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Risk based earthquake pricing using catastrophe model output

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As the insurance market trends toward more analytical and data-driven decisions, insurers are continually exploring ways to rate risk better and more precisely. For the case of earthquake risk, this means an enhanced understanding of the relationship between event location, frequency, severity, how buildings respond to an event and the ensuing financial costs. The increased quantity, quality and granularity (resolution) of the available underwriting data and highly refined rating engines give insurers the opportunity to become extremely risk-specific in their pricing. Risk-based pricing – charging different rates depending on different risk characteristics of specific policies and in contrast to portfolio underwriting – leads to stability and confidence in pricing. Risk based pricing aims to ensure that premium levels are commensurate with individual property risk profiles, with those in highly exposed areas experiencing a specific rate on the earthquake component of their coverage. This seems to be a fairer and more equitable way of pricing risk. The ability to differentiate between perceived risk and actual risk affords insurers a better way to achieve their financial goals, allocate capital and meet client needs for coverage.

Several features of earthquake hazards and risks render them readily amenable to risk-based pricing. First, the level of seismic hazard is not uniformly distributed across a country. New Zealand is an extreme example in which Wellington is located directly on a tectonic plate boundary having extremely high seismic hazard, whereas Auckland is remote from the plate boundary and has a seismic hazard level comparable to that of Australia (Figure 1). However, even in Australia, the seismic hazard level also varies by an order on magnitude between relatively high levels in northwestern Western Australia, the Yilgarn region east of Perth, Adelaide, and southeastern Australia on the one hand and the extremely low levels in Queensland.

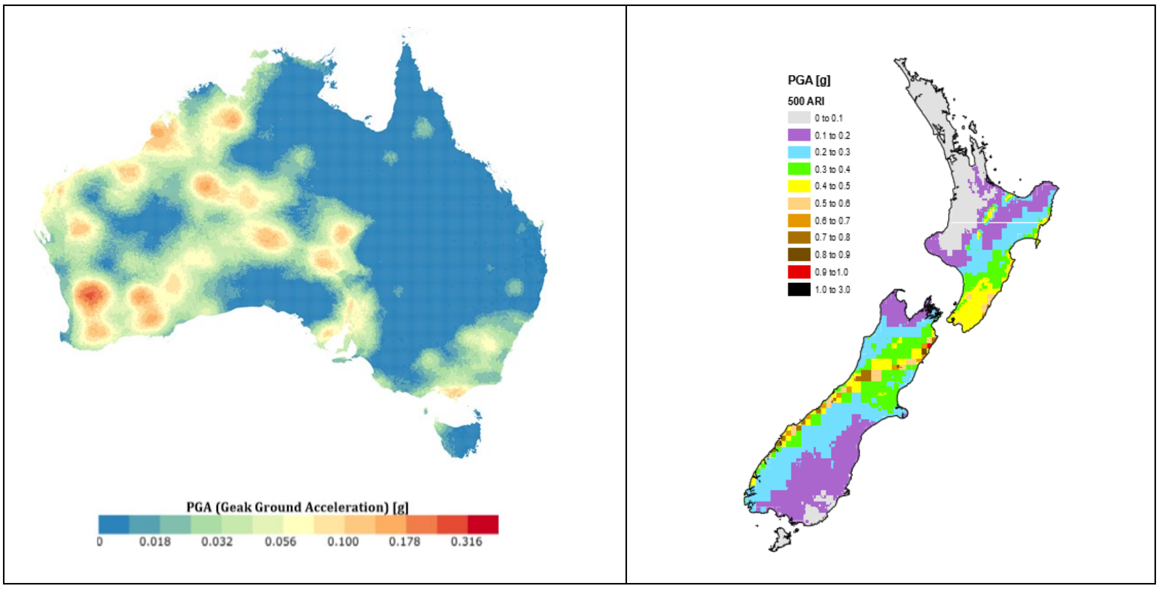


Figure 1. Peak acceleration maps for 1:500 AEP on Risk Frontiers' Variable Resolution Grid for Australia and New Zealand.

Second, the factors that increase the level of the hazard are well understood and mapped. These include the presence of soils that amplify the level of ground shaking compared with that on rock, and the presence of saturated sands that can be liquefied during earthquake shaking, as occurred in Christchurch during the 2010-2011 Canterbury earthquake sequence.

