MAF Fall Meeting
September 2006

What Reserve Range Makes You Comfortable?

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Why Ranges Have Become So Important

- Actuarial opinion on reserves and summary
  - Reasonable provision
  - Declaration of the range
- Increased emphasis on required capital
  - One of the largest risks faced by a company is reserve risk
- Increased emphasis on Enterprise Risk Management (ERM)
  - Rating agencies
- Communication within and externally of risks in general
- Commutations of reinsurance contracts
- Loss Portfolio Transfers (LPT's) or adverse development covers
- Optimal pricing
  - Understanding the driving forces of your rate change calculations
  - Building in risk margins

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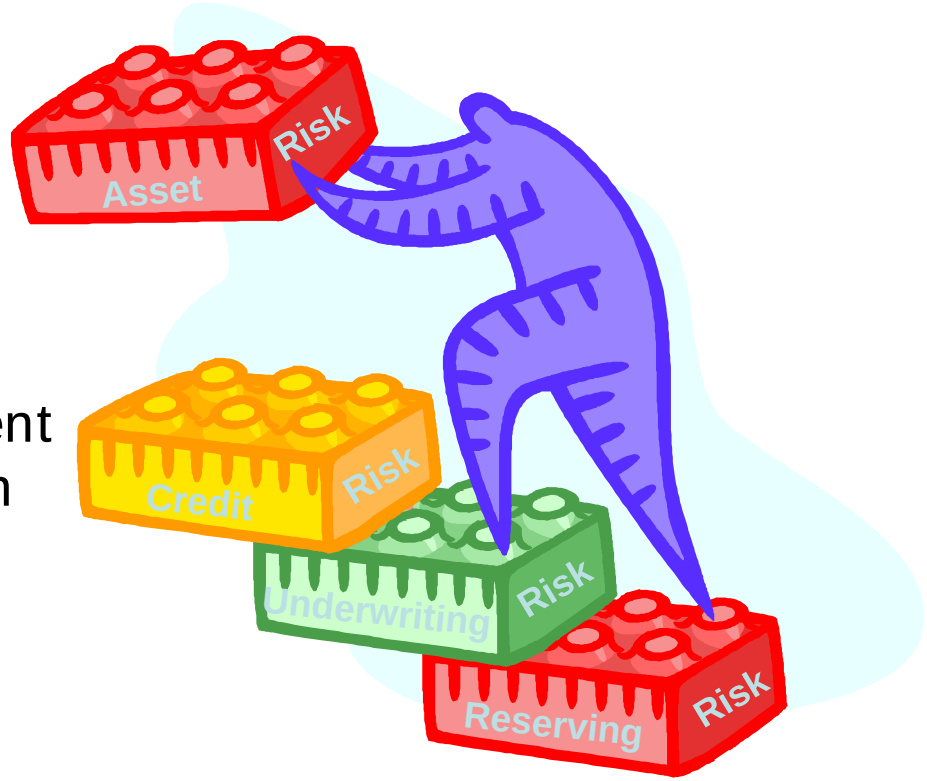
Why Ranges Have Become So Important

- It is the cornerstone to building a ERM/capital model
- The reserving team can own the process for developing the reserving risk
- It provides for a consistent approach to comment on reserves and set capital
- Needed for economic capital calculation



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What is Reserving Risk

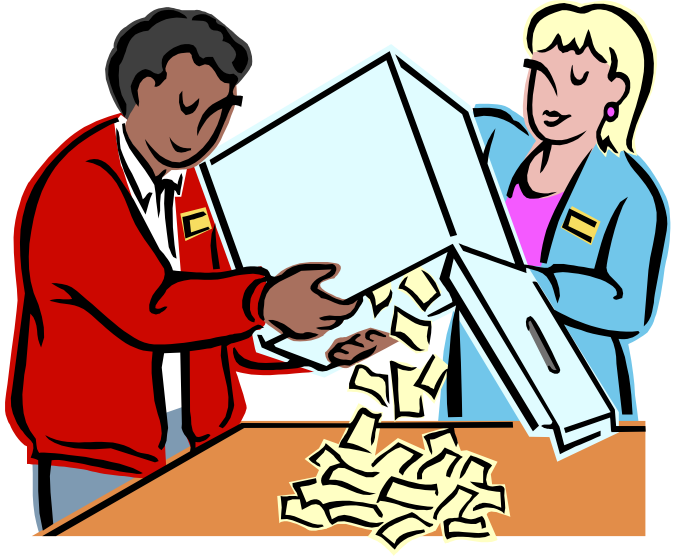
- Reserving is concerned with forecasting outstanding liabilities
- There is uncertainty associated with any forecast
- Reserving risk measurement attempts to capture that uncertainty
- Ultimately we are interested in the “predictive distribution” of ultimate losses AND the associated cash flows
- We need methods that can provide both

Poll #1

- How far up the ladder do your reserve ranges reach in your organization?
  - Actuarial Opinions
  - Capital Setting
  - Enterprise Risk Management
  - Trash Bin

Poll #1 Results

- How far up the ladder do your reserve ranges reach in your organization?
  - 49% - Actuarial Opinions
  - 11% - Capital Setting
  - 3% - Enterprise Risk Management
  - 12% - Trash Bin
  - 25% - No Answer



Notes:

1. 80 entities participating in poll
2. An entity may represent multiple attendees logged on at one site and the poll reflects one vote per entity.

Goals of a Good Analysis

- Reflects the full (predictive) distribution
  - Include process and parameter risk
- Recognizes the type of risk being modeled
  - Long-tail vs. short-tail
  - Size of company
- Recognizes the maturity of business
  - The more mature the less risky
- Allows the analyst to insert knowledge
  - Not a black box
- Scaling of results to best estimate
- Allows for proper aggregation across lines of business or classes
  - Dependencies

