THE Review

WORLDWIDE REINSURANCE

A GUIDE TO CATASTROPHE MODELLING

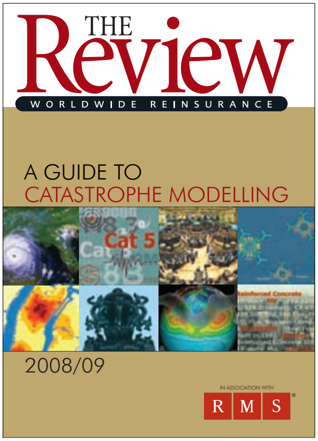
IN ASSOCIATION WITH

RMS®

CATASTROPHE MODELLING: A STEP-BY-STEP EXAMPLE

The basic framework for modelling perils is similar. This example illustrates the steps a user would take to arrive at an estimation of modelled losses from hurricane risk to a given location.

1. User enters location data and building characteristics into model
2. Model geocodes location to its geographic coordinates, identifying location's distance to coast
3. Stochastic event module defines event set for specified location and storm type
4. Hazard module generates event information including wind speed and storm surge to determine hazard intensity
5. Vulnerability module retrieves hazard intensity and generates average damage (ie, mean damage ratio) and associated uncertainty factoring in building characteristics (eg, roof type, construction type)
6. Based on the estimated mean damage ratio and uncertainty, financial module calculates losses based on building values and insurance policy terms
7. Financial loss is quantified for specified coverage(s) and line(s) of business based on the mean damage ratio and its variation.



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A Guide to Catastrophe Modelling

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A shifting spectrum

From floods in Australian mines, to the devastation left behind by Hurricane Ike, 2008 was an active year for insured catastrophe losses.

Even with the close of the North Atlantic hurricane season, the toll of natural disasters across the world continues to steadily mount.

By all accounts, we should steel ourselves for more of the same in the future.

Recent figures from one leading reinsurer put weather-related insured losses at a projected $40bn a year by 2010.

Of course the impact of global warming must be factored into the equation, adding to the increasing numbers of climate-linked events and their intensity.

Meanwhile, growing risks from terrorism, earthquakes and epidemics mean that in the near future insured catastrophe losses may hit over $100bn in severe years.

And if all that wasn't enough to contend with, another peril has been recently making its presence truly felt in the global credit markets – that of the financial crisis.

In a world of increasing uncertainty one thing is sure – bigger and more frequently occurring catastrophes are set to test the mettle of modelling companies in the extreme.

Over the past century, catastrophe modelling technology has progressed from little more than a collection of maps to the cutting edge application we see today.

But in the modern world, issues such as exposure data quality and risk mitigation have moved to the forefront, urgently requiring the attention of both re/insurers and policymakers.

Today, risk managers must contend with a mind-boggling array of perils for which they must attempt to make the best possible preparations.

Therefore, the art and methodology of modelling has never been so sharply under focus from all angles.

In such an environment, this guide's illuminating insight into the world of models and explanation of how they can aid with an ever shifting spectrum of risk, is most timely.

Ruth Lythe
Deputy Editor
The Review – Worldwide Reinsurance

Learning lessons from the unexpected

The human and financial consequences of catastrophes – whether these are earthquakes, hurricanes or floods, disease pandemics or terrorist attacks – can be devastating. However, risks are rising, as populations grow along exposed coastlines and mega-cities rapidly expand, and a warmer climate affects the frequency of some extreme events, such as wildfires and flash floods, as well as the intensity of hurricanes.

Catastrophic risks are inherently challenging to model, due to the limited knowledge about what determines the probability of extreme events occurring, and the need to understand all the potential pathways to loss. But models provide a mechanism to integrate and synthesise all the relevant science, data, engineering knowledge and even behaviour of claimants and insurers in the aftermath of a catastrophe. They also provide an environment and toolset in which all this knowledge can then be harnessed by re/insurers, property owners and policymakers to make informed risk management and mitigation decisions. While originally focused on managing risks in countries with established insurance industries, catastrophe models are also being used today to help create new risk transfer mechanisms in the developing world.

The more that users of catastrophe models understand about how they are developed and calibrated, the better enabled they are to make informed decisions on how to stress test their pricing and accumulation strategies

Uncertainty lies at the heart of risk modelling, and demands an appreciation at all stages, including in the quality and completeness of the exposure data fed into the models and in the interpretation of model results. The more that users of catastrophe models understand about how they are developed and calibrated, and the quality of the data on insureds, the better enabled they are to make informed decisions on how to stress test their pricing and accumulation strategies.

This guide aims to outline the foundations of catastrophe modelling by providing background information on how specific perils are modelled, as well as how the resulting loss metrics are used by re/insurers. It traces catastrophe modelling from its research beginnings to its present status as a core business application, and covers key issues related to best practice in the use of models within the world of re/insurance. For those in the industry who are aware of cat models, but are not familiar with the concepts or applications, I hope this provides an introduction to how probabilistic models can aid in making better risk management decisions for events we cannot predict but can prepare for.

Hemant Shah
President and CEO
RMS

Catastrophe modelling fundamentals

Catastrophe models can trace their roots back to the 1800s but today's sophisticated techniques are helping to manage 21st century risks, explain Patricia Grossi and Cheryl TeHennepe

ORIGINS OF CATASTROPHE MODELLING

Catastrophe modelling has its origins both in the field of property insurance and in the science of natural hazards. In the 1800s, residential insurers covering fire and lightning risk used pins on a wall-hung map to visualise concentrations of exposure. The common practice of mapping ended in the 1960s when it became too cumbersome and time consuming to execute.

The origin of catastrophe modelling also lies in the modern science of understanding the nature and impact of natural hazards. In particular, the common practice of measuring an earthquake's magnitude or a hurricane's intensity is one of the key ingredients in a catastrophe model. A standard set of metrics for a given hazard must be established so that risks can be assessed and managed. This measurement began in the 1800s as well, when the first modern seismograph, measuring earthquake ground motion, was invented and modern versions of the anemometer, measuring wind speed, gained widespread usage.

The reliability of such models depends heavily on an understanding of the underlying physical mechanisms that control the occurrence and behaviour of natural hazards

These two separate developments – mapping risk and measuring hazard – came together in a definitive way in the late 1980s through catastrophe modelling. Computer-based models for measuring catastrophe loss potential were developed by linking scientific studies of natural hazard measurements and historical occurrences with advances in information technology and geographic information systems (GIS).

While the birth of probabilistic catastrophe risk modelling occurred in the late 1980s, the use of such sophisticated, technical means of monitoring risks was not widely accepted until Hurricane Andrew made landfall in Southern Florida in 1992. As a result of the unprecedented losses, insurance companies struggled to stay in business and catastrophe risk management was changed forever. It became clear that a probabilistic approach to loss analysis was the most appropriate way to manage catastrophe risk. Hurricane Andrew illustrated that the actuarial approach to managing catastrophe risk was insufficient; a more sophisticated modelling approach was needed.

