Latest issues surrounding catastrophe modelling

The actuarial profession

March 29th, 2011

Topics for discussion

Section 1  The Science and Art of Cat Modelling
Section 2  Impact of Climate Change on Natural Catastrophes
Section 3  Death & Disability Catastrophe Risk
Section 4  Impact On Demand to Manage Catastrophe Risks
Section 5  Partial Internal Models for Catastrophe Risk
Section 1: The Science and Art of Cat Modelling

- Evolution of natural catastrophe losses
- The history of catastrophe models
- Lack of experience introduces significant volatility
- Historical results show rather large model misses
- Access to data is key!

Global Catastrophe Activity indicates importance of the science

<table>
<thead>
<tr>
<th>United States</th>
<th>Rest of World</th>
</tr>
</thead>
</table>
| **Significantly higher severe weather and winter storm in the U.S. in 2010**  
  - At about 50% of average losses based on prior years  
  - High hurricane activity, no hurricane losses  
| **Higher non-U.S. catastrophe activity in 2010**  
  - Economic losses were gargantuous in 2010 with insured losses at $26bn being more than twice as large as the U.S. 2010 insured loss |

![Graph showing economic vs. insured losses in the United States and Rest of World](chart.png)
Catastrophe Modelling – A rather young science

- RMS (Risk Management Solutions)
  - Founded 1989
  - Owned by Daily Mail & General Trust

- AIR (Applied Insurance Research)
  - Founded 1987
  - Owned by Insurance Services Office

- EQECAT
  - Founded 1994
  - Owned by ABS Consulting

- Impact Forecasting
  - Founded in 1995
  - Aon Benfield subsidiary

Evaluate and Decide
Combining results, experience, knowledge

Index Model: beyond experience

Model Reliance

Overall view of risk?

Experience

Loss

Return Period
What is the value of frequency for catastrophe models?

- Frequency of 1:200 does not mean much for EQ risks!
- New Zealand: a 1:1,000 event?
  The second Christchurch earthquake occurred directly underneath the city on a fault that wasn’t in any of the vendor models since it had not been previously identified!
- Japan?
  Vendor models did not have relevant event in database. RMS took two events, averaged them and then added 30% to the result.

Eurowind Model 2010

<table>
<thead>
<tr>
<th>Total Market Share of Companies Providing Claims Data</th>
<th>Model A</th>
<th>Model AB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Germany</td>
<td>70%</td>
<td>80%</td>
</tr>
<tr>
<td>Sweden</td>
<td>40%</td>
<td>60%</td>
</tr>
<tr>
<td>France</td>
<td>50%</td>
<td>70%</td>
</tr>
<tr>
<td>UK</td>
<td>30%</td>
<td>50%</td>
</tr>
<tr>
<td>Austria</td>
<td>20%</td>
<td>40%</td>
</tr>
<tr>
<td>Denmark</td>
<td>10%</td>
<td>30%</td>
</tr>
</tbody>
</table>
Section 2: Climate Change and Natural Catastrophes

- Who believes that climate change will have a major effect on natural catastrophes?
- Increasing losses from natural catastrophes
- Normalising the results
- Stable number of cat events
- Loss of life due to tsunami risk can not be underestimated

Munich Re data suggests an increase in the number of natural catastrophes…
…or is the data just much better today?
1926 Great Miami hurricane would show $140-157bn losses today

Miami Beach 1926

Miami Beach 2006

Open Atlantic
Ocean Differences

2005 Hurricane Season

1933 Hurricane Season
Tropical storm and hurricane events
Upward trend gone after adding in “Missed” and removing very short-lived cyclones

EQ activity worldwide fairly constant

- There is no statistically significant increase in earthquake activity worldwide:

"According to long-term records (since about 1900), we expect about 17 major earthquakes (7.0 - 7.9) and one great earthquake (8.0 or above) in any given year. Although it may seem that we are having more earthquakes, earthquakes of magnitude 7.0 or greater have remained fairly constant."

Stable pattern of EQ events occurring since 1990

Loss of life is a real risk although under-insured
Significant tsunamis have occurred in the Mediterranean Sea. 