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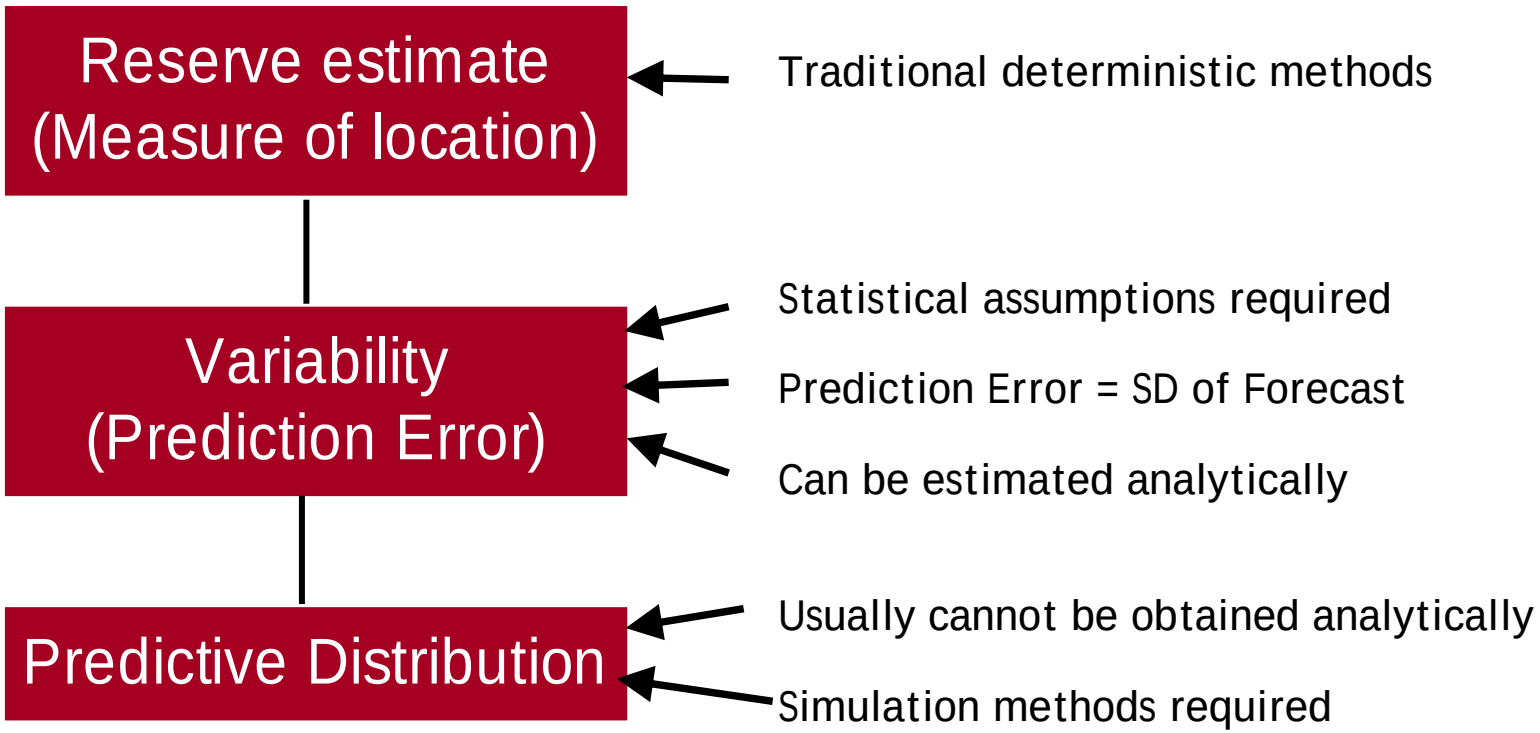
The Full Predictive Distribution



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Survey of Different Approaches*

- Rules of thumb
  - McClenahan[1]
- Range indicated by different methods
  - Patel and Raws.
- Picking high and low loss development factors

* Majority of papers can be found by using the CAS Library Search at http://www.casact.org/CASBibSearch.cfm and searching on the authors name and "ranges" or "variability" for the abstract keyword.

1. McClenahan covers a couple of different methods and touches upon the history of ranges.

Survey of Different Approaches*

- Stochastic reserving
  - Log regression models and GLM's
    - Christofides[1]
    - Zehnwirth
    - Taylor (keywords "regression models")
  - Other stochastic models
    - Mack
    - Over Dispersed Poisson
  - Simple loss development factor models
    - Hayne
    - Kelly
  - Individual claims models
    - Murphy and McLennan
- Bootstrapping
  - Kirschner, Kerley, and Isaacs
  - England and Verrall[2]

* Majority of papers can be found by using the CAS Library Search at http://www.casact.org/CASBibSearch.cfm and searching on the authors name and "ranges" or "variability" for the abstract keyword.

1. "Regression Models based on Log-Incremental Payments" by Stavros Christofides in the Claims Reserving Manual (Volume 2) published by the Institute of Actuaries.
2. Additional documentation not stored in the CAS library available upon request thru EMB America.

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Poll #2

- What type of variability approach does your company use?
  - Nothing
  - Rules of Thumb
  - Range Indicated by Different Methods
  - More Complex Statistical Models
  - Don't Know

Poll #2 Results

- What type of variability approach does your company use?
  - 4% - Nothing
  - 8% - Rules of Thumb
  - 43% - Range Indicated by Different Methods
  - 18% - More Complex Statistical Models
  - 5% - Don't Know
  - 21% - No Answer

Notes:

1. 76 entities participating in poll
2. An entity may represent multiple attendees logged on at one site and the poll reflects one vote per entity.

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Pros and Cons of Different Approaches

- Rules of thumb
  - Pros:
    - Easy to apply
  - Cons:
    - No real basis
    - Does not give a full distribution
    - No cash flow variability
- Range indicated by different methods
  - Pros:
    - Intuitive and can be easily explained
  - Cons:
    - Highly dependent on methods selected
    - Only considers (some of the) parameter risk
    - Does not give a full distribution
    - No cash flow variability

Pros and Cons of Different Approaches

- Picking high and low loss development factors
  - Pros:
    - Easy to apply
  - Cons:
    - Consistency in selections
    - Does not provide a full distribution
    - Problematic combining across lines
    - No cash flow variability

Log Regression Models or GLM's

- One method involves fitting a set of piece-wise exponential curves in all three dimensions of triangle
  - (development, origin and calendar directions).
  - Each number represents a different expected level and parameter
  - Light blue reflects expected levels to be modeled

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Origin	Development	Calendar	Triangle	Min	Max	Default	Re-Number	Copy

Development Period Changes	(1) 12-24	(2) 24-36	(3) 36-48	(4) 48-60	(5) 60-72	(6) 72-84	(7) 84-96	(8) 96-108	(9) 108-120	(10) 120-132	(11) 132-Ult
Base Parameter Numbers	1	2	3	4	4	4	4	4	4	4	4
Specific Parameter Numbers											
1984	1	2	3	4	4	4	4	4	4	4	4
1985	1	2	3	4	4	4	4	4	4	4	4
1986	1	2	3	4	4	4	4	4	4	4	4
1987	1	2	3	4	4	4	4	4	4	4	4
1988	1	2	3	4	4	4	4	4	4	4	4
1989	1	2	3	4	4	4	4	4	4	4	4
1990	1	2	3	4	4	4	4	4	4	4	4
1991	1	2	3	4	4	4	4	4	4	4	4
1992	1	2	3	4	4	4	4	4	4	4	4
1993	1	2	3	4	4	4	4	4	4	4	4
1994	1	2	3	4	4	4	4	4	4	4	4