Today, catastrophe models are prevalent throughout the insurance industry, assisting re/insurers and other stakeholders in managing their risk from both natural perils and more recently, man-made catastrophes, across the globe.

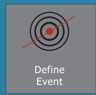
THE STRUCTURE OF CATASTROPHE MODELS

Models, by definition, provide a representation of complex physical phenomena. While it is generally agreed that a probabilistic approach is the most appropriate method to model the complexity inherent in catastrophes, probabilistic modelling itself is multifaceted. It requires simulating thousands of representative, or stochastic, catastrophic events in time and space; compiling detailed databases of building inventories; estimating physical damage to various types of structures and their contents; translating physical damage to monetary loss; and, finally, summing over entire portfolios of buildings. From the modeller's perspective, the task is to simulate, realistically and adequately, the most important aspects of this very complex system. Risk managers need to familiarise themselves with the underlying assumptions of the models and understand the implications and limitations of their output in order to utilise the results effectively.

Catastrophe models require substantial amounts of data for model construction and validation. In addition, the reliability of such models depends heavily on an understanding of the underlying physical mechanisms that control the occurrence and behaviour of natural hazards. While no one individual would claim to have a complete understanding of all the intricacies of these physical systems, scientists and engineers, aided by increasingly sophisticated instrumentation and computing capabilities, have accumulated vast amounts of information and knowledge in these areas. By incorporating this information, the sophisticated theoretical and empirical models currently being developed can reasonably simulate these complex phenomena.

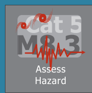
The basic framework for modelling the impacts of natural hazards on building inventories can be broken down into the following four modules:

- Stochastic Event Module
- Hazard Module
- Vulnerability Module
- Financial Analysis Module



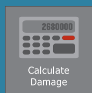
STOCHASTIC EVENT MODULE: DEFINING THE HAZARD PHENOMENA

The first stage of catastrophe modelling begins with the generation of a stochastic event set, which is a database of scenario events. Each event is defined by a specific strength or size, location or path, and probability of occurring or event rate. Thousands of possible event scenarios are simulated based on realistic parameters and historical data to probabilistically model what could happen over time.



HAZARD MODULE: ASSESSING THE LEVEL OF HAZARD

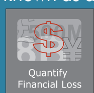
The hazard component of catastrophe models assesses the level of physical hazard across a geographical area at risk. For example, an earthquake model estimates the level of ground motion across the region for each earthquake in the event set, considering the propagation of seismic energy. For hurricanes, a model calculates the strength of the winds around a storm, considering the region's terrain and built environment.



VULNERABILITY MODULE: QUANTIFYING THE PHYSICAL IMPACT OF HAZARD ON PROPERTIES AT RISK

The vulnerability component calculates the amount of expected damage to the properties at risk. Vulnerability functions are region-specific, and vary by a property's susceptibility to damage from earthquake ground shaking or hurricane winds. Parameters defining this susceptibility include a building's construction material, its occupancy type, its year of construction, and its height. In catastrophe models for insurance applications, different vulnerability curves are used to estimate damage for a structure, its contents, and time element coverages such as business interruption loss or relocation expenses. Damage is quantified as a mean damage ratio, which is the ratio of the average anticipated loss to the replacement value of the building. This module also includes critical estimates of uncertainty around expected damage (ie, standard deviations).

Together, the stochastic event, hazard and vulnerability modules comprise what is traditionally known as a probabilistic risk analysis.



FINANCIAL MODULE: MEASURING THE MONETARY LOSS FROM VARIOUS FINANCIAL PERSPECTIVES

Catastrophe loss models can be thought of as one application of probabilistic risk analysis, characterised by their refinement of the financial analysis module. This module translates physical damage into total monetary loss. Estimates of insured losses are then computed by applying policy conditions (eg, deductibles, limits) to the total loss estimates.

MODELLED OUTPUT – THE KEY STATISTICS

The main output of a probabilistic catastrophe model is the exceedance probability (EP) curve, which illustrates the annual probability of exceeding a certain level of loss. Typically, EP curves are displayed graphically, but they can also be summarised by key return period loss levels. For example, a 0.4% annual probability of exceedance corresponds to a 250-year return period loss (ie, 1/250 = 0.4%).

One key risk metric derived from an EP curve is the average annual loss (AAL). AAL is an estimate of the annual premium needed to cover losses from the modelled peril(s) over time, assuming that the exposure remains constant. It can be calculated as the area under the EP curve or as the sum product of the mean loss and the annual likelihood of occurrence (ie, the event rate) for each event in the event set, and can be used to evaluate the catastrophe load portion of an insurance rating function. AAL is often referred to as the pure premium or 'burn cost'.

In addition, the uncertainty around the AAL also plays a role in measuring risk. For example, the coefficient of variation (CV), defined as the standard deviation divided by the mean (AAL), gives an indication of the variability around the AAL estimates. The statistic is a normalised measurement and is appropriate for comparing the volatility of one exposure to another.

As a simple example, consider the following two sets of numbers:

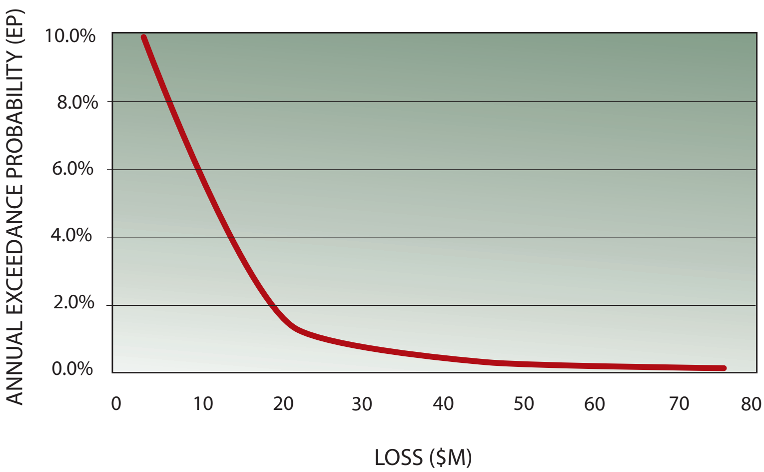
Distribution A: 20, 25, 30
Distribution B: 0, 25, 50
Both distributions have an average value of 25.

Distribution A has little variation from the average value, while distribution B has a wide variation from 0 to twice the average. Since the CV allows us to compare the volatility of one distribution to another, we should expect that the CV of distribution B will be higher than that of distribution A, which is true (CVDist-A = 0.2 and CVDist-B = 1.0).