Source: Tsunami Alarm System  

A long history of tsunamis in the Mediterranean Sea

29 events in the last 100 years with tsunamis ranging from 30cm to 15m

<table>
<thead>
<tr>
<th>Code</th>
<th>Zone</th>
<th>Number of events of different origin</th>
<th>Average period of repetition, years</th>
<th>Magnitude of earthquakes</th>
<th>Intensity of tsunami Year</th>
<th>Probability of the next tsunami</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>total</td>
<td>volcanic</td>
<td>unknown</td>
<td>landslides</td>
<td>unknown</td>
<td>M</td>
</tr>
<tr>
<td>AE</td>
<td>Island of Malta, Rhodes and Sicily</td>
<td>11</td>
<td>3</td>
<td>0</td>
<td>2</td>
<td>20</td>
</tr>
<tr>
<td>AM</td>
<td>Aegean coast of southern Greece</td>
<td>7</td>
<td>5</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>AS</td>
<td>Mediterranean coast of Asia Minor</td>
<td>32</td>
<td>20</td>
<td>0</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>AS</td>
<td>Aegean Sea</td>
<td>20</td>
<td>20</td>
<td>0</td>
<td>1</td>
<td>9</td>
</tr>
<tr>
<td>AS</td>
<td>Helles Island Arc</td>
<td>17</td>
<td>5</td>
<td>0</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>AS</td>
<td>Total of Ionian</td>
<td>7</td>
<td>3</td>
<td>0</td>
<td>1</td>
<td>10</td>
</tr>
<tr>
<td>AS</td>
<td>Coast of Crete</td>
<td>22</td>
<td>22</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>AS</td>
<td>Coast of western Greece</td>
<td>88</td>
<td>34</td>
<td>0</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>AM</td>
<td>Total of Ionian</td>
<td>7</td>
<td>3</td>
<td>0</td>
<td>1</td>
<td>10</td>
</tr>
<tr>
<td>AL</td>
<td>Coast of Athens</td>
<td>7</td>
<td>5</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>AL</td>
<td>Coast of Montenegro and Croatia</td>
<td>12</td>
<td>16</td>
<td>0</td>
<td>1</td>
<td>8</td>
</tr>
<tr>
<td>AS</td>
<td>Gulf of Venice</td>
<td>5</td>
<td>5</td>
<td>0</td>
<td>0</td>
<td>12</td>
</tr>
<tr>
<td>AS</td>
<td>Eastern Adriatic and Ionian coast of Italy</td>
<td>18</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>12</td>
</tr>
<tr>
<td>AL</td>
<td>Calabrian Island Arc (Calabria and Sicily)</td>
<td>36</td>
<td>20</td>
<td>0</td>
<td>1</td>
<td>12</td>
</tr>
<tr>
<td>AM</td>
<td>Western coast of Italy</td>
<td>20</td>
<td>16</td>
<td>0</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>AS</td>
<td>Ligurian Sea</td>
<td>36</td>
<td>17</td>
<td>0</td>
<td>0</td>
<td>10</td>
</tr>
<tr>
<td>AS</td>
<td>Coast of Liguria</td>
<td>2</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>AL</td>
<td>Coast of northern Africa</td>
<td>3</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

Overview of main tsunamigenic coasts in the Mediterranean Sea

Source: Gerassimos A. Papadopoulos and Anna Fokaefs, ISET Journal of EQ Technology, Dec-2005

Section 3: Death & Disability Catastrophe Models

- Earthquake related loss of life can be modelled, but...
- … the quality of the output depends on the quality of the data
The casualty of life can be deduced from structural fragility curves times casualty rates for related structural damage.

\[ R_{\text{casualty}}(sd) = \sum_{sd=3}^{4} P[SD] R[SD] \]

where

- \( P[SD] \) = the probability of structural damage
- States: 3 – severe damage,
  4 – complete damage.
- \( R[SD] \) = casualty rates for related structural damage.
Better data quality will ensure much more certainty on results

Property loss estimates

Loss estimates

Casualty Estimation Model
Intensity, construction type and time of the EQ are very important

![Graph showing casualty rates for different intensity levels across various locations like New Zealand (2011), Japan, Chile, and Haiti.]

Earthquake Human Loss curves for four casualty states
(C2-slightly injured; C3-moderately injured, C4-heavily injured, C5-dying or dead)

Timing and portfolio do play a role as well

![Graph showing occupancy rates over time for residential and non-residential properties.]