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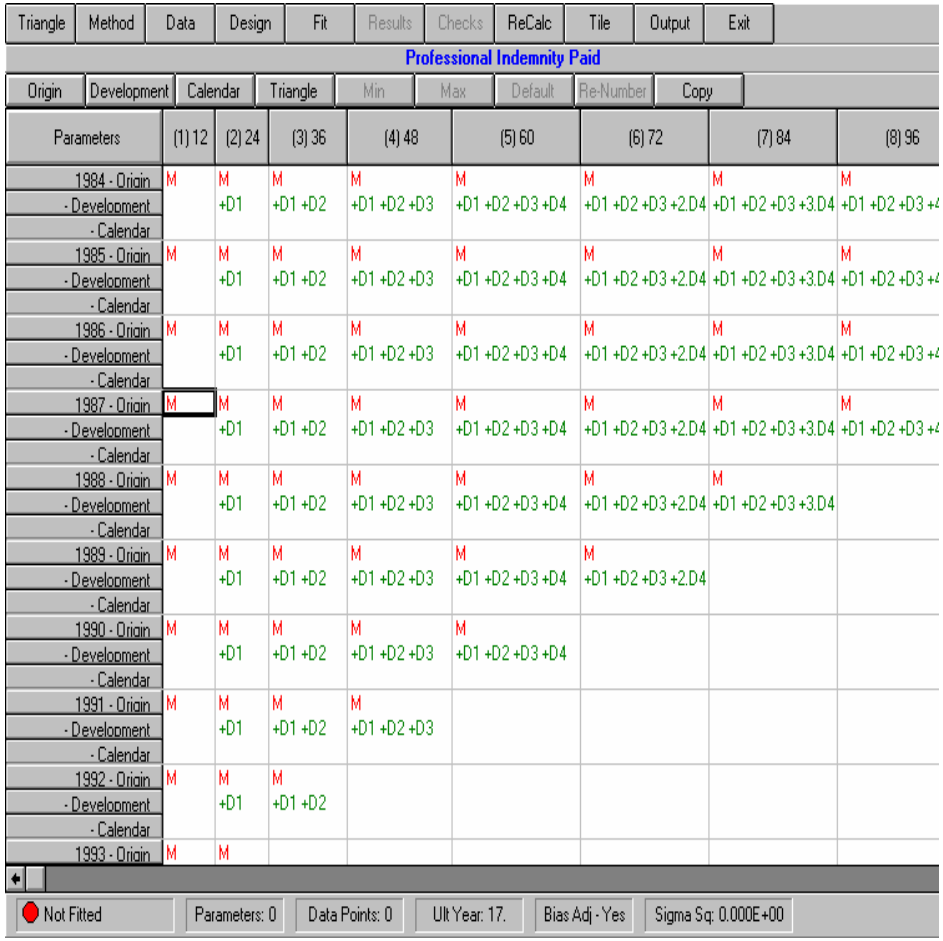
Log Regression Models or GLM's

- Process includes a model of the variance and this is used to estimate standard errors and probability distributions of reserves
  - A lot of trial and error may be involved
  - Design matrix starts to resemble GLM based models



Pros and Cons of Different Approaches

- Log Regression models or GLM's
  - Pros:
    - Can be used to develop a robust model
    - Can produce a full distribution
    - Can be used to develop cash flow variability
  - Cons:
    - May be difficult to explain the results
    - Potential for over-parameterization
    - Piece-wise exponential model may not be appropriate
    - Not suited for negative development (incurred modeling)
    - May take more time to produce a reasonable model
    - May only reflect parameter risk if not careful
    - GLM's only give you a maximum likelihood estimates of parameters and require Bayesian methods to arrive at full predictive distribution

Other Stochastic Models - Mack

- Based upon underlying loss development factors
- Assumes the underlying model is distribution free
- Specifies first two moments only of the distribution
- Problem reduces to estimating the process and parameter risk which can be reduced to:

$$RMSEP\left[\hat{R}_i\right] \approx \sqrt{\hat{D}_{in}^2 \sum_{k=n-i+1}^{n-1} \frac{\hat{\sigma}_{k+1}^2}{\hat{\lambda}_{k+1}^2} \left(\frac{1}{\hat{D}_{ik}} + \frac{1}{\sum_{q=1}^{n-k} D_{qk}} \right)}$$

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Pros and Cons of Different Approaches

- Mack models
  - Pros:
    - Can handle negative values
    - Can be made to produce a full distribution with bootstrapping
    - Can be used to develop cash flow variability
  - Cons:
    - Only provides the first two moments of the predictive distribution
    - Underlying method implies a normal distribution for the process risk

Simple Loss Development Factor Models

- Tries to directly evaluate the underlying variability in LDF's
- A simple approach fits distributions to each development period
- Simulate future period LDF's
- Curves can be fit across simulated development period LDF's to smooth or extract into tail
- Project new ultimates and corresponding reserves

	(1) 12-24	(2) 24-36	(3) 36-48	(4) 48-60	(5) 60-72	(6) 72-84	(7) 84-96	(8) 96-108	(9) 108-120	(10) 120-132
1995	1.23814	1.02909	1.01387	1.00456	1.00103	1.00393	1.00246	1.00009	1.00001	1.00000
1996	1.19500	1.01811	1.01413	1.00334	1.00254	1.00012	0.99997	1.00003	1.00041	
1997	1.35511	1.03238	1.01760	1.00848	1.00804	1.01297	1.00146	1.00064		
1998	1.25571	1.02131	1.01375	1.01032	1.00029	1.00418	1.00066			
1999	1.34200	1.04615	1.01943	1.00418	1.00526	1.00029				
2000	1.44251	1.03279	1.01850	1.00670	1.00325					
2001	1.39003	1.04745	1.02137	1.00765						
2002	1.37938	1.05789	1.02028							
2003	1.23405	1.02581								
2004	1.34042									
2005										

Fit Distributions To Columns

Fit Curves to Smooth or Extract Tail Factors

Pros and Cons of Different Approaches

- Simple loss development factor models
  - Pros:
    - Can be used to develop a robust model
    - Can be made to produce a full distribution
  - Cons:
    - May be difficult to explain the results
    - Potential for over-parameterization
    - May require substantial dependency analysis
    - May only reflect parameter risk if not careful

Individual Claim Models

- Builds variability potential based upon underlying individual claim detail
- Requires knowledge of reported claim distribution as well as IBNYR (true IBNR) claims:
  - Fit distributions for reported claims by accident year
    - Simulate ultimate loss and subtract actual paid to date
  - Develop IBNYR model by accident year
    - Simulate frequency and corresponding severity

Pros and Cons of Different Approaches

- Individual claim statistical model
  - Pros:
    - Can be used to develop a robust model
    - Can be made to produce a full distribution
    - Reinsurance can be applied
  - Cons:
    - Calculation of IBNYR (true IBNR) not always easy
    - May require substantial dependency analysis (IBNYR freq vs IBNYR severity vs IBNER severity)
    - May not reflect change in variability on IBNER claims as they mature.
    - May only reflect process if not careful
    - Requires individual claim detail
    - May require additional assumptions around cash flows

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Bootstrapping vs. Statistical Methods

- Bootstrapping is a sampling technique that is an alternative to or can be used in conjunction with traditional statistical methodologies.
- Traditional statistical approaches try to postulate the underlying distribution that gave rise to the observed outcomes.
- Bootstrapping does not concern itself with the underlying distribution. The bootstrap says that all the information needed to create new samples lies within the variability that exists in the already observed historical data.

