WINDSTORM INSURANCE ISSUES

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INSURANCE

Insurance is a system for sharing financial risk through the creation of a pool of funds into which subscribers make a regular payment (the premium) which is generally set on an annual basis. Insurance works best if the risk of an individual insured loss from within the premium pool is small, there are a large number of contributors to the pool, each insured risk is similar in magnitude of potential loss and is statistically independent of other insured risks within the pool, and the occurrence of loss is random, with statistical characteristics that remain stationary with time, or only vary slowly over time frames of the order of years.

Property insurance was originally developed to provide protection against large individual losses arising from building fires, which generally fit the tests of low probability of occurrence, independence and randomness. With houses and small buildings particularly, providing there is a reasonably large number of them insured in the pool, the other conditions also tend to be satisfied. Under these conditions the central limit theorem applies and ensures that annual total losses tend not to have large fluctuations, so that premiums can be set with a relatively high degree of confidence to ensure all losses will be met, administrative costs covered, some reserves set aside in the good years to cover the years when larger than average annual losses occur, and shareholders, in the case of private companies, get an adequate return on their investment.

As an example suppose a pool comprises 1,000,000 individual risks, for each of which the annual risk of occurrence of a fire loss is 1:1000, and the average cost of damage if a fire occurs is $50,000 with a standard deviation of $30,000. This will result in an average of 1000 properties from the pool being damaged by fire each year, resulting in an average annual payout from pool of $50,000,000 per year, with a standard deviation of about $1,000,000 - ie an average of $50 with a standard deviation of $1 per individual risk. This is a very manageable situation which an annual premium of the order of $75 would be expected to very adequately cover.

Unfortunately this ideal situation rarely exists. In most cases even with fire insurance the spread of property values will be large with a large number of properties of small value and a decreasing number of increasing value. This can have the effect of significantly increasing the annual variability, thus increasing the need for reserves or protection through reinsurance, which will thereby require increased premiums. The insurance industry has also widened the scope of property insurance to cover many other forms of losses. Some of these like theft have similar characteristics to fire losses, but some are fundamentally different, because they break the rule about independence and as a result can lead to extremely large losses from the pool from a single event. Losses of this type are known as catastrophe losses. Losses from tropical cyclones are one of the most severe forms of this type of loss.

WINDSTORM LOSS CHARACTERISTICS

While the occurrence of windstorms with time may be regarded as relatively random, individual windstorm losses would only satisfy the condition of independence of risks if the individual insured properties were far enough apart not to be affected by the same windstorm. In tropical cyclone prone areas there can be a high level of dependence within groups of insured properties located within 40 or 50 kilometres of each other. This can create a large problem for the operation of an insurance pool

Consider, for example, an equivalent cyclone insurance situation to the fire insurance example described previously. Assume the individual property risk is the similar, with the annual risk of a building experiencing a major damaging cyclone being 1:100, and of those that do experience such a cyclone the individual property damage cost averages \$5,000, with a standard deviation of \$3,000. Suppose the properties are all located in one community. The fund is now faced with paying out on average 5 billion dollars once in a hundred years. The variance in individual costs will be partly due to variability of resistance and partly due to variability of magnitude of the event. The latter component will not be subject to reduction due the central limit theorem so that if the two effects contribute equally to the individual variance the standard deviation of the payout could be of the order of \$2 Billion. There is a one percent probability that the community could be hit in the next year. How satisfactory would a \$75 per year premium be now when this would only produce a pool of \$75,000,000 per year. Who would pay the losses if a major cyclone loss occurred in the next few years, bearing in mind that due to population increase and increasing wealth the accumulated insured values in each community will continue to increase exponentially.

This simple example highlights the problem of catastrophe insurance and why insurers have become wary of insuring for tropical cyclones, even in apparently low risk areas, if there is a large accumulation. If a company had to retain all the risk itself it would be regarded as an uninsurable risk even though the individual risk might be very small.

The problem is not as serious in general for thunderstorms since these are smaller in extent, more common and widespread in occurrence, and more limited in intensity. However thunderstorms, and associated hailstorms, can still cause large variations in insured losses on an annual basis which an insurance company must be able to meet.

REINSURANCE

Insurance for tropical cyclones has only been made possible through the development of a secondary level of insurance known as a reinsurance. Through reinsurance, insurance companies, and other large corporations, are able to lay off some of their risk to international companies specialising in this area of risk financing. These companies are able to provide this service by operating internationally, accepting only a limited portion of the risk of loss from individual events, and covering a range of different types of risk.

