EQC's use of computer modelling in a catastrophe response

NZSEE 2002
Conference

D. A. Middleton

Earthquake Commission

ABSTRACT: The Earthquake Commission has a suite of models which combines seamlessly a geographical information system, hazard model and dynamic financial analysis model. For individual events they provide projections of claim numbers in categories of size, geographical spread, and total value. The system will also analyse investment and reinsurance strategies and changes in terms and conditions of the base cover.

The Commission must also plan for the logistical challenges facing an organisation of sixteen people having to cope with the possibility of over 100,000 claims. Our systems dynamics model provides constraints analyses of our claims process and is being extended to project cash flows.

EQC's strategic planning and catastrophe response are based upon its modelling tools. They have become so important to the Commission that they are one of the few things that the EQC "virtual organisation" has insisted on having the ability to operate in-house.

1 INTRODUCTION

1.1 *The Earthquake Commission*

The New Zealand Earthquake Commission (EQC) is a wholly owned Crown company, set up under the rules governing Crown Entities.

EQC's main function is to administer the scheme which insures homes and their contents against damage by earthquake, volcanic eruption, natural landslip, hydrothermal activity, tsunami and fire following any of these. Cover is given also for residential land lost by storm or flood.

All residential property owners who buy fire insurance automatically acquire EQCover, the Commission's insurance cover. Dwellings are insured up to a maximum of $100,000 plus gst, personal effects up to $20,000 plus gst, and land cover is provided in addition to these limits. This insurance is on a "first loss" basis. A premium of five cents per $100 of cover is applicable throughout the country; this is paid through insurance companies and passed on to EQC, less a small commission. The maximum premium payable is $67.50 per year, including gst.

EQC has other functions relating to coping with disasters, namely, investment and reinsurance of the Natural Disaster Fund, facilitating research and educating the public about natural disasters and ways to mitigate damage. This combined role necessitates expenditure of most of EQC's premium income on reinsurance, funding the development and operation of New Zealand's seismic hazard monitoring network, research support, advertising campaigns and catastrophe response planning.

1.2 *The Catastrophe Response Programme*

The sixteen people at EQC are adequate for routine operations, including the few thousand claims which arise each year. However, a major event in New Zealand could result in tens of thousands of claims being made on the Commission. EQC has planned to cope with such an event by a programme of extensive out-sourcing of the services and additional resources it will require. Once in place, an out-sourcing arrangement operates at all times in order to give parties knowledge and experience of the services expected by EQC and ensure the capability will be there at the critical time.

EQC regards itself as being in some state of catastrophe response all the time. Mostly this is the planning stage, characterised by ongoing programme development, testing, exercising and continuous improvement. The short activation period is one of high activity to set up the response immediately after an event. Then follows the period of sustaining that response through the months – and possibly years - of the claims settlement process. Finally, there is the wind-down as outstanding claims numbers dwindle and the Commission strives to return to normal – the planning stage again.

The key to this cycle of activity is information. First of all, intelligence of the event – its size and location – triggers an exercise to work out what is to be expected in terms of number, dispersion and cost of claims. Knowledge of local conditions is then required for decisions on where to centre the EQC response and to set up support offices. Assessments of the length of time to settle all claims and rates of escalation and deflation of numbers are important for planning the resources on the ground and in support. Numbers of staff available for each role, with their readiness and timetables, are further items of information needed.

2 HISTORY OF EQC'S USE OF MODELS

2.1 *First Attempts to Quantify the Risk*

The Earthquake Commission and its predecessor have been bedevilled by the difficulty of measuring their liabilities. As well as problems common in the insurance sector of estimating the costs of catastrophe events, EQC has never had a database of its own policyholders. Insurance companies are not obliged to provide information on individual policies. To date, EQC has relied on the national records of real estate property (compiled for the purpose of levying local body taxes) as its basis for its own situations of risk.

An early attempt to project premium income and total values at risk, and to quantify the liabilities of the Earthquake and War Damage Commission was made by actuaries E.J Jones and J. Lockett in a report to the Commission by a consortium of reinsurance brokers following a request from the Minister in Charge in 1984. They used available indexes and the Commission's own short-term forecasts for the first two items in the assignment. They managed to break down values at risk into regions utilising Valuation Department information – the same basis as that used in today's computer models. They then turned their attention to the liabilities.