Bootstrapping - Parameter Uncertainty

- Bootstrapping is a simple but effective way of obtaining a distribution of parameters
- The method involves creating many new data sets from which the parameters are estimated
- The new data sets are created by sampling with replacement from the observed data
- Results in a ("simulated") distribution of the parameters
- Process risk still needs to be added to this

Bootstrapping Basics

- Bootstrapping assumes the data are independent and identically (i.i.d.) distributed
- With regression type problems, the data are often assumed to be independent but are not identically distributed (the means are different for each observation)
- However, the residuals are usually i.i.d, or can be made so
- Therefore, with regression problems, it is common to bootstrap the residuals instead

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A Bootstrapping Process

- Step 1 - Create a development factor model.
- Step 2 - Calculate residuals
  - The differences between the actual data and the expected data according to the model for each cell in the development triangle.
- Step 3 - Adjust the residuals using the variance model/assumptions to make all the residuals appear as though they come from the same distribution (i.i.d.).
- Step 4 - Generate a new data triangle. This is done for each cell of the triangle by taking the fitted value from the initial model, selecting a residual at random and deriving a new data point. This is known as "pseudo data".

A Bootstrapping Process

- Step 5 - Refit the original model to the pseudo data and estimate future development.
- Step 6 - For each projected future development point, apply process risk based upon an assumed distribution.
- Step 7 - Sum the projected future data to derive reserve estimates.
- Step 8 - Repeat steps 4 to 7 ten thousand times, saving the reserve estimates from each simulation.
- Step 9 - Use the saved reserves from step 8 to produce a probability distribution.

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Pros and Cons of Different Approaches

- Bootstrapping
  - Pros:
    - Can be made to produce a full distribution
    - Produces cash flows
    - Can be applied easily to different levels of data
    - Gives results consistent with complex models
  - Cons:
    - User may expect too much of the model
    - If you can't model it, you can't bootstrap it!
    - Different models will give different results
    - Need to have solid understanding of underlying models
    - Assumptions around process risk need to be added

The Issues

- What constitutes "reasonable"
  - Opinion letter "reasonable"
  - IRS "reasonable"
  - Regulator/rating agency "reasonable"
  - What information do you need to make a reasonable determination
- Is a distribution including process and parameter risk appropriate for selecting reasonable ranges?
  - Be careful assessing percentiles if only parameter or process risk is utilized.
- Was the data underlying the model for the group or the individual company.

The Issues

- How do you estimate variability when multiple methods are used to arrive at your best estimate?
  - Few of us rely on one method
  - How do you combine?
    - Different weightings by year?
  - When do you combine?
  - Does it add anything to the process?
    - Opinion ranges
    - Economic capital needs

The Issues

- Gross vs. Net
  - Net modeling should be done with care
  - Changing reinsurance programs across years may create appearance of additional variability
- Model components vs. aggregate
  - Do you model BI, PD, med or indemnity, medical, expense …. separately or combined
- Changing data vs. variability
  - Has there been a shift in the way claims have been handled
  - Is the variability due to a shift in mix of business? Adding new states. See point above
  - Ideally would like to have a homogeneous data set

The Issues

- Tail assumptions
- Measuring goodness of fit
- Aggregating across lines, classes, or companies
  - Cannot just add endpoints
- Explaining to auditors, regulators, rating agencies, and management.
- Reconciliation to your point estimate (mean or some other point of the distribution)

The Issues

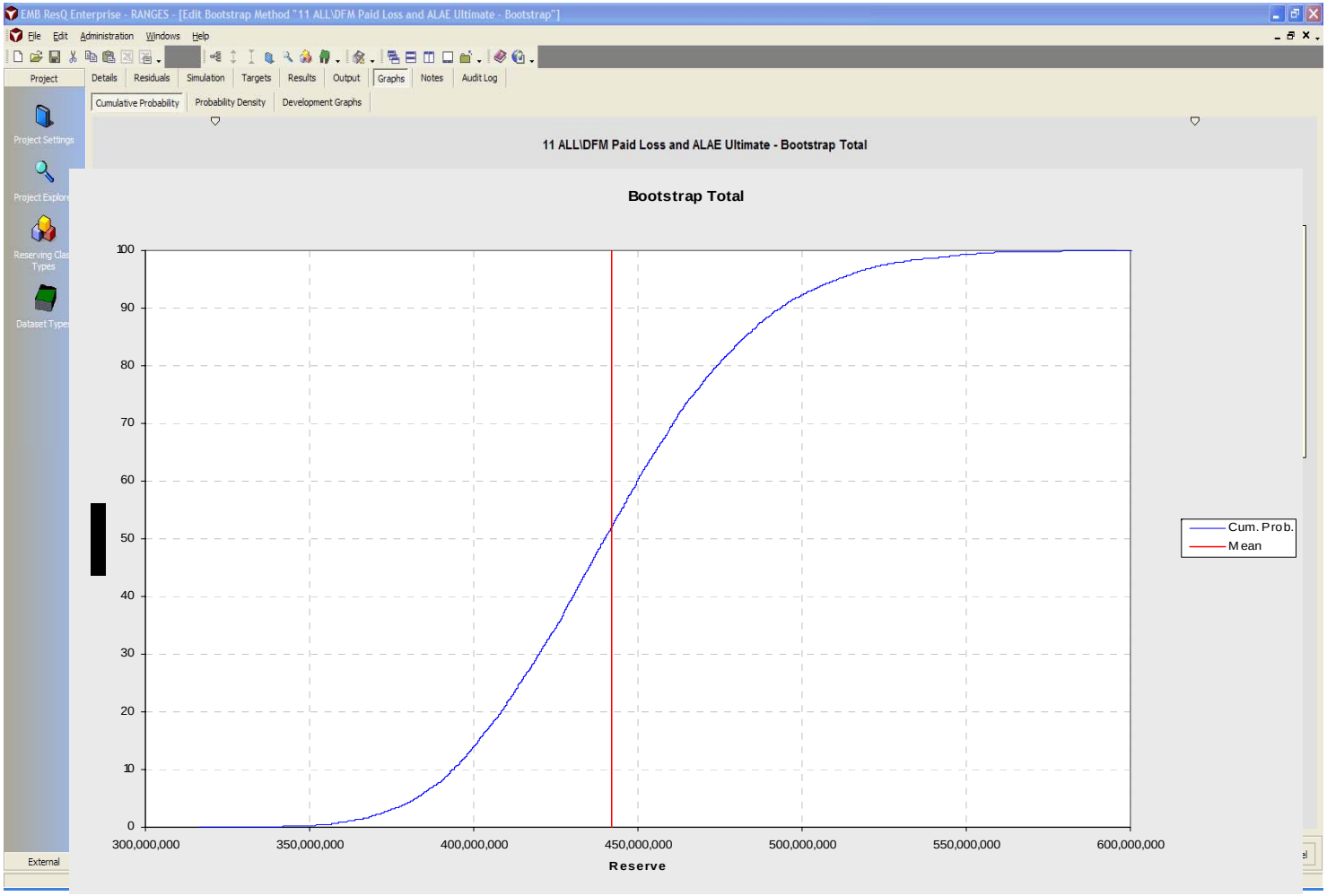
- How do you estimate variability when multiple methods are used to arrive at your best estimate?
  - Few of us rely on one method
  - How do you combine?
    - Different weightings by year?
  - When do you combine?
  - Does it add anything to the process?
    - Opinion ranges
    - Economic capital needs
- Just because a method produces a result does it make it reasonable?
  - Examples:
    - No losses reported to date

ERM Issues

- Mismatch may exist between reserve risk model and other risks
  - Did you include parameter risk in your other models?
  - Does your embedded inflation assumptions tie into your inflation model results?
    - What kind of dependencies do you apply

Sample of Results

- Graph represents total variability of gross reserves.



