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CAT Risks: Uncertainties and Optimization

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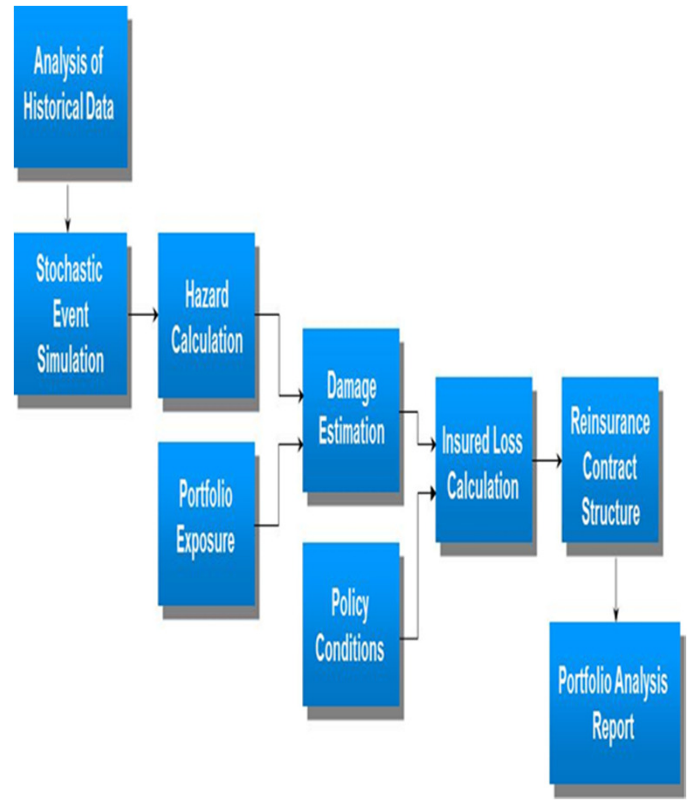
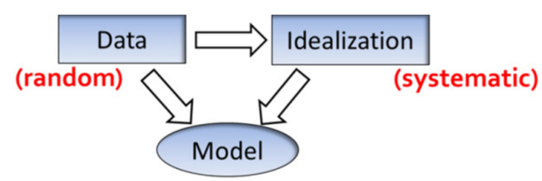
Agenda

- **CAT Model Uncertainties**
- **CAT Model Adjustments**
- **Heuristic Portfolio Optimization**
  - Methodology
  - Case Study
- **Uryasev Portfolio Optimization**
  - Algorithm
  - Case Study

CAT Modeling Framework

- **CAT models**
  - science module
  - engineering module
  - financial module
- **Each module has two sub-components**
  - Data
  - Idealization
- **Each component has uncertainties**
  - Aleatory Uncertainty is related to variability in the underlying natural phenomena
  - Epistemic Uncertainty is related to limited data, measurement error, incomplete knowledge, imperfect models, and subjective judgment