Using various corrective mechanisms applied to historical data, the actuaries first suggested estimates of mean (average) annual claims. Their exhibits included hand-drawn bar graphs. Following a description – which would not be out of place in a modern catastrophe model's manual - of the factors that influence the cost of an earthquake event and references to work by

W.D. Smith and A.R. Lillee, the actuaries confined themselves to suggesting the range of damage ratios that may apply to particular Modified Mercalli Scale intensities (for example, MM VIII area losses would range from 2% to 10% of indemnity value).

For a decade, the Commission seems to have simply accepted as an adequate state of knowledge, the assumption that its liabilities far exceeded its assets, and would always do so. The Earthquake Commission Act, with its restriction of the compulsory insurance scheme to residential property only (in order, in part, to resolve the imbalance of assets and liabilities) forced further and deeper consideration.

2.2 *The Impact of Computers*

In 1993, Frank Russell Company developed for EQC a computer programme for loss simulations. The model estimated the probability distribution for total annual earthquake losses to EQC under the new residential property cover. The model:

- utilised scientific estimates of inter arrival times for earthquakes of given magnitudes,
- assigned each local authority area a probability of experiencing an earthquake of a given intensity,
- allowed for attenuation to adjacent regions,
- relied on the Valuation Department's property database but applied replacement values from estimates of average building costs, numbers of properties and a ratio of contents to building values,
- obtained damage ratios from studies by D. Dowrick of the 1987 Eastern Bay of Plenty earthquake,
- extrapolated the effects of EQC's new first loss situation from a study of part of New Zealand.

With varying veneers of sophistication, this is the basis for New Zealand earthquake hazard models to this day. This hazard model has been utilised by Frank Russell Company in its consultancy work for EQC up to the present time. By combining with a financial analysis model when required, the company has been advising EQC on its level of annual average losses, the risk/reward trade-offs of competing investment strategies and reinsurance options, the adequacy of its premium income and the technical solvency of the scheme (without the Crown guarantee). Some of these assessments have been included in the Commission's Annual Reports, in support of analyses of its financial health.

2.3 *Developments in Modelling*

In 1995, Instrat, then part of the Sedgwick Group, now of Guy Carpenter and Company Inc., worked with Frank Russell to produce a combined model. Essentially, this added a "front end" to allow EQC staff to operate the model themselves. The output, in DOS format, provided the data for the risk/reward graph that EQC got used to as the sole output from the model. At a time when the debate with Treasury about the nature of the Natural Disaster Fund and the exposure of the Crown guarantee was at its height, the graphs illustrated many papers with their provocative x-axis label "Probability of Ruin", the y-axis more prosaically called "Fund Size". Practical application of the graphs revolved around comparison of investment strategies and the measurement of reinsurance plans against the strategy that EQC had decided upon:

- to enable EQC to meet its probable maximum loss without calling on the Crown guarantee
- to not increase the risk to the Crown in the short term
- after meeting the previous requirements, to maximise the value of the Natural Disaster Fund

This strategy, and prudent management, required EQC to refine its probable maximum loss calculations. It commissioned Works Consultancy Services Ltd. in 1996 to find out. Having

identified the 1 in 600 year Wellington Fault earthquake as the probable maximum event, Works estimated losses to EQC within about 100 kilometre radius from the ends of the fault rupture length. Insured risks were grouped into "suburbs", each one being assigned a certain building character after extrapolating from a sample of site visits. Each suburb was placed in one of twelve construction groups, which influenced the damage ratio applied.

The method used involved:

- evaluation of construction details from site surveys determining vulnerability estimates which were then applied to the suburb
- superposition of the scenario earthquake isoseismal pattern and soft ground amplifications to establish the loss suburb by suburb
- accumulation of the loss values according to EQC exposures, which were established in similar manner to other models

The result was the first estimate of EQC's probable maximum loss supported by a robust system of calculation. The study gave PML figures with degrees of confidence; not the least valuable piece of information it contained was that there was an 85% growth between the mean and the ninety percentile confidence level.

