledge.
- Multi-modelling approaches – document the decision process when choosing to use one or more models, and how the output(s) are to be used. For example, alternative outputs may be used in a simple comparison, or in a more advanced blending to form a bespoke loss probability distribution.
- Treatment of uncertainty in catastrophe modelling output – the difficult balance between communicating key uncertainties without devaluing the modelled results is highlighted. Nevertheless, decisions should be taken with reference to the fact material uncertainties in the output exist.

9.2 ABI – Non-modelled risks

Following on from the above report, Non-modelled Risks is the result of collaboration between industry professionals to consider ways to identify, quantify, monitor, report and manage non-modelled catastrophe risks. Non-modelled risks (NMR) are defined as potential sources of loss that aren't covered by existing (third-party) catastrophe models. Non-modelled losses can be very material, such as the tsunami following the 2011 Tokyo earthquake, and liquefaction following the Canterbury earthquakes.

The process of dealing with NMR should follow a standard risk management control cycle – establishing context, identify risks, analyse risks and evaluate risks and materiality. Tail risk events will be more important in the context of solvency than for pricing, for example.

NMR can be identified using one or more three broad methods: exposure-based, claims-based, and expert judgement. Claims-based investigations may use claims experience from both industry and own-company. Underwriters, claims experts, catastrophe modelling vendors and risk engineers are valuable resources when utilising expert judgement. Local knowledge and expertise should not be overlooked, particularly when the insurer is entering new markets.

When it comes to quantifying NMR, the authors categorised methods into: expert judgement, actuarial/statistical, geospatial and catastrophe model modification and building. The selection depends on three considerations: the purpose of the quantification, the materiality of the NMR, and what data is available.

The report concludes with an approach to including NMRs in capital modelling.

9.3 Oasis – open source natural catastrophe modelling software

http://www.oasislmf.org/

Oasis is a non-profit organisation with the aim of providing a marketplace for models and data to widen access to tools for catastrophe risk assessment. From 2014, the software, data standards and methodologies will be freely available together with a commercial portal allowing customers and vendors to buy and sell models, data and services.

10 Questions for the Profession

We have compiled a number of questions below which we hope will provide the basis for discussion at the Conference.

- What do you think of the wording of the CRCC in the Non-Life solvency standard? Wellington vs non-Wellington earthquakes? 1 in 1000 for earthquakes vs 1 in 250 for other perils.
- What are AAs doing at present to satisfy themselves that their EEE complies?
- What do actuaries think of catastrophe models?
- Should the RBNZ mandate an approach?
- Which suggested approach for RBNZ is preferred?

And lastly, a cheeky one to finish

- The Canterbury earthquake events were undoubtedly a catastrophe far in excess of prudential requirements. Given the industry has largely survived this, do we need a CRCC?

New Zealand Society of Actuaries
31 October 2014

Determining a Catastrophe Risk Profile
Appendices

Presented at NZSA Conference 2014

Adam Follington, Clinton Freeman, Craig Lough

A Terms of Reference

Alternative Approaches to the calculation of the Catastrophe Risk Capital Charge in the Solvency Standard for Non-Life Business

The Solvency Standard for Non-Life Business requires insurers to calculate the Catastrophe Risk Capital Charge by considering an insurer's Extreme Event Exposure ("EEE"). The calculation of the EEE usually requires the use of a catastrophe model for most general insurers. The NZSA has expressed concerns around the use of catastrophe models to calculate Extreme Event Exposure. Following discussions with the Reserve Bank of New Zealand ("RBNZ"), NZSA is proposing to establish a working party to investigate alternate methods of calculating Extreme Event Exposure. It is intended a report be prepared which is suitable for NZSA Council to submit to RBNZ.

The aim of the working party will be to investigate alternative methods for calculating EEE. The working party will not specify the specific calculation or parameters that should be used by any alternate methods. The working party will instead consider the conceptual approach of each alternative method, the pros and cons of the method, any practical implications from an industry prospective and what might be needed to actually calibrate an alternative method. This may involve the identification of external parties who could potentially provide input into the actual calibration of the alternate method for the purpose of calculating EEE for the Solvency Standard.

The working party will only consider the method for the calculation of Extreme Event Exposure. It will not consider the return period of the EEE. The working party will report into the NZSA General Insurance Committee, The deliverables of the working party will be a report outlining each alternate method that has been considered, together with a recommended method. Draft copies of this report will be provided to the NZSA General Insurance Committee, and NZSA Council. If appropriate a final copy of the report will be addressed to the RBNZ for their consideration. The RBNZ has indicated they are interested in receiving a report but has stated they are under no obligation to use or act on any recommendations in the report. Timeframes around the delivery of the final report will be agreed with the NZSA Council prior to commencement of the working party.

B Catastrophe Risk Charge – Non Life Solvency Standard

3.2. Catastrophe Risk Capital Charge
Concept

45. The Catastrophe Risk Capital Charge for non-life **insurers** is intended to protect the **licensed insurer's** solvency position from the potential exposure of the **licensed insurer** to Extreme Events.

Calculation
46. The calculation of the Extreme Event Exposure must include all exposures under any **contract of insurance** issued by the **licensed insurer** that could arise as a result of an Extreme Event.

47. The **licensed insurer's** Extreme Event Exposure is the greater of the following:

(a) the projected insurance losses incurred by the licensed insurer in respect of a major earthquake event affecting Wellington (defined as everywhere within a 50 kilometre radius from the Beehive), calibrated to a minimum loss return period as detailed in paragraph 48; or

(b) the projected insurance losses incurred by the **licensed insurer** in respect of a major earthquake affecting any place other than Wellington (as defined above), calibrated to a minimum loss return period as detailed in paragraph 48; or

(c) the projected insurance losses incurred by the **licensed insurer** in respect of a non-earthquake Extreme Event occurring anywhere within New Zealand or elsewhere, calibrated to a minimum loss return period of 1 in 250 years.