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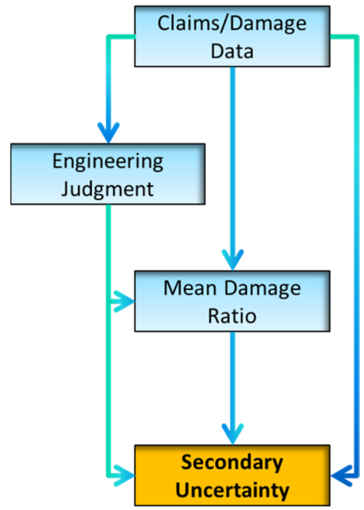
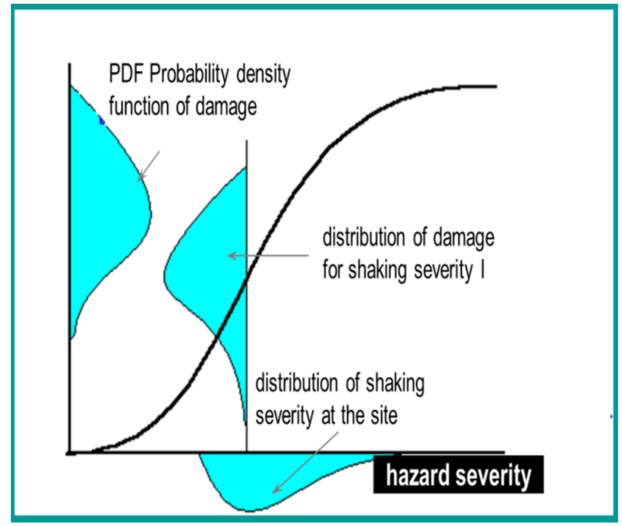
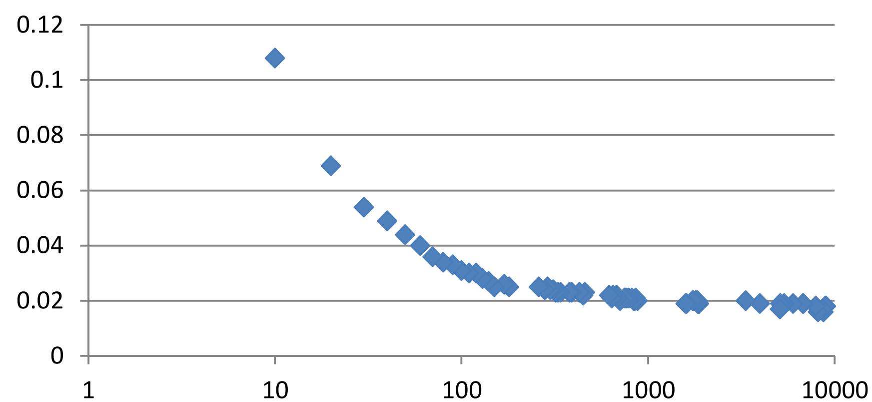
Modeling Uncertainties

- **Primary Uncertainties**
  - **Related to natural hazard**
  - **Simulation Approach**
    - Uncertainties using probability distribution
    - Model extremely complex processes
  - **Logic Tree Approach**
    - alternative parameter values or mathematical relationships
    - relative weights are assigned to each alternative
- **Secondary uncertainties**
  - **Related to vulnerability**
  - **Insufficient data, lacking of data and engineering judgment introduce uncertainties**





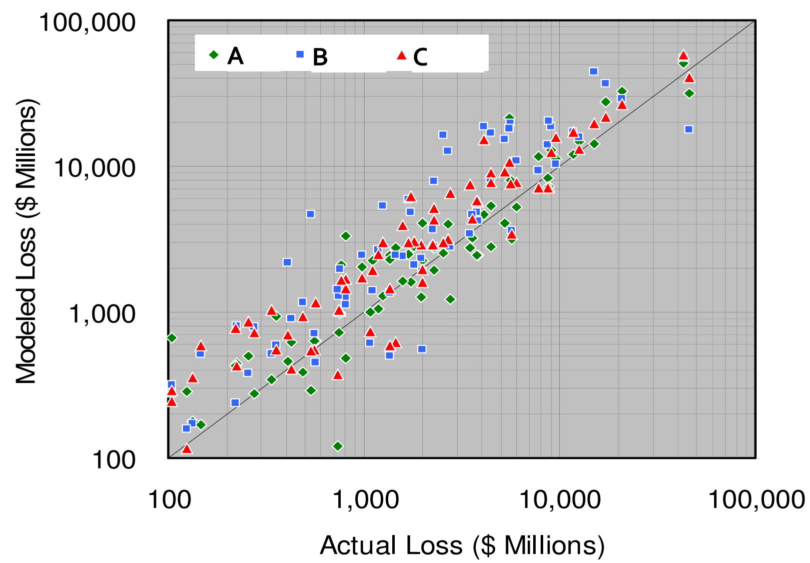


Best Use of CAT Models

- **CAT model losses often vary substantially across vendor models**
- **The most appropriate view is based on multiple CAT models**
  - Customize the model to better fit company's actual experience and unique exposure
  - Minimize large changes due to model changes
  - Reduce model risk that results from a reliance on a single vendor model's opinion
- **Use of multiple models**
  - Select best model for different sub-portfolios or perils or region
  - Blend multiple models

