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CATASTROPHE MODELLING

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Background

'Difficult to use', 'time-consuming', and 'frequently inaccurate' - just some of the terms once used to describe the earliest attempts at catastrophe modelling. Today, techniques have improved beyond recognition, and the rambling, often confusing models of the past are now just distant cousins of the new sleek, fast and efficient models.

But while methods may have improved, catastrophe modelling remains a peripheral tool for many companies - but for how long can this remain the case? With climatic changes and population shifts, has the time now come for the insurance industry to finally - and fully - embrace the science of catastrophe modelling?

In essence, catastrophe modelling is the application of scientifically-based computerised models to the assessment of losses arising from natural catastrophes, such as earthquake, hurricanes and tropical cyclones, windstorms and floods.

The origins of catastrophe modelling techniques lie in the safety-assessment studies carried out by engineering consultants during the design phase of projects such as nuclear power-plants, dams and roads. Engineers assess the probability of events that could lead to catastrophic failure and, if necessary, build in design features to reduce these risks to acceptable levels. Due to the safety-critical nature of the task, considerable resources would often be applied to ensure the reliability of the results for each project. In fact, the state-of-the-art in hazard assessment is still defined by these engineering studies.

The birth of today's more sophisticated modelling techniques was a response to the string of natural disasters between the late 1980s and the mid-1990s. In Europe the storms of 1990 shook the industry from its slumber, while the effects of Hurricane Andrew in the US brought things into sharp focus for insurers and reinsurers alike.

Gradually it became obvious that the analysis of cover and damage was, for these types of natural disaster, wholly inadequate. During that six or seven year period, it is now estimated that the insurance industry suffered global losses in excess of £600m, or put another way, more than the cumulative historical losses prior to that period. The industry needed more accurate and sophisticated methods to estimate what they might have to pay out and how better to spread their risks. And they needed them quickly.

Furthermore, the increasingly competitive nature of insurance markets meant that the insurer who could make better provision for losses and set more realistic rates for any given portfolio of business would instantly gain a competitive edge.

Historically, insuring and reinsuring low frequency, high severity events was quite straightforward, partly because expected worse case losses were generally understated. Property owners bought cover that gave them peace of mind, insurers were comfortable that they could fund losses, particularly with the availability of relatively inexpensive reinsurance cover, and in turn, reinsurers rarely experienced significant catastrophic losses.

Gradually though things began to change, the reverie was broken and everyone was effected.

Demographics began to change. Populations migrated towards cities, many of which were located in coastal settings susceptible to hurricanes, earthquakes and tidal waves. The concentration of this exposure was exacerbated by higher levels of economic development and construction, much of which was built as quickly and inexpensively as possible. And the results of this policy have recently and tragically been seen in Turkey. In short, low income housing was being built in highly exposed areas, where the potential for damage was huge.

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Cat Modelling Today

The current state-of-the-art in catastrophe modelling has also come about as a direct result of the recent IT revolution, as well as a natural evolution of traditional analytical methods. Although the actuaries and underwriters of 20 years ago were certainly aware of the value that information from diverse fields such as engineering, meteorology and finance could provide, it was simply not feasible to access such information given the time, cost and information processing constraints of the day.

As David Whiting, head of EQECAT in the UK says: "The knowledge of hazards was all there ten or 15 years ago. It's just that the knowledge and expertise hadn't been brought together for the purposes of insurance and reinsurance."

With the advent of powerful personal computers, it became feasible to apply the techniques of safety-assessment studies to the assessment of risk for the insurance industry within a desktop system.

The basic theory behind the models is straightforward. By simulating a peril in a specific geographic region, the model can assess the potential loss to any given insurer's portfolio. They can provide technical and market rates, pricing information for both insurer and reinsurer, risk/ return ratios, and can quantify the model's margin of error. The data held by both the provider and the client are critical to predict an accurate loss estimate, and in the past this is what the model has lacked.

Three basic factors make up modelling: the methodology employed; the treatment of uncertainty; and the quality of the data. It is a general rule that the more systematic and precise the data, the more accurate predictions can be.

Nowadays the availability of massive computing power on the desktops of technical analysts has expanded the level of sophisticated analysis which can be used to support business decisions which, along with greater access to loss information and better historic loss data being provided by suppliers, has resulted in the growth of catastrophe modelling.