48. Subject to paragraph 49, the projected insurance losses referred to in paragraph 47 are calibrated as follows:

(a) for financial reporting periods commencing before 8 September 2015, the greater of the maximum amount of catastrophe **reinsurance** (expressed in New Zealand dollars) held by the **licensed insurer** before the date of granting a full **licence** under Subpart 1 of Part 2 of the Act, or an amount equivalent to the **licensed insurer's** calculation of a 1 in 500 years loss return period;

(b) for financial reporting periods commencing on or after 8 September 2015: the greater of the maximum amount of catastrophe **reinsurance** (expressed in New Zealand dollars) held by the **licensed insurer** before 8 September 2015, or an amount equivalent to the **licensed insurer's** projected insurance losses calibrated to a specified loss return period set out in the paper "*Policy Position Paper, Solvency Standard for Non-life Insurance Business, Calibration of Catastrophe Risk Capital Charge"* issued October 2011 (and includes any document that amends or replaces it). This paper is published by the Reserve Bank and is available on the Reserve Bank's website. The paper sets out the Reserve Bank's future loss return period requirements, moving progressively to a maximum calibration of 1 in 1000 years.

49. If the amount of catastrophe **reinsurance** (expressed in New Zealand dollars) held by a **licensed insurer** before the date of granting a full **licence** under Subpart 1 of Part 2 of the Act is greater than the **licensed insurer's** projected insurance losses calibrated to a loss return period of 1 in 1000 years then the **licensed insurer** may (but is not obliged to) reduce its catastrophe **reinsurance** to a level equal to the **licensed insurer's** calculation of projected insurance losses calibrated to a loss return period of 1 in 1000 years.

50. In assessing whether the **licensed insurer** must report to the Reserve Bank under Section 24 of the Act, the **licensed insurer** must use the return period that will be applicable to the **licensed insurer** at the date of the forward assessment of solvency.

51. The Catastrophe Risk Capital Charge is the net cost (after **reinsurance** recoverable amounts) to the **licensed insurer** of the Extreme Event Exposure, including any gap or shortfall in the **reinsurance** cover, plus the cost (if any) of one reinstatement of the full catastrophe **reinsurance** programme.

52. For a **licensed insurer** that does not have an exposure to an Extreme Event, and does not have other per risk exposures greater than the **licensed insurer's** net retention, the Catastrophe Risk Capital Charge is two times the largest per risk retention of the **licensed insurer** plus the cost (if any) of one reinstatement of the **reinsurance** programme.

53. The largest per risk retention is the cost to the **licensed insurer** of the largest individual claim to which it could reasonably be exposed under policies issued, net of **reinsurance** recoveries and including the cost (if any) of one reinstatement of the appropriate **reinsurance**. If the **licensed insurer** issues policies that do not have a maximum sum insured, or are not protected by excess of loss **reinsurance**, then the **licensed insurer** must seek the advice of its **appointed actuary** as to a reasonable approximation for the largest per risk retention.

Actuarial Review

54. The **appointed actuary** of the **licensed insurer** must review the basis on which the Catastrophe Risk Capital Charge has been calculated. In carrying out this review, the **appointed actuary** must consider all relevant factors. If the **appointed actuary** has any concerns with respect to the Catastrophe Risk Capital Charge, the **appointed actuary** must report them to the **licensed insurer's** board as soon as reasonably possible and report those matters to the Reserve Bank along with the **licensed insurer's** solvency calculation.

55. If the **appointed actuary** is of the opinion that the Extreme Event Exposure of the **licensed insurer** or other form of catastrophe risk (in the case of non- property exposure) is not adequately reflected in the Catastrophe Risk Capital Charge, the **appointed actuary** must recommend an increase in the Catastrophe Risk Capital Charge or an alternative method of calculation for determining the Catastrophe Risk Capital Charge for the **licensed insurer**, and the **licensed insurer** must increase its Catastrophe Risk Capital Charge accordingly, or use that alternative method, as the case may be. This provision must not be used to reduce the Catastrophe Risk Capital Charge.

C Authors

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Adam manages the Deloitte Auckland Actuarial team.

He has a diverse range of financial services experience having worked across insurance, reinsurance and consulting firms and in actuarial and marketing teams. Particular strengths include liability valuations, company valuations, solvency calculations, taxation, pricing, product development and reinsurance.

He balances good analytical skills with a pragmatic approach to problem solving

C.2 Clinton Freeman

Clinton Freeman is the Senior Market Analyst for Mighty River Power, where he analyses competitor behaviour and modelling various problems, such as wholesale electricity price forecasting.

Prior to Mighty River, Clinton worked in the general insurance industry for Deloitte and Willis in London, and later for Vero in Auckland. Clinton also spent time overseas studying, first at ANU in Canberra and then George Washington University, where he was the EQC-Fulbright Scholar in Natural Hazard Studies. He qualified with the UK Institute of Actuaries in 2012, specialising in general insurance.

C.3 Craig Lough

Craig Lough is a Principal at Melville Jessup Weaver. He is an actuary specialising in the field of general insurance.

He began his career at Melville Jessup Weaver before working in Australia and then the UK. During his time away he worked for a large London consulting office as well as multinational insurance companies both in Australia and the UK.

Craig's broad array of experience includes valuation, basis setting, auditing, process improvement, and exposure to IFRS and USGAAP.

He currently serves on the NZSA general insurance practice committee.