

**AR4: IMPROVING ACTUARIAL RESERVE  
ANALYSIS THROUGH CLAIM-LEVEL  
PREDICTIVE ANALYTICS**

2016 CLRS

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Presenters: Brian Janitschke & Chris Gross



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**Disclaimer**

Any opinions expressed here are those of the presenters, not those of Capital Insurance Group or of Gross Consulting.



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## Case Reserve Adequacy Example

Accident Period	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
	7,425	9,161	8,555	15,436	6,572	15,662	24,329	13,195	19,990	24,451								
	5,418	7,361	14,058	13,784	15,392	6,633	10,383	18,718	21,325	4,504								
	6,023	7,660	12,017	13,242	22,099	11,470	12,114	14,543	4,401	6,422								
	6,667	11,333	12,659	11,197	7,531	18,592	2,718	20,921	13,429	7,004								
	5,647	8,594	10,021	23,137	15,536	11,719	12,401	4,044	7,681	55								
	9,031	8,283	12,626	12,802	17,409	33,697	7,833	35,736	11,894	13,454								
	7,333	12,039	8,452	30,860	12,491	32,925	27,371	13,483	18,818	16,353								
	8,290	15,097	11,663	12,336	19,280	14,183	50,042	37,290	14,578	40,260								
	8,292	14,563	12,252	31,963	15,778	15,291	15,324	14,548	15,318	15,589								
	5,733	7,960	8,312	14,460	8,781	20,298	7,253	7,433	15,853									
	6,172	8,008	8,994	17,823	17,125	17,383	17,468	8,057										
	7,964	10,467	13,008	8,360	10,024	19,829	20,106											
	5,695	7,318	9,937	14,810	19,155	12,661												
	5,086	7,900	9,373	15,745	23,693													
	5,595	7,308	8,055	11,351														
	6,293	9,071	7,172															
	5,207	7,730																
	4,605																	

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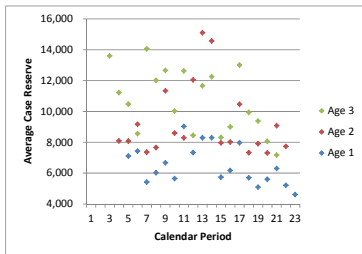
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## Case Reserve Adequacy Example




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## Case Reserve Adequacy Example

- Mix issues
  - Different classes of business
  - Different causes of loss
  - Geography
  - Etc.
- Can generate average case reserve triangles at each of these levels but **reduced volume of data/increased volume of triangles** can make the situation more difficult to see.

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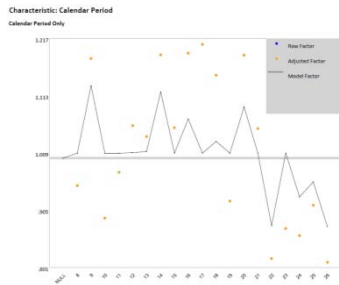
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## Case Reserve Adequacy Example

Same calendar period data, but include credibility (in this case based on rank based t-statistic of observations) and smoothing techniques.




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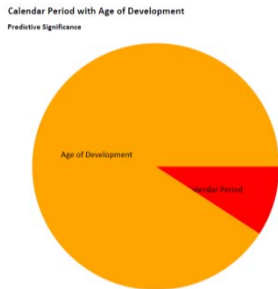
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## Case Reserve Adequacy Example

At the very least, the inclusion of Age of Development is appropriate in a predictive model of case reserves

In this case it is very predictive




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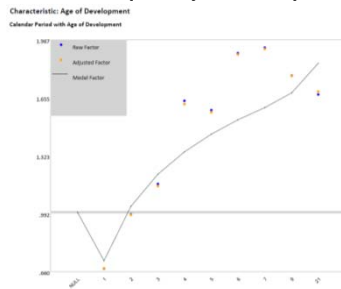
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## Case Reserve Adequacy Example

Not surprisingly, the age of development has a strong impact on the size of the case reserve.