Aon Benfield Analytics
Proprietary & Confidential | 29 March 2011

Aon BENFIELD
Case study: Calibration of estimated losses

- Aon Benfield selected two specific earthquakes for whom sufficient data was available to calibrate the death and injury losses:
  - Izmit EQ in Turkey, occurred on Aug 17, 1999, 3 AM, magnitude 7.6, number of death: about 17,000 and number of injuries about 43,000. It lasted about 37 seconds.
  - Athens EQ, 1999, moment magnitude, lasted about 15 second. It struck between Achames and Mount Parnitha National park at 2:56 AM. Number of death was about 143 and number of injuries about 1,500.

Loss Estimate Range

The average RoL for death & disability cat cover is below 1%
Section 4: Impact On Demand to Manage Catastrophe Risk

- Innovative geographical tool to manage catastrophe risk exposures
- Data quality is critical

Highlights

- No Limit to Number of Locations
  - 40 million + records
- Optimized for Speed
  - e.g. display 500,000 locations in 5 seconds
- New User Interface
  - Desktop look and feel
  - Large mapping area
- Personalized Settings
- Satellite and Aerial Imagery
- Overlay Multiple Datasets
- Multiple Map Types
  - Heat maps
  - Thematic points
- Global Solutions
  - Street-level detail maps ready for 35 countries
  - Available in 67 countries
Used for Many Lines of Business

- Personal Property
- Commercial Property
- Personal & Commercial Auto
- Workers' Compensation
- Offshore Platforms
- Any Address with Latitude/Longitude

Single Point Terror Ring Analysis

<table>
<thead>
<tr>
<th>RING</th>
<th>COUNT</th>
<th>EXPOSURE</th>
<th>DAMAGE FACTOR</th>
<th>LOSS</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>$ 0.00</td>
<td>100%</td>
<td>$ 0.00</td>
</tr>
<tr>
<td>90</td>
<td>0</td>
<td>$ 0.00</td>
<td>75%</td>
<td>$ 0.00</td>
</tr>
<tr>
<td>180</td>
<td>0</td>
<td>$ 0.00</td>
<td>50%</td>
<td>$ 0.00</td>
</tr>
<tr>
<td>360</td>
<td>1</td>
<td>$ 0.682.00</td>
<td>10%</td>
<td>$ 6.084.20</td>
</tr>
<tr>
<td>540</td>
<td>4</td>
<td>$ 1.465.129.80</td>
<td>1%</td>
<td>$ 14.261.24</td>
</tr>
<tr>
<td>720</td>
<td>5</td>
<td>$ 1.555.046.00</td>
<td></td>
<td>$ 22.019.44</td>
</tr>
</tbody>
</table>
Underwriting Capabilities

ExposureCube

- Drag and Drop Functionality
- Drill down to location detail
- Export to Excel

- Unlimited Sorting, Grouping, and Filtering Capabilities
- Charting and Graphing Capabilities
- Conditional Formatting
Section 5: Partial Internal Models for Catastrophe Risk

- Who is planning an internal model for catastrophe risk?
- The Standard Formula ignores data quality
- Is an Internal Model worth it?
- Do not underestimate the complexity!
- Internal models could be the answer, but will they be?
QIS 5 results show the importance of EQ risk (net of reinsurance)

- Overall reinsurance is a key aid to reduce the exposure to NatCat risks
- Overall (net) EQ exposure within a local Cypriot non-life insurer would be about 25% of the total capital requirement
- "The CTF recommends a more accurate and appropriate estimation of the undertaking’s catastrophe risk through the use of a partial internal model"

NatCat: Earthquake

Calculate the gross 1/200 OEP per country

\[ CAT_{Earthquake} = Q_{Earthquake} \sum AGG \times (F_{Zone} \times TIV_{Zone}) \times (F_{Zone} \times TIV_{Zone}) \]

1 in 200 OEP factor

Parameters-non-life-catastrophe-risk_en.xls
EQ_CRESTA_CY
Evaluating catastrophe models – components

Several steps along the catastrophe modelling chain where we can evaluate and compare models:

- Geocoding
- Vulnerability
- Loss
- Occupancy Type
- Construction Type
- Post-Loss Amplification
- Loss by Geographical Region
- Deductibles
- Industry Exposure database
- Line of Business
- Regional Correlation
- Losses by LOB / Coverage
- Hazard EP Curves / RPs
- Post-Loss Amplification
- Occupancy Type
- Construction Type
- Vulnerability Regions

QIS 5: Life and Health Cat Risk 11% of U/W risk pre-diversification

**LIFE CAT RISK**

1.5 per mille on capital at risk

**HEALTH CAT RISK**

- Arena risk (50% of stadium) +
- Concentration risk (100% + 300m around) +
- Pandemic risk (0.075 per mille)

<table>
<thead>
<tr>
<th>Risk Type</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accidental Death</td>
<td>10%</td>
</tr>
<tr>
<td>Permanent total disability</td>
<td>1.5%</td>
</tr>
<tr>
<td>Long term disability</td>
<td>5%</td>
</tr>
<tr>
<td>Short term disability</td>
<td>13.5%</td>
</tr>
<tr>
<td>Medical / Injuries</td>
<td>30%</td>
</tr>
</tbody>
</table>
Internal Models – too complex or worth the effort?

