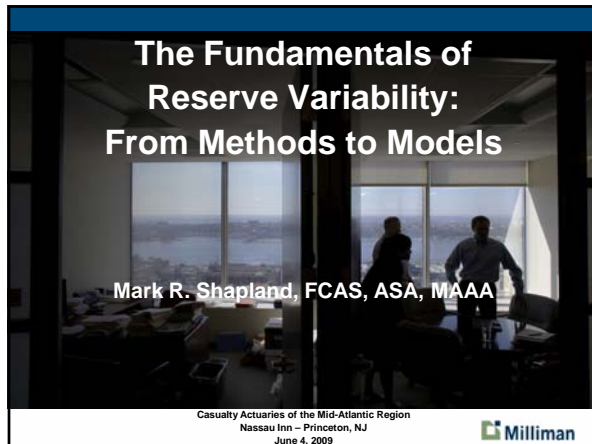


The Fundamentals of Reserve Variability: From Methods to Models

Casualty Actuaries of the Mid-Atlantic Region


June 4, 2009



The Fundamentals of Reserve Variability: From Methods to Models

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Casualty Actuaries of the Mid-Atlantic Region
Nassau Inn - Princeton, NJ
June 4, 2009



Overview

- Definitions of Terms
- Ranges vs. Distributions
- Methods vs. Models
- Types of Methods/Models
- What is “Reasonable”?
- What is a “Reserve Range”?
- Model Evaluation


2



Definitions of Terms

- **Reserve** – an amount carried in the liability section of a risk-bearing entity's balance sheet for claims incurred prior to a given accounting date.
- **Liability** – the actual amount that is owed and will ultimately be paid by a risk-bearing entity for claims incurred prior to a given accounting date.
- **Loss Liability** – the *expected value* of all estimated future claim payments.
- **Risk** (from the “risk-bearers” point of view) – the uncertainty (deviations from expected) in both timing and amount of the future claim payment stream.


3



Definitions of Terms

- **Process Risk** – the randomness of future outcomes given a *known* distribution of possible outcomes.
- **Parameter Risk** – the potential error in the estimated parameters used to describe the distribution of possible outcomes, assuming the process generating the outcomes is *known*.
- **Model Risk** – the chance that the model (“process”) used to estimate the distribution of possible outcomes is incorrect or incomplete.

4




Definitions of Terms

Measures of Risk from Statistics:

- Variance, standard deviation, skewness, average absolute deviation, Value at Risk, Tail Value at Risk, etc. which are measures of dispersion.
- Other measures useful in determining “reasonableness” could include: mean, mode, median, pain function, etc.
- The choice for measure of risk will also be important when considering the “reasonableness” and “materiality” of the reserves in relation to the capital position.


5



Ranges vs. Distributions

- A “Range” is not the same as a “Distribution”
- A *Range of Reasonable Estimates* is a range of estimates that could be produced by appropriate actuarial methods or alternative sets of assumptions that the actuary judges to be reasonable.
- A *Distribution* is a statistical function that attempts to quantify probabilities of all possible outcomes.

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Ranges vs. Distributions

A Range, by itself, creates problems:

- A range can be misleading to the layperson – it can give the impression that any number in that range is equally likely.
- A range can give the impression that as long as the carried reserve is “within the range” anything is reasonable.

7



Ranges vs. Distributions

A Range, by itself, creates problems:

- There is currently no specific guidance within the actuarial community (e.g., +/- X%, +/- \$X, using various estimates, etc.).
- A range, in and of itself, needs some other context to help define it (e.g., how do you calculate a risk margin?)

8



Ranges vs. Distributions

A Distribution provides:

- Information about “all” possible outcomes.
- Context for defining a variety of other measures (e.g., risk margin, materiality, risk based capital, etc.)

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Ranges vs. Distributions

A Distribution can be used for:

- Technical Provisions / Unpaid Claim Estimates
 - IFRS: Discounted Best Estimate + CoC Risk Margin
 - GAAP / Statutory: Undiscounted Best Estimate
- Economic / Risk-Based Capital / Solvency II
 - Reserve Risk
 - Pricing Risk
 - Duration Risk

→ Allocated Capital
- Reinsurance Analysis
 - Quota Share
 - Aggregate Excess
 - Stop Loss
 - Loss Portfolio Transfer

→ Risk Transfer
- Dynamic Risk Modeling (DFA) → Parameterize ANY Model
- Strategic Planning / Performance Management / ERM
- Regulatory & Rating Agency Support
- Compare Expected vs. Actual Variability / Back Testing
- Mergers & Acquisitions

10



Ranges vs. Distributions

Should we use the same:

- criterion for judging the quality of a range vs. a distribution?
- basis for determining materiality? risk margins?
- selection process for which numbers are “reasonable” to choose from?