Although there are a number of different terms used in describing the different types of reinsurance available, they can be split into two major sub-divisions, proportional reinsurance and excess of loss reinsurance. With proportional reinsurance a reinsurance company agrees to pay a specified proportion of the loss. With excess of loss reinsurance a reinsurance company agrees to pay a specified proportion of the losses above a specified level up to a specified limit.

Ignoring a major catastrophe like a cyclone, a company will experience considerable variability arising from occasional large industrial or commercial fires, severe thunderstorms and hailstorms, or bushfires. Non-proportional reinsurance is primarily used for covering large risks of this type against which the company may have inadequate reserves. Excess of loss insurance is intended for the extreme but rare catastrophic events like a tropical cyclone which may impose a loss that would far exceed normal annual property losses.

While the use of excess of loss reinsurance makes it possible for insurance companies to offer insurance for cyclones it is not without a cost. Even when spread throughout the world wide reinsurance industry, tropical cyclone losses are still highly variable on an annual basis, and therefore a risky business, for which a high price relative to the individual property risk has to be paid.

WINDSTORM INSURANCE RISK ESTIMATION

Historically catastrophe loss estimation has been based on extrapolation of past events, in combination with the subjective judgement of 'experts'. In a situation where extreme events are rare, where the nature of individual insured property is always changing, and accumulations of insured property are rapidly increasing in areas with short historical records, particularly in relation to insurance, and there is a competitive industry, this approach has a high potential for failure. This has been well demonstrated in the last 30 years.

From the mid-1960's to the mid-1990's the world experienced a benign period as far as major catastrophe losses were concerned. During this period insured values and their accumulations increased dramatically, but, with few major losses, catastrophe insurance was a profitable business, even though it was based on what was rapidly becoming out-of-date historical information. In the last decade this has all changed, as shown in Figure 1, which is based on data published by Swiss Re [1] of annual insured catastrophe losses from 1970 to 1994. The sequence of big losses from 1989, which were dominated by windstorm losses, has had a huge impact on the catastrophe insurance industry.

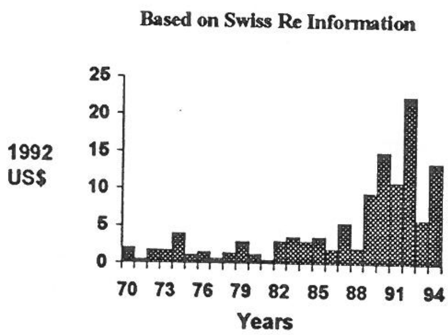

Figure 1 World Wide Catastrophe Insurance Losses

One impact has been a restructuring of the reinsurance industry with Lloyds of London declining in importance and a new centre, Bermuda, becoming a major source of catastrophe reinsurance. There has been a big increase in reinsurance premiums, and a decrease in the amount of reinsurance available for catastrophe insurance. Apart from paying more for reinsurance, insurance companies and corporations seeking reinsurance have had to demonstrate a much higher level of competence in estimating their potential catastrophe losses than in the past. This has led to the development of a new approach to catastrophe loss estimation - catastrophe loss modelling.

Catastrophe loss modelling is a technique, largely pioneered by engineers, of simulating on a computer the economic impact of large natural hazards such as earthquakes and tropical cyclones.

A typical catastrophe insurance loss model uses a geographic information system (GIS) to map the relevant physical parameters of the hazard and local geology and topography - the *hazard model* - and the characteristics of the insurance exposure - the *portfolio model*. It combines this with information on the vulnerability of typical insured property to the hazard - the *vulnerability model* - and information on the occurrence of the hazard in statistical terms - the *occurrence model*. Walker [2] has described the current state of development of these models and the way they are likely to be used once the industry appreciates their full potential value and develops the expertise to realise this.

The advent of catastrophe modelling has been coincident with, and indeed has only been made possible by, the revolution in information technology that is sweeping the world. The use of these models in combination with these developments in information technology is expected to revolutionise catastrophe insurance.