APPLYING RESULTS TO MANAGE RISK

Modelled loss results provide valuable insight into the potential severity and frequency of catastrophic losses, and into the volatility of the analysed risks. The quantification of these components can then be used to assist companies with critical decisions around key issues such as portfolio management, individual risk assessment, and pricing. The following example shows how modelling output can be used to ascertain the

SUMMARY RESULTS OF AN EP ANALYSIS



After running an EP analysis, the summary results are as follows:

EP	RETURN PERIOD	LOSS AMOUNT ($M)
0.02%	5,000	76
0.10%	1,000	57
0.20%	500	48
0.40%	250	40
1.00%	100	28
2.00%	50	20
10.00%	10	4

compatibility of a company's portfolio with its risk appetite and to compare the potential volatility of two risks.

A fictitious commercial insurance company called AtRisk Property Insurance is exposed to hurricane risk in the state of Florida. AtRisk feels prepared to retain a loss up to $30m, which is 15% of its policyholder surplus. AtRisk realises that it cannot achieve 100% certainty and remain in business; however, being a conservative organisation, it would like to feel confident it will not exceed $30m from a single event in any given year 99.6% of the time.

AtRisk reviews the 1-in-250 year return period loss, which is the level where it has a 0.4% chance of exceeding $40m in a year, ie, a 99.6% chance of not exceeding $40m in a year. AtRisk is concerned that this loss is $10m higher than its previously stated target of $30m. Armed with this information, it can now identify options for moving closer to its goal, such as:

- Purchasing additional reinsurance
- Reviewing policy structures and data quality
- Diversifying so that premiums increase faster than losses
- Reviewing its risk appetite. ®

Patricia Grossi is senior research scientist, science and technology research.

Cheryl TeHennepe, CCRA is vice president, client training at RMS.

HOW MODELS CAN HELP TO MANAGE RISK

Mr Smith, an underwriter, is reaching his capacity limit in Miami-Dade County. He has just received two submissions for new business. Writing either account will mean declining any future business unless he gets further approval. Mr Smith asks the modelling team to provide him with hurricane loss estimates to help him determine which risk is more acceptable.

	Pure Premium (AAL)	Standard Deviation	CV
Account A	24,000	135,000	5.6
Account B	30,000	86,000	2.9

After considering a 15% expense load on the pure premium, Account A appears to carry a lower risk than Account B.

Account A	1.15* $24,000 = $27,600
Account B	1.15* $30,000 = $34,500

However, Mr Smith is also concerned with managing the year-on-year hurricane results for his portfolio, and is therefore apprehensive about basing his decision solely on average annual loss. Using CV as the comparative metric, he sees that Account A is almost twice as volatile as Account B. In addition to the 15% expense load, Mr Smith adds 20% of the CV to build a 'technical price' so that both average annual hurricane loss and volatility are considered in his analysis. Based on this new information, Mr. Smith decides to write Account B.

Account A	(1.15* $24,000) + (20%* $135,000) = $54,600
Account B	(1.15* $30,000) + (20%* $86,000) = $51,700

This example provides a simple introduction to the ways in which analytical methods can help to identify and manage risk. Model results and the data underlying catastrophe models can help companies with pricing, portfolio management, traditional reinsurance purchasing, alternative risk transfer, insurance and reinsurance design, portfolio optimisation, rating agency analyses and many other core business decisions.

MODELLING HURRICANE RISK

Models can simulate the entire life cycle of a hurricane, explain Josh Elllingson and Matthew Novak

A hurricane is a low-pressure cyclonic system with the lowest pressure at its centre, or eye, where its intensity potential is a function of the underlying sea surface temperatures (SSTs) and winds aloft, with respect to speed and direction, eg, vertical wind shear.

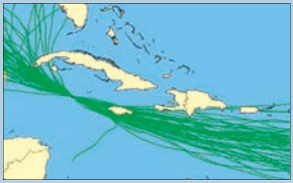
Hurricane catastrophe models simulate thousands of potential hurricane tracks based on atmospheric parameters and science, as well as the historical record, creating event sets used to probabilistically model possible outcomes over time from virtually any event. The storm tracks represent the entire lifecycle of a hurricane, from initial development, to potential transition and eventual decay.

To accurately capture the change, the model calculates wind speeds at at intervals ranging from minutes to hours depending on the forward speed of the hurricane.

MODELLING WIND SPEED AND STORM SURGE

To determine the amount of damage caused by wind at a location, the time-stepping process applies the peak gust wind speed recorded at that location.

To model the peak wind gust in a way that accurately reflects actual hurricanes, key parameters of hurricanes must be captured in the data: central pressure, the hurricane track or path, and the distance from the centre of the eye to the area of maximum winds, known as the radius of maximum winds (Rmax).



Stochastic hurricane storm tracks demonstrating the possible outcome of Hurricane Ivan in 2004

Rmax characterises storm 'size,' and can vary from storm to storm. Rmax indicates where the highest wind speeds are and thus where the maximum damage is likely to occur.

Models must also account for damage from storm surge – quickly-rising ocean water levels that can cause widespread coastal flooding.

ASSESSING DAMAGE

The track of the hurricane has a significant impact on the damage it inflicts, with the greatest damage occurring in areas closest to the eye of the hurricane. A location's distance from the coast is also an important factor, as storm surge can have devastating effects.

A building's vulnerability to hurricane risk is highly dependent on its structural characteristics. For example, a wood-frame dwelling has a higher risk of damageability from winds than a reinforced concrete building. Having detailed information on building characteristics improves the quality of the loss estimate.®

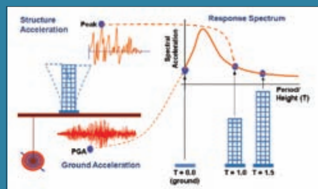
Josh Ellingson CCRA is senior director, client training at RMS.

Matthew Novak is senior account manager at RMS.

MODELLING EARTHQUAKE RISK

Models must take into account a range of measurements to gauge an earthquake's impact, say Sahar Safaie and Chesley Williams

There are two common parameters used to assess an earthquake's effects: magnitude, a quantitative measure of the amount of energy released; and intensity, a qualitative assessment of an earthquake's shaking effects at a location measured using the Modified Mercalli Intensity (MMI) scale. Whereas earthquake intensity decreases with distance from the epicentre, the magnitude assigned to an earthquake is location independent.



Spectral Acceleration: Buildings of different heights respond differently to the same ground motion because they have different vibrational periods

SIMULATING EARTHQUAKE EVENTS

The stochastic earthquake event set characterises the observed or scientifically modelled probabilities of earthquake size, frequency of occurrence and location.