11



Methods vs. Models

- A **Method** is an algorithm or recipe – a series of steps that are followed to give an estimate of future payments.
- The well known chain ladder (CL) and Bornhuetter-Ferguson (BF) methods are examples.
- The search for the “best” pattern.

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Methods vs. Models

- A **Model** specifies statistical assumptions about the loss process, usually leaving some parameters to be estimated.
- Then estimating the parameters gives an estimate of the ultimate losses and some statistical properties of that estimate.
- The search for the “best” distribution.

13



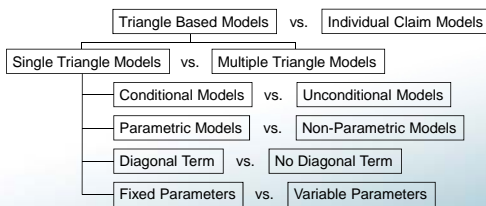
Methods vs. Models

- Many good probability models have been built using “Collective Risk Theory”
- Each of these models make assumptions about the processes that are driving claims and their settlement values
- None of them can ever completely eliminate “model risk”
“All models are wrong. Some models are useful.”

14



Types of Models



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Types of Models

- Processes used to calculate liability ranges can be grouped into four general categories:
 - 1) Multiple Projection Methods,
 - 2) Statistics from Link Ratio Models,
 - 3) Incremental Models, and
 - 4) Simulation Models

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What is “Reasonable”?



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What is “Reasonable”?

- Premise:**
- We could define a “reasonable” range based on probabilities of the distribution of possible outcomes.
 - This can be translated into a range of liabilities that correspond to those probabilities.

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What is "Reasonable"?

A probability range has several advantages:


- The "risk" in the data defines the range.
- Adds context to other statistical measures.
- A "reserve margin" can be defined more precisely.
- Can be related to risk of insolvency and materiality issues.
- Others can define what is reasonable for them.

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What is "Reasonable"?

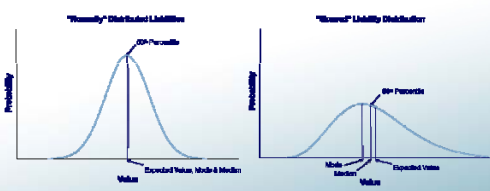
Comparison of "Reasonable" Reserve Ranges by Method


Method	Relatively Stable LOB			More Volatile LOB		
	Low	EV	High	Low	EV	High
Expected +/- 20%	80	100	120	80	100	120
50 th to 75 th Percentile	97	100	115	90	100	150

20 

What is "Reasonable"?

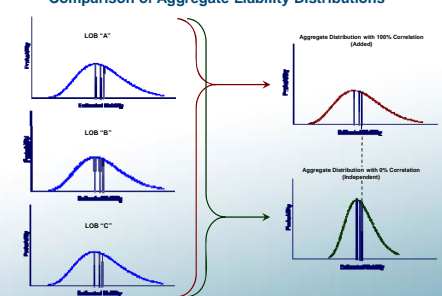
Comparison of "Normal" vs. "Skewed" Liability Distributions




21 

What is "Reasonable"?

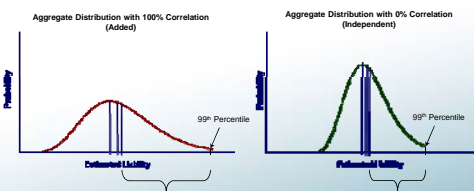
Comparison of Aggregate Liability Distributions




22 

What is "Reasonable"?

Comparison of Aggregate Liability Distributions



23 

What is "Reasonable"?

Others can Define Reasonability



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What is "Reasonable"?

Comparison of "Reasonable" Reserve Ranges with Probabilities of Insolvency

"Low" Reserve Risk

Loss Reserves		Corresponding Surplus Depending on Situation					
		Situation A		Situation B		Situation C	
Amount	Prob.	Amount	Prob. Of Ins.	Amount	Prob. Of Ins.	Amount	Prob. Of Ins.
100	50%	80	40%	120	15%	160	1%
110	75%	70	40%	110	15%	150	1%
120	90%	60	40%	100	15%	140	1%


25 

What is "Reasonable"?