The development of these models continues as better scientific and engineering data becomes available, and as the capabilities of desktop computers continue to increase. Within the insurance industry, the acceptance and credibility of these models is increasing as more organisations see the advantages over traditional methods, and appreciate the benefits that they can offer.

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Uses

The models provide a value for Probable Maximum Loss (PML) on an insurers or reinsurers portfolio of business, together with an appreciation of the technical rate that is appropriate to cater for these perils.

These results can be used to:

- Set appropriate rates
- Accumulate potential exposures across the company
- Ensure the appropriate level of reinsurance cover is in place
- Determine an appropriate level of capital allocation for the exposures covered
- Perform Dynamic Financial Analysis to review the impact of variance in underwriting performance & other variables upon the Balance Sheet and Profit and Loss Account.

The models are therefore used alongside traditional methods and commercial judgement to provide an insight into potential catastrophe losses and their impact.

Also, in some instances, the parameters of actual recent events can be input into the models to allow an early assessment of likely losses. These post-event estimates are highly dependent upon the accuracy of the information known regarding the event, but have often produced good indications of the losses incurred by individual companies or by the industry. For example, the EQECAT models provided a close estimate of the Hurricane Georges losses for a number of insurers.

Some industry analysts have put the total losses of the recent disaster in Turkey at around £1.2bn. CAT models had predicted a loss of around 33 per cent in advance of the disaster.

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How It Works

Catastrophe modelling is a mathematical model which provides insurers with guidance on the levels of reinsurance for any given set of circumstances. It forecasts the loss expectancy and protects the account by helping underwriters to measure the level of risk.

The basis of reinsurance is to protect against major pay-outs but reinsurance is expensive. By developing a better picture of where the risks, or natural disasters, are, underwriters can give international insurers a more accurate reflection of reinsurance costs and what should and should not be reinsured.

Underwriters are vital to the success of any insurance company and the more information they can be given the better. This will ensure that the company can offer competitive prices or even set higher rates if that is the way in which the new information and data leads them.

Two basic approaches can be used. A market-share analysis, that estimates an industry loss and from this calculates an individual company's loss based upon market-share, or a more detailed portfolio specific analysis.

A portfolio-specific analysis will produce more reliable results where, as is generally the case, the geographic distribution or nature of companies portfolios are different.

For a portfolio-specific model there are four key components:

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Technical Information

- **Hazards**

This data will be based upon the historical record of past events, but will also allow for the probability of comparable events occurring - with differences in intensity or spatial parameters. A large number of possible events are simulated, and for each one the wind-speed or ground-shake at every affected location is defined.

Other points to consider are whether all, some or none of the buildings insured are near seismic faults? Is the area prone to hurricanes? Is there a threat of flooding? Is wind intensity data available? Or for countries like the UK, what is postcode of the area?

One factor that makes setting premiums easier are Catastrophe Risk Evaluating and Standardising Target Accumulations (CRESTA) zones. These zones are sacred to the insurance industry and form an excellent way of breaking up a country into manageable segments before examining their exposure to certain risks.

- **Vulnerability**

This data is gathered from claims data, and from engineering analysis, and defines the losses that will occur for a particular level of hazard. So, for example, damage ratios will be defined for UK commercial property - for wind-speeds of 55mph and upwards. Companies should look for patterns or certain types of property which have been prone to a certain type of damage. Are some buildings more likely to burn than others? This helps to produce a vulnerability curve.

When you are putting this vulnerability curve together, do you actually know if the buildings you are insuring are fully built or only part constructed? If some are only half built then they are open to a whole new set of hazards which completed buildings have been built to withstand. Many companies will usually assume that a certain percentage are not complete but when each point of a percentage could stand for several million pounds, isn't it worth getting the most accurate picture possible?

Portfolio Data
This data is provided by the user of the model, and defines the portfolio of risks that is exposed to the hazard and helps the user to build a much more detailed picture of exactly what it is insuring. At it's simplest this data can consist of an aggregate value at risk in each location, however it can include a more detailed breakdown of structure types and method of construction. This data-set also defines the limits and deductibles that apply.

Many companies will simply know that they insure, for instance, all the buildings belonging to the Y Corporation. But what exactly does this entail? How many buildings are there? Where are they? What proportion are fully built?