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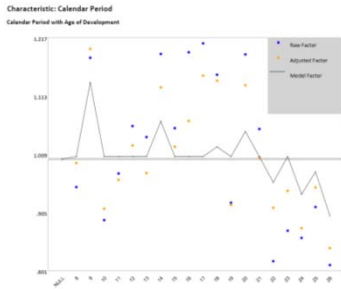
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## Case Reserve Adequacy Example

The calendar period, when adjusted for age of development (orange dots) now shows a more muted impact on case reserves, but still cause for concern.



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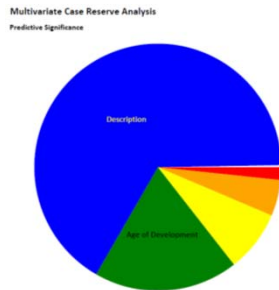
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## Case Reserve Adequacy Example

Addition of other variables is easy—particularly those that are already on the claim record.



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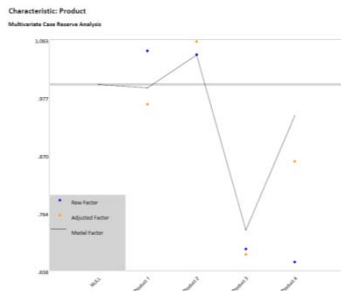
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## Case Reserve Adequacy Example

The policy form was also predictive.



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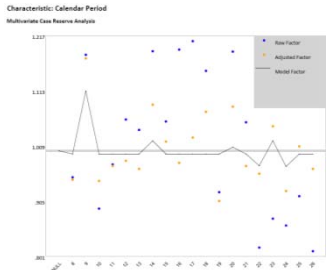
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## Case Reserve Adequacy Example

Our primary question remains. Is there a change by calendar period?

After adjusting for the other variables, there is much less evidence of a change in adequacy over time.




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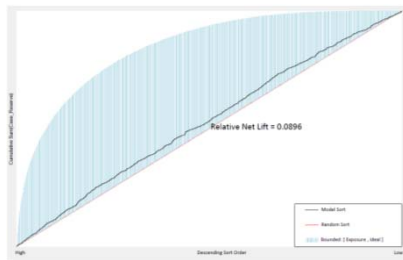
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## Case Reserve Adequacy Example

A lift chart for the model that uses Calendar Period alone.

Calendar Period by itself, does little to describe the size of the case reserve in this example.




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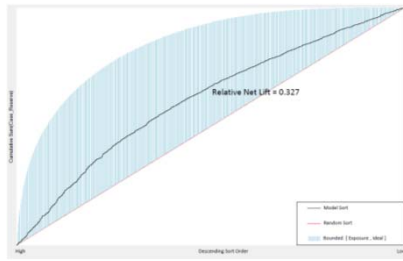
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## Case Reserve Adequacy Example

A lift chart using Calendar Period and Age of Development.

This model does a considerably better job of describing case reserve size. (Hence our use of average case triangles)




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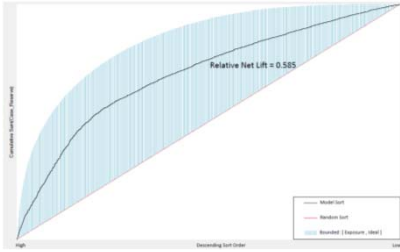
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## Case Reserve Adequacy Example

This lift chart includes the impact of other variables.

Adding variables like cause of loss results in a **much** better model of case reserves.




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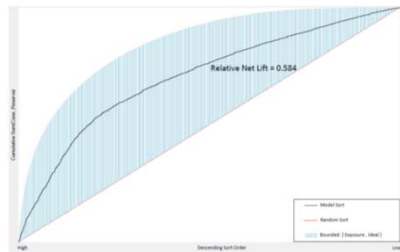
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## Case Reserve Adequacy Example

This lift chart shows a model where the other variables are left in, and calendar period is removed.

The impact of calendar period is relatively insignificant, after normalizing for the impact of other variables.




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## Case Reserve Adequacy Example

- Consider the following scenario:
  - Pressure on underwriting to write tougher, more severe classes.
  - Pressure on claim department to be more aggressive on setting case reserves.
  - What would this combination look like in terms of average case reserve?
  - Could very well be flat. Normal diagnostics may miss it.
  - Predictive modeling could help alert the actuary to this situation.

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## Ways to Incorporate Predictive Modeling Into Reserve Analysis

- Analysis of specific loss development data/processes, for example:
  - Case reserve adequacy
  - Closure rates
- Modification of triangles
- Reserve segmentation
- Full description of the entire process, with resulting estimate of reserves

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## The Mix Problem... An Example

- Two classes of business
  - Class 1.
    - Faster developing
    - Lower ultimate loss ratio (60%)
  - Class 2
    - Slower developing
    - Higher ultimate loss ratio (90%)
- Class 2 has always been there, but only recently started growing significantly

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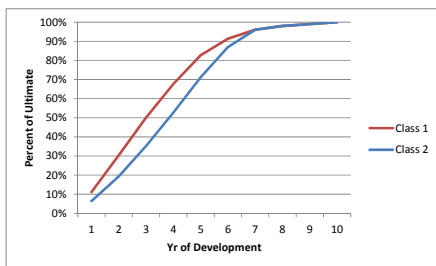
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## Different Development



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## The Triangle

Year	Premium	Loss as of:									
		Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10
2006	105	7.53	20.40	32.67	43.49	52.72	58.08	61.20	62.36	63.28	64.50
2007	105	8.06	20.72	32.65	43.52	54.68	60.16	63.87	64.15	63.71	
2008	105	6.48	19.23	30.80	42.47	52.70	58.32	60.99	62.91		
2009	105	7.21	19.21	30.81	42.44	52.93	59.64	61.78			
2010	105	7.43	21.88	34.36	43.89	53.76	59.81				
2011	105	6.76	19.19	33.07	43.90	54.42					
2012	105	7.11	18.49	30.01	40.40						
2013	120	8.44	22.18	37.25							
2014	140	8.65	25.87								
2015	160	9.81									

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## Development Factors

2006	2.709	1.602	1.331	1.212	1.102	1.054	1.019	1.015	1.019
2007	2.571	1.576	1.333	1.256	1.100	1.062	1.005	0.993	
2008	2.967	1.602	1.379	1.241	1.107	1.046	1.031		
2009	2.666	1.604	1.378	1.247	1.127	1.036			
2010	2.944	1.570	1.277	1.225	1.113				
2011	2.840	1.724	1.327	1.239					
2012	2.602	1.622	1.346						
2013	2.630	1.679							
2014	2.990								
Last 3	2.740	1.675	1.317	1.237	1.115	1.048	1.018	1.004	1.019
Cumulative	9.108	3.324	1.984	1.506	1.218	1.092	1.042	1.023	1.019

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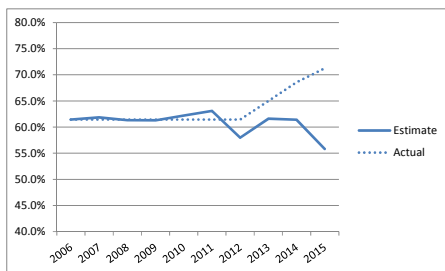
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## True Loss Ratio vs Estimate




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## Potential Differences

- Industry classification
- Geography
- Deductible/Limit Profile
- Size of account
- Type of Claims
- Etc.

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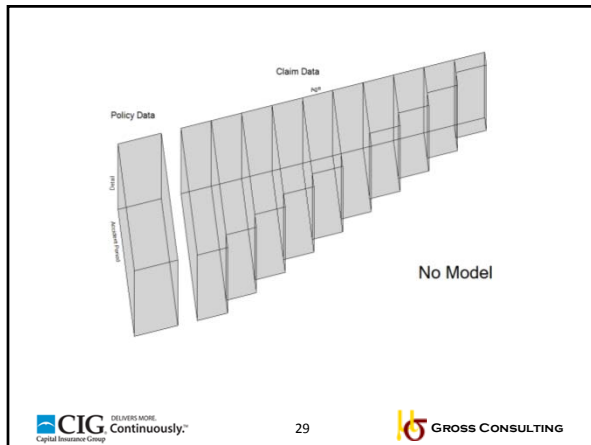
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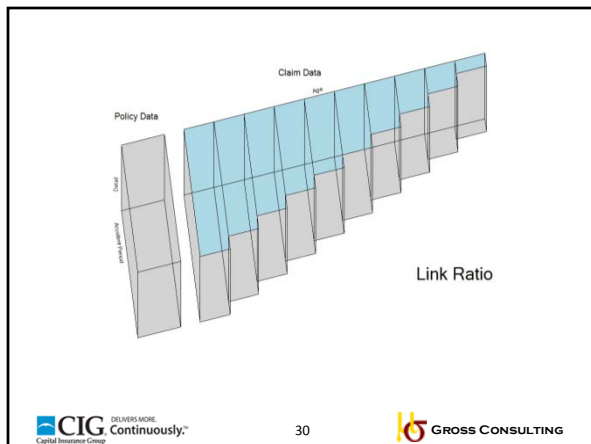
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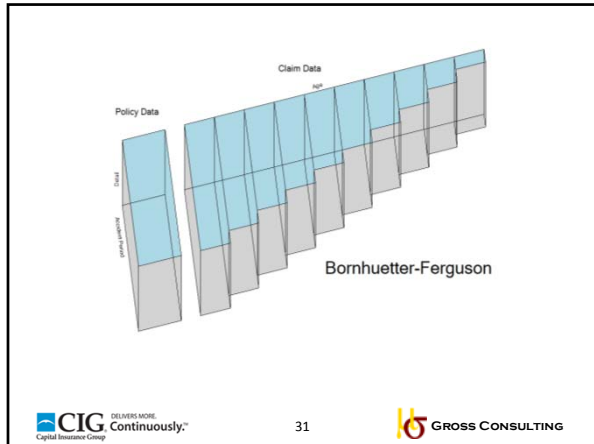
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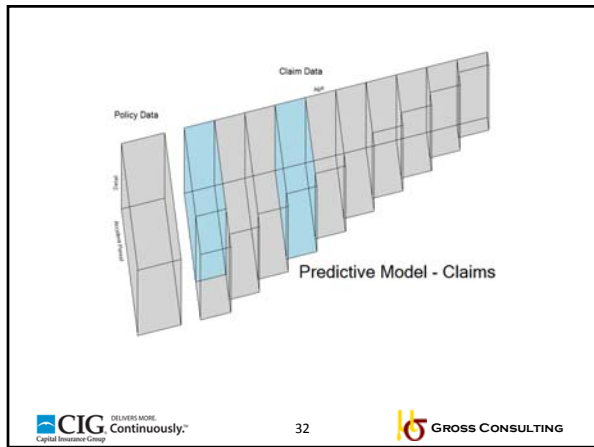
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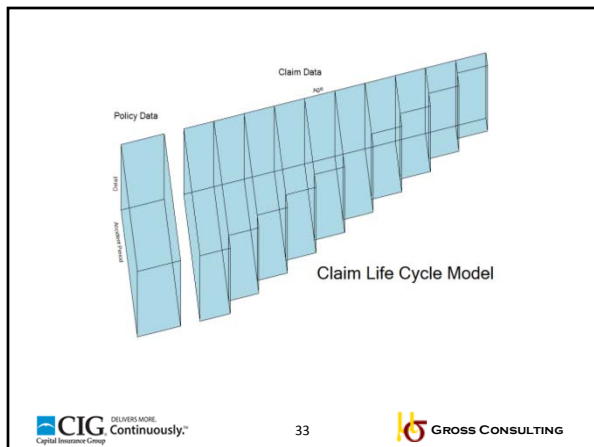
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## One approach to building a claim life cycle model

- Helpful to concentrate on individual time-steps (e.g. beginning of quarter to end of quarter)
- Many facets of loss development within that time step
- Analyze the facets using predictive modeling techniques (predictive variables!)
- Simulate to bring it together and project to ultimate

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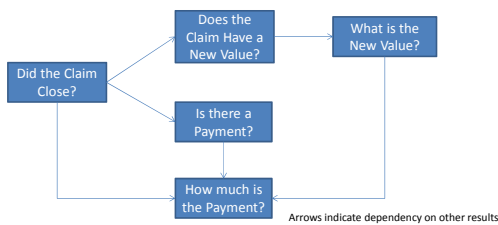
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## Claim Development



A number of available claim or exposure characteristics may have predictive value for any of these questions.

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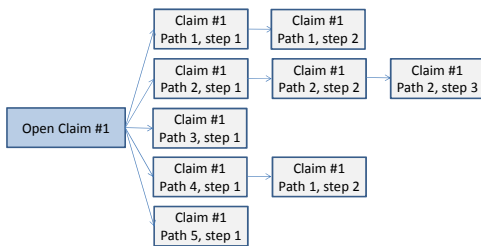
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## Claim Simulation to Ultimate



Each arrow represents the simulation from one time-step to the next (time-step simulation). Claims-path-steps that do not have an arrow emanating from them closed within the time step.

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### Claim Emergence

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    graph TD
      A[Claim Development Simulation] --> B[Ultimate Claim Severity]
      B --> C[Report Lag]
      C --> D[Claim Frequency]
  
```

Arrows indicate dependency on other results

A number of exposure characteristics may have predictive value for any of these questions.

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### Why do it?

- Use more of the information contained in your data
- Improve predictive accuracy
- Quicker recognition of changing environment
- Better reserve allocations
- Layering of losses
- Improved operational or strategic business decisions

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### Uses

- Reserve Analysis
- Claim management
- Pricing Analysis
- Underwriting Management
- Risk Management
- Reinsurance

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## Case Study - Background

- Capital Insurance Group
- Reasons for interest in the approach
  - Validate ultimate selections made from traditional triangle-based methods
  - Insights that can be gained by applying predictive modeling to reserving
  - Triangle segmentation ideas
  - Support pricing predictive modeling by using estimated ultimate claims as the target variable

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## Case Study - Background

- Began the process in Q4 of 2015
- Analyzed Q4 2014 (1 Year Lag) to be able to compare against traditional approach
- Involved three individuals in the actuarial department
- Single line of business
- Longer-tailed LOB

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## Learning Curve

- Main challenge was organizing the data and gaining familiarity with the approach
- Refining models to be simpler where possible
- After getting over the initial learning curve, results were rapid

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## Case Study - Process

- Organized data
- Built and refined the predictive models
- Simulated development and emergence
- Analyzed output vs. current reserve model vs. actual development

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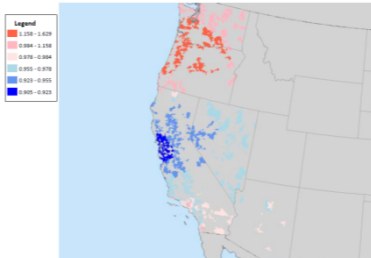
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## Case Study – Selected Highlights

Characteristic: ZIP\_CODE  
Pricing Comparison: CLM-Based vs CaseInured-Based



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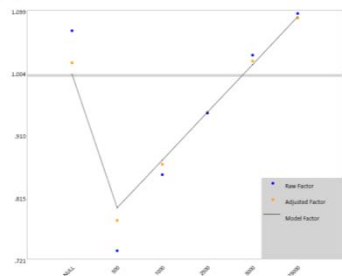
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## Case Study – Selected Highlights

Characteristic: DEDUCTIBLE  
Pricing Comparison: CLM-Based vs CaseInured-Based



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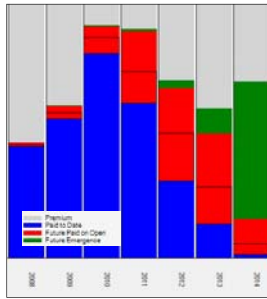
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## Case Study– Selected Highlights




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## Case Study – Overall Impressions

- Challenges
  - Reconciliation with other analysis
- Value
  - Depth of information available
  - Statistically significant segmentation
  - Visual aids for decision making are an invaluable part of the process
  - Easy to evaluate performance of one model iteration to the next

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## Case Study – Thoughts for the future

- Reserving
- Pricing
- Other

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## A Simplified Example

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## Data

<p><b>Financial Data</b></p> <ul style="list-style-type: none"> <li>Beginning Case Reserve</li> <li>Ending Case Reserve</li> <li>Payment in Period</li> </ul> <p><b>Timing Data</b></p> <ul style="list-style-type: none"> <li>Accident Quarter</li> <li>Report Quarter</li> <li>Valuation Quarter</li> </ul>	<p><b>Exposure Characteristics</b></p> <ul style="list-style-type: none"> <li>Type</li> <li>Product</li> <li>ZIP Code</li> </ul> <p><b>Claim Characteristics</b></p> <ul style="list-style-type: none"> <li>Loss Cause</li> <li>Loss Cause - Detail</li> </ul>
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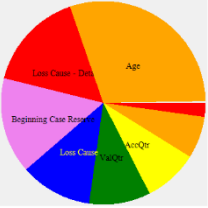
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## Probability of a Claim Closing

- Base probability of 71%
- Modification of this probability by various claim characteristic values that were found to have predictive value



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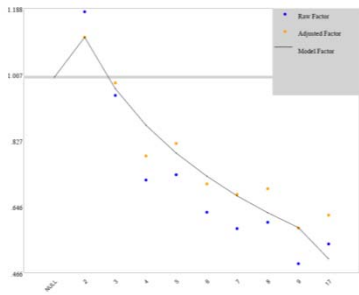
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### Close Probability – Claim Age




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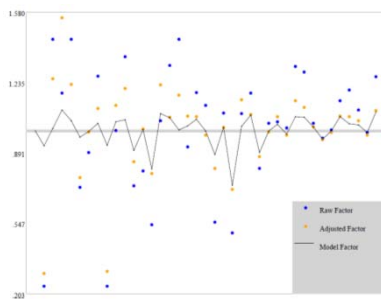
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### Close Probability – Loss Cause (detailed)




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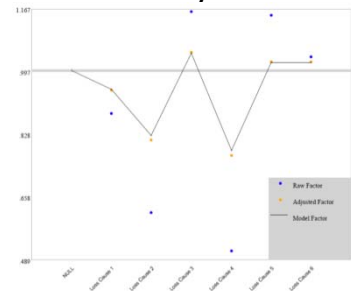
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### Close Probability – Loss Cause




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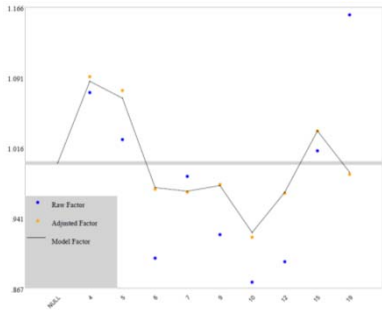
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### Close Probability – Accident Quarter




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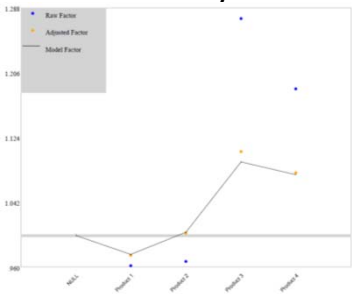
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### Close Probability - Product




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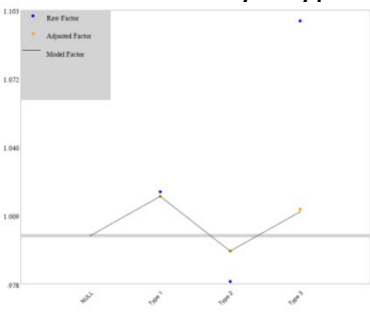
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### Close Probability - Type




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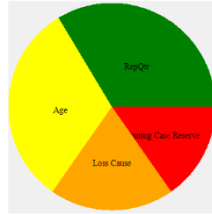
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## Probability of Change in Value (Given Not Closed)

- Base probability of 37%
- 4 characteristics found to be predictive




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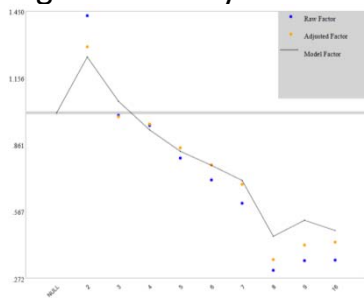
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## Change Probability – Claim Age




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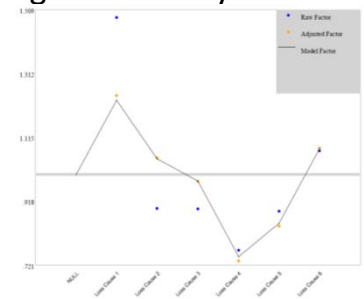
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## Change Probability – Loss Cause




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## New Claim Value (Given Changed but Not Closed)

- Base factor of 1.98 to beginning case reserve
- Modification to this linear relationship, as well as five additional predictive characteristics




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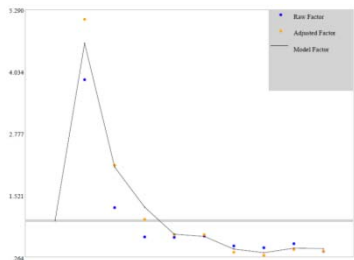
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## New Claim Value - Case Reserve




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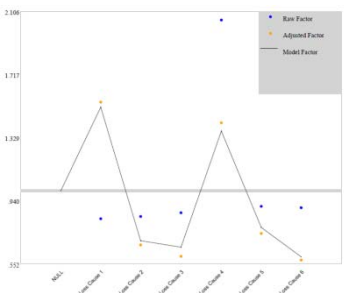
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## New Claim Value – Loss Cause




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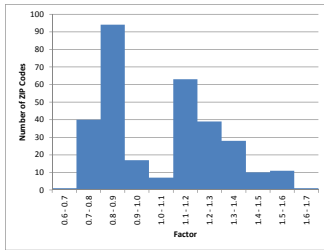
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## New Claim Value – ZIP Code




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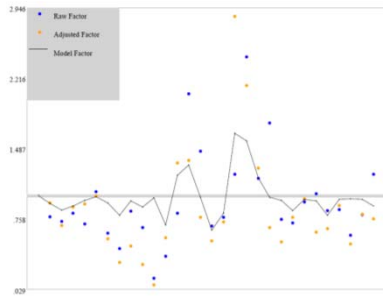
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## New Claim Value- Loss Cause (Detail)




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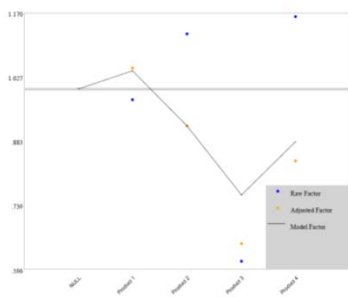
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## New Claim Value - Product




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## Simulate Going Forward

- Claim Development
  - Start with current inventory of open claims
  - For each open claim simulate a number of potential outcomes for the next time-step (using the claims' characteristics)
  - For those simulated claim-paths that are still open simulate forward another time-step.
  - Continue until all simulated claim-paths are closed

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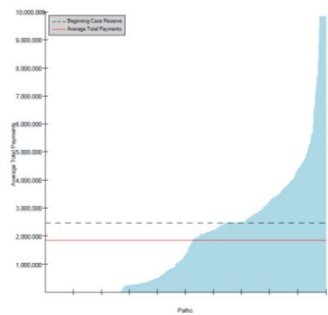
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### Claim 1




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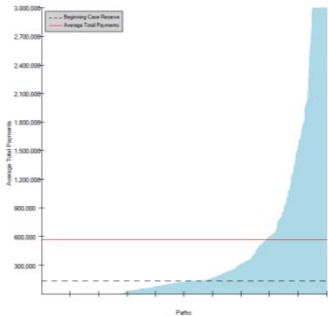
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### Claim 2




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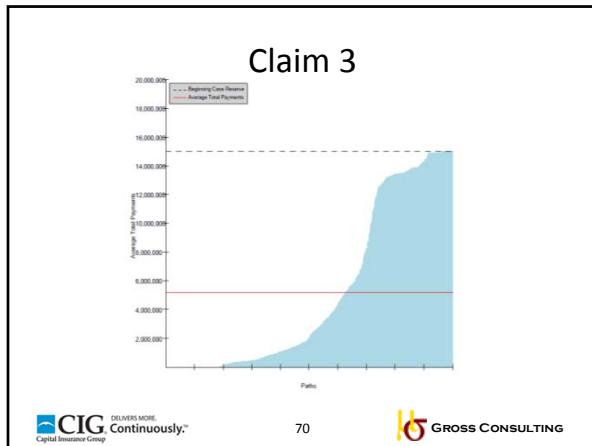
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