Comparison of "Reasonable" Reserve Ranges with Probabilities of Insolvency

"Medium" Reserve Risk

Loss Reserves		Corresponding Surplus Depending on Situation					
		Situation A		Situation B		Situation C	
Amount	Prob.	Amount	Prob. Of Ins.	Amount	Prob. Of Ins.	Amount	Prob. Of Ins.
100	50%	80	60%	120	40%	160	10%
120	75%	60	60%	100	40%	140	10%
140	90%	40	60%	80	40%	120	10%


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What is "Reasonable"?

Comparison of "Reasonable" Reserve Ranges with Probabilities of Insolvency

"High" Reserve Risk


Loss Reserves		Corresponding Surplus Depending on Situation					
		Situation A		Situation B		Situation C	
Amount	Prob.	Amount	Prob. Of Ins.	Amount	Prob. Of Ins.	Amount	Prob. Of Ins.
100	50%	80	80%	120	50%	160	20%
150	75%	30	80%	70	50%	110	20%
200	90%	-20	80%	20	50%	60	20%

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What is "Reasonable"?


Satisfying Different Constituents:

- **Principle of Greatest Common Interest** – the "largest amount" considered "reasonable" when a variety of constituents share a common goal or interest, such that all common goals or interests are met; and the
- **Principle of Least Common Interest** – the "smallest amount" considered "reasonable" when a variety of constituents share a common goal or interest, such that all common goals or interests are met.

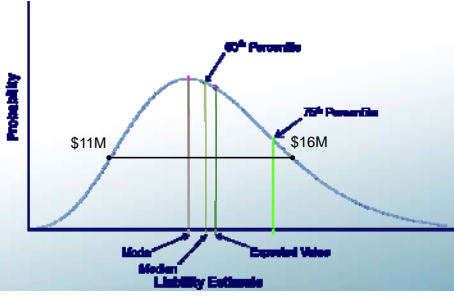
28 


What is "Reasonable"?

\$11M ————— \$16M

29 

What is "Reasonable"?

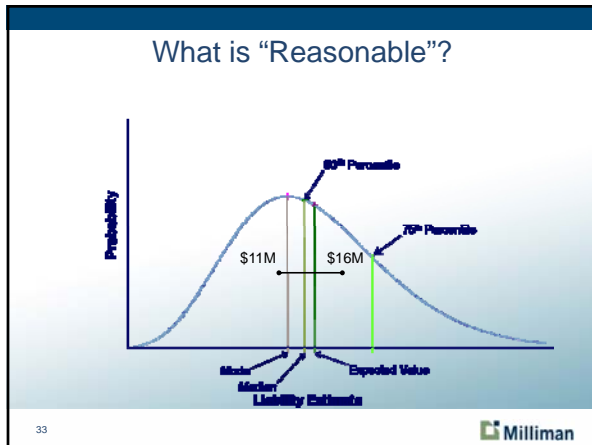
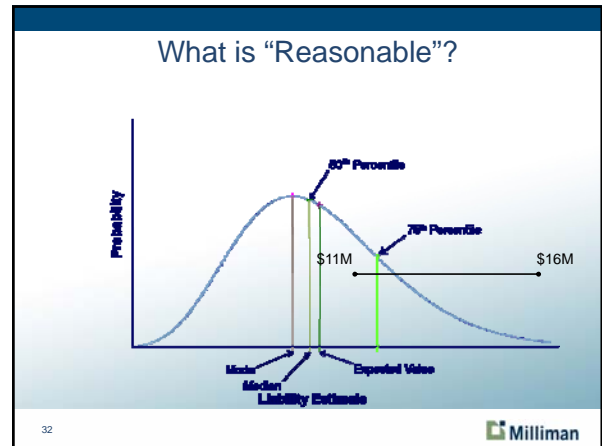
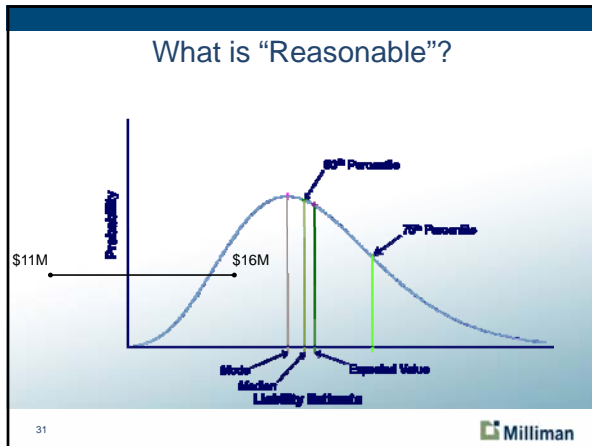


