Catastrophe Risk Assessment and Management

Weiling Chiang
Professor, Department of Civil Engineering, National Central University, ROC

December, 2005
Hong Kong
Characteristics of Catastrophe Event

High Uncertainty

Catastrophe
Earthquake, Super Typhoon, Terrorism Attack

Tremendous impact

Low occurrence rate

History loss data is not enough !!

Application of Engineering Model
Catastrophe Risk Assessment and Management

Risk = Hazard * Vulnerability * Exposure

Risk Information

Risk Management

Retention  Mitigation  Transfer
Background - Loss of global natural catastrophe incident (10 Year)

Source: Munich Re (2002)
Topics: Natural Catastrophes 2002
Number of events 1970 - 2004

Source: Swiss Re Sigma Report (2005)
Background

Average 200 sensible earthquakes occurred in Taiwan per year.
Background

- Chi-Chi Earthquake struck Taiwan and caused severe damage
  - September 21, 1999
  - More than 13,000 injuries
  - Destruction of more than 50,000 buildings
  - US$ 11.5 billion economic loss
Earthquake Loss Model Framework

1. Define Earthquake Event
2. Assess Ground Shaking
3. Calculate Damage
4. Quantify Financial Loss

Stochastic Event, Hazard Analysis, Vulnerability Analysis, Financial Analysis
Build Event Loss Table

Stochastic Event generator

Hazard Analysis procedure

Vulnerability Analysis procedure

Event Table & Hypocenter

Magnitude

Intensity

Structural, Content, and BI Losses Considered

Policy conditions
Deductible, Limit

Portfolio

ID | Annual Mean Rate $\lambda_i$ | Loss$ L_i$ | CV
---|---|---|---
#0001 | 0.010 | 0.65 Billion | 2.00
#0002 | 0.002 | .. | ..
#0003 | .. | .. | ..
.. | .. | .. | ..
.. | .. | .. | ..

17,710 hypothetical earthquake events
Build Exceeding Probability Curve

<table>
<thead>
<tr>
<th>ID</th>
<th>Annual Mean Rate $\lambda_i$</th>
<th>Loss$ L_i$</th>
<th>CV</th>
</tr>
</thead>
<tbody>
<tr>
<td>#0001</td>
<td>0.010</td>
<td>0.65 Billion</td>
<td>2.00</td>
</tr>
<tr>
<td>#0002</td>
<td>0.002</td>
<td>....</td>
<td>....</td>
</tr>
<tr>
<td>#0003</td>
<td>....</td>
<td>....</td>
<td>....</td>
</tr>
<tr>
<td>....</td>
<td>....</td>
<td>....</td>
<td>....</td>
</tr>
<tr>
<td>....</td>
<td>....</td>
<td>....</td>
<td>....</td>
</tr>
</tbody>
</table>

$\hat{\lambda} = \sum \lambda_i$

Poisson Model

How severe?
Severity Distribution (Loss distribution)

Aggregated & Occurrence loss
Simulation (Monte Carlo Simulation)

How many times?
(Monte Carlo Simulation)
Taiwan Residential Earthquake Insurance Pool - TREIP

- Became effective starting April 1, 2002
  - EQECAT provides the analysis
- Standard policy terms
  - Fixed premium **NT$ 1,459** proportion to the policy limit
  - The contract limit for direct physical damage is fixed as pre-agreed replacement cost subject to a maximum of **NT$ 1.2 million**.
  - Policies also cover additional **NT$ 180,000** for contingent living expense.
  - The maximum available under TREIP is **NT$ 50 billion** per event. If loss exceed this amount, policyholder will receive pro rata payments.
  - Binary payout; if a constructive total loss occurs, the policyholder is entitled to a payout of the entire policy limit.
Risk Sharing Structure of TREIP (NT$)

- 50 bn: Government Guarantee
- 40 bn: Second Layer Reinsurance
- 30 bn: First Layer Reinsurance
- 20 bn: Cat Bond (100 million US$)
- 2 bn: Foundation Layer
- 2 bn: Domestic Insurers Private Sector
Data Collection of TREIP

- **Residential earthquake insurance was taken effect since April 1, 2002.**
  - The effective insurance policies were 1,244,803. until June 30, 2005
  - Liabilities accumulates was 1.6 trillions.
  - The take-up rate is 17.6%

- **TREIP data collection was quite intact, include:**
  - Policy ID
  - Zip Code
  - Building Type
  - Number of stories
  - Year Built
  - Insured amount
Exposure of TREIP

Policies Distribution

Exposure (%)
- 0 - 5.0
- 5.0 - 10.0
- 10.0 - 15.0
- 15.0 - 20.0
- 20.0 - 25.0

Exposure ($ Billion)

- Z1
- Z1.1
- Z2
- Z3
- Z4
- Z5
- Z6
- Z7
- Z8
- Z9
- Z10
- Z11
- Z12
Exceeding Probability Curve of Loss

Loss vs. Return Period

- Event Loss (NT$ Billion)

