FROM BACKGROUND TO FRONT

Catastrophe Modelling – a quick tour

Lawrence Cheng
Peak Re
May, 2015
Outline

• Why do we need Catastrophe Model?
• Evolution of Catastrophe Models
• How to build a Catastrophe Model
• Risk Management
Why do we need Catastrophe Model?
What are Catastrophes?

- Infrequent events that cause severe loss, injury or property damage to a large population of exposure.

- The term is most often associated with natural events.
  - Examples: Earthquake, Flood or Typhoon

- It can also be used when there is concentrated or widespread damage from man-made disasters
  - Examples: Fires, Explosion, or Terrorism.
Traditional Ways?

CAT Loss Ratio

Average: 4%
Traditional Ways?

CAT Loss Ratio

Average: 3%
Traditional Ways?

CAT Loss Ratio

Average: 3%
Traditional Ways?

CAT Loss Ratio

Average: 5%
Traditional Ways?

CAT Loss Ratio

Average: 12%

1989 Loma Prieta Earthquake
M6.9, 18KM

Traditional Ways?

CAT Loss Ratio

Average: 13%
Traditional Ways?

CAT Loss Ratio

Average: 108%

1994 Northridge Earthquake
M6.7, 19KM

Why do we need Catastrophe models?

• High severity of events: Importance of accurately estimating losses

• Company experience inadequate due to long return periods and historical change of portfolio’s geographic characteristics

• Provide for a better understanding of risk and the vulnerability of a company’s assets to this risk
Evolution of Catastrophe Models
Some History

1987  AIR
1988  RMS and Hurricane Gilbert
1989  Hurricane Hugo/Loma and Prieta Earthquake
1991  Typhoon Mireille
1992  Hurricane Andrew
1994  EQECAT and Northridge Earthquake
1995  Kobe Earthquake
1999  Europe Winter Storm
2001  911 Attack
2003  RMS Model for Terrorism
2004  Indian Ocean Earthquake and Tsunami
2005  Hurricane Katrina
2008  Wenchuan Earthquake
2011  Japan Earthquake and Thai-Flood
2013  Typhoon Fitow, Haiyan
2014  JP Snow Storm, AU Hail, CN EQ
2015  ……
Models in Asia

EQ Model Coverage

TY Model Coverage

- RMS and AIR
- RMS Only
- AIR Only
- None
Model Outside Asia

AIR PERIL MODELS

TROPICAL CYCLONES (HURRICANES, TYFHOONS)

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<th>Central America</th>
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<td>United States</td>
<td>Greenwood</td>
<td>Puerto Rico</td>
<td>Hong Kong</td>
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| (Or hurricane force and the
  District of Columbia) | Saint Lucia    | Philippines| India        |
|               | Belize         |           | South Korea  |
|               |                |           |              |

EARTHQUAKES

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<td>(Including earthquakes)</td>
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Peril Models, Industry Exposure Databases, and Industry Loss Curves List
RMS® RiskLink® RiskBrowser® Version 13.1
March 7, 2014

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Builder and USER

- Building the model is interpreting the complexity of how the various natural perils work in the sophisticated earth system into formulas and computer languages for best estimating the event impact to human society.

- Earth Science
  - Geologist
  - Meteorologist
  - Hydrologist
  - GIS/RS Expert

- Engineering Science
  - Civil Engineer

- Computer Science
  - Programmer

- Mathematics
  - Mathematician
  - Statistician
  - Actuary
The Notion of Risk

Risk = Probability of loss = function of (Hazard, Exposure, Vulnerability)

- Peril/Hazard
  - Earthquakes
  - Tornadoes
  - Hurricanes
  - Tsunami

- Risk
- Frequency and Severity

- Exposure
  - Value and location
- Vulnerability
  - Susceptibility to Hazard

You need all three to realize a loss
Modules of Model

- **Hazard**
  - Define Event
  - Define Location

- **Vulnerability**
  - Define Risk Attribute
  - Determine Damage

- **Financial**
  - Generate Loss
  - Apply Policy Terms

- **Model Input – Risk Data**
  - Risk Location
  - Risk Properties
    - Occupancy
    - Construction
    - Height
    - Replacement value of risk
    - Quality
    - ...