Third, we are able to quantify the variations in building vulnerability to earthquake damage due to different building types, heights, ages of construction, and whether seismic building code provisions were used in design on a very specific basis. G-NAF (Geocoded National Address File) is a geocoded address index listing all valid physical addresses in Australia. NEXIS (National Exposure Information System) is a database developed by Geoscience Australia containing building details for residential commercial and industrial buildings in Australia at a Statistical Area 1 (SA1) level. There are 57,523 SA1 in Australia. These datasets allows wood, Mid-rise Steel, Concrete, and Reinforced Masonry and low-rise Unreinforced Masonry buildings damage ratios to be modelled and enable customised underwriting in Australia at the location, SA1 or postcode level. For New Zealand, the use of a variable resolution grid created using the Linz NZ street addresses database enables us to calculate the ground shaking hazard at a resolution as fine as 500 m while the liquefaction hazard is calculated at the address level with a resolution of 16 m.

Finally, Risk Frontiers' QuakeAUS and QuakeNZ models use a level of refinement in property damage estimation that is unique in the worldwide catastrophe loss modelling industry. Conventional earthquake loss estimation uses building fragility functions that are precomputed using standard capacity curves for each building category of interest with a simplified representation of the building demand curve in response to ground-shaking. We instead account for the entire response spectral shape of the ground motion, which varies with many factors, including the earthquake magnitude, earthquake distance, and soil category at the risk location. Accordingly, our loss model dynamically calculates fragility curves for each building category at each site for each earthquake in the event set. This produces building- and event-specific damages for each building category for each event, enhancing the accuracy and reliability of the loss calculation.

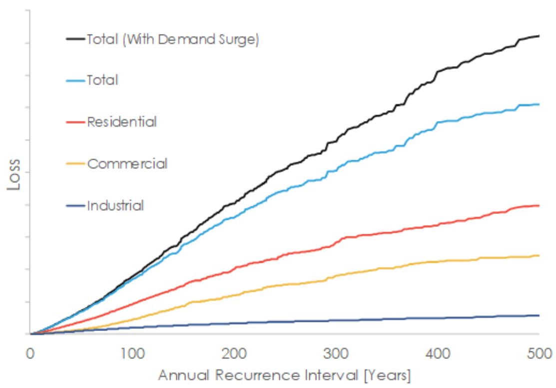
These four categories of information are combined to make detailed estimates of losses for each building that are then aggregated to obtain portfolio loss estimates. However, it is an easy step to use this detailed information to quantify potential losses for any soil type or building category at any desired level of spatial resolution. For example, our model output can provide postcode level risk premiums (average annual loss AAL's) for all of Australia and New Zealand for a nominal risk to estimate loss rate due to earthquakes for the following building modifiers, as shown in the example in Table 1:

- Structure Type: Unknown, Wood/Light Frame low-rise, Steel Moment Frame mid-rise, Concrete Moment Frame mid-rise, Reinforced Masonry Bearing Walls mid-rise, unreinforced masonry low-rise. Mid-rise is defined as 4+floors, low rise as 1-2 floors
- Year-built: pre-code (1980) and post-code
- Damage calculated separately for buildings and contents
- Separate estimates of direct damage and demand surge

Postcode	Structure Type	Construction Date	Risk Premium Building	Risk Premium Contents
2294	Light Wood	Unknown	74	64
2294	Mid-rise Steel Moment Frame	after 1981	26	3
2294	Mid-rise Concrete Moment Frame	before 1981	44	7
2294	Mid-rise reinforced Masonry Bearing Walls	Unknown	35	25
2294	Low-rise Unreinforced masonry bearing Walls	after 1981	226	58
2294	Unknown	before 1981	111	71
2294	Low-rise Unreinforced masonry bearing Walls	after 1981	141	58
2294	Low-rise Unreinforced masonry bearing Walls	unknown	142	59
2286	Low-rise Unreinforced masonry bearing Walls	before 1981	51	10
2295	Low-rise Unreinforced masonry bearing Walls	before 1981	168	42
2291	Low-rise Unreinforced masonry bearing Walls	before 1981	90	21

Table 1. Newcastle region risk premiums for building and contents with a nominal sum-insured. Earthquake risk based on location (postcode), construction type and year of construction can inform better underwriting decisions.

This bottom-up understanding of risk and pricing will also lead to better alignment of risk-premium and capital management.



Location	Oak St, Upper Hutt, Wellington
Latitude	-41.11
Longitude	175.07
Property Replacement Value	NZD 350,000
Annual Probability of Experiency a loss due to Earthquake	1.7% (AAL: 1,320 NZD)
Liquefaction Potential	Very low
Soli Type	Firm to hard rock
Selected Vulnerability Parameters	
Building Age	1978
Building Type	Reinforced Masonry
Number of stories	2

Figure 2. By introducing earthquake risk pricing, insurers have an opportunity to align portfolio risk (left) and capital management with original premium rating and risk selection (right).