Catastrophe Modeling "PMLs"
CASE: 25 March 2010

Statistics

- **Determinism**
  - A theory or doctrine that acts of the will, occurrences in nature, or social or psychological phenomena are causally determined by preceding events or natural laws.
  - "If A, then B"
  - Examples
    - The sun rises every morning
    - What goes up must come down
    - Water boils at 100º C at standard pressure

Cause and Effect

- History of determinism, Pre-history to 16th Century
  - World was deterministic (albeit extremely complex and multivariate at times)
  - Everything was causal
    - Rain dances, sacrifices
  - Events were thought to be driven by
    - Fate, the will of gods, movement of planets and stars
  - Earthquakes were thought to be caused by
    - Giant catfish (Japan), frogs (China), elephants (India)

- **Probabilism**
  - A theory that certainty is impossible especially in the sciences and that probability suffices to govern belief and action.
  - “If A, then maybe B, or maybe C, or …”
  - Examples
    - Throwing dice
    - Tossing a coin
    - Brownian motion
    - Black-Scholes option valuation
    - Behavioral economics

- **Historical Development, 17th Century to present**
  - Pascal (1623-1662): probability theory
  - Lloyds of London (1688)
  - Bayes (1702-1761): Bayesian probability
  - Institute of Actuaries (1848)
  - Casualty Actuarial Society (1914)
  - Cat modeling companies:
    - Risk Engineering (1984)
    - AIR (1987)
    - RMS (1988)
    - EQECAT (1994)
    - ERN (1996)
    - Baseline (2007)

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- **What is a PML?**
  - Maximum loss under certain specified conditions
  - Engineering interpretation
  - Verbal interpretation
  - Frequency interpretation
  - Statistical interpretation
  - Practical interpretation

- **Deterministic approach**
  - Largest possible loss which it is estimated may occur, in regard to a particular risk, given a postulated combination of circumstances
- **Probabilistic approach**
  - All losses from 0% to 100% are possible
  - “Maximum Possible Loss” is 100% of insured values (less deductibles)
  - “Maximum Foreseeable Loss” is generally associated with the extreme “tail” of a distribution (e.g., cat model output; realistic disaster scenario)
  - “Probable Maximum Loss” is explicitly or implicitly associated with a frequency (“return period”)

Probable Maximum Loss

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- There exist a range of PMLs for various interested parties with various risk appetites and time horizons
  - 0% at frequent return periods (e.g., per day, per month)
  - 100% at remote return periods (e.g., per millenium, per eon)

Cat Modeling

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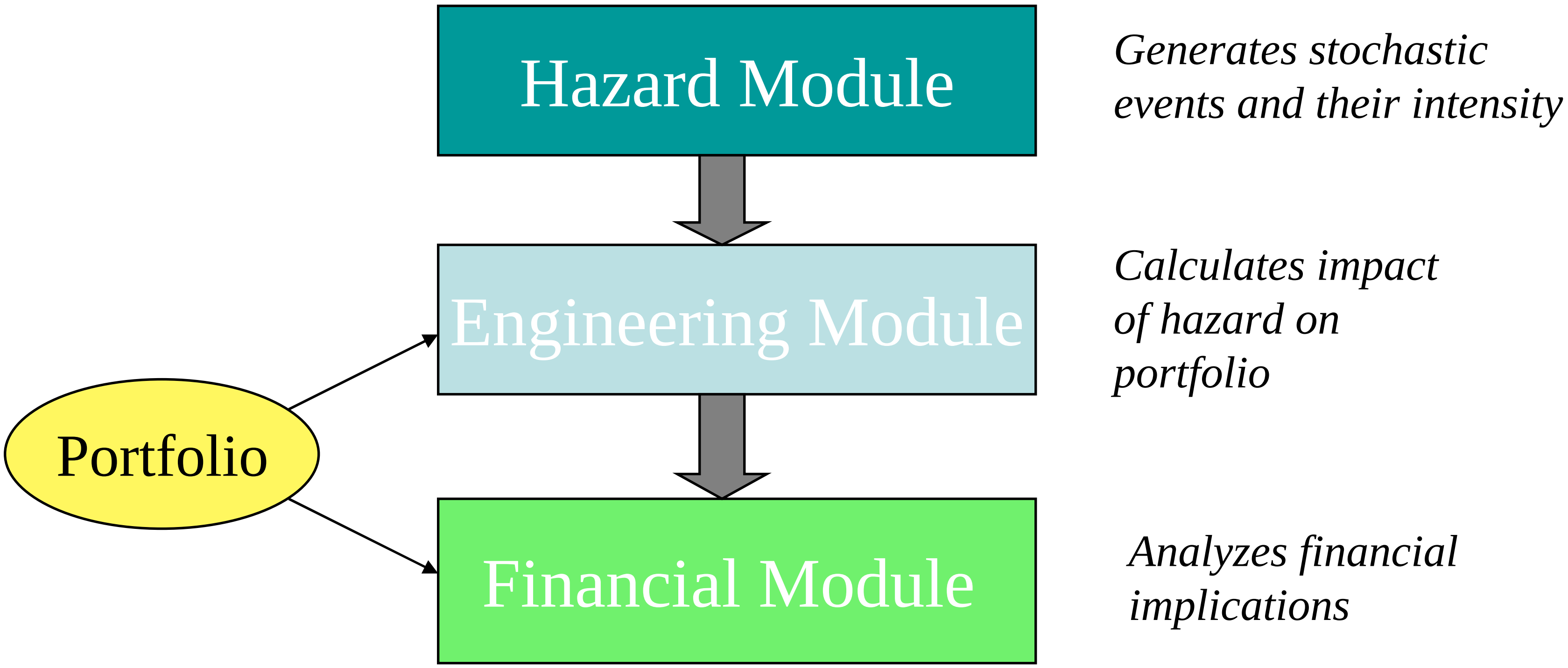
Cat “PMLs”