CAT Model Blending—Model Evaluation

- **Simple blend unadjusted outputs**
- **Develop blending factor for mean and STDV of loss events and/or event frequencies**
- **Blending factor based on detailed model evaluation:**
  - Model performance: Loss validation
    - Historical loss
      - Industry loss
      - Company loss
    - Stochastic loss
      - Industry EP
      - Company loss cost
      - Key event return period
  - Review of Science: Component soundness
    - Hazard module
    - Vulnerability module
    - Financial module
  - Model testing: Sensitivity study
    - Understanding of notional portfolio behavior



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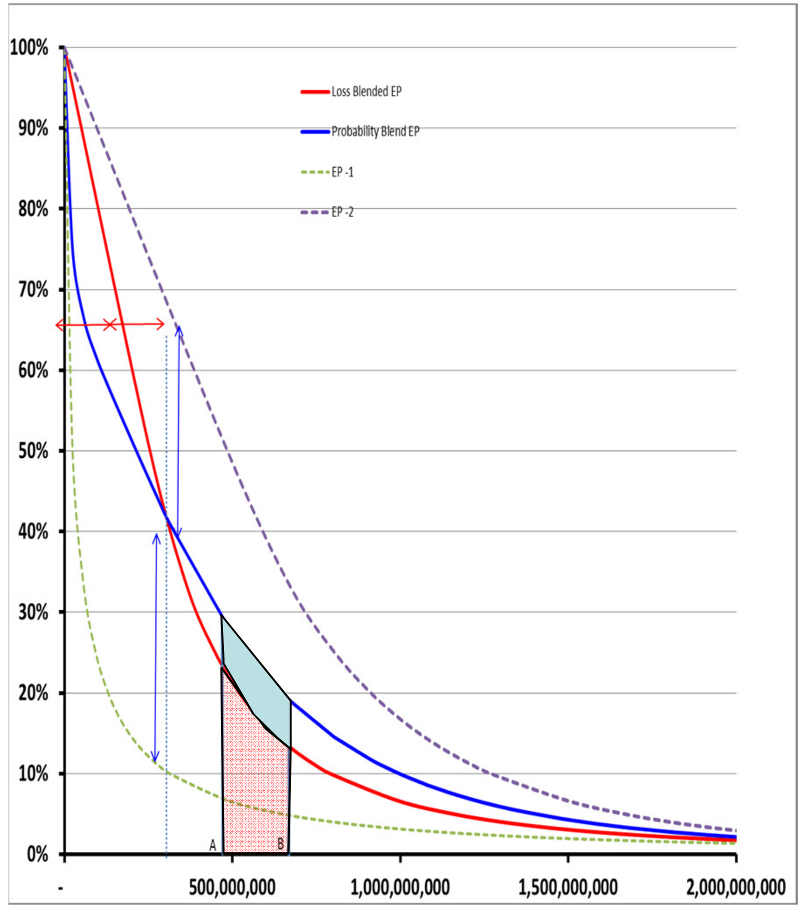
CAT Model Blending

- **Model blending can be done at different levels**
  - Blending of Mean loss from multiple EP curves
    - Loss Blending: weighting dollars across common probabilities
      - Map the event sets regardless of their physical characteristics
    - Probability Blending: weighting the probabilities across common threshold
      - Introduce more event sets
      - Higher volatilities
  - Secondary uncertainty change the shape of EP curves
    - Take secondary uncertainty (volatility) into account
    - Nonlinear effect for adjustment on access of loss reinsurance contracts
  - Frequency adjustment
    - Long-term view vs near term-view of hurricane rates
    - Elevated EQ frequency due to time dependency