- For a model to be approved the following need to be satisfied:
  - Use test: have to show that the model is used as a decision tool in daily risk management work
  - Statistical quality standards
  - Calibration standards
  - Profit and Loss attribution
  - Validation standards
  - Documentation standards
  - Internal Model governance
  - Integration of external models needs to be understood
- In general: what regulators want to see is a controlled process around the internal model, acknowledged and used by management
- Most popular use test example: reinsurance!

Do regulators have the capabilities or will they rely on outside consultants (like they are doing in Switzerland for the SST)

An example of a pre-application timetable (FSA)

<table>
<thead>
<tr>
<th>2010</th>
<th>2011</th>
<th>2012</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scoping and planning</td>
<td>contents of application meetings</td>
<td></td>
</tr>
<tr>
<td>Completion of self assessment</td>
<td>Meetings to agree work-plan</td>
<td></td>
</tr>
<tr>
<td>Monthly reporting by company</td>
<td>Quarterly face to face meetings</td>
<td></td>
</tr>
<tr>
<td>Reviews and assessments of internal model</td>
<td>Application submission</td>
<td></td>
</tr>
<tr>
<td>FSA Review</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Experience shows that it takes at least 2 years from kickoff to approval (expect over 50 on-site visits from regulator)
- Hundreds of documents
- Thousands of pages
- About 200 meetings
- About 100 employees involved (60% quantitative people)
- About 15 departments involved
Catastrophe Partial Internal Models

<table>
<thead>
<tr>
<th>Area</th>
<th>Considerations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model Approval Process</td>
<td>• Internal model approval process is currently very onerous required detailed documentation and validation of the science behind the catastrophe model.</td>
</tr>
<tr>
<td></td>
<td>• If the client cannot answer questions about the internal model (including the underlying external models), the model will not be approved.</td>
</tr>
<tr>
<td></td>
<td>• Potential issue for most commercial models, which are largely black boxes.</td>
</tr>
<tr>
<td></td>
<td>• One regulator indicated preference for Impact Forecasting due to transparency.</td>
</tr>
<tr>
<td>Model Change</td>
<td>• Clients fix the “model boundaries” at the outset.</td>
</tr>
<tr>
<td></td>
<td>• If model changes fall within the boundaries, no need for renewed model approval.</td>
</tr>
<tr>
<td></td>
<td>• One regulator indicated that they prefer a multi-model approach.</td>
</tr>
<tr>
<td></td>
<td>• Advantage: a change in one of the models would only partially impact the results.</td>
</tr>
<tr>
<td></td>
<td>• No need for equal weighting of different models: is this ensuring best practice?</td>
</tr>
<tr>
<td>Simplified Approval Process</td>
<td>• Some regulators indicated a pragmatic approach to facilitate the use of external commercial cat models and have the clients benefit from their data quality.</td>
</tr>
<tr>
<td></td>
<td>• Possible solution: simplified internal model approval process for cat (proposal submitted in February 2011 to EIOPA by Aon Benfield).</td>
</tr>
<tr>
<td></td>
<td>• A simplified Internal Model approval process would be beneficial to insurers and to regulators and lower significantly the barrier for internal models as well as reduce the workload (and cost) for regulators.</td>
</tr>
<tr>
<td></td>
<td>• Focus for a simplified approval process should be on input data requirements and the process to correctly apply the catastrophe models.</td>
</tr>
</tbody>
</table>

Catastrophe Models: The good, the bad and the ugly

- Better risk management and transparency
- Push for higher quality and more granular data
- Accepted method for measuring catastrophe risk

- Model miss is still significant
- Not accepted for Solvency II Standard Formula
- Limited knowledge outside of reinsurance market

- Black box, lack of transparency?
- Will regulators understand the models?
- Correct interpretation of the results is key
Time for questions?

Thank you for your attention