There are two basic elements used to define an earthquake event set. The first is a geographic definition of fault source. The second assesses the probability of an earthquake occurring on each fault source, and the associated rates of earthquake occurrence for potential event magnitudes. To assess earthquake hazard, the model calculates the amount of ground motion at a particular location for every stochastic event.

Ground motion attenuation – the decay of ground motion intensity with distance from the event source – is also considered. The decay is characterised by an empirical function called an attenuation relationship, which is affected by factors including distance from the source and the geological environment.

FROM GROUND MOTION TO BUILDING DAMAGE

To assess structural damage at a location, earthquake vulnerability functions are used to model the relationships between ground motion and the level of damage. Damage calculations also utilise the acceleration response spectrum, which defines how buildings with different construction characteristics are expected to respond to a single ground motion. A building's response to ground motion at a site is directly correlated to the natural vibrational period of the building, which is influenced by the height, the structural system, and the building material.

Thus, when assessing building vulnerability to earthquakes, a building's structural characteristics such as construction type, height, and construction date play a significant role in the quality of the damage assessment. For example, an unreinforced masonry building is much more vulnerable than a reinforced concrete building. The building's construction date is also a considerable factor as it identifies the building code which has been followed in design and construction. ®

Sahar Safaie is product manager for America's natural catastrophe models at RMS.

Chesley Williams is senior project director, model development at RMS.

MODELLING TERRORISM RISK

Everything from modes of attack to counter terrorism measures are incorporated into terrorism models, explains Maria Lomelo

Intent, capability and opportunity influence the targeting strategy of major terrorist groups. Modellers begin by defining those specific areas and targets of greatest interest to terrorist organisations, and use the application of game theory to quantify attack likelihoods.

To prioritise potential targets, a terrorist group's ability to maximise the expected 'utility' of an attack is assessed by considering not only the potential economic loss and number of casualties, but also the target's symbolic or inspirational value.

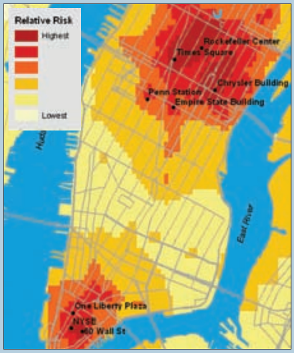
Increased security 'hardens' potential targets, decreasing the likelihood of attacks at those locations – but at the same time increasing the likelihood of attacks at less secure targets.

A number of representative attack modes ranging from conventional weapons to worst-case chemical, biological, radiological and nuclear attacks are incorporated into the model. Each type of attack has a relative likelihood of occurrence based on its logistical burden score.

ASSESSING THE PROBABILITY OF ATTACK

The likelihood of having multiple attacks make up a single terrorism event is also factored into the model. Attack multiplicity distributions are determined based on historical attack patterns, target type defenses, weapons availability, the chance of detection and expert opinion.

The likely number of attacks in a year is parameterised through assessments of the number of attempted attacks and the interdiction rates. Government response to an attack decreases the likelihood of successive attack.



Probabilistic assessment of relative terrorism risk for Manhattan

DETERMINING EXPECTED DAMAGE

Detailed analyses considering the effects of explosions, aircraft impact, fire, decontamination and spreading of chemical and biological agents through a population are performed to model the impact of potential terrorist attacks on building stock. Although vulnerability functions are derived based on building characteristics – terrorism risk is typically not mitigated through measures such as building reinforcement. The global nature of terrorism risk requires that mitigation factors involve activities such as increased security and other counter-terrorism activities. ®

Maria Lomelo is the director of client services, emerging risk models at RMS.

Exposure data quality

Hurricane Katrina propelled the importance of accurate exposure data to the top of the boardroom agenda, where it must remain, say Ajay Lavakare and Kenna Mawk

The quality of exposure data used for catastrophe risk modelling has been a growing concern for the insurance industry in recent years, triggered by the differences between modelled losses and actual claims experiences from the 2004-2005 Atlantic hurricane seasons. A post-mortem analysis of 2004 claims data by RMS (*see table*) highlighted the significant impact of poor-quality data on modelled loss results, and indicated that data quality issues contributed up to 45% of the gap between modelled and actual incurred losses. In the aftermath of Katrina, the topic has pushed its way firmly onto the boardroom agenda, as executives increasingly realise the detrimental effects of ignoring the details in the data.

THE IMPACT OF DATA QUALITY ON CAT MODELS

As science and technology continue to advance cat models have become more sophisticated and data hungry. They are now far more sensitive to higher resolution, location-specific exposure data, and results can change significantly based on the level of geographic resolution, property details and the characterisation of hazard at a location.

Modelled results are only as robust as the exposure data entered into them. In fact, when missing or incorrect information is enhanced, it is not uncommon to see loss estimates change by a factor of four on a single building (*see figure 1*). In the complex and probabilistic world of catastrophe modelling, exposure data quality is the one element of uncertainty in the models that can be controlled.

Coding a structure's exact location (ie, latitude and longitude) and physical characteristics (construction, occupancy, year built, height, square footage, etc), into a model yields a loss distribution with a significantly lower spread (ie, lower standard deviation) than if it were coded at the ZIP Code level with all physical characteristics coded as unknown.

REACHING THE BOARDROOM AGENDA

Improving data quality has become a pressing concern for many re/insurance companies as well as rating agencies, which take the view that if a company does not have control over issues that

CATASTROPHE MODELLING DATA QUALITY ISSUES DISCOVERED IN 2004 TO 2005 POST-MORTEM

Low-resolution location data:
Beachfront properties identified only at ZIP Code level
Incomplete building characteristics:
Unknown year built/construction class
Inaccurate coding of risks: Floating casinos coded as reinforced concrete buildings; light metal construction coded as steel frame
Miscoded policy information:
Coverage limits being used instead of actual values
Undervaluation.

impact the balance sheet – like data quality and modelling – they are unlikely to have rigorous internal controls.

However, it is not just the increased scrutiny from the rating agencies and regulators (eg, Solvency II) that is propelling the topic of exposure data quality from the engine room of the catastrophe modelling team to the boardroom. Many reinsurers are now differentiating cedants on the basis of the quality of their exposure data.

Also, enterprise risk management (ERM) disclosure and management best practices are calling attention to the quality of data that is at the heart of decision-making in increasingly analytic enterprises.

There is a strong feeling amongst the leaders in the insurance industry that the topic of data quality must be kept at the forefront of the boardroom agenda; otherwise, the next catastrophe may reveal the unintended consequences of an underwriting discipline that does not have data quality written into its rulebook.