Put another way, imagine a holding company buying catastrophe cover across five different businesses each of which operates in a different business, in different areas. How do you allocate the costs from the reinsurance for these different business units? Do you simply divide by five or come up with a more accurate method of finding our how much of the capital and expense each unit is using.

Whatever the scenario, the more precise this portfolio information is, the more scientific the model will be.

- **Analysis Engine**

The software at the core of the model uses the above data to assess damage for each risk, and then applying the insurance (and reinsurance) structures to assess insured (and reinsured) losses. The results can be aggregated to produce reports for the portfolio, or to provide event-by-event results to allow further actuarial analysis.

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Who Uses It?

Catastrophe models are now widely used by insurers and reinsurers to assess their potential losses and in the case of reinsurance brokers, to assist in the design of reinsurance programmes, and with the Dynamic Financial Analysis of an insurers balance sheet.

Increasingly they are also being used, directly or indirectly, by a variety of other organisations such as:

Rating agencies to assess the financial stability of insurers and reinsurers; Natural Perils Pools such as the New Zealand Earthquake Commission to assess potential losses; supervisory bodies like the Florida Insurance Commissioners, to review the rate-making process; investment banks to structure and price alternative risk transfer (ART) products; and also industrial/commercial organisations to set up Catastrophe Bond arrangements, as an alternative to traditional insurance.

But the largest user group are naturally insurers who use Catastrophe Models in a number of ways and particularly commercial insurers with property portfolios:

Underwriting: The models provide an assessment of potential catastrophe losses for a property book of business. This can be used to understand the factors driving catastrophe losses, and hence to feed-back to the underwriting process.

Assess reinsurance needs: The most common use of the models is to assess the probability of varying levels of catastrophe loss, and hence to support decisions regarding the appropriate level of reinsurance cover. This approach allows confirmation that reinsurance cover is purchased for catastrophe losses, subject to company policy (eg. 100 year return period losses).

Accumulation across divisions/territories: As well as identifying potential losses for an individual territory and book of business, it is possible to accumulate losses across territories and classes of business, in order to derive divisional or group-wide losses. It is very difficult to accurately carry out this process using traditional techniques as it requires an assessment of the correlation between different groups of losses. The use of a computerised model allows the combination of such losses in a statistically sound fashion.

There are generally diversification benefits to be gained in the reinsurance pricing of a geographically spread book of business. The use of a catastrophe model allows the potential for reinsurance savings arising from this diversification to be recognised and explored.

Assess losses net of reinsurance: Given the definition of the insurer's reinsurance arrangements it is possible to assess catastrophe losses net of reinsurance. This allows a direct assessment of the potential impact of catastrophe losses upon profitability.

Input to actuarial analysis: The models provide detailed actuarial analysis to support decisions regarding catastrophe peril rating or the assessment of reinsurance programmes.

The second main group of users are reinsurers.

Underwriting and pricing: Many reinsurers use the results of catastrophe modelling as part of their underwriting and pricing process. Even in a soft market, where market rates fall below the level that would be indicated by a technical assessment of exposures, the models provide a basis to compare the attractiveness of the business offered to them. Some reinsurers use multiple models, both vendor-supplied and in-house, to provide as wide an assessment as possible of the catastrophe risk.

Reinsurers frequently use proprietary actuarially-based pricing techniques, which draw upon the outputs from catastrophe models.

Portfolio accumulation: Reinsurers also use catastrophe models to assess the potential accumulation of losses for their portfolio of treaties, and to determine the most appropriate allocation of capital to a diversified portfolio of risks.

Reinsurance brokers also commonly use catastrophe models to provide value-added services to their clients.

Design of reinsurance programmes: The outputs from catastrophe models allow the protection offered by a variety of reinsurance programmes to be actuarially assessed. This allows the selection of a programme that best meets the clients objectives, at a realistic cost. The options of different reinsurance purchasing strategies eg. central/diversified, can also be examined.

Dynamic financial analysis: Catastrophe models help a company to assess the vulnerability of its investment funds against the potential for loss. The result of this analysis could have serious implications for an organisation's balance sheet and stability of the business overall.

