Akhtar & Hasan (Pvt) Ltd
Actuaries

3rd Floor (Annexe), State Life No 1 Building, Chundrigar Road, Karachi 74000, Pakistan
Phone (021) 111-00-00-53 Fax (021) 3241-7810 E-Mail actuaries@akhasan.com

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Catastrophe Events – A Challenge

Some actuarial aspects

by
Samee-ul-Hasan
FIA, FPSA, FCII, FLMI, ASA
Consulting Actuary
Akhtar & Hasan (Pvt) Ltd, Actuaries, Karachi

Ladies and Gentlemen, Assalamu aleykum, I wish you peace

Introduction

Catastrophes have a big impact. But their number is relatively small. So they present great challenges to insurers, re-insurers, actuaries and regulators, which is the subject of this conference. We should look beyond our insurance industry, and also discuss challenges to society as a whole.

2.Classification by IAA's Solvency Working Party of Risks to insurers

The Solvency Working Party of the International Actuarial Association (IAA), in its report of February 2002, listed the following categories of risks to which an insurer is subject:

(a) Underwriting risks: "Risks that the product design and/or underwriting process were flawed, that the premiums charged proved inadequate, the retention and reinsurance arrangements were unable to with-stand events that the technical reserves proved to be insufficient. **Risks arising from random fluctuations in claims also fall in this category.**"

(b) Credit risks: Risks that counter-parties like re-insurers and co-insurers default or their credit-worthiness is down-graded, [other details not relevant today].

(c) Market risks: [Details not relevant today]

(d) Operational Risks: [Details not relevant today]

(e) Event Risks: These include unexpected law suits, unexpected bad publicity, **major disasters like earthquakes and floods,** changes in laws and regulations and political actions by governments.

"Random fluctuations" are included in Underwriting Risks. But "Major disasters like earthquakes and floods", i.e. catastrophes, are included in "Event Risks."

3. Solvency II requires Life and Non-Life insurers to include catastrophe component in Solvency Capital

"Solvency II" says that the solvency capital of Life and Non-Life insurers should include a component to deal with catastrophe risks. Catastrophe risk is defined as follows:

> "the risk of loss, or of adverse change in the value of insurance liabilities, resulting from significant uncertainty of pricing and provisioning assumptions related to extreme or exceptional events (non-life/life catastrophe risk)."

Solvency II relates to Europe. But the above requirement seems sensible, irrespective of regulatory requirements.

4. Framework of today's discussion

These statements encourage this paper to lead up to catastrophe risks, in the following steps:

Law of Large Numbers
Random fluctuations
Catastrophes
Mega Catastrophes

This paper primarily relates to the catastrophe exposure of a direct insurer's retained business, net of all proportional and non-proportional re-insurances. It does not specifically discuss the following subjects:

Special problems that Re-insurers may have in handling catastrophes.
Risks of default or down-grading of re-insurers and co-insurers.
Health Insurance.
Taxation.

Portfolios where Law of Large Numbers operates to a substantial extent

5. Law of Large Numbers

Suppose we toss a coin once. We don't know which way it will fall. It could be heads or tails. But suppose we toss a coin a thousand times. Then we are confident that approximately 50% will come up heads, but with some variation. And if we toss it a million times, then almost exactly 50% will be heads. The variation from 50% would be negligible.

This illustrates the Law of Large Numbers, which Barron's Insurance Dictionary states as follows:

> "The greater the number of exposures,
>
> (a) the more accurate the prediction;
>
> (b) the less the deviation of the actual losses from the expected losses; and
>
> (c) the greater the credibility of the prediction"

6. Illustration of Law of Large Numbers at work: Pakistan's NADI scheme

Pakistan introduced a National Accidental Death Insurance (NADI) scheme in 1986. This provided accidental death cover to the whole population of bread-winners between the ages of 20 and 60. Murder was deemed to be an accident.

If an insured bread-winner was killed by an accident, his or her family received Rs 15,000.

The premium was paid by the Federal Government. Tens of millions of individuals were covered with a uniform sum insured. The Law of Large Numbers certainly operated in respect of "normal" accidents. Random fluctuations in the number and amount of claims could be ignored.