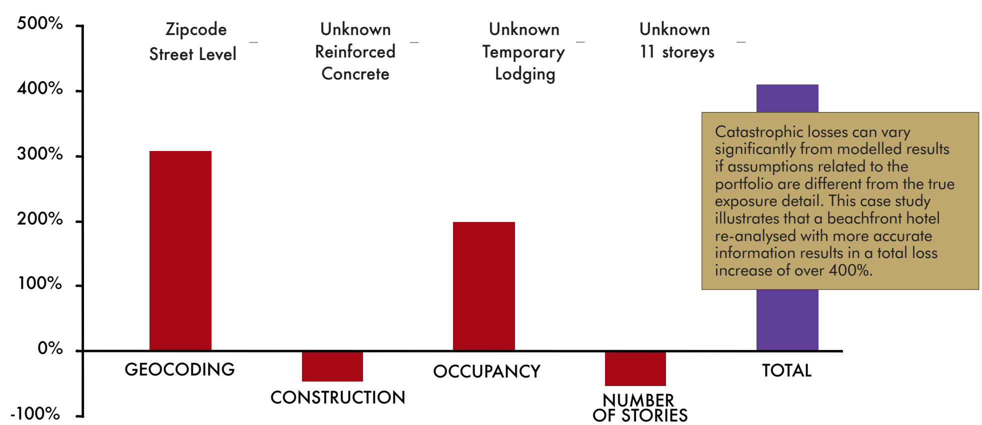
Modelled results are only as robust as the exposure data entered into them. In fact, when missing or incorrect information is enhanced, it is not uncommon to see loss estimates change by a factor of four on a single building

THE ADDED VALUE OF BETTER DATA

Those companies that get the data issue right not only benefit from reducing their operational risk, but also immediately realise advantages by improving their financial strength ratings and securing the right level of capital for regulatory purposes.

Data quality also informs the reinsurance placement and pricing process. For reinsurers, the quality of cedant data is a highly significant factor influencing their valuation of a company's ability to underwrite property cat risk. Reinsurers find risks more attractive if a data quality report indicates good controls around collection, maintenance and enhancement of data – to the extent that they are willing to provide pre-

FIGURE 1: CASE STUDY – BEACH FRONT HOTEL



IMPACT OF IMPROVED DATA ON HURRICANE CHARLEY LOSS ESTIMATE

Inaccurate coding of risks following Hurricane Katrina led to unexpectedly high losses

Image credit: EEMA/IllinoisPhoto.com

mium credits and extend additional capacity to insurers who have received a good report from an independent source.

THE ROAD AHEAD

Companies leading the charge in data quality processes are assessing the current state of their data to benchmark improvement efforts and seeking to understand the degree to which their modelled results could be affected by their data quality. Perhaps most importantly, though, these companies are trying to understand the costs and benefits of data improvement initiatives to determine which changes will have the most impact.

So, what difficulties does the industry face in its efforts to implement data quality best practices? Perhaps the most significant issue is the lack of a systematic measure of data quality, as there is currently no accepted industry standard to follow. This means that establishing proper objectives for a data quality drive, and incorporating the metrics into business decision-making can be extremely challenging.

To tackle this issue, ACORD, an insurance industry nonprofit association, has set up a Cat Exposure Working Group to develop a scalable, international exposure data standard and improve catastrophe data capture, transfer and storage.

Once an industry standard has been adopted, the next challenge is to institutionalise an agreed-upon data quality practice throughout the re/insurance industries that includes more rigorous metrics and a better understanding of the associated uncertainties, inaccuracies and biases on risk. A simple yet comprehensive framework for exposure data quality assessment can help to achieve this (*see box, left*).

Data is being increasingly being used by the insurance industry as a competitive advantage. Those companies that are able to demonstrate good data quality will see the benefits monetised by the market through insurance ratings, regulatory capital, and reinsurance – making it no surprise that the issue has risen to the executive level. ®

RMS DATA QUALITY FRAMEWORK

Consistency – Assessment of the extent to which data is presented in a consistent format and in the appropriate units for input into catastrophe risk models

Completeness – Assessment of the resolution (or granularity) of the data as well as amount and significance of unknown data

Accuracy – Assessment of data correctness as well as the following:

- Credibility: Whether the data is believable and logical
- Objectivity: Whether the data is coded in a manner that is unbiased, unprejudiced and impartial
- Comparisons with reputed sources: How well the data compares with data ascertained from reputed independent/third party sources.

Ajay Lavakare is senior vice president and managing director, data solutions at RMS.

Kenna Mawk is director, data validation solutions at RMS.

Risk mitigation and policy

Re/insurers must embrace risk mitigation if they are to weather the host of challenges facing the industry in the long-term, say Celine Herweijer, Nicola Patmore, Bob Ward and Michael Young

Risk mitigation offers the best solution to many of the challenges facing the global property insurance industry in both the public and private sector. A number of factors are driving up risks to homes and businesses, and, on current trends, insurance systems are going to be placed under increasing pressure, creating problems for both insurers and the insured.

The only long-term solution will be for the insurance industry to embrace and promote risk reduction, as well as risk transfer, mechanisms. Catastrophe models are tools that can help decision-makers in the public and private sector assess the relative benefits of different risk mitigation measures.

THE IMPACT OF MITIGATION ON VULNERABILITY

Risk mitigation, in its broadest sense, means acting to reduce or limit any of the components of risk: hazard, vulnerability or exposure.

Risk mitigation efforts tend to focus on reducing vulnerability, and to a lesser extent, exposure.

Current trends suggest that, without risk mitigation, the global insurance industry will face a growing crisis in the coming decades

In general, measures to tackle the vulnerability of properties to damage have been driven by a need to save lives and lessen injuries. In hazard-prone areas, engineers and builders often understand the need to make buildings able to withstand strong winds or ground shaking.

Building codes have been proven to reduce the impact of natural disasters. Although they may require greater expenditure during construction, in order to invest in safer designs and materials, these codes have been shown to be cost-effective by reducing the potential losses that might be suffered. Recent research in Florida after the active hurricane seasons of 2004 and 2005 showed that homes and businesses constructed in compliance with the most up-to-date building codes suffered the least financial loss by far.

Catastrophe models can show the reduction in losses that are possible through the implementation of building codes. Most of the individual features of a building that are specified by a code can be represented in a catastrophe model through secondary characteristics, such as roof sheathing attachments to reduce wind damage. These can be switched on and off as appropriate for each property in an exposure data set. Each feature reduces the vulnerability of a property when switched on, lowering the mean damage ratio and hence the loss. The model can also quantify the net benefit of combined secondary characteristics.

Insurers can distinguish ▷

properties they cover that comply with building codes or individual resilience or resistance measures by using the switches to compile profiles of the secondary characteristics. However, this means they need accurate and detailed information about the properties they insure.