So what are the benefits? As can be seen on the previous page, catastrophe models are applied by a wide variety of organisations in different ways. The benefits arising can differ from user to user, but may include:

- Quantification of risk exposures - providing greater confidence amongst rating agencies and investors
- Improved selection of risks
- Improved pricing of risk - and hence improved underwriting results
- Reduction in risk-transfer costs - whether via traditional reinsurance or not
- The ability to implement Alternative Risk Transfer (ART) solutions
- Accurate assessment of benefits of portfolio diversification - and hence potential reduction in capital requirements

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Catastrophe Modelling & Engineering Business

There is no evidence that automated catastrophe modelling has been applied to the assessment of losses on Construction All Risks or Engineering All Risks (CAR/EAR) business.

As reviewed earlier, catastrophe modelling arose out of engineering consultancy work on civil engineering and construction projects and one-off assessments of catastrophe risks are still commonly undertaken in respect of major projects. However these studies are labour intensive, and do not offer a practical means of assessing exposures on a portfolio of such business.

While modelling organisations that have continuing links with this sector certainly have the expertise to tackle the automated modelling of CAR/EAR business, this expertise has yet to be translated into a software product that is suitable for use within the insurance industry.

Any approach to the automated modelling of CAR/EAR business requires the following issues to be addressed:

- Available Portfolio Data
- Nature of Risks
- Project phases
- Low number of high-value projects
- Vulnerability/Claims data

- Modelling comparable property risks
- Developing a specific catastrophe model

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Limits/Obstacles

One of the limiting factors upon the accuracy of any catastrophe modelling exercise is the quality of the data available to describe the portfolio of exposures. The minimum data requirement is aggregated sum insured, broken-down by zone - however a further breakdown, perhaps by project-type, would be highly desirable.

Many models can accept locations that are only specified at country level, however this requires the model to dis-aggregate the data on some basis such as population statistics. Whilst this may be a reasonable approach for residential business, it is unlikely to give a reasonable outcome for CAR/EAR business. Therefore it would be preferable if CRESTA zone locations were available for at least the majority of risks.

The increasing trend of insurers to take on world-wide capital CAR/EAR portfolios is also a limiting factor which makes it difficult for the model to predict with any degree of accuracy the total loss picture.

The nature of risks is also a factor. Catastrophe modelling is based upon the definition of damage ratio curves for generic groups of risks such as residential, commercial, industrial, although the wide range of CAR/EAR projects makes their classification into generic groups difficult. For many construction projects it may be feasible to categorise the risks in the same manner as the completed structure, however this would leave out projects where such generalisation of exposures would be difficult to make, such as tunnels and petrochemical plants. One possible approach would be to initially model only the portion of the portfolio that was amenable to classification, such as different kinds of design of office blocks, with well-known behavioural patterns under given different environmental conditions.

CAR/EAR projects go through a number of distinct phases during which time the values at risk and the degree of exposure to catastrophe perils can vary considerably. One approach to this issue is to base all modelling on an average value/exposure profile. Providing the mix of projects in all different stages stayed relatively constant over time, then this could provide a reasonable approximation. Nevertheless a more sophisticated model would take into account the phase of individual projects.

There is likely to be little information available regarding the value or nature of contractors' equipment on site. However, this coverage generally represents a small proportion of the overall project value and it could be possible to make a simple set of assumptions to cater for this coverage.

One draw back of catastrophe modelling is that unlike many other types of cover, it cannot legislate for third party liability arising from catastrophic perils. For instance, if a crane from a construction site should collapse and demolish part of a nearby hotel, most current policies would cover this. However, this is too much of a variable to factor into catastrophe modelling.

A statistical consequence of the modelling approach is that there is greater certainty in the results where the portfolio consists of a large number of risks for each zone or territory. However, for much CAR/EAR business this will not be the case and the portfolio will consist of a relatively low number of high-value projects. And while this can still be modelled, it tends to lead to greater uncertainty in the possible range of results.

In order to develop a robust model that is specific for CAR/EAR business, it is necessary to develop vulnerability curves for each classification of project type. While initial vulnerability can be developed based upon engineering experience, it would be preferable if actual claims data for catastrophe losses was available in order to validate and calibrate the model. This would ideally involve the gathering of portfolio or loss data for CAR/EAR business from a number of insurers, in order to provide a sample as wide a possible.

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Solutions

One relatively straightforward approach to the modelling of CAR/EAR business would be to utilise the existing capabilities for the modelling of property business. Under this approach each risk would be classified according to its comparable property risk-type. It would then be necessary to apply an exposure loading representing the higher exposure to catastrophe perils of part-completed projects.