Such was the usefulness of the information, and EQC's continuing inability to model it in-house, that EQC had the study updated in 1999, when Works had metamorphosed into Opus International Consultants Ltd.

2.4 *The Hazard Modelling Industry*

Also in 1996, EQC gained experience of the work of the fledgling international modelling industry when it commissioned Risk Management Solutions Inc. (RMS) to provide some output for the request for proposals for reinsurance intermediary services EQC was issuing that year. RMS were also involved in evaluating the proposals by running suggested reinsurance schemes through their own proprietary hazard model, called IRAS.

The RMS work gave EQC staff an insight into the dexterity of hazard models in professional hands. As well as confirming previous PML assessments, it introduced the Commission to occurrence exceeding probability analysis, aggregate exceeding probability analysis and scenario event analyses. It was also introduced to a problem with using the output from proprietary models – restrictions on its distribution meant only a minimum of information could be included in the request for proposals.

The reinsurance broking firm engaged by EQC, Benfield Greig Ltd, pride themselves in their own modelling prowess, which they have continued to enhance. EQC was provided with Benfield Greig's Remetrica model for the evaluation of reinsurance programmes. New insights were granted by Remetrica, necessitating the dubious innovation of three dimensional graphs. Remetrica further showed the power and value of computer modelling but its demand for lengthy training and experience was rather too high for occasional users like EQC staff. The usefulness of Remetrica was most evident in the hands of the experts, in London, at the time of renewal negotiations. It is a sophisticated, complex tool for the professionals.

2.5 *EQC's Requirements*

By the end of the last decade it had become apparent that computer tools could be critical for aspects of EQC's operations besides reinsurance and debates with Treasury.

The likely number of claims arising from a particular earthquake event was one example. Since 1998 the Commission relied on the work of Dr. W.D. Smith who had mapped the boundaries of epicentres of similar magnitude earthquakes giving the same number of claims.

To further aid its catastrophe response planning, EQC was developing a systems dynamics model (SDM) of its claims settlement process to assist decisions about the optimum balance of resources required, from telephone operators taking claims registrations to claims clerks processing the information provided by site inspectors. Conceptually, a hazard model could inform "Logjam" (as the SDM was casually christened) of the numbers of claims within categories of severity. Further intelligence on a scenario earthquake could be gained with indications of geographical dispersion of claims and the likely cash outflow timetable.

Another project needing support through quality analysis was a review of the terms and conditions of the new insurance scheme once it had operated for several years.

So, in 1999, EQC sent out a request for proposal for the provision of catastrophe insurance loss and financial systems, including the ability for residential property loss analysis, claims processing logistical management and financial protection analysis.

Nine organisations were invited to submit proposals, giving a mix of existing providers, "off the shelf" application vendors, financial experts and risk management experts. As was expected, some of these submitted partial proposals and some formed consortia to fulfil the request in entirety. With the help of some external technical consultants, the Commission elected to proceed with the proposal from Aon Re Worldwide.

At an initial facilitated two-day meeting at a vineyard north of Wellington, the project was placed on the footing of a partnering agreement, firm project management procedures were agreed and the project and model were christened "Minerva" (with a good deal of debate culminating in an executive decision) after the Roman god of wisdom and good counsel (and war). The eighteen month project has delivered within budget and only a little late, a state of the art hazard and dynamic financial analysis model.

3 APPLICATIONS OF THE MODELS

EQC utilises several models. Financial accounting models forecast future premium and investment income, and all the costs of employing staff. A model developed by a Victoria University PhD student calculates the statistical probability of aftershocks within a set time, following a main shock of a set size. The full implications of this for EQC's reinsurance programme (with its limit on the time an "event" can continue for) and for the emergency services, have still to be explored.

The two most sophisticated models EQC has are the systems dynamics model "Logjam" and the hazard/financial analysis model "Minerva".

3.1 *Catastrophe Response*

Minerva and Logjam work in tandem when EQC has to determine the response to a scenario earthquake, real or postulated. The steps are:

- The specific details of the event are set up in Minerva, which is then run in scenario mode,
- The output is a table of claim numbers by categories of size (which are user defined) with total payments for each category, a map depicting these categories by geographical dispersion and a curve depicting the size distribution of payments. It is made easy to export this information to other spreadsheets, geographical information systems or other applications to provide full scope for further analysis and presentation.
- The claims size categories having been selected to coincide with set criteria (those capable of settlement site unseen, those requiring one visit, those requiring more than one, those requiring expert assistance), the numbers are given to Logjam, which is set up with resource particulars approximated through trial and error as part of the planning process.
- The payment distribution curve is also exported to Logjam.