30 

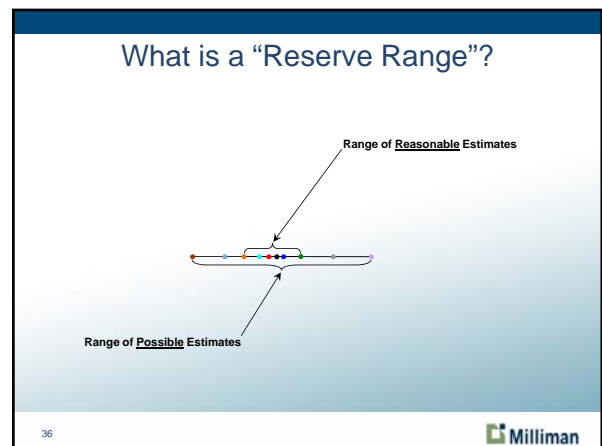
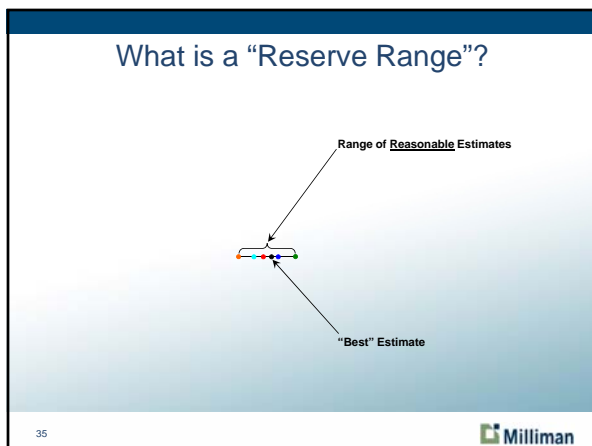
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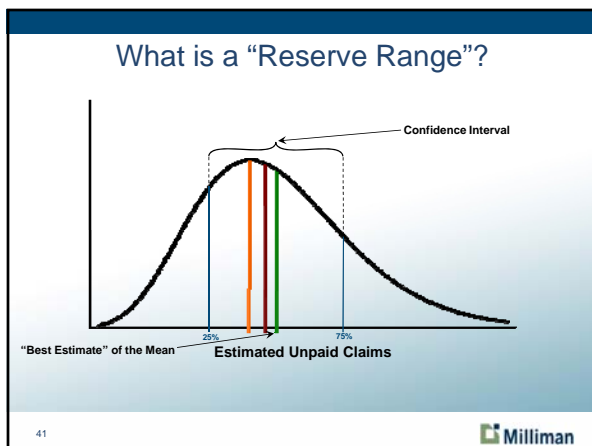
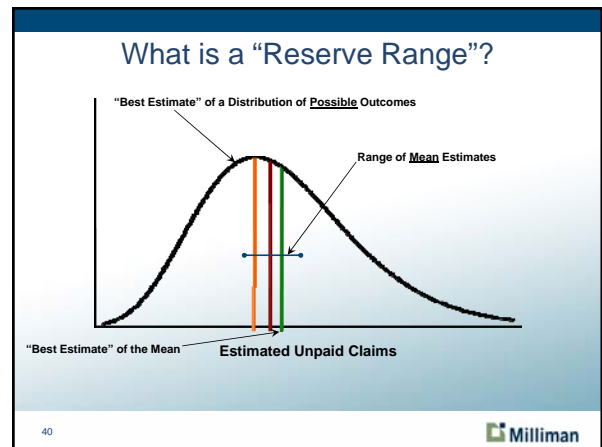
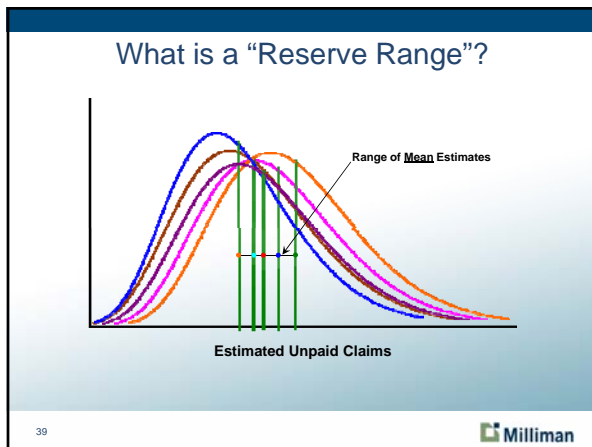
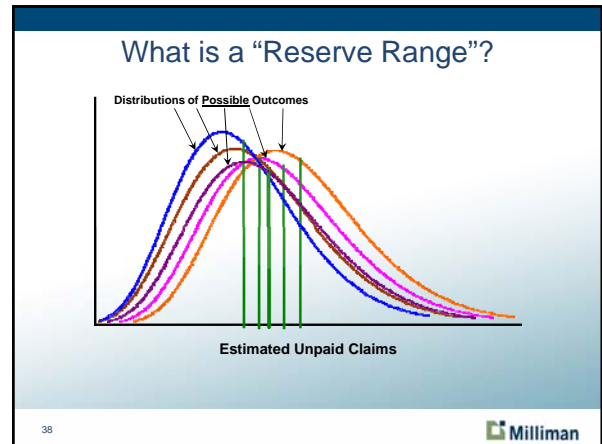
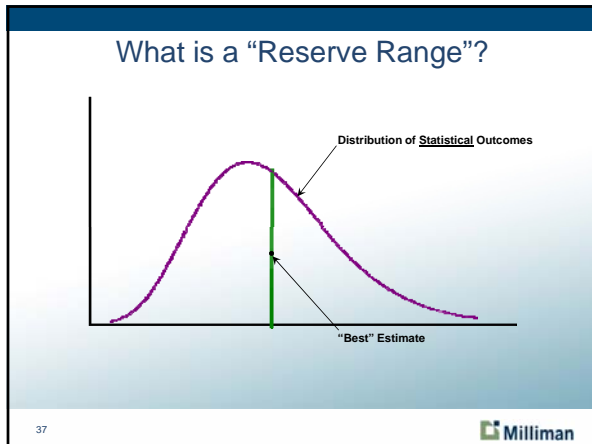
- ### What is a "Reserve Range"?
- A "range" is generally considered to be either a subset of the "possible outcomes" or a subset of "central estimates".
 - A "possible outcome" will generally include random movements in the incremental values (e.g., calendar period payments within each accident period).
 - For a "central estimate" the incremental values will essentially have the random movements "averaged" or "smoothed" out.
- 34
- Milliman