Model Blending - Mean Loss

- **Blending impact**
  - Expected losses for the entire EP: credibility weighted average of the mean losses. No difference either loss blending or probability blending
  - No impact for Quota Share treaties either way
  - Certain impact to Excess of Loss treaties:
    - For higher return period (lower Exceedance probability), Probability blended EP curve is favorable to reinsurers
    - Expected losses between threshold A and B – the area below the Probability blended EP curve(blue) is greater than the Loss blended EP curve(red)



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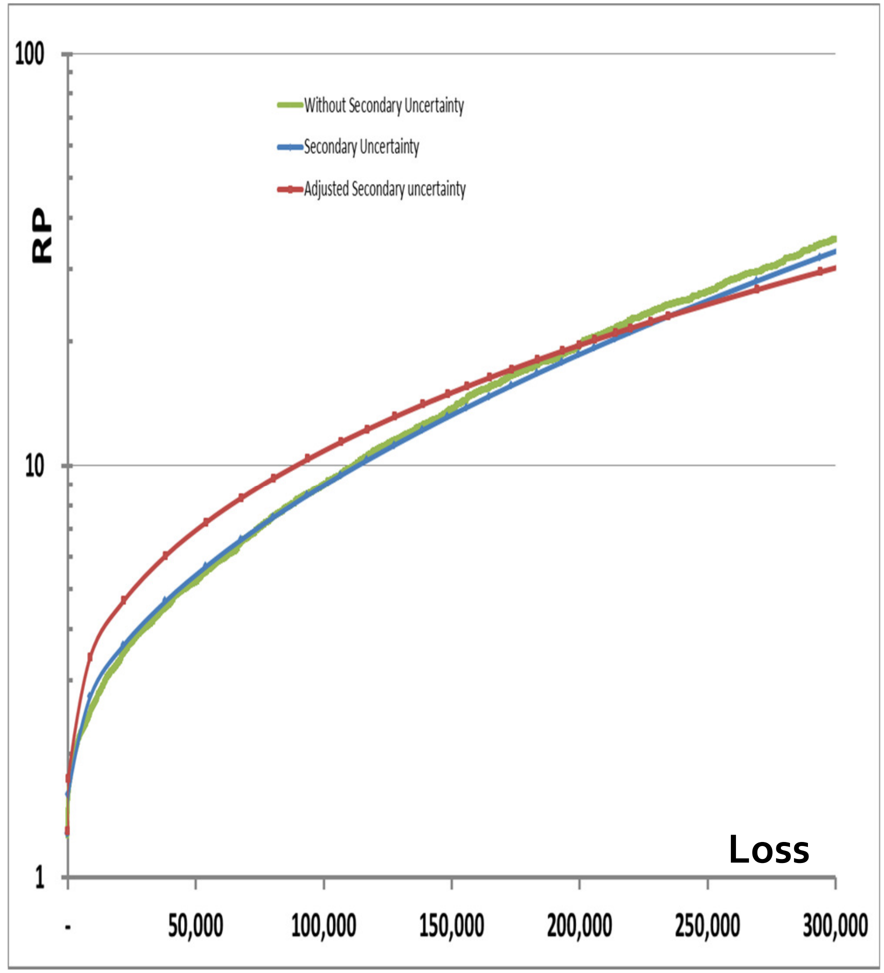
Model Blending - Secondary Uncertainty

- **Blending impact**
  - EP curve shape adjusted to reflect the fact that extreme loss has relatively lower volatility(COV)
  - Non-uniform effect for volatility adjustment – crossing effect
    - Same adjustment to the standard deviation of all losses having different impact to the shape of EP curve



Model Blending - Frequency adjustment

- **Simple overall adjustment**
  - Simple but not recommended since it does not account for event specific information
- **Credibility blending of near-term and long-term view**
  - Preferred since it reflects both long and short term views according to the credibility weights
  - More complex to implement
  - More volatility and non-uniform affect on AAL and EPs
- **Key events frequency adjustment only**
  - Account for EQ time dependency
  - More effort to identify the key events and the adjustment factor