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Sample of Results

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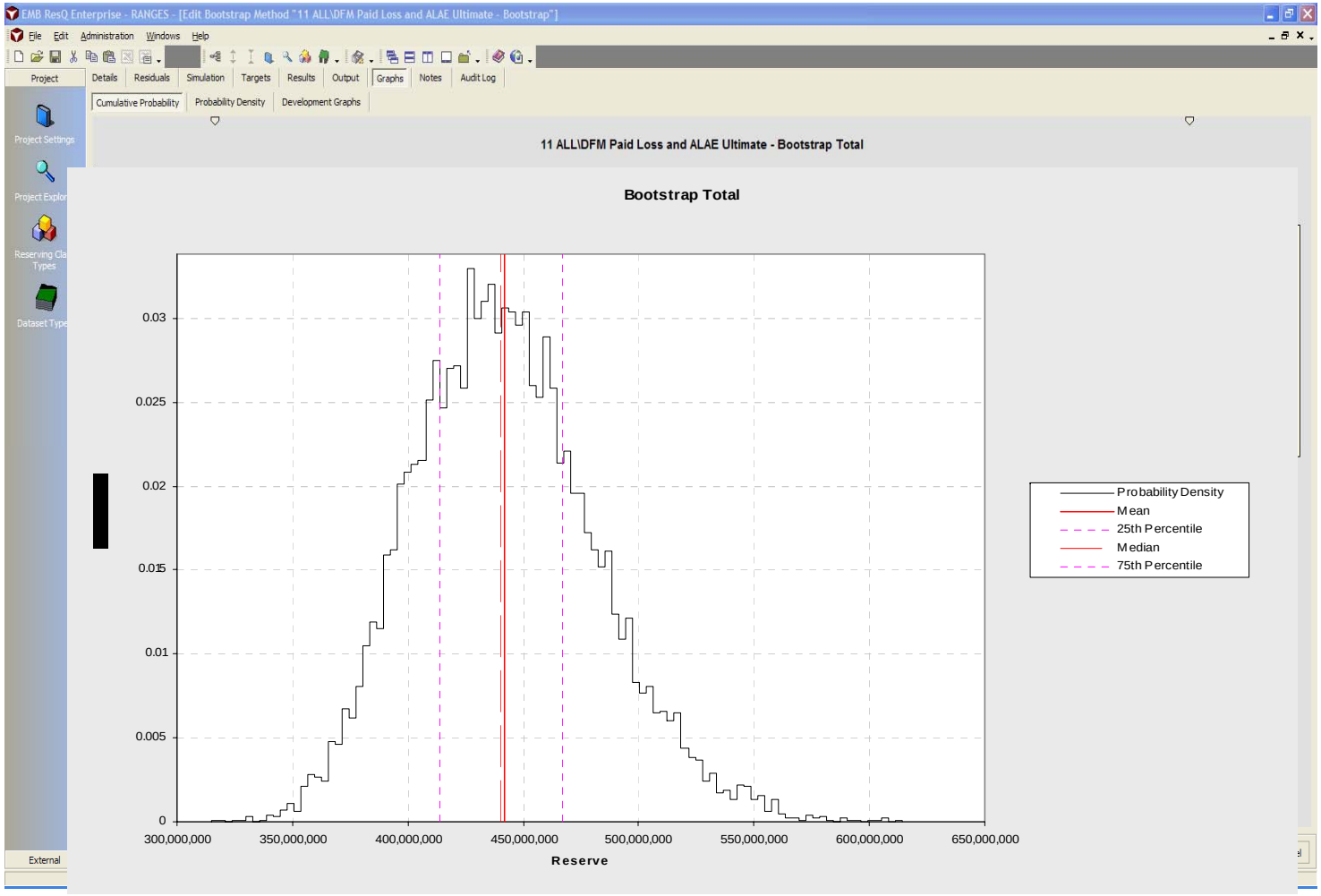
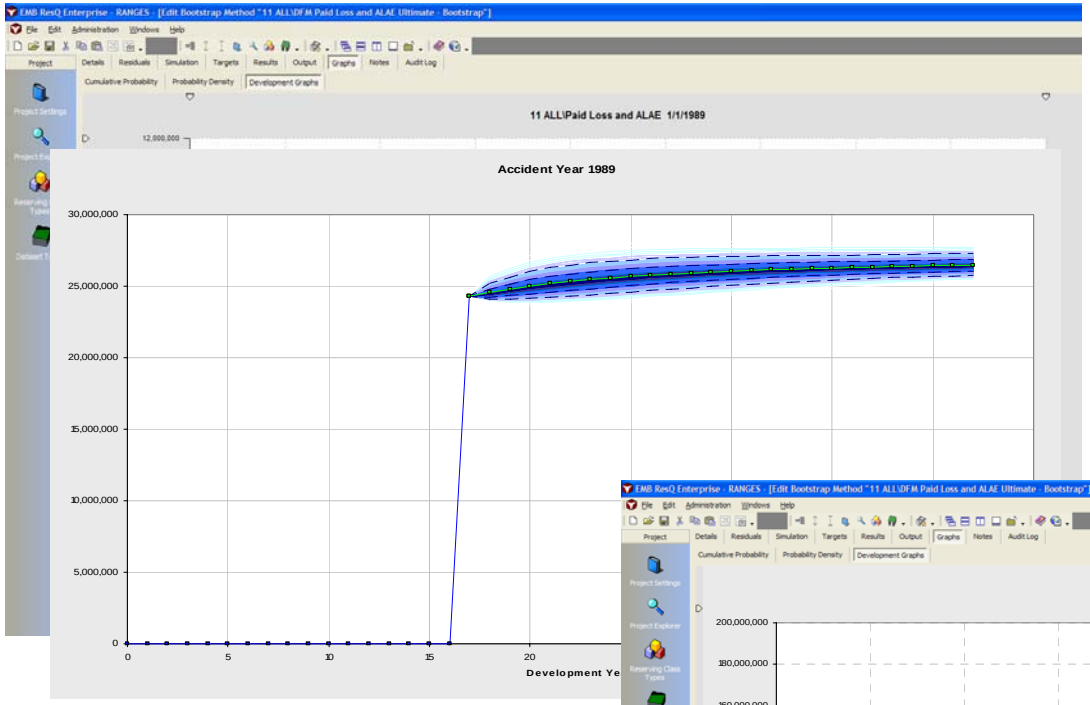