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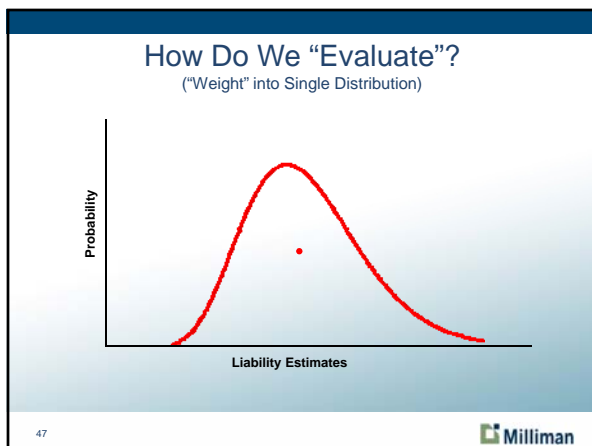
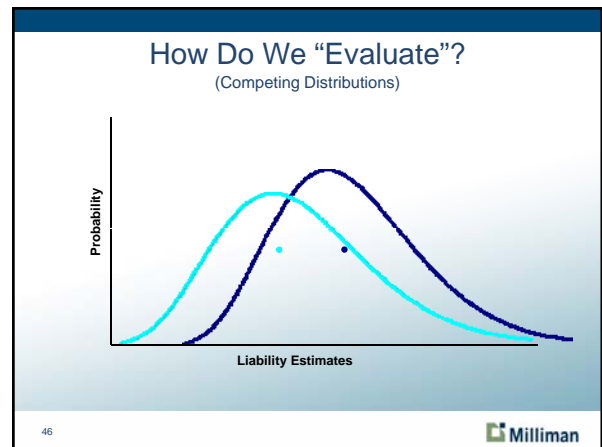
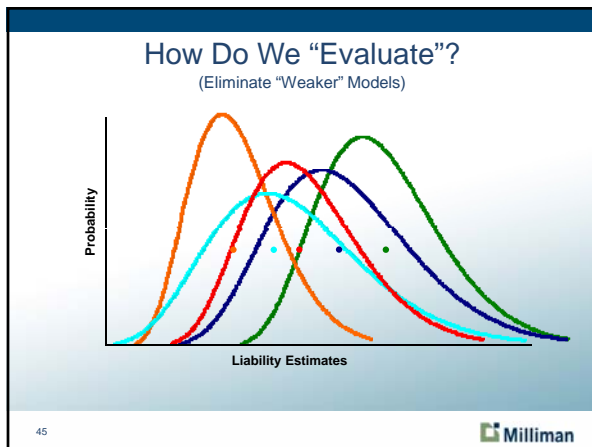
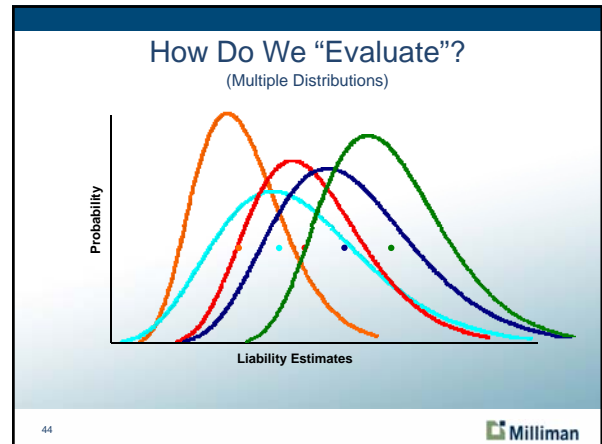
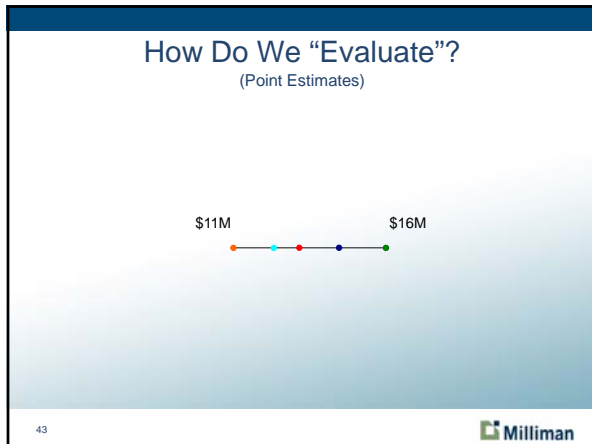