Heuristic Portfolio Optimization

- **Premise**
  - Accounts with insufficient premium to cover cost of capital
  - Account of too much concentration
  - Internal risk limit guidance unmet
  - Inefficient reinsurance program
  - other fees or losses rendering cost of writing too high
- **Maximize the portfolio margin subject to the following constraints:**
  - TVaR< Given limit
  - Minimum bound <account participation < Maximum bound
- **Input data**
  - Net profit results for each account for all trial
  - Lower and upper bounds of participation for each account

HPO-Implementation

- **Determines a unique optimal portfolio that**
  - Maximizes portfolio margin
  - Subject to capital requirement constraints from shareholders, rating agencies and regulators and internal risk limit guidance
  - Guarantees optimal portfolio is most profitable
- **Approach**
  - Calculate the Risk Capital TVaR for the portfolio
  - Calculate the Co-TVaR and RAROC for all the accounts
  - Stratify the accounts into segments by RAROC
  - Increase the TVaR by one unit and calculate the incremental Co-TVaR for each segment
  - Calculate the incremental RAROC for each segment
  - Sort segments by RAROC in ascending order and increase the best and reduce the worst
  - Repeat till maximum portfolio margin

HPO Case Study

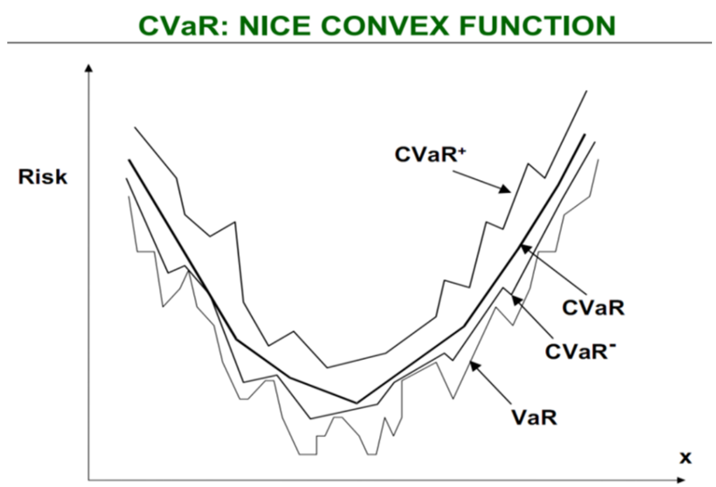
- **Portfolio of international CAT reinsurer**
  - FR WS
  - NZ EQ
  - US CEA
  - UK WS
  - AU EQ
- **Steps**
  - Decrease the worst account (NZ EQ)
  - Increase the participation of the best account (US CEA)
  - Then Increase UK and reduce NZ
  - Continue till optimal
- **Observations**
  - HPO is intuitive and simple to implement
  - Is it global optimal solution? Almost

Accounts	Initial Part	Initial RAROC	Optimal Part
FR WS	1.0	0.077	1.25
NZ EQ	1.0	0.016	0.88
US CEA	1.0	-1.093	1.5
UK WS	1.0	0.113	1.4
AU EQ	1.0	0.0218	1.2
Initial Margin	1.3m	Optimal Margin	1.6m

Portfolio Optimization Uryasev Algorithm

- **Conditional VaR (CVaR): Algorithms and Applications by Prof. Uryasev at UFL**
- **Easy to optimize real world business strategies**
  - CVaR usually coincides with TVaR
  - Linear programming (LP) can be used for optimization of very large problems
  - Fast and stable algorithm
  - Can be applied to non-normal distribution
  - Many real world business constraints can be translated into CVaR optimization

Source: Dr. Stan Uryasev, Conditional Value-at-Risk (CVaR): Algorithms and Applications