- Logjam is run to show if the resource supply is likely to create any constrictions in the process and what the cash flow could be for settlements and costs of fielding the resources.
- Adjustments are made to resources in an attempt to remove constrictions and Logjam tests each new hypothesis.
- Decisions are made about what resource strength and mix to start the response with, what to advise as the likely time before most claims are settled, cash flow requirements and where to locate one or more EQC disaster site offices.
- During the time the catastrophe response has to be sustained, the process (or parts of it) will be repeated to take advantage of actual data coming from the field and from the claims processing centres. The response can then be adjusted in the light of real information.
- As claims activity begins to tail off, information will be required to inform decisions about the winding down process in order to get back to normal (that is, the planning stage of the catastrophe response programme).

3.2 *Review of Insurance Terms and Conditions*

Minerva is capable of showing, for different insurance terms and conditions, the financial implications, changes in assets and liabilities, and key statistical outcomes.

For example, EQC can model the effects of changing:

- its maximum sums insured, including removing the "caps" altogether,
- its excess/co-insurance provisions, including the basis (for example, the effects of a franchise)
- its premium rate, including its basis (for example, differential rating by region)
- cover on structural appurtenances
- cover on land
- take-up rates of insurance, including by region
- the types of buildings it insures

This ability will enable EQC to ground in solid foundations forecasts of the effects of many of its suggestions for changes, for up to ten years from the present. Some changes can be made to take effect at some time in the future, or to alter dynamically as time goes on.

3.3 *Dynamic Financial Analysis*

Minerva simulates performance ten years into the future, allowing for portfolio growth and inflation, and outputs statements of financial performance and position, cash flows and contingent liabilities for different investment strategies or returns, and various reinsurance or fund protection arrangements.

EQC has now received permission from its Minister to invest up to one third of the Natural Disaster Fund offshore. That amounts to about NZ$1.3 billion (about US$600 million). Obviously, great care is required in selecting the investment strategy to be followed and any decisions have to be substantially buttressed by thorough analysis. Insights gained from the use of Minerva will be very influential to this development and ongoing investment decisions by the Commission.

Reinsurance premiums paid by the Commission exceed $50 million each year. Not only does this level of expenditure warrant utmost scrutiny to ensure best value, but the reinsurance market is developing rapidly and suggestions for alternative forms of cover require evaluation. The ability to test risk transfer structures against established objectives – and sometimes to

perform such tests under time pressure – is one which the Commission has craved for some years.

To an extent this ability has been available to the Commission for some time. However, a feature of Minerva which was instrumental in its winning the contract is putting a new complexion on investment strategy decisions, reinsurance testing and hazard modelling. Minerva allows a choice of hazard assumptions. There are four vulnerability models plus a user-defined area, six attenuation models, three earthquake source models and three earthquake fault models to tantalise the user. There are also alternative asset models, one traditional and the other leading edge. With the elimination of the "black box" of other models comes a need for education and responsibility in the user, and Minerva poses such challenges as well as promises so much.

4 **THE FUTURE**

EQC's future must include the occurrence of events larger than it has experienced to date, up to the PML event which crystallises the central challenge: how sixteen people are going to handle over 100,000 claims (Minerva informs us the figure is closer to 100,000 than 200,000) registered within the statutory time limit of three months.

There is no doubt that the influence and reach of computer models in EQC's catastrophe response programme will grow. During a catastrophe event, the models will be run and re-run to help manage the activation, sustaining and wind-down phases. The last phase will include recalibration exercises intended to make the models better informed for the future.

The other perils besides earthquake which effect EQC's asset/liability balance, risk management and catastrophe response programme need to be modelled. Already research for the extension of Minerva to model the effects of volcanic eruption is under way and the other perils covered by the EQC scheme will also be studied. These include fire following the disaster and contemplation of this suggests that other perils in combination could also be included (for example a tsunami following an earthquake).