- ### Model Selection and Evaluation
- Actuaries Have Built Many Sophisticated Models Based on Collective Risk Theory
 - All Models Make Simplifying Assumptions
 - How do we Evaluate Them?
- 42
- Milliman

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- ### Fundamental Questions
- How Well Does the Model Measure and Reflect the Uncertainty Inherent in the Data?
 - Does the Model do a Good Job of Capturing and Replicating the Statistical Features Found in the Data?
- 48

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Modeling Goals

- Is the Goal to Minimize the Range (or Uncertainty) that Results from the Model?
- Goal of Modeling is NOT to Minimize Process Uncertainty!
- Goal is to Find the Best Statistical Model, While Minimizing Parameter and Model Uncertainty.

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Model Selection & Evaluation Criteria

- Model Selection Criteria
- Model Reasonability Checks
- Goodness-of-Fit & Prediction Errors

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Model Selection Criteria

- **Criterion 1: Aims of the Analysis**
 - Will the Procedure Achieve the Aims of the Analysis?
- **Criterion 2: Data Availability**
 - Access to the Required Data Elements?
 - Unit Record-Level Data or Summarized “Triangle” Data?

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Model Selection Criteria

- **Criterion 3: Non-Data Specific Modeling Technique Evaluation**
 - Has Procedure been Validated Against Historical Data?
 - Verified to Perform Well Against Dataset with Similar Features?
 - Assumptions of the Model Plausible Given What is Known About the Process Generating this Data?

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Model Selection Criteria

- **Criterion 4: Cost/Benefit Considerations**
 - Can Analysis be Performed Using Widely Available Software?
 - Analyst Time vs. Computer Time?
 - How Difficult to Describe to Junior Staff, Senior Management, Regulators, Auditors, etc.?

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Model Reasonability Checks

- **Criterion 5: Coefficient of Variation by Year**
 - Should be Largest for Oldest (Earliest) Year
- **Criterion 6: Standard Error by Year**
 - Should be Smallest for Oldest (Earliest) Year (on a Dollar Scale)

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Model Reasonability Checks

- **Criterion 7: Overall Coefficient of Variation**
 - Should be Smaller for All Years Combined than any Individual Year
- **Criterion 8: Overall Standard Error**
 - Should be Larger for All Years Combined than any Individual Year

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Model Reasonability Checks

Accident Yr	Mean	Standard Error	Coefficient of Variation
1996	26,416	37,927	143.6%
1997	26,216	38,774	147.9%
1998	50,890	54,508	107.1%
1999	90,705	74,824	82.5%
2000	148,110	99,986	67.5%
2001	186,832	117,230	62.7%
2002	418,461	183,841	43.9%
2003	638,082	268,578	42.1%
2004	607,107	477,760	78.7%
2005	1,521,202	1,017,129	66.9%
Total	3,714,020	1,299,184	35.0%