Policymakers can also use catastrophe models, for instance, to investigate the impact of building codes on proposed new property developments. When combined with information about expenditure required to implement a code, catastrophe models allow costs and benefits to be weighed against each other.

INCENTIVISING MITIGATION EFFORTS

More attention is being paid to voluntary measures that property owners can take to make their homes and businesses more resistant and resilient to damage. In many places, public authorities operate incentive schemes to encourage homeowners to invest.

One of the challenges in making such schemes successful is to persuade property owners to make an up-front investment to accrue benefits over a number of years through reduced losses.

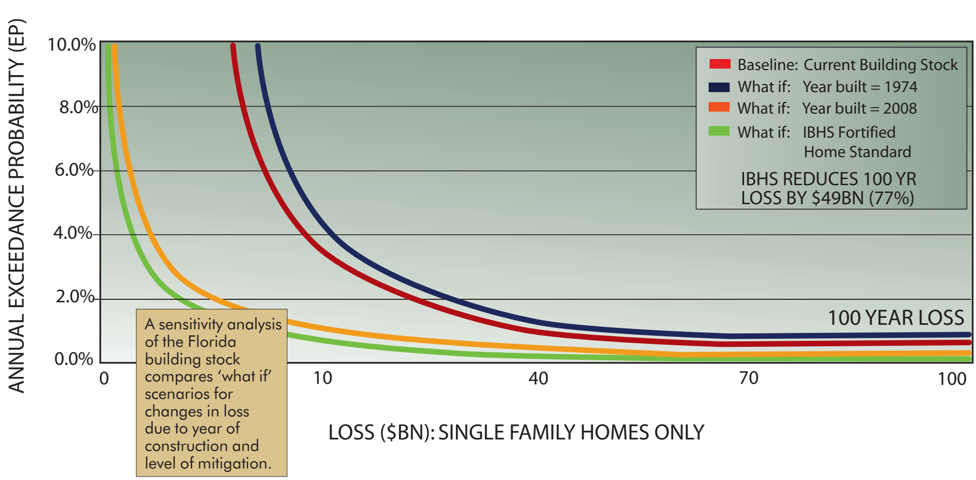
People might be reluctant to make these investments, particularly if they transfer the risk of losses through insurance policies. In these instances, insurers may find that it is cost-effective to provide incentives to their policyholders to lower their potential losses through risk mitigation, for instance by charging a premium that directly reflects the level of risk to which a property is exposed.

Insurers can use catastrophe models to calculate the annual average loss for each property to help inform premiums. Property owners who have invested in mitigation measures will experience lower losses and so can be charged lower premiums.

ASSESSING POPULATION GROWTH AND EXPANSION

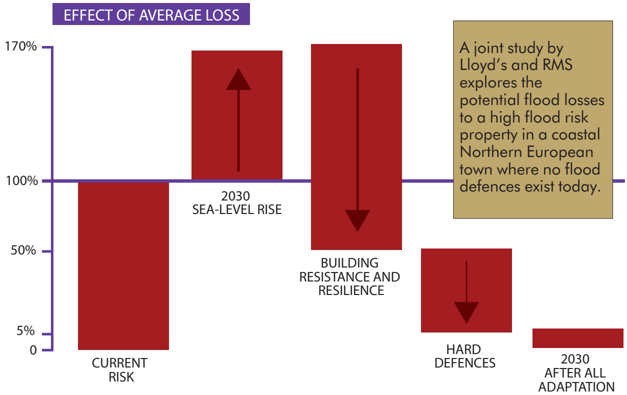
While reducing the vulnerability of properties is clearly an effective method of risk mitigation, rather less attention has been paid to the importance of lowering risk through decreasing exposure. With rising global population, more people are now living in areas that are exposed to the risks of natural disasters. In some countries, population growth has been greatest in

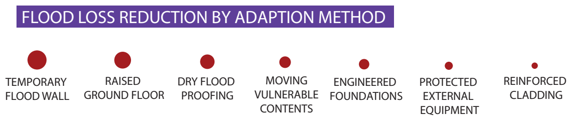
HARDENING THE FLORIDA BUILDING STOCK



A sensitivity analysis of the Florida building stock compares 'what if' scenarios for changes in loss due to year of construction and level of mitigation.

LLOYD'S/RMS FLOOD LOSS STUDY





areas of highest risk, such as along low-lying coastal areas that are subject to tropical cyclones.

It is clear that the development of communities in high-risk areas is often driven by perceived economic advantages. However, it is not clear that the risk of natural disasters is taken into account during development. Even in places that have been devastated by natural disasters, there does not seem to be much pause for thought before efforts begin to rebuild.

Insurers, property developers and policymakers can all use catastrophe models to quantify the risks to which new infrastructure might be exposed in particular locations. Models allow likely losses to be calculated in advance, and therefore aid in assessing the potential affordability and availability of insurance for new properties.

INFLUENCING CHANGE

Risk mitigation measures have taken on greater significance in light of the emerging understanding of the potential impacts of man-made climate change.

In many areas, weather-related hazards will increase, potentially causing risk to rise unless there is effective mitigation.

Measures to reduce and cope with the impacts of climate change are known as adaptation.

Catastrophe models can be conditioned to reflect possible future changes in hazard, such as bigger storm surges due to higher global sea levels. They can also show how rising hazards can be combated through adaptation to reduce the vulnerability and exposure of properties. The models can quantify how adaptation measures undertaken today to deal with future climate change can yield immediate benefits in terms of reduced losses from weather-related events.

Current trends suggest that, without risk mitigation, the global insurance industry will face a growing crisis in the coming decades.

Private re/insurers, informed by catastrophe models, can play a leadership role by helping society not only to transfer risks but also to reduce them. ®

☐ *Celine Herweijer is the director of the climate change practice at RMS.*

☐ *Nicola Patmore is senior research analyst at RMS.*

☐ *Bob Ward is a director of public policy at RMS.*

☐ *Michael Young is senior director, mitigation and regulatory affairs at RMS.*

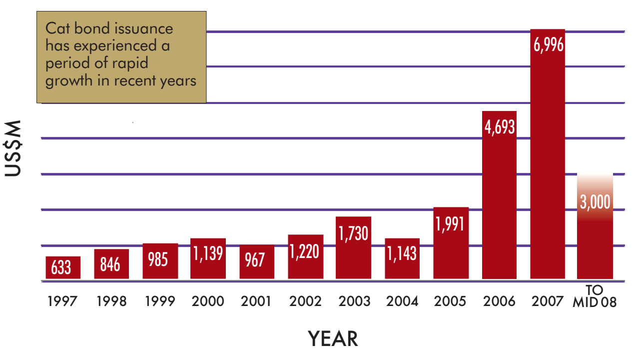
Capital markets transfer

The potential of transfering cat risk to the capital markets is yet to be fully tapped, say John Stroughair and Ben Brookes

The catastrophe risk insurance market is highly concentrated, posing a significant challenge for re/insurers who must attempt to diversify this risk to balance their portfolios. One need only look at Florida to confirm this – according to RMS models, Florida alone accounts for 80% of extreme hurricane risk in the US. Many insurers have significant exposure in Florida, but few have a profile that closely matches the average industry exposure to the state. This means that a solution based on state-level industry losses can leave many re/insurers exposed to significant levels of basis risk.

