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ESTIMATING THE RISK TO INSURANCE COMPANIES FROM EARTHQUAKES - A CASE STUDY BASED ON SYDNEY

George R. Walker ME PhD FIEAust FIPENZ FAIB
Head of Strategic Studies
Alexander Howden Australia Limited

THE AUTHOR

George Walker began PhD studies in earthquake engineering research in 1961 at the University of Auckland, obtaining his degree in 1966. After 21 years at James Cook University, where his major specialisation was in wind engineering, and 5 years at CSIRO, he now works in the reinsurance industry as a specialist in modelling catastrophe insurance losses.

ABSTRACT

Currently the insurance industry is going through a major period of change in the way it analyses and copes with catastrophic risks such as earthquakes and tropical cyclones. GIS based models simulating the impact of natural hazards on property portfolios, originally developed by earthquake engineering researchers, are being increasingly used as the basis for a sound financial risk management approach to the determination of company policy in regard to catastrophe insurance.

The paper describes the current state of art of these developments through a case study approach based on a hypothetical insurance company with a major concentration of its portfolio in the Sydney area. It highlights the particular problems which insurance companies face in insuring for earthquake losses in a relatively low risk environment. The purpose of the paper is to demonstrate the role of earthquake loss modelling in the financial risk management of insurance companies, and foster discussion on the reliability of the scientific data being used in these models.

1 THE SCENARIO

Company XYZ Home Insurance Limited is a fictitious small locally based insurance company operating in the Sydney area in conjunction with a home lending institution. Its operations are solely concerned with the insurance of single family houses and their contents. It has a portfolio of 50,000 homes with an average value of $125,000, from which it receives an average annual premium of $500 per property. It has net assets of $50 million including general reserves of $10 million dollars. The company has requested an assessment of its earthquake risk for use in designing its financial risk protection program.

2 THE NEED

In designing the financial risk protection program for an insurance company, a major objective is protection of its balance sheet to ensure it will be able to remain in business, and meet its obligations to its policy holders, after a major loss. Natural hazards such as earthquakes are just one of the types of risk to which the balance sheet of an insurance company is subject. The term volatility is used to describe a company's variability of financial performance due these combined risks. Systems now exist that enable all the risks to a company to be rationally analysed in an integrated manner, the outcomes of various alternative approaches to be simulated, and optimum solutions to be determined. These systems are heavily based on probability and statistics, and input to them is required to be in probabilistic form.

Figure 1 shows the projected financial position of XYZ Home Insurance Limited at the end of the next financial year assuming no major catastrophe losses and no protection against them. The variation primarily reflects uncertainties about claims, the performance of the stock market, and interest rates.

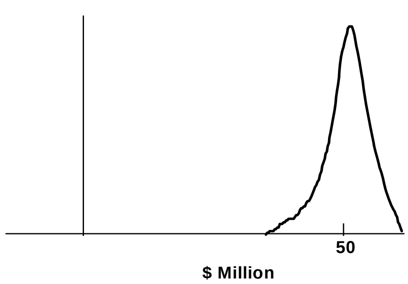

Figure 1 Expected Net Assets after Tax and before Dividend Distribution

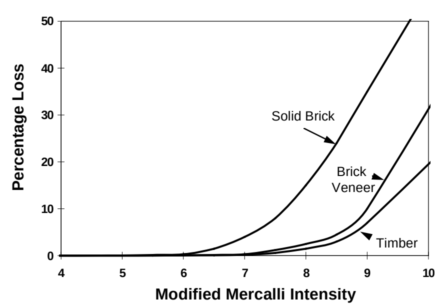

Figure 2 Vulnerability Curves

What is needed is the corresponding probability curve for catastrophe losses, which when combined with the curve in figure 1 will give an indication of the company's volatility without protection. The corresponding curve for earthquake losses will be a major component of this.

3 THE EARTHQUAKE MODEL

Losses were modelled using the Alexander Howden Australian earthquake model. This is a GIS model which, for a specified earthquake in terms of Richter magnitude, location and depth:

1) maps the estimated ground shaking intensity in terms of Modified Mercalli (MM) intensity or peak ground acceleration, including amplification due to soft soils;
2) maps an insurance company's property portfolio in terms of different building characteristics which are expected to influence the response to an earthquake, and superimposes it on the map of the estimated earthquake ground shaking intensity;
3) evaluates the anticipated losses for each building type based on the estimated ground shaking intensities and assumed vulnerability curves relating expected loss to ground shaking intensity for each building type, and combines them to produce the total expected loss.

The estimated ground shaking intensities are based on the attenuation relationships given in Gaull, Michael-Leiba and Rynn [(1)]. For the analysis of XYZ Home Insurance Limited's portfolio the study was undertaken in terms of MM intensities based on the recommended attenuation relationships for Southeastern Australia. The model assumes that these relate to firm ground or rock and provides for these to be increased by up to 1.5 MM units on soft soil.

The property portfolio was assumed to be a mixture of solid brick, brick veneer, and timber homes, with a higher concentration of solid brick homes in the older suburbs on soft ground than elsewhere. It was considered on a post code basis and assumed to be spread across the whole of the Sydney area encompassed by the Insurance Council of Australia (ICA) Risk Zones[(2)] 41, 42 and 43 roughly in proportion to post code populations.

The vulnerability curves used are shown in figure 2. They are based on the general shape of vulnerability curves used overseas - eg Applied Technology Council[(3)], and Coburn and Spence[(4)] - but the actual shapes have been derived by using them to calibrate the model against past earthquake losses in Australia.