Within the earthquake peril, refinements are under consideration; for example to reflect aftershocks and to incorporate an earthquake fault model based on conditional probabilities of occurrence rather than the traditional Poisson or independent distributions.

Logjam, too, will be extended to events arising from perils other than earthquake, but a priority for this model is to incorporate repair delays due to lack of materials or skills or both, once some reliable data can be found to substantiate modelling assumptions. This may require EQC to engage the construction industry in planning exercises in order to access their opinions and information.

Extension of Minerva and Logjam will no doubt be accompanied by the development of other models. At present EQC has a building cost database on which it is basing repair costs used in the settlement of claims. This was developed for EQC and the Building Industry Authority by Maltby and Partners. Minerva's claims cost estimates are an associated database. To make the database easier to use, a model for estimating repair or replacement costs is being considered.

4.1 *The GeoNet Project*

The Institute of Geological and Nuclear Sciences and EQC have signed a contract under which EQC will fund the substantial upgrade, operation and maintenance of New Zealand's geological hazard monitoring network. The upgrade will include a denser network of seismological reading equipment, a network of ground positioning systems to measure ground deformation and real time satellite communications. Data will be available free to the public.

Over the next few years, the GeoNet Project will result in the significant expansion of data available for research and evaluation. Current assumptions based on existing knowledge of this

country's seismicity could be revised. With Minerva, EQC is in a position to be able to test any new source, fault or attenuation models for sensitivity to its financial or liability situation, with a short lead time relative to the commercial models available.

5 CONCLUSION

Computer models have brought EQC a long way in most areas of its operations. The organisation is fully aware of the warning that it should not take the findings of models as conclusive – or as anything more than indicative – but models cannot be ignored either. Models do not just assist in workload relief, they provide new insights and alter work patterns. To put the above maxim another way, models replace the uncertainty of just not knowing with the uncertainty of having only a possible solution – or several possible and discrete solutions. Many who are presented with output from computer simulation models and invited to make decisions based on it, do not appreciate the limitations of the output. This is a challenge facing EQC in its ongoing negotiations, deliberations and debates with other authorities.

For example, EQC's models allow the organisation to activate a catastrophe response by giving initial indications of what it is facing. No doubt the accuracy of the various indications will be variable and EQC will be constantly reminded of the more glaring inexactitudes by the news media and even parliamentarians and other community leaders. So long as EQC can react swiftly enough to counter mis-estimations, then this tenor of criticism will be a minor irritant.

Whatever the shortcomings of computer models, EQC is convinced that those who emulate Canute by standing in the waves of modelling developments and trying to deny them access to the shore will end up like that king – in a box in the rafters of Winchester Cathedral with nothing to show posterity but an enigmatic story.

6 ACKNOWLEDGEMENTS

My thanks to Bruce Shephard and Paul Martin for reading and commenting on a draft of this paper.

REFERENCES

Consortium of Insurance Brokers (Bowring Burgess Marsh and McLennan Ltd., Reed Stenhouse Ltd., Bain Dawes (NZ) Ltd. and Jardine Wrightson Ltd.) 1984. *Excess Loss Protection for the New Zealand Earthquake and War Damage Commission*

Earthquake Commission 1999. *Briefing for the Minister in Charge of the Earthquake Commission*

Earthquake Commission 1999. *Request for Proposal for the Provision of Catastrophe Insurance Loss and Financial Systems*

Frank Russell Company Pty Ltd 1993. *Earthquake and War Damage Commission: Computer Program for Loss Simulations*

New Zealand Government 1993. *The Earthquake Commission Act 1993*

Risk Management Solutions Inc. 1996. *Portfolio Risk Assessment: New Zealand Earthquake Commission*.

Opus International Consultants Ltd. 1999. *Probable Maximum Loss of Insured Earthquake Residential Risks in the Wellington Region.*

Smith, A. 1999. *Managing the Big One: How the Earthquake Commission helps New Zealanders recover from natural disasters*. Victoria Link Ltd, Wellington, New Zealand.

Works Consultancy Services Ltd 1996. *Probable Maximum Loss Assessment of Insured Earthquake Residential Risks in the Wellington Region for the Earthquake Commission*