- Often based on extrapolation of extreme events from relatively small sample event sets
- Insurance and Reinsurance market rules of thumb
- Regulatory requirements
- Rating agency requirements

- Market practice can and does vary widely from insurer to insurer due to variances in deductibles, spread of exposure, quality of construction, coverages provided, level of capitalization, and risk appetite


Hazard Module
Generates stochastic events and their intensity
Engineering Module
Calculates impact of hazard on portfolio
Portfolio
Financial Module
Analyzes financial implications

Cat "PMLs"

- Cat modeler models
- Reinsurer models
- Insurer models
- Broker models
- Consultant models

Limitations of Cat Models

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- **Randomness**
  - We don't know if a natural perils event will happen in the future, even if we can estimate the probability of an event
- **Uncertainty**
  - We can't be certain our probability estimates are correct

Limitations of Cat Models

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- **Sources of uncertainty in catastrophe modeling**
  1. Limited data sample
     - For example, estimating 100-year Hurricane losses with only 100 years of detailed data
  2. Model specification error
     - For example, Poisson frequency (iid assumption)
  3. Nonsampling error
     - Identification of all relevant factors
     - For example, global climate change
  4. Approximation error
     - Process risk
     - For example, limited simulations and discrete event sets

Limitations of Cat Models

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- **Cat models are collections of event scenarios**
  - Discrete approximations, with Poisson probabilities attached to each scenario
  - Not exhaustive
  - Limited perils
  - Calibrated using historical experience
    - Recalibrated as required, based on research and actual event experience

Limitations of Cat Models

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- ☐ **Market PML**
- ☐ **90% market PML confidence interval**
  - About 0.5x to 2.5x point estimate (assuming good data)
- ☐ **Confidence intervals for individual company PMLs will vary more**
  - Not always the same market share of each event
  - In a given market “PML” event, one company may lose less, another more
  - In a different market “PML” event, those same companies’ results could be dramatically different

Data Quality

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- The quality of model output is only as good as the input data
  - Critical in making informed risk management decisions
- Data quality is within the control of the insurer
  - Could be a source of confidence
  - Could be another source of uncertainty

Data Quality

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2008 E&Y Cat Exposure Data Quality Survey

Insured values	
Always problematic	25%
Often problematic	50%
Sometimes problematic	17%
Rarely problematic	8%
Secondary Characteristics	
Always problematic	33%
Often problematic	33%
Sometimes problematic	17%
Rarely problematic	17%

Definitions: Quantify where possible

- **Define "PML"**
  - Geography (worldwide, peak region, peak subregion)
  - Basis (OEP, AEP, TVaR)
  - Frequency (1-in-100, 1-in-250, 1-in-1000)
  - Assumptions (demand surge, LAE, ITV, growth, fire following, secondary uncertainty, unmodeled exposures, data quality)
- **Use catastrophe models as a guide**
- **Risk tolerance will vary by insurer ownership and management**

PMLs: First principles

- PMLs range from 0% to 100%
- PMLs are associated with return periods (frequency)
- PMLs less than 100% may be exceeded

- **Insurance is a business**
  - It’s impractical to hold capital and/or purchase reinsurance up to full limits (“MPL”)
    - Suboptimal use of capital
  - The market (e.g., insureds, regulators, ratings agencies) deems it acceptable to provide less than perfect insurance and reinsurance security
  - Need to quantify risk appetite
    - Probability of default
    - Risk-adjusted returns
  - Need to use best available tools in a cost-effective manner to make sound business decisions
    - Multiple cat models, combined with first principles

- Most people want certainty, not "sufficiently low probabilities"
  - Most insurance companies think and plan in terms of "point estimates" rather than distributions
  - Regulators want policyholders to be paid
  - Cat models should be used as a guide, not a rule
    - Never lose sight of first principles

- Deterministic thinking pervades society
- Statistics is a relatively young science

Risk Management Decisions

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- Where there is risk, there is opportunity