An average loading of two has been suggested, which is broadly in line with the higher rates that apply to construction and engineering business. In a slightly more refined approach, this exposure loading would be varied according to construction type. However, in the absence of objective claims data, this could well require a subjective assessment of relative exposure factors.

This approach is clearly very broad and requires a number of assumptions regarding the nature of the business and it's exposure to catastrophe perils. Nevertheless it provides a means of obtaining an initial estimate of catastrophe exposures by territory and as a first step could at least determine the territories for which further work is necessary.

A more refined approach would require the commissioning of a model specific to EAR/CAR business. A positive feature of this approach is that many components of existing property based models would be equally applicable to an CAR/EAR model. For example, providing the model was developed in a suitable fashion, the hazard event-sets and software features of the model would be directly applicable to this different set of exposures.

The work that would be required to tailor the model to CAR/EAR business would primarily be the developing of a set of vulnerability curves defining the damage ratios applying for each wind-speed/ ground-shaking intensity and project type. The variety of project types could mean that a large number of such curves are required and that it is difficult to gather reliable data for each one. If participating insurers can provide claims data, matched back to the relevant portfolio, then this could greatly assist this process.

The other major component of the development project would be to incorporate the resulting vulnerability curves into a deliverable software project, and the subsequent testing of that software.

The extent of this work is currently difficult to estimate as it depends on the classification of project types agreed, the data available and the level of sophistication required in the approach. But it is possible to envisage a project of this type ranging from anything from a month to a year or more to complete.

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Next Steps

Questions to be considered by IMIA members

It might sound dramatic but have you ever considered how close to disaster the insurance industry actually is? The case studies about Turkey and the recent devastation caused by the Caribbean's annual hurricanes can't be ignored.

Catastrophe modelling has come on leaps and bounds in recent years and is something that the insurance industry should be embracing. Companies need to start sharing claims data to build up a more accurate picture of what is and what isn't vulnerable.

Another question for the industry to consider is that at the moment catastrophe modelling only applies to fully completed commercial or residential property and not part-completed buildings.

Some companies have introduced models able to assess the less catastrophic events that account for larger annual dents in an insurer's portfolio. In the UK this includes theft, fire and subsidence. Theft and fire account for 60% of claims in the UK each year, and subsidence claims reached over £300m in 1996.

The model providers stress that the models don't have the answers to everything. Their purpose is to quantify the risks and give the probability of losses to an insurer or reinsurer and, just as importantly, to quantify the uncertainty of the models. They cannot say what is going to happen tomorrow but they can provide a tool to make better judgements based on improved information.

Working closely with the construction industry is also a possible step forward and developing a better classification of building types, detailing what they are made of, and even what their strengths and possible weaknesses may be, as well as a general analysis of different materials' vulnerability to natural disasters.

There are two ways the insurers can take advantage of catastrophe modelling. Either by using an off-the-shelf package of ratios or a bespoke package based on their individual needs.

There are a number of vendor companies that supply these models to the insurance industry, with the prime ones being RMS, AIR & EQECAT. EQECAT catastrophe analysis models are already widely used within the Royal & SunAlliance group for the assessment of potential losses on their property book of business. Some brokers and reinsurers have also developed their own in-house models.

But whichever way insurance companies choose, they cannot afford to be left behind by their competitors by not investing in this new technology.

Modelling is now able to draw on the best geographical, scientific and computing developments and is becoming an art which is impossible to ignore for those with a stake in the reinsurance market.

These tools can provide enormous competitive advantages to underwriters who have learnt to use them effectively and can provide traditional underwriters with the ability to understand and manage highly volatile risks far more effectively than ever before. Reinsurers are also taking more interest in the systems because they, after all, have more to lose than most.

All companies have to keep an eye on their premiums but they need to know where they can keep premiums low in safe areas. The use of catastrophe models will improve the profitability of insurers, offer competitive advantages that result in lower cost of capital, and result in continued availability of insurance products.

Do IMIA members feel it would be worthwhile moving forward with this initiative and populating the model with data?

"Everyone wants an edge on their competitors," said EQECAT's UK marketing manager Dickie Whittaker in an interview for reactions in July 1997. "How do you get an edge? You get better data and use it more efficiently."

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