Transferring catastrophe risk to the capital markets instead of using traditional reinsurance provides access to a very large pool of capital. Because insurance risk is uncorrelated with most investment portfolios, catastrophe risk is an attractive proposition for capital markets investors. As issuers and investors have sought to take advantage of this, the last decade has seen a dramatic increase in the volumes of insurance-related risk transferred to the capital markets. The majority of this risk transfer has been accomplished through the use of insurance linked securities (ILS). If the risk being securitised is natural catastrophe-related then the ILS is often referred to as a catastrophe bond, usually abbreviated as a 'cat bond'.

CAT BOND ISSUANCE



CAT BOND TRIGGERS

The ILS market for cat bonds can typically be described in terms of four different types of cat bond triggers: indemnity, industry loss, parametric and modelled loss.

Indemnity – Risk transfer mechanisms triggered by direct insurance and reinsurance losses are often referred to as indemnity based structures. These have a clear benefit to the sponsor of the transaction – the precise loss experience is used as the trigger, and thereby the structure matches the underlying claims as closely as possible. From the investor standpoint, these types of transactions include not only natural catastrophe risk, but also insurance risk.

Due to the nature of the risk, indemnity transactions usually require a significant lead time for settlement following an event. As a consequence, indemnity transactions include significant extension periods – it can take over two years for a final loss to be determined.

Industry Loss – In some regions, especially the US, the availability of industry-wide insured loss surveying allows the structuring of industry loss based transactions. The simplest of these are industry loss warranties, whereby the total industry loss in a particular region is the trigger.

Industry loss-based structures are essentially a 'pooled indemnity' solution – the indemnity loss experiences of many companies are used to determine the industry loss estimate through surveys. As such, these industry loss structures have many of the same properties as indemnity transactions. For an insurer or reinsurer with a profile much like the industry as a whole, they can be a good mechanism for hedging insurance risk, whilst not linking directly to the re/insurer's own portfolio and indemnity loss experience. Should the re/insurer have a significantly different distribution of exposure to the industry, the industry loss estimates may be indexed according to regional market shares, providing a more tailored cover. However, there is likely to remain a material risk that the structure will not pay the precise loss amount experienced.

Parametric – A parametric transaction uses the direct drivers of physical damage in a catastrophic event as triggers. Transactions are usually based on an index of these event parameters, which is designed to correlate to modelled portfolio losses.

Event parameters are measured as the event occurs, and are generally published within a matter of days. Parametric transactions are therefore much more rapidly settled compared to other ILS structures, and as such can lead to greater liquidity in the marketplace.

Parametric structures remove insurance risk from the transaction structure – but these risks then become basis risk for the sponsoring re/insurer. Thus, there is a risk that the structure will not pay the precise loss amount experienced following an event.

However, the intuitive nature of a parametric index benefits investors – the probability of a region experiencing 100mph winds is much easier to understand than the probability of a particular insurer incurring $1bn of losses. Such transparency and reduction in 'insurance risk' should lead to tighter spreads and the potential to open the market to non-insurance specialists.

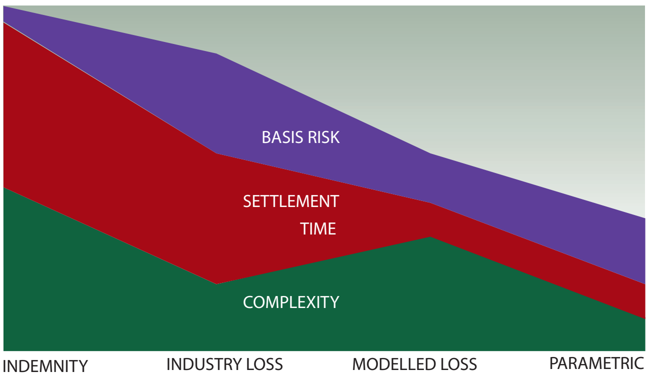
CAT BOND ISSUANCE

The mechanics of a cat bond transaction are more complex than a reinsurance contract, but it effectively serves the same economic purpose from the perspective of the ceding re/insurance company. The first stage in issuing a cat bond is to establish a special purpose vehicle (SPV), which provides reinsurance coverage to the sponsor of the transaction in return for regular premium payments, and funds itself by issuing a cat bond to the capital markets. The cat bond is structured to pay investors a regular coupon payment of LIBOR plus a spread, where the spread will be driven by the risk level of the transaction; the principal will be repaid at the end of the transaction so long as a triggering event (ie, a natural catastrophe such as a hurricane or earthquake) has not occurred.

The proceeds from the cat bond issuance are placed in a collateral account and invested in low-risk, highly liquid assets; the returns from these assets are swapped, through a total return swap, for LIBOR. Effectively, the counterparty on the total return swap is guaranteeing that the SPV will receive a return equivalent to LIBOR on its investments in the collateral account. Together the ceding insurer's premium payments and the swapped investment returns generate the required cash flow to meet the bond's coupon payments.

Cat bonds are structured so that principal repayment is reduced or even eliminated if certain trigger conditions, related to events that would cause significant loss to the sponsor, are met. If the bond is triggered, the SPV can reduce both its principal repayments and its regular coupon payments to the investors and use the funds in the collateral account to meet its obligations.

TRIGGER PROPERTIES



Modelled Loss – A modelled loss transaction applies a modelled representation of a catastrophe event to a notional portfolio that represents the underlying insurance risk in order to determine a loss estimate that is used as a trigger. In essence, modelled loss is a more complex and less transparent version of a parametric structure – the modelled event parameters form the representation of the event that is fed into a catastrophe model instead of an index function.

AN OPTIMAL SOLUTION?

Each type of transaction has its own associated advantages and disadvantages. Broadly, the overall utility of each can be assessed using three factors: complexity, basis risk and settlement time. Each factor has its own varying level of importance depending on the type of transaction .

At the simplest level, a sponsor's choice of the optimum solution comes down to a question of price versus basis risk, with price being a function of complexity, and the market appetite for the risk in question.

THE FUTURE OF ILS

Although less than 12% of natural catastrophe risk is currently transferred to the capital markets, an argument based on diversification suggests that the capital markets could hold significantly more of this risk – since most investment portfolios are not correlated with catastrophe risk, the return required to hold catastrophe-linked insurance risk is typically lower for a capital markets investor than for a reinsurance company. Why then, has investment in the capital markets remained limited?