CATASTROPHE INSURANCE AND THE INFORMATION REVOLUTION

The traditional relatively crude approach to catastrophe insurance can be largely explained in terms of industry economics. Because the value of annual catastrophe risk per policy is so small the amount of time and resources that can be devoted to its analysis and application per policy is small. Before the age of computers the cost of manually recording information on catastrophe losses, analysing it, storing it, and recalling it, made it uneconomic to treat natural catastrophe insurance in detail. The situation was further aggravated by the fact that when a catastrophic event occurs resources are stretched and it has usually been deemed expedient to dispense with detailed recording of loss information. Relatively low levels of catastrophic losses over many years during which catastrophe insurance was very profitable also acted as a disincentive to expending too much effort on the estimation of catastrophe insurance risk.

This situation has now changed. The computer and associated telecommunication networks are underpinning a revolution in information technology that is changing the whole economics of information processing. Historically the processing of raw information to generate customised information for the consumer has been largely a manual exercise. The information revolution which essentially began with the advent of the digital computer is changing this, although it has taken the advent of networked computers to induce the revolutionary impact. Information processing is largely associated with the service industries, of which insurance, along with engineering design and education, is a typical member.

The information revolution is set to have the same impact on information based service industries as the industrial revolution had on manufacturing. As a result of the industrial revolution machines largely replaced manual labour in the manufacturing of goods. As a result of the information revolution networked computer based systems will largely replace manual labour in the provision of information based services. Students will learn from computers, not from a teacher in the classroom. Insurance will be purchased from the internet in a two way communication which will require the customer to provide the information on the risk to be insured. The computer system will use this information to rate the risk, determine if it is acceptable, if so specify the premium and the any other conditions, and provide the means for the consumer to agree to the policy and pay the premium electronically.

Up until now it has not been general practice to rate individual catastrophe risks. The costs of doing so manually were too prohibitive. But catastrophe modelling and other developments in insurance information systems will change this. Without individual rating of risks, all risks for a particular hazard in a region have been treated the same, and insurance has been a disincentive to mitigation - Walker [3]. With rating, the premiums and other conditions can reflect the individual risks and insurance can become a real incentive to mitigation.

IMPACT OF CATASTROPHE MODELLING ON WIND ENGINEERING

Historically the insurance industry has had a very limited impact on wind engineering. The insurance industry has supported the development of improved wind resistant requirements, and benefited from them, but it has not been a driving force in their development.

The development of catastrophe modelling is changing this. It is doing it in two ways. In the first place catastrophe modelling of windstorm events is heavily dependent on wind engineering expertise. Secondly the ability to rate individual properties in terms of risk provides the means for insurance to become an incentive for mitigation, and thus a force in relation to the design of wind resistant buildings.

Wind Damage Loss Modelling

Current catastrophe modelling of insured losses from wind is still at a relatively crude stage of development despite the apparent sophistication of the models. The reason for this is the limitations of knowledge about the input variables.

Cyclone modelling is relatively well established but wide differences in output from apparently similar studies suggest that there is still much to be done to achieve highly reliable results.

The basic hazard model of cyclone winds that is used is one developed for cyclones over the ocean. There are many arguments about the appropriate values to use for the parameters in this model, but of greater importance may be that it is assumed that the model also applies over land. Topography and terrain have a strong influence on local wind speeds, but most of the models use relatively crude approaches to taking this into account. One of the problems is the difficulties in developing suitable algorithms to handle complex topography and terrain in a practical manner. Maybe the application of pattern recognition techniques might be the answer.

The occurrence models in Australia are largely based on records obtained since the advent of weather satellites in the 1960's and assume that random fluctuations in cyclone occurrence over this period of time are stationary. However there is increasing evidence that this is not so and that there are natural variations in climate - quite apart from Greenhouse effects - that have a much longer time frame than 30 years. In 1918 Queensland experienced two Category 4 cyclones crossing the coast. During the last 30 years there have been none, and during almost half this period the weather has been under the influence of abnormally persistent El Nino conditions which reduce cyclone activity in the Australian area.

The vulnerability models being used are very crude because they are based on very limited information. There is some information available from engineering reports of damage but almost none on insured losses and their relationship to the damage - and it is not a simple one to one relationship. The next major event is potentially the best source of data for improving, in the short term, the quality of the vulnerability models used for Australia. The full potential, however, will only be realised if there is good planning before the event occurs. There appears to be two fundamentally different approaches that can be adopted. One is the essentially empirical approach of relating losses directly to estimated wind speed and building category, and the Insurance Council of Australia is putting in place a scheme which will assist in this. The other approach would be to adopt the more scientific approach of developing models of the failure of buildings as a function of the wind speed and the consequential economic losses, and use the occurrence of the event to calibrate these models.