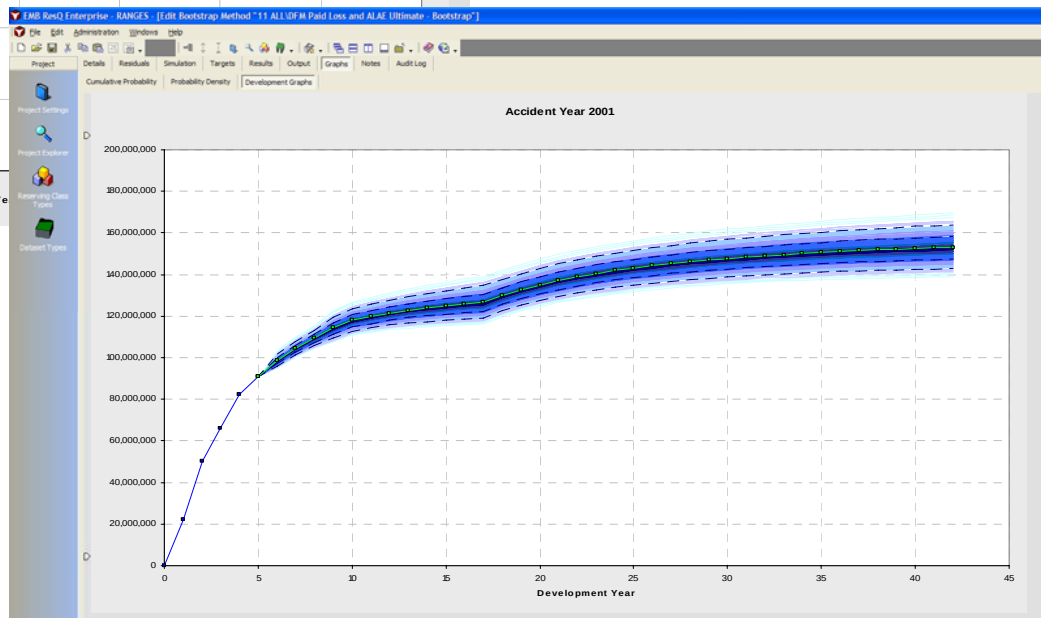
Sample of Results

- Individual accident year distributions along with cashflow variability can be seen from results:



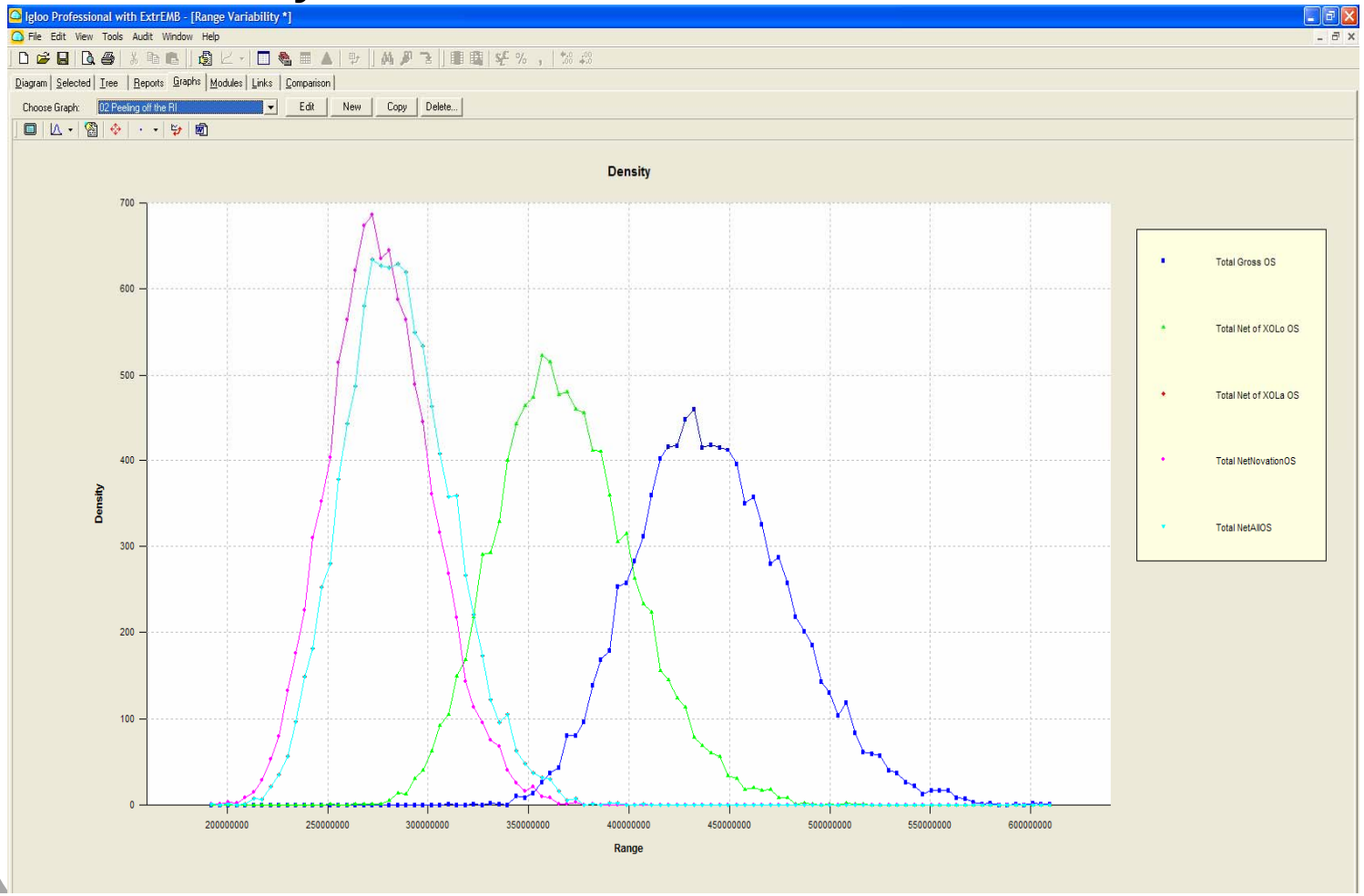
- The bottom graph represents an accident year and its actual development and then the projected development by year and the corresponding variability.
- The application of an XOLa treaty changed the overall distribution for 2001 considerably.

- The top graph represents an old accident year that did not have any historical data (flat line at 0)but was able to develop estimates of variability using limited triangle data and distributions to fit tails to the data.