CVaR Optimization Uryasev Algorithm

- **CVaR minimization**
  - x=a set of decision vector (line size, growth factor, limits, etc)
  - y=random vector (CAT losses of various LOBs)
  - f(x,y)=loss function (overall company net profit)
  - Minimize CVaR
- **Use of Uryasev Algorithm**
  - Maximizes portfolio performance measure (i.e. margin) subject to TVaR constraint
  - TVaR constraints can be replaced by a set of linear constraints
  - VaR is also optimized (nearly)
  - Multiple TVaR constraints
  - Transaction cost constraints

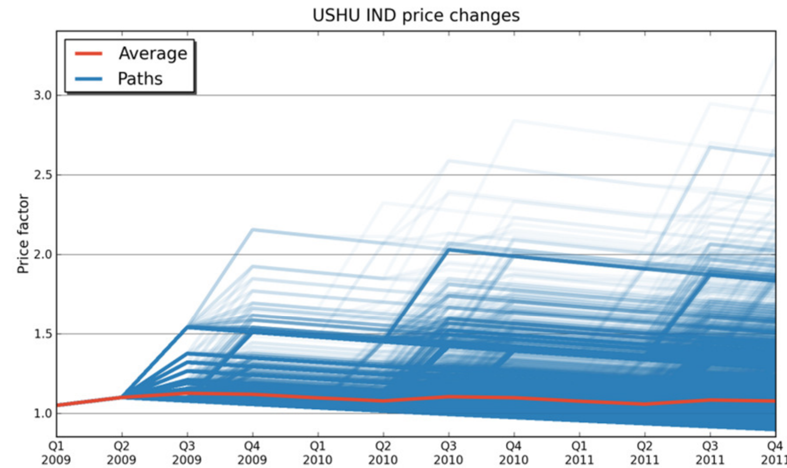
Uryasev Algorithm-Case Study

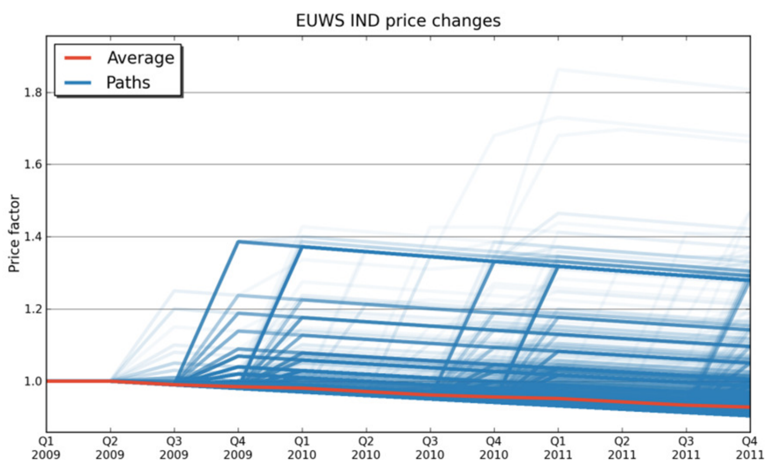
- Optimize CAT reinsurance portfolio growth strategy for the three years business plan given
  - price change assumptions depending on industry loss

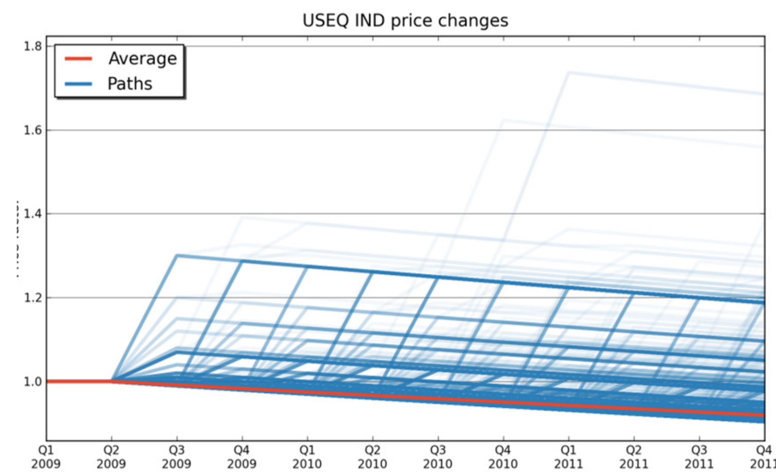
- Project Outline
  - Price Change Simulation
  - Portfolio Growth Strategies
  - Portfolio Statistics Comparison