- Return Period (Year)

0 200 400 600 800 1000

0 10 20 30 40 50 60 70 80 90

14/23
Exceeding Probabilities of Risk Sharing Structure

- **Domestic Insurers Private Sector**
  - 324.7 yr (0.31%) 50 bn
  - 229.6 yr (0.43%) 40 bn
  - 189.3 yr (0.53%) 30 bn
  - 161.9 yr (0.62%) 23.2 bn
  - 149.1 yr (0.67%) 20 bn
  - 32.2 yr (3.06%) 2 bn

- **Foundation Layer**
  - Government Guarantee
  - Second Layer Reinsurance
  - First Layer Reinsurance
  - Cat Bond (100 million US$)
  - Domestic Insurers Private Sector
## Background - Typhoon definition

<table>
<thead>
<tr>
<th>Taiwan</th>
<th>Hong Kong</th>
<th>Saffir-Simpson Scale (US)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Type</strong></td>
<td><strong>Winds (Near center)</strong></td>
<td><strong>Winds (Near center)</strong></td>
</tr>
<tr>
<td>Slight Typhoon</td>
<td>62~117 km/hr</td>
<td>Tropical Depression</td>
</tr>
<tr>
<td>Moderate Typhoon</td>
<td>117~183 km/hr</td>
<td>Tropical Storm</td>
</tr>
<tr>
<td>Violent Typhoon</td>
<td>183 km/hr above</td>
<td>Violent Tropical Storm</td>
</tr>
<tr>
<td>Typhoon</td>
<td>117 km/hr above</td>
<td>Typhoon</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Characteristics of HAITANG Typhoon

Max Winds (m/s) | 53
---|---
Max Winds (mph) | 119.25
TYPE (TW) | Violent Typhoon
TYPE (US) | Category 3

Data from Central Weather Bureau
Statistics of Typhoon track

Track 1: 27%
Track 2: 13%
Track 3: 32%
Track 4: 12%
Track 5: 6%
Track 6: 7%
Track 7: 4%
There are 33 basins in Taiwan.
The greater part of inundation potential map for each basin are established in 200 × 200 meter resolution. Only Taipei and part of Tao-Yuan areas are 40 × 40 meter resolution.
There are 4 levels of rainfall for flood map such as 150, 300, 450, 600(mm). (GIS format)
Build Basin Loss Table (Policy Level)

Vulnerability Analysis

(Commercial, Residential, Industrial)

Policy Conditions

<table>
<thead>
<tr>
<th>Basin</th>
<th>150MM (Loss, P)</th>
<th>300MM (Loss, P)</th>
<th>450MM (Loss, P)</th>
<th>600MM (Loss, P)</th>
<th>Mean</th>
<th>Stdv</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basin1</td>
<td>(0.1bn,0.1)</td>
<td>(0.2bn,0.3)</td>
<td>(0.4bn,0.8)</td>
<td>(0.7bn,0.9)</td>
<td>14.7</td>
<td>0.6</td>
</tr>
<tr>
<td>Basin2</td>
<td>(0.2bn,0.2)</td>
<td>(0.3bn,0.5)</td>
<td>(0.4bn,0.7)</td>
<td>(0.5bn,0.8)</td>
<td>10.8</td>
<td>1.3</td>
</tr>
<tr>
<td>...</td>
<td>......</td>
<td>......</td>
<td>......</td>
<td>......</td>
<td>......</td>
<td>......</td>
</tr>
<tr>
<td>Basin3</td>
<td>(0.3bn,0.1)</td>
<td>(0.7bn,0.4)</td>
<td>(0.8bn,0.7)</td>
<td>(1.1bn,0.9)</td>
<td>14.9</td>
<td>1.4</td>
</tr>
</tbody>
</table>

Hazard Analysis

GIS Tool

Portfolio

Basin Loss Table
Build Exceeding Probability Curve

@Risk Developer Kit

Severity Distribution

Correlation Matrix Table

Basin Loss Table

Frequency Distribution

Poisson Model

How many times?

(Monte Carlo Simulation)

Simulated M times

\[ L_M = \sum_{i=1}^{N_M} (L_{B1,i} + L_{B2,i} + L_{B3,i} + \ldots + L_{B33,i}) \]

\[ N_M : \text{number of events in } M^{th} \text{ year} \]

\[ L_{B?,i} : \text{loss of } i^{th} \text{ event of } B^{th} \text{ basin} \]

\[ L_M : \text{aggregate loss in } M^{th} \text{ year} \]
Application of Loss Exceeding Probability Curve

Probable Maximum Loss

PML

Capital arrangement

Insurance, Cat Bond

Risk Tolerant

Loss (1 Billion)

Exceeding Probability (%)
Summary

• Application:
  – Engineering model can help decision maker to assess the risk and to help developing the management strategy in catastrophe event such as Earthquake or Typhoon.

• Further research:
  – Time – dependent
  – Business interruption
Thank You