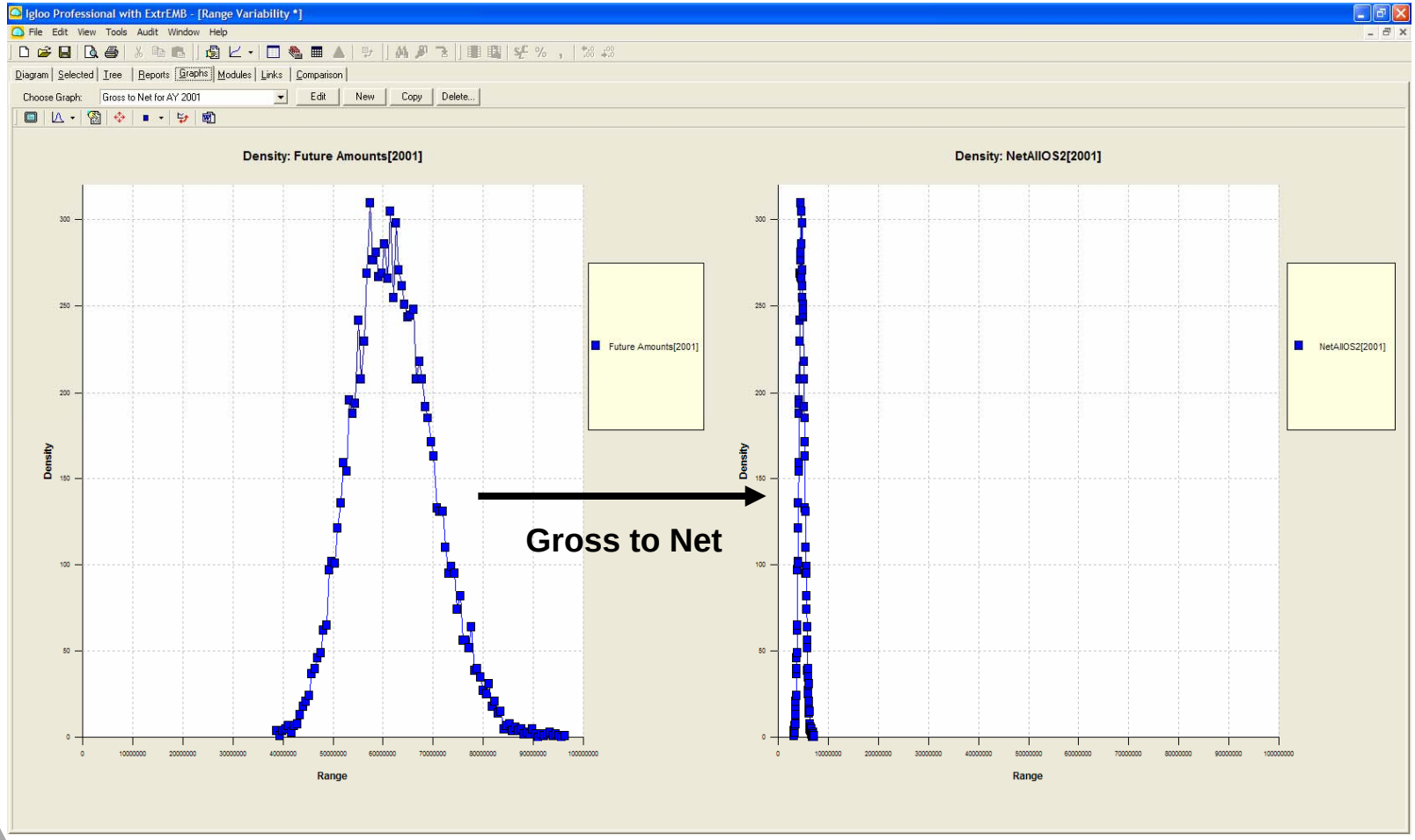
Sample of Results

- Bootstrap results can be sent to simulation software to model reinsurance with greater accuracy.



Sample of Results

- Effect of reinsurance on accident year results can also be dived into in more detail.
- XOLo and XOLa has a material impact on AY 2001.



Sample of Results

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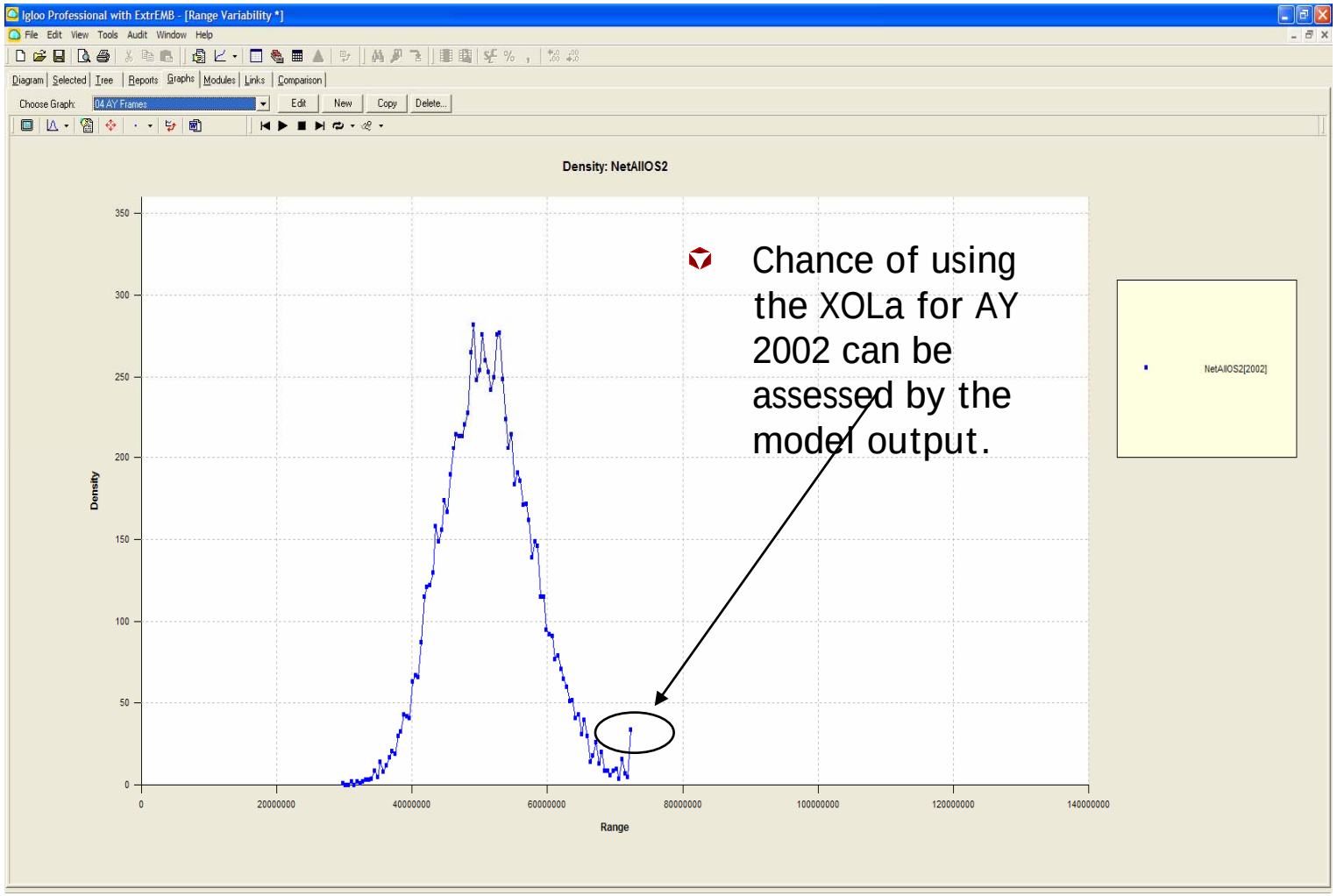

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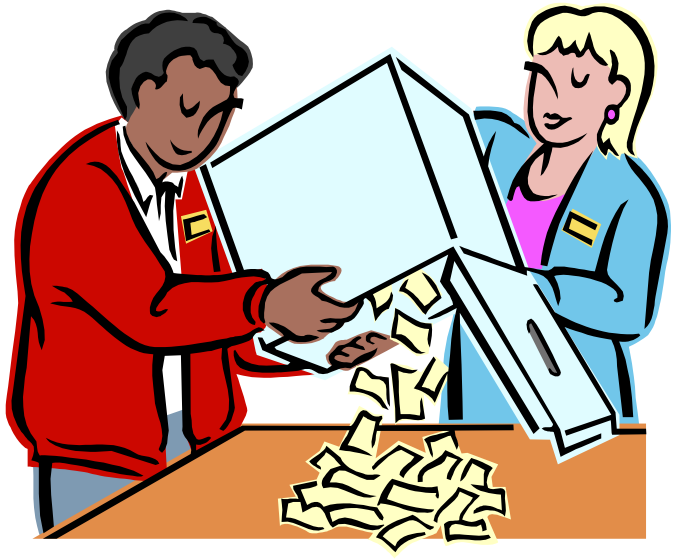
Poll #3

- What would be a reasonable bottom end of the range for an analysis including process and parameter risk?
  - 1st Percentile
  - 30th Percentile
  - 40th Percentile
  - 45th Percentile
  - 50th Percentile

Poll #3 Results

- What would be a reasonable bottom end of the range for an analysis including process and parameter risk?
  - 1% - 1st Percentile
  - 30% - 30th Percentile
  - 31% - 40th Percentile
  - 4% - 45th Percentile
  - 3% - 50th Percentile
  - 30% - No Answer



Notes:

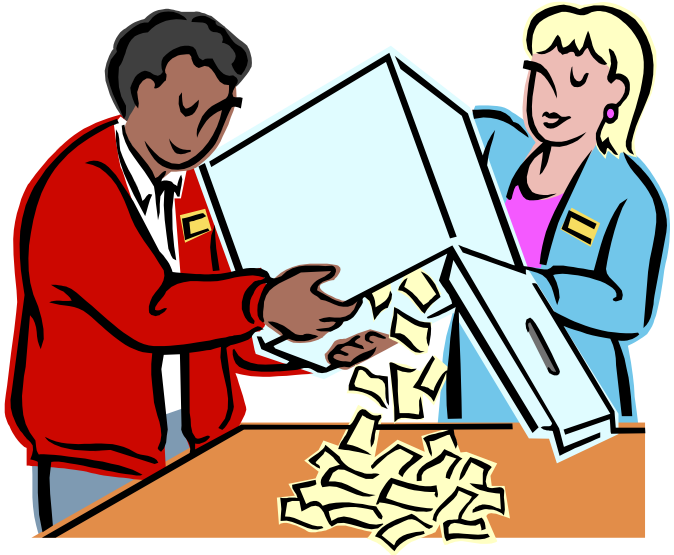
1. 70 entities participating in poll
2. An entity may represent multiple attendees logged on at one site and the poll reflects one vote per entity.
3. "Bottom end" as used in developing the "Reasonable Range" in the Actuarial Opinion of Reserves.

Poll #4

- What would be a reasonable top end of the range for an analysis including process and parameter risk?
  - 50th Percentile
  - 60th Percentile
  - 65th Percentile
  - 70th Percentile
  - 75th Percentile

Poll #4 Results

- What would be a reasonable top end of the range for an analysis including process and parameter risk?
  - 0% - 50th Percentile
  - 5% - 60th Percentile
  - 11% - 65th Percentile
  - 23% - 70th Percentile
  - 34% - 75th Percentile
  - 26% - No Answer



Notes:

1. 70 entities participating in poll
2. An entity may represent multiple attendees logged on at one site and the poll reflects one vote per entity.
3. "Top end" as used in developing the "Reasonable Range" in the Actuarial Opinion of Reserves.

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A Recommendation

- Build good gross underlying reserve models
- Bootstrap reserve models to address parameter risk
  - Not just a push of a button exercise
  - Test bootstrap on different underlying models
  - Choose the most appropriate model
- If bootstrap process does not consider process risk build it in
  - Test impact of different process risk assumptions and distributions
  - Choose the most appropriate process
- Apply reinsurance structures to arrive at net results
- Apply dependencies to roll up results across lines, classes, or companies

Going the Next Step

- Building in inflation assumptions
  - Current models tend to implicitly reflect inflation
  - Will future inflation be consistent with past
    - E.G. WC medical inflation
  - Building in consistent (with other pieces of corporate ERM model) inflation assumptions is important
  - Need a process that provides cash flows
- A process:
  - Explicitly adjust triangles for historical inflation and bring to current inflation levels
  - Link future claims inflation to an economic scenario generator (ESG)
  - Model specific inflation adjustments at time of payment

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Going the Next Step

- More robust net modeling
  - If gross and net are bootstrapped separately, inference can be very difficult due to dependency issues
  - To properly reflect changing reinsurance terms a more robust model may be needed
- A process:
  - Model attritional and large claims separately
    - Bootstrap attritional claims in aggregate
  - Netting down gross claims using origin year and line of business specific reinsurance programs
  - Be careful as combining attritional and large claim results may exceed aggregate analysis
  - Consistency tying back to original estimate

A Challenge

- Don't be afraid to understand your reserving risk
- Don't let NAIC requirements limit your understanding
- Build simple models first and then expand into more robust ones
- Start educating your senior management on the benefits

Summary

- Reserve ranges and distributions are becoming more and more important in insurance operations
- There are numerous methods that develop reserve ranges
  - Not all methods develop distributions suitable for all purposes
  - While some develop predictive errors they do not develop full predictive distributions
- Boostrapping can be used in conjunction with other stochastic methods to develop full predictive distributions of the reserve risk
- Bootstrap results can be coupled with ESG's to produce robust cash flow models

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