Portfolio models are also currently very crude particularly in their characterisation of buildings. There is a need for a standardised system of classifying buildings in terms of their different vulnerability characteristics to wind. A common system would mean that when losses occurred the data could more readily be used to improve the vulnerability models, and would also make the portfolio models more portable between different catastrophe models.

Thunderstorm modelling, including the effect of hail, is still in the development area. It is an area of increasing interest to insurance companies and there is likely to be a significant investment in research directed at the development of the component models during the next year or two.

Upgrading Existing Structures

Cyclones Winifred and Aivu clearly demonstrated that wind damage losses in tropical cyclones would be dramatically reduced if all buildings performed as well as those built to current codes. In almost all communities buildings which do not conform with the principles of modern wind resistant design pose a very high proportion of the total risk. Where the accumulation of these is large and the cyclone risk is significant these may become uninsurable in large numbers.

One solution is upgrading older buildings. However it is expensive to fully upgrade a building to current standards.

Upgrading to current standards is however not the only option. Any upgrading that will significantly reduce insurance losses is worthwhile, and the insurance industry is likely to recognise this, providing there is a reference standard against which it can be certified, and the industry can be convinced that the upgrading will be effective. There is a large difference between the potential losses from many existing properties in a major event, and what they would be if the buildings were designed to current standards. Less costly intermediate levels of upgrading that will significantly reduce losses may be a much more cost-effective option in many cases. To be useful to the insurance industry, however, the intermediate levels need to be standardised.

This approach was pioneered for housing in Fiji in 1985 following cyclones Eric and Nigel with the development of a partial upgrading standard [4] that became the minimum acceptable level for obtaining cyclone insurance. Currently the Insurance Council of Australia is developing a more comprehensive set of partial upgrading standards for application in cyclone areas of Queensland. This provides for five levels of structural performance, with Level 1 corresponding to existing older housing built to pre-1970 standards of construction, and Level 5 corresponding to housing built to current standards. Level 2 prescribes simple perimeter tiedown systems which are expected to reduce potential Level 1 losses by at least 35 percent on average, Level 3 prescribes detailed upgrading systems which are expected to reduce Level 1 losses by 50 percent on average, and Level 4 requires engineered upgrading to specified criteria which is expected to reduce Level 1 losses by at least 70 percent on average. Construction or full upgrading to current standards (Level 5) is expected to reduce Level 1 losses by at least 85 percent on average. It will be a standard for use by the insurance industry on a voluntary basis, but in conjunction with the catastrophe modelling systems being developed to individually rate buildings at point of sale, it will provide insurance companies with a powerful tool to reduce accumulations of exposure through incentives to upgrade construction.

There is a need for similar standards to be developed in respect of small commercial and apartment buildings in respect of tropical cyclones. Such developments may not stop at Level 5. Where consequential losses to contents or from business interruption may be large, and could be reduced significantly by a higher level of structural performance than required by current standards, it is conceivable that there could be a need for a Level 6 standard as well.

CONCLUDING REMARKS

An historic change is occurring within the catastrophe insurance industry, of which the emergence of catastrophe loss modelling is just one sign. This change could have significant implications for the building industry, and especially wind and earthquake engineering, for it could see the development and implementation of standards focussed on insurability becoming more important than standards focussed on regulation, particularly in relation to determining appropriate levels of structural performance from a cost-benefit point of view. This would involve a major cultural change for many engineers

In relation to catastrophe loss modelling the development of rational vulnerability models is one of the big current structural engineering challenges. Structural reliability theory is reasonably well advanced, but it has been primarily developed in terms of identifying the boundary between failure and no failure of a component or system. Statistical modelling of the financial consequences of structural failure has not been part of this approach to date. This is what is needed to underpin the development of rational vulnerability models. Instead of just focussing on the point of failure, structural models are required that look at the consequences of failure, especially the financial ones, including business interruption. It should be possible to develop vulnerability models based on such an approach which can be calibrated against observed losses. Such models should prove much more reliable than the empirical models currently used, especially in regards to portability from one region to another. But such modelling will require wind engineering researchers to extend their interests beyond the study of purely physical phenomena - another cultural change that some might find difficult to manage.

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