But the actuaries who designed the scheme were aware of the potential of catastrophes, especially earthquakes. So deaths arising from any event which caused more than 5,000 fatalities were excluded.

This shows that even portfolios with millions of risks cannot operate solely on the basis of the Law of Large Numbers. **Almost every portfolio is exposed to catastrophic risks.**

The scheme was discontinued in 1989. Fortunately, no catastrophe took place while it was in force.

Portfolios where Law of Large Numbers does not operate, and random fluctuations are important

7. Portfolio of Fire Policies in Pakistan

Fire Portfolios in Pakistan cannot rely on the Law of Large Numbers, because the number of policies is relatively small. Random fluctuations are important for this reason, and also for the following reasons:

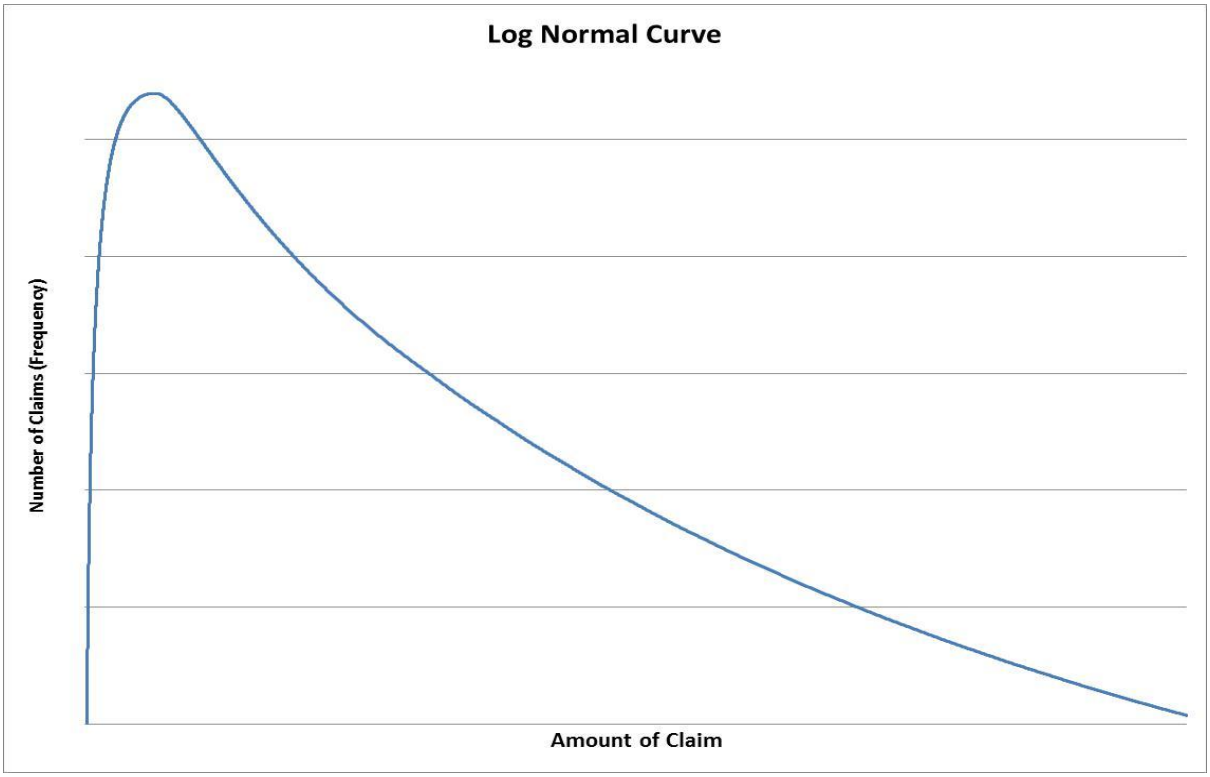
(a) Multiple risks are covered, including Fire, Earthquake, Atmospheric Disturbance and others.
(b) There is a great variation in the sum insured
(c) Most claims are partial claims, and there is a great variation in the ratio of claim to sum insured.
(d) Accumulation or Concentration of risks.

In 1978, a study was done of the gross amount of all claims paid by all insurers under Pakistani Fire policies, in respect of events occurring during the 4 years 1973 to 1976. "Gross" means before reinsurance recoveries, and includes directly related claim expenses. Payments on different dates in respect of the same event, and payments by different co-insurers, were aggregated. After this aggregation, the number of events reduced to 3,218.

We believe this was the first actuarial study carried out in respect of Pakistani non-life insurance. The results proved useful in many ways.

Probability Density Functions (pdf's) based on past claim data can be used to study random variations.

The log-normal pdf function gave the best fit, but not a perfect fit. A conceptual graph is shown below.



There are many small claims. As the claim size increases, the frequency reduces. Such a curve has the advantage that even if no actual claim occurred in a certain claim range, the curve will generate a number. This will enable the insurer to reckon with random variations.

Theoretically, the tail of this pdf can stretch to infinity. Actually, the upper limit to claims on gross account from a single event was the total sum insured in the location where there was the maximum Accumulation or Concentration of risk. Suppose this total is Rs *x* billion. If we follow the tail to the right, we will come to a point where the claim amount is Rs *x* billion. This could result only from a catastrophe. But the probability of a random variation at that point in the curve will be so low as to be outside practical possibility. Unfortunately, catastrophes are practical possibilities. Therefore, we cannot rely on pdf curves based on non-catastrophic losses, like the above, to study catastrophes.

Catastrophes

8. Classification of Catastrophes

Ms J.E. Lockett submitted a comprehensive paper on 18 March 1980 entitled "Catastrophes and Catastrophe Insurances" to the UK Institute of Actuaries Students' Society (now called the Staple Inn Actuarial Society). Despite the elapse of over 30 years, her paper is still well worth reading.

This is how she classified catastrophes:

`

> "(a) *Natural hazards.* Storm, particularly windstorm, including hurricane and tornado; flood; bush fire; volcanic eruption; earthquake, both shock and ensuing fire damage.
>
> (b) *Man-made hazards.* Riot; some cases of aviation or marine losses; pollution, particularly of the seas, or generally by chemical accident or explosion etc.; some types of product liability; nuclear accidents."

From the point of view of society as a whole, Wars should be added, as man-made catastrophes.

9. The Law of Large Numbers, and Pdf curves, do not apply to catastrophes

By definition, the Law of Large Numbers does not operate for catastrophes. As mentioned above, pdf curves based on non-catastrophic losses, used to study random variations, are not useful for catastrophes. Non-catastrophic losses under different insurance policies are usually independent of each other. But catastrophic losses are generally not independent of each other, because the area where a catastrophe strikes is frequently large enough for it to strike at different insured risks.

So how do we handle the catastrophe risk?

10. Exclusions

Exclusions from coverage constitute the first line of defence for insurers. This audience is familiar with exclusions of wars, radioactivity, nuclear weapons, and other perils likely to result in catastrophes.

We have already mentioned the exclusion in Pakistan's NADI scheme of events which result in more than 5,000 deaths.

Instead of a total exclusion, there could be a high deductible, coupled with a low indemnity ratio for the damage in excess of the deductible.

Exclusions can be contested in the courts, so they are not a total protection.

11. Retentions, Reinsurance, Capital adequacy

The second line of defence is always to keep catastrophes in mind in the following areas:

Retentions, Reinsurance, Capital adequacy

Particular attention should be paid to under-writing and retentions in locations where there is a large risk Accumulation or Concentration.

12. Historical approach to estimating the catastrophe risk

As with all insurance, the "frequency" and the "intensity" of the claim must both be estimated for scientific rate making, reserving and determining Solvency Capital.

One method of estimating the catastrophe risk is to go back over a period (the longer the better, and not less than 10 years) and study the experience of catastrophes. Unfortunately, this suffers from the drawback that

"the future ain't what it used to be". (Yogi Berra)

Ms Lockett's paper contains the following passage:

> "…earthquake records in Japan from 1498 are used in rating. Four-hundred and eighty years may seem to be a very long period, but, for any one location, few large earthquakes will have affected it, even in such an active area. Therefore, it may be unwise to attach full credibility to any estimate of return periods for severe events, even based on such long past records. Also, there is no way of knowing whether the activity indicated over the available data period can be considered representative of levels of activity which may occur in any future period. Similar problems affect any data available for other hazards in other parts of the world."

However, despite its drawbacks, the historical approach could be useful for some cases.

13. Catastrophe modelling

The field of "catastrophe modelling" has developed, to study the frequency of catastrophes, and the intensity of losses caused by them. Data from past catastrophes is used to generate catastrophic scenarios, by mathematical modelling and/or computer simulation. These models draw on the skills of "seismologists, meteorologists, other physical scientists, engineers, mathematicians, statisticians, actuaries, and computer technology specialists"[1]. Instead of a single result, such models can generate a range of results.

The Catastrophe Management Work Group of the American Academy of Actuaries, in their report of June 10, 2001, refers to the increasing use of such models for hurricanes and earthquakes.

The results of this modelling deserve attention and respect.

However, an eminent British actuary, the late F.M. Redington, made the following remarks in his paper "An exploration into Patterns of Mortality" (presented to the UK Institute of Actuaries, 24 Feb 1969, JIA Vol 95, Part II):

[1] Quotation from June 10, 2001, report of Catastrophe Working Group of American Academy of Actuaries

> "I am very conscious of the fact that if you manipulate any statistics for long enough you can always find patterns in them. Only time will tell if these patterns are reflections of the truth or a transient trick of the light. In the meantime the only test is commonsense."
>
> "We must be cautious because the data is scanty, and because all these figures are measurements at the tip of the waving bough."

We do have to make estimates for the catastrophe risk, through logical procedures But only time will tell how good our estimates were. And we have to update and revise them periodically.

14. Use of estimates of the catastrophe risk

A. Use them for premium construction

Under A, the risk component of the premium would consist of two parts:

Cost of "usual risks" including random fluctuations + Cost of catastrophe risks

Considering the infrequency of catastrophes, the second part should be accumulated for 20 or more years to build up a catastrophe reserve.

B. Use them for calculating technical reserves and/or towards calculating the Solvency Capital

As mentioned earlier, Solvency II requires the Solvency Capital to include a catastrophe component. If an entity does this, it may have to consider how to avoid duplication or partial duplication with A.

15. Alternative system to use estimates of estimates of the catastrophe risk

In preference to the above, the following is perhaps a more straightforward and internally consistent system of using estimates of the catastrophe risk.

Step1: Use the estimates to calculate the catastrophe risk component of Solvency Capital. Solvency II requires other components to be included, in addition to the catastrophe risk.

Step 2: When constructing a premium, include the following components:

> Cost of "usual risks" including random fluctuations + Contribution to the annual cost of remunerating the Solvency Capital.
>
> The second term replaces "Cost of catastrophe risks".
>
> Of course, there will be other components in the premium, like commission and expenses.

This system would avoid

(i) the administratively complicated task of segregating the catastrophe components of office premiums, and setting them aside for 20 or more years to build up a catastrophe reserve.
(ii) the tax and accounting problems which may arise from that segregation and setting aside.

It would enable unearned premium reserves and unexpired risk reserves to be calculated in the normal way.

It would comply with Solvency II, because there would be an adequate catastrophe component *ab initio* in the Solvency Capital, rather than waiting for this to build up.

It would be consistent with the IAA's Solvency Party's listing of insurers' risks.

Mega catastrophes

16. Scale, causes, and examples of mega catastrophes

These kill and injure very many people, and cause enormous property damage, resulting in huge consequential losses. The scale is national or international.

Mega catastrophes may result from hazards listed in Ms Lockett's paper.

Or they may be Wars. These man-made mega catastrophes may persist for years. In the past, they caused vastly more deaths and property damage than Ms Lockett's hazards.

The following Table gives examples of mega catastrophes.

No	Year(s)	Where	Cause	Deaths	Property Damage	Source
1	1939-1945	Europe	World War II	40 million, incl 20 million non-combatants	Not known	Various
2	1939-1945	Outside Europe	World War II	14 million, incl 11 million non-combatants	Not known	Various
3	2005	Pakistan	Earthquake	73,338	PKR 300 billion	fritzinstitute.org
4	2007	Pakistan	Benazir Assassination	100 +	PKR 73 billion	Wikipedia
5	2010	Pakistan	Floods	1,985	Over PKR 1 trillion	Pakistan Economic Survey, 2010-11

Only a small part of the property damage caused by item No 4 was covered by insurance. Apart from this, insurance coverage for the mega catastrophes listed was zero or negligible.

17. WWII's effect on Germany

WWII killed 3,350,000 combatants and 3,269,000 non-combatants, a total of 6,619,000, which was 9% of Germany's 1938 population[2]. The property damage was enormous. A character in Lee Child's novel "The Enemy"[3] says:

> "No nation ever lost a war the way Germany lost. Like everyone, I had seen the pictures taken in 1945. *Defeat* was not a big enough word. *Armageddon* would be better. The whole country has been smashed to powdered rubble by a juggernaut."

The Reconstruction Loan Corporation was set up to finance urgent reconstruction projects. Among other things, this Corporation allocated Marshall Plan aid, which totalled US $ 1.45 billion (= approx US $ 15 billion in today's money) during 1949-52. Owners of property not destroyed by the War paid a tax of half the value of their property. This tax was spread over 30 years. Effectively, it was a wealth tax of 1.67%, payable for 30 years. The large number of Allied military personnel stationed in Germany spent their pay there, and this helped. The bold economic policies of Finance Minister Prof Ludwig Erhard made a huge contribution.

Reconstruction was greatly enabled by technical skills of Germans, and their hard work.

[2] Source: www.worldwar–2.net
[3] The novel is a good read!

18. Pakistan's 2005 earthquake

The Pakistan Government set up the Earthquake Reconstruction & Rehabilitation Authority (ERRA). ERRA aimed to provide housing, livelihood, health, education, water and sanitation.

19 Mega-catastrophes require Government intervention

The insurance industry cannot cope with mega-catastrophes.

Insurers cannot possibly maintain solvency capital large enough to cope with mega catastrophes.

In the case of Wars, the risks are un-foreseeable, un-insurable and the question of insuring them does not arise[4].

For catastrophes listed in paras (a) and (b) of Ms Lockett's paper, cited above, insurance may be available, but people may not buy it. She mentions heavy under-insurance in the USA and other highly developed countries.

So the State has to intervene.

Germany's post-war reconstruction, and the reconstruction after Pakistan's 2005 Earthquake, are just two examples of mega-catastrophes which required Government intervention. Ms Lockett's 1980 paper gives many other instances.

Way forward for Pakistan

19. PII and PSoA joint study group, to study:

Catastrophe modelling for Pakistan Earthquake and Floods etc risk

Pakistan is exposed to earthquake risks, and risks of floods and other "atmospheric disturbances". Irrespective of regulatory requirements, insurers need to measure their exposure to these catastrophes, for their own purposes. We should lead, not follow the regulator.

The Pakistan Insurance Institute and the Pakistan Society of Actuaries should set up a joint study group. This would examine how Catastrophe Modelling can be applied to Pakistan, with suitable modifications.

System to meet reconstruction costs of future mega catastrophes in Pakistan

The cost of reconstruction after a mega catastrophe can be estimated only after it strikes. It will be very large, and has to be financed. After the 2010 floods in Pakistan, a flood surcharge on income tax was imposed towards meeting reconstruction costs. Instead of such *ad hoc* measures, it would be much better to formulate a plan in advance.

[4] War risk may be insurable in some cases.

We already have a statutory War Risk Insurance scheme, which was invoked and implemented in the past. The proposed Study Group should consider a system to meet the reconstruction costs for future mega catastrophes, like earthquakes, floods, hurricanes and other "atmospheric disturbances".

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Appendix

Brief reading list

1. "Catastrophes and Catastrophe Insurances" by Ms J. E. Lockett, presented on 18 March 1980 to the UK Institute of Actuaries Students' Society [Staple Inn Actuarial Society], JSS Vol 24, 1980.
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