The three earthquakes considered were the Adelaide earthquake of 28 February 1954; the Meckering earthquake of 14 October 1968; and the Newcastle earthquake of 28 December 1989. The firm ground shaking intensities were based on the isoseismal maps of the events published by the Australian Geological Survey Organisation [(5,6)] and modified for soft ground according to the algorithms incorporated in the model. Published information suggests the insured losses as a percentage of the insured values were of the order of 0.8% for Adelaide, 0.05-0.075 % for Meckering, and 3-4 % for Newcastle. The modelled losses using the curves in figure 2 were of this order. This does not mean that all the assumptions in the model are correct, but does suggest that in combination they are producing results in the right ball park.

Earthquake occurrence characteristics were based on those given for the Lachlan fold belt, which includes Sydney, by Gaull, Michael-Leiba and Rynn[1], with the exception that no upper limit was placed on the earthquake magnitude.

4 EARTHQUAKE LOSS PROFILE

The earthquake loss profile was evaluated by dividing the Sydney region into a grid and evaluating the loss for earthquakes of different magnitudes at the centre of each grid. Using the earthquake occurrence data, the probability of exceedance of different levels of loss was determined for each grid area. The overall loss profile was then obtained by adding these probabilities of exceedance over the whole region. The resulting curve is shown in figure 3.

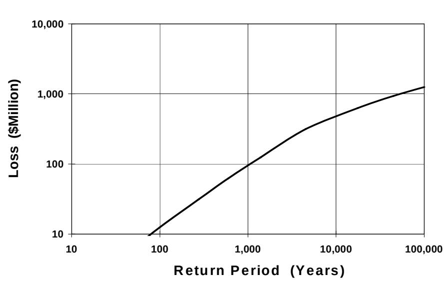

Figure 3 Earthquake Loss profile

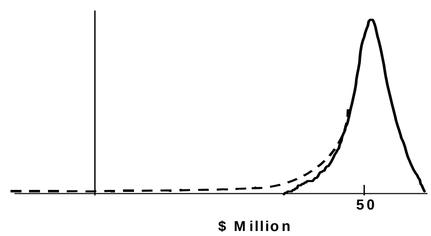

Figure 4 Effect on Expected Net Assets

The effect of this on the probable net assets at the end of the financial year, including earthquake risk, is to produce a long negative tail as shown in figure 4.

In the case of XYZ Home Insurance Limited this could bankrupt the company as the study indicates losses could be of the order of hundreds of millions of dollars, and their total net assets are only of the order of $50 million. XYZ Home Insurance Limited can protect itself against this risk through reinsurance or other means of financial risk protection. The cost of this protection will of course reduce the probable net assets of the company. While the earthquake risk could be fully covered, the cost of this is normally regarded as too high, and a balance is sought between the unprotected risk and the costs of risk protection. Key factors in making this decision are the risk of the net loss to the company exceeding general reserves, and the risk it will exceed total net assets. Table 1 shows the risks associated with different levels of loss protection using excess of loss reinsurance.

Table 1

Protection	Risk of Exhausting General Reserves	Risk of Exhausting Net Assets
None	0.013	0.0022
$50M XS 0	0.0017	0.001
$50M XS $5M	0.0017	0.001

$50M XS $10M	0.013	0.001
$100M XS $5M	0.0009	0.0006

5 DISCUSSION

The primary purpose of this paper is to demonstrate the use of earthquake loss modelling in the insurance industry and to stimulate discussion on the scientific information on which it is dependent. Some comments for discussion follow:

1) The loss profile curve in figure 3 is a conditional probability curve, as it purports to give the expected value of loss for an event of the given return period, not the probability of exceedance of a given value of loss, which is the way it is usually interpreted. To obtain the latter it is necessary to derive the associated family of confidence limit conditional probability curves and from these obtain the true probability of exceedance curves. It can be shown that providing the confidence limit range is not too great, using the expected loss conditional probability curve is conservative. To obtain the expected curve it is necessary to use the expected values of variables, not conservative values, with the uncertainties being incorporated in the confidence limits. Is this the basis of the information given in Gaull, Michael-Leiba and Rynn(1)?

2) The shape of the loss profile is very significant, but also dependent on not imposing limits on the likely maximum magnitude of earthquakes in the Sydney region. Are there sound scientific reasons for imposing the limits suggested in Gaull, Michael-Leiba and Rynn(1)?

3) In applying the attenuation formulae in Gaull, Michael-Leiba and Rynn(1) it has been assumed that they produce maximum ground vibration on rock or firm ground. Is this correct?

6 REFERENCES

1. Gaull, B.A., Michael-Leiba, M.O. and Rynn, J. (1990). "Probabilistic Earthquake Maps of Australia", *Aust J Earth Sciences*, Vol.37, pp 169-187.

2. Insurance Council of Australia (1990). *Risk Zone Accumulation Guide*, Melbourne.

3. Applied Technology Council (1985). "Earthquake Damage Evaluation Data for California", *ATC-13*, California.

4. Coburn, A.W. and Spence, R.J.S. (1992). *Earthquake Protection*, Wiley, U.K.

5. Everingham, I.B., McEwin, A.J. and Denham, D. (1982) "Atlas of Isoseismal Maps of Australian Earthquakes", *BMR Bull 214*, AGPS, Canberra.

6 McCue, K.F. (1996) "Atlas of Isoseismal Maps of Australian Earthquakes, Part 3", *AGSO Record 1995/44*, AGPS, Canberra.