Cyclical economic factors play a role, institutional barriers also exist – for example, the time and expense involved in understanding and issuing cat bonds may reduce the economic advantages of ILS in comparison to reinsurance.

Analytical firms like RMS who recognise the growth opportunity in the capital markets are working to lower these institutional barriers, thus reducing the cost and complexity of cat bond issuance. To do so, RMS has developed the Paradex suite of indices, which provides parametric solutions for perils such as hurricanes in the US and windstorms in Europe, in a standardised format.

Insurers and reinsurers are uniquely positioned to understand the relative risks and exposures associated with particular insurance portfolios, as well as the relative pricing requirements in order that such a portfolio may be profitable. However, re/insurers may be less advantaged in determining the likelihood of occurrence of the physical phenomena causing damage – the catastrophic hazard. As such, insurance linked securities provide a simple and efficient mechanism for significantly reducing the volatility of returns on an insurance portfolio. ®

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Ben Brookes is director, RMS Capital Markets.

New risk modelling frontiers

The cat modelling world is expanding its horizons to cover an even broader array of risks in future, explains Robert Muir-Wood

Since the early 1990s, the domain of insurance cat loss modelling has continued to expand.

The loss of the World Trade Center towers on September 11, 2001 highlighted that man-made catastrophes could be every bit as significant as natural catastrophes, prompting the development of terrorism risk models. Now modelling is expanding its frontiers to new classes of problems in life and casualty, for which the term 'catastrophe' is less familiar. Losses tend to accumulate more slowly over a longer timeframe, but with the potential for unforeseen correlations in loss across many independent insurance policies and lines of business, the consequences can become catastrophic.

Modelling these classes of catastrophe risk requires comprehending the structure of those processes that drive correlation. For many of the new classes of models, it is human biological processes such as the spread of viruses, toxicity and disease morbidity that determine outcomes. Then there are the drivers of human behaviour and choices that need to be represented in a model, as by using applications of game theory to infer terrorist actions.

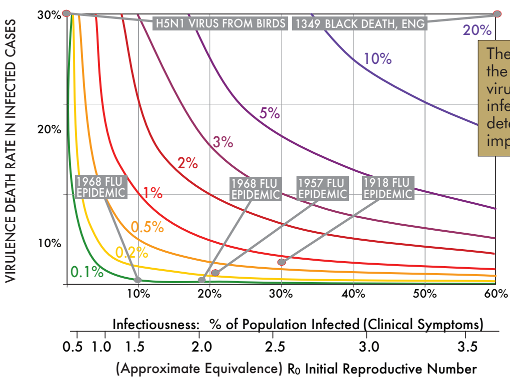
MODELLING PANDEMIC RISK

For life and health insurers, the most critical catastrophic events concern pandemics – major, widespread outbreaks of illness resulting in large increases in hospitalisation – in particular where accompanied by a rise in deaths and long-term disability. RMS began modelling pandemics in 2004 and developed a probabilistic pandemic influenza model in 2006 to 2007. Pandemic modelling also includes expectations around the effectiveness of the governmental response. The pandemic risk model was developed both for exploring potential peak health costs and outbreaks of excess mortality, and the correlation of these costs across a life and health insurer's portfolio.

The combination of the infectiousness and virulence of an infectious disease determines its overall impact.

The focus on influenza in 2006-2007 was in response to the rise and spread of the H5N1 strain of influenza among bird populations and the potential that a mutation might allow this deadly strain

IMPACT OF PEST PANDEMICS



The combination of the infectiousness and virulence of an infectious disease determines its overall impact.

REFERENCE MORTALITY Total death rate in a disease cycle to the entire population, without intervention to shift to human-to-human transmission. However, the most recent near-pandemic among humans was not influenza at all, but a previously unrecognised coronavirus that caused SARS. Work is therefore now underway to expand the RMS pandemic model to cover a wide range of new infectious disease outbreaks.

IMPACTS OF INCREASED LONGEVITY

Correlations of loss exist not only across those events that increase mortality, but also around changes in lifestyles and medical intervention that prolong lives. Traditionally, the life insurance and pensions field has been entirely dependent on actuarial analysis to set premiums and manage reserves. However, over the past 30 years the average human lifespan has continued to increase. For a pension awarded to a 65-year-old male in 2008, an extension of expected life by a single year increases the pension payments by 7 to 8%. Also the longevity of someone today may be determined by treatments currently only in development. There are many such medical interventions in the pipeline. Instead of modelling longevity trended from mortality statistics likely to be a minimum of 20 years out of date, disease progressions and probabilities can be modelled. A cure for one disease simply makes other diseases become larger contributors to mortality. While currently restricted for application by insurers, genetic information will also transform predictions around diseases and expected lifespans.

LIABILITY CAT RISK

Another area in which correlated loss is of critical concern to insurers is liability. Outbreaks of linked claims for liability are catastrophes in slow motion, working their way through an insurer's book of legacy business for many years. When a casualty insurer writes liability business she may have little idea of how to price the underlying technical risk in the contract. When a new area of litigation arises or new information about known risks emerges, an insurer's emerging risk committee will attempt to get new exclusions written into contracts, but by then it is often too late. RMS has teamed up with research economists and lawyers at the US-based RAND Corporation to develop modelling capabilities around casualty lines for all of these users, starting with product liability.

An area of risk that could benefit from structural modelling is the financial markets

This work has required a new vocabulary to be created around understanding the science of liability risk.

As insurers have to fund the defence of new lawsuits that fall within the terms of the insurance coverage, they are interested in identifying the earliest possible indications around new (and previously recognised) litagions.

LOOKING TO THE FUTURE

An area of risk that could benefit from structural modelling is the financial markets, which created a pyramid of over-leverage based on optimistic, historically calibrated statistical models without reflecting the potential systemic risk that existed across the market. One of the strengths of cat models is that the party ceding the risk also has to provide comprehensive information on all the individual properties and contracts contained in a portfolio. If mortgage-backed securities and the collateralised debt obligations (CDOs) derived from them, came with full details of all the underlying exposure, at individual property level, investors could analyse their own risk and correlation using probabilistic structural risk models linked across all the asset classes and vetted by the financial regulator. Using such an approach, the means through which cat modelling has enhanced the stability of the insurance industry can be applied to the financial sector. ®

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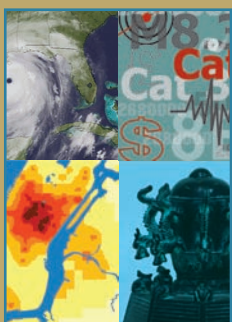

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