Case Study-Price Change Simulation

- **Price change assumptions depending on industry loss**
  - US HU: -2% if industry loss<$5b
  - US HU: 0% if $5b<industry loss<$10b
- **Current growth strategy**
  - Growth by price change
- **Portfolio**
  - US HU
  - US EQ
  - EU WS

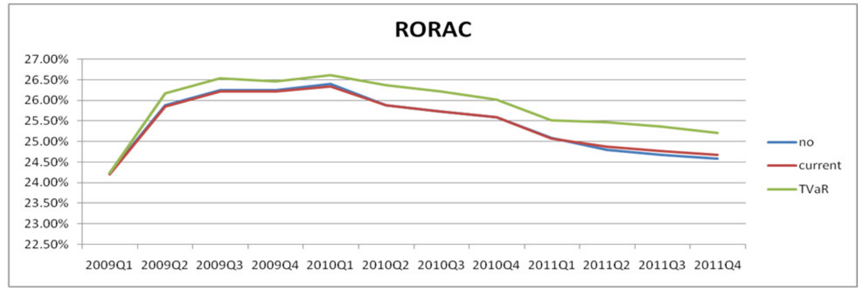


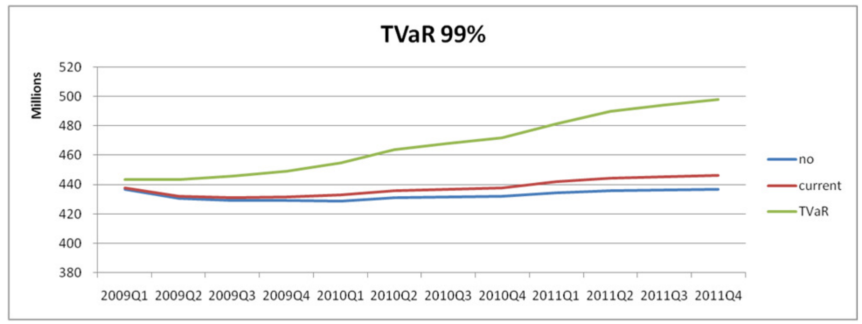


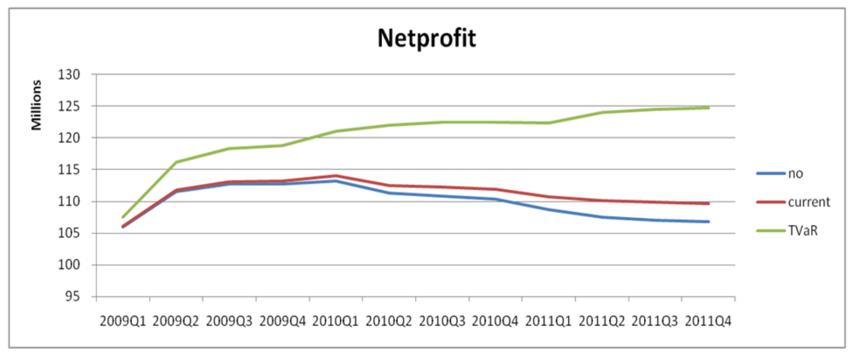


Case Study-Portfolio Stats Comparison

- No strategy: based on price change assumptions, net profit will decrease overall in the next 3 years
- Current strategy: This strategy improves the loss ratio for each major peril. However, it only slightly improves the overall RAROC and net profit
- Uryasev portfolio optimization strategy: Improves RAROC and net profit over time







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