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Model Reasonability Checks

Accident Yr	Mean	Standard Error	Coefficient of Variation
1996	25,913	37,956	146.5%
1997	25,708	38,846	151.1%
1998	50,043	54,780	109.5%
1999	89,071	74,987	84.2%
2000	145,388	100,373	69.0%
2001	183,864	118,502	64.5%
2002	411,367	185,211	45.0%
2003	628,347	271,722	43.2%
2004	1,113,073	229,923	20.7%
2005	1,263,550	253,596	20.1%
Total	3,936,326	599,048	15.2%

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Model Reasonability Checks

- **Criterion 9: Correlated Standard Error & Coefficient of Variation**
 - Should Both be Smaller for All LOBs Combined than the Sum of Individual LOBs
- **Criterion 10: Reasonability of Model Parameters and Development Patterns**
 - Is Loss Development Pattern Implied by Model Reasonable?

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Model Reasonability Checks

- **Criterion 11: Consistency of Simulated Data with Actual Data**
 - Can you Distinguish Simulated Data from Real Data?
- **Criterion 12: Model Completeness and Consistency**
 - Is it Possible Other Data Elements or Knowledge Could be Integrated for a More Accurate Prediction?

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Goodness-of-Fit & Prediction Errors

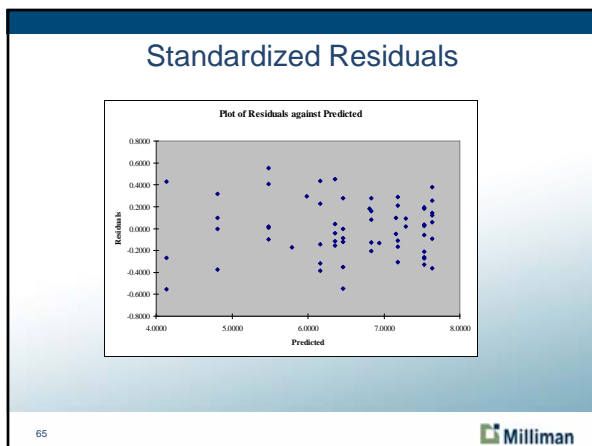
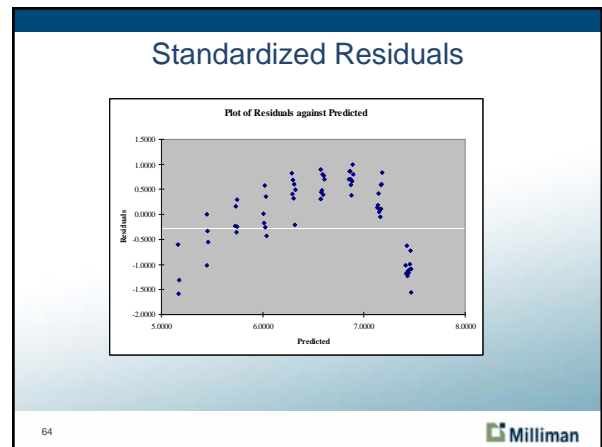
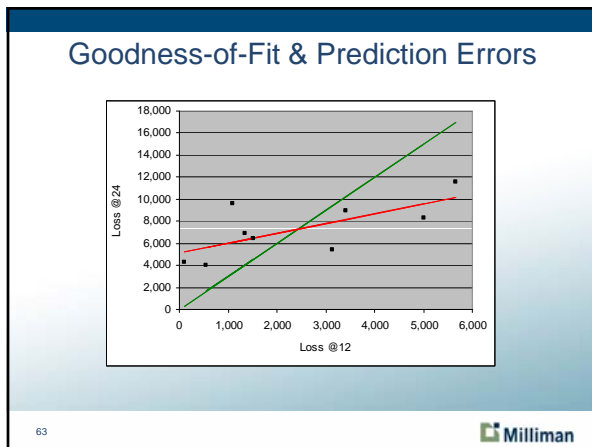
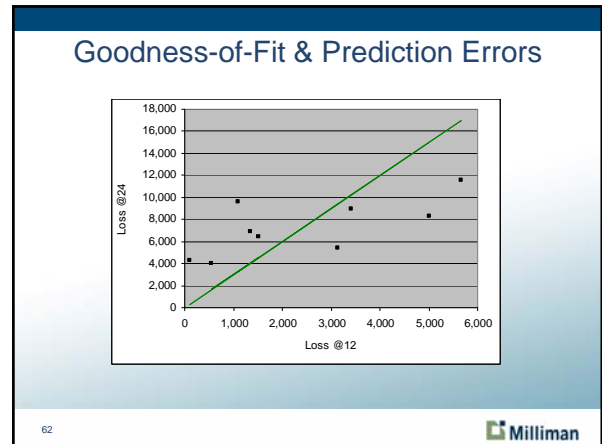
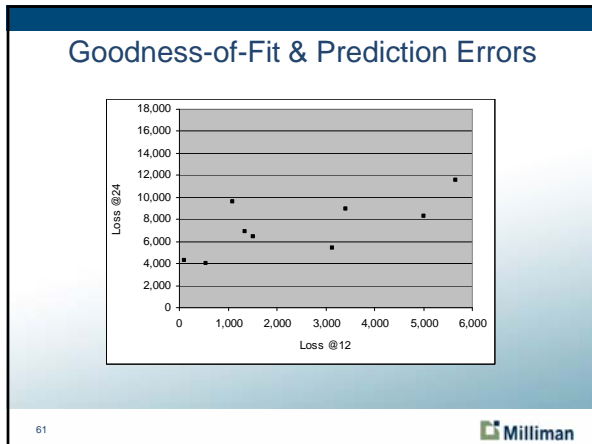
- **Criterion 13: Validity of Link Ratios**
 - Link Ratios are a Form of Regression and Can be Tested Statistically
- **Criterion 14: Standardization of Residuals**
 - Standardized Residuals Should be Checked for Normality, Outliers, Heteroscedasticity, etc.