- **Model Output**
  - Estimated Losses
    - Ground Up Loss
    - Gross Loss
    - Treaty Loss
    - Retained Loss
    - PML
    - Event Loss Table
    - ...

- ... ...
Stochastic Event Set

- Start from researching natural of the event based on Historical events
  - Event forming, Event Tracking, Event parameters
- Build up the probabilities of the occurrence database
- Simulate event occurrence parameters and filter un-possible events to build the stochastic event set
- Validate the stochastic event set to the realities
Hazard Module

• Geocoding
  – Convert the location of the Risk from model input to the model codes

• Hazard Lookup
  – Determine landcover, background soil type, elevation, liquefaction, etc, based on location

• Intensity Lookup
  – Determine the events’ intensity based on Hazard lookup

Geocoding  Hazard Lookup  Intensity Lookup
Vulnerability Module

- Determine the damage caused by the event to the risk compare to risk’s fully replacement value
  - Damage Function
  - Damage Curve/Ratio

- Sensitive to
  - Location
  - Year of build
  - Structure type
  - Construction material
  - Usage of the property
  - … …

- Follow Hazards module
  - Determine the damage ratio of the risk
  - Calculate the ground-up loss of the impact

Ground Up Loss = \( \sum_{i=1}^{n} (Replacement \ Value \times \text{Damage \ Ratio}) \)

\( n \) is Number of Risks

Source: AIR Worldwide
Work flow in side

Location of Risk

Local Conditions (Soil Type, Land Cover, Liquefaction, etc)

Event Intensity at Risk Location

Damage Ratio at Risk Location

Ground-up Loss

Gross Loss

Net Loss

Reinsurance Loss

Attributes of Risk (Exposure Value, Occupancy, Building Height, Construction, Year Build, etc.)

Event Set

Event Property (Max Wind, Eye Location, Epicenter, Magnitude)

Hazard Lookup

Intensity Lookup

Pre-defined Input Lookups Output

Geocoding

Apply Policy Terms

Apply Reinsurance Terms
How a model is built

- Model the HAZARD
  - Historical data
  - Scientific understanding

- Model the VULNERABILITY
  - Industry inventory data
  - Develop Damage functions

- Model the LOSSES
  - Loss amplification factors
  - Validate with claims/loss data

- Model the UNCERTAINTY
  - Secondary uncertainty
## Uncertainties

- **Un-modelled perils**
  - Primary
    - Tsunami, Hail
  - Secondary perils
    - Tsunami followed by seaquake or earthquake
    - Landslides followed by earthquake

- **Empirical factor in certain territory for certain peril**
  - Localized experience and local damage factors
  - Localized building standards

- **Different damaging function perspective**
  - Damage curve varies by different model

- **Input data integrity, completeness**
  - Accuracy and Availability
  - Location and Coverage
Accumulation to CAT LOSS

Different kinds of risk accumulate

Catastrophe Loss
STILL Challenging

Pudong, Shanghai, 1987
Importance of robust data record
Catastrophe management

• Managing Catastrophe Risk is key and vital to insurance industry

• One event may cause significant impact
  – 1992 Hurricane Andrew
  – 2005 Hurricane KRW
  – 2010/2011 Canterbury Earthquake
  – 2011 Tokohu Earthquake
  – 2011 Thai Flood
  – 2013 Typhoon Fitow

• “3M” rule to manage catastrophe risks
  – Monitoring
  – Measurement
  – Mitigation
Risk monitoring

• Monitoring
  – Where is the risk
  – What is this risk
  – Is there any over concentration

• Traditional method – local surveying
  – Details of risk attributes

• Assisting by 3S (GIS, GPS, RS) technologies
  – Visualizing the risk remotely
  – Loss surveying and adjustment

• Involve in research – more understanding of hazards
  – In-depth understanding of the nature of hazards
Risk mitigation

• Transferring risk is one way but not the only way

• Bottom-up approach
  – Sophisticated risk registration
  – Strict underwriting guideline
  – Risk selection and diversification
  – Self-disciplined operation
  – Robust data management system
Risk Diversify – By LOB, by Territory
Conclusions – Catastrophe models

• Modelling of risk leads to a greater understanding of risk

• Hazard, Vulnerability and Exposure

• Data quality is a important driver of model uncertainty

• Catastrophe model is not a black-box and actuaries should not use it like a black-box
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