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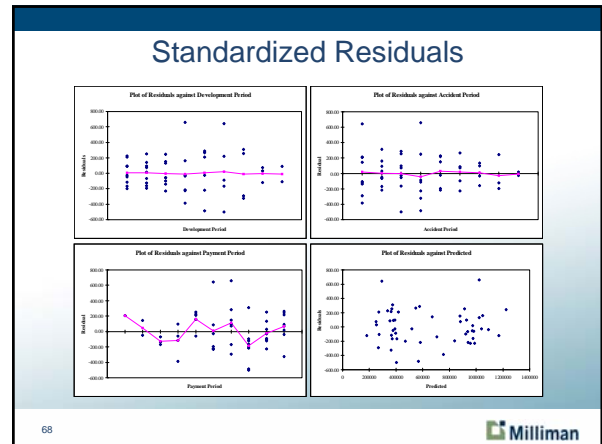
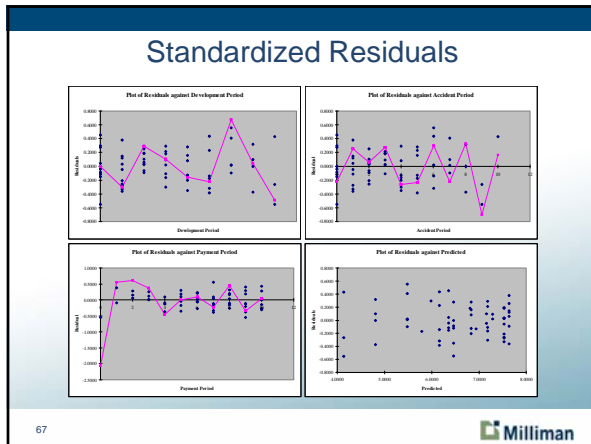


- ### Goodness-of-Fit & Prediction Errors
- **Criterion 15: Analysis of Residual Patterns**
 - Check Against Accident, Development and Calendar Periods
 - **Criterion 16: Prediction Error and Out-of-Sample Data**
 - Test the Accuracy of Predictions on Data that was Not Used to Fit the Model
- 66

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- ### Goodness-of-Fit & Prediction Errors
- **Criterion 17: Goodness-of-Fit Measures**
 - Quantitative Measures that Enable One to Find Optimal Tradeoff Between Minimizing Model Bias and Predictive Variance
 - Adjusted Sum of Squared Errors (SSE)
 - Akaike Information Criterion (AIC)
 - Bayesian Information Criterion (BIC)
- 69

- ### Goodness-of-Fit & Prediction Errors
- **Criterion 18: Ockham's Razor and the Principle of Parsimony**
 - All Else Being Equal, the Simpler Model is Preferable
 - **Criterion 19: Model Validation**
 - Systematically Remove Last Several Diagonals and Make Same Forecast of Ultimate Values Without the Excluded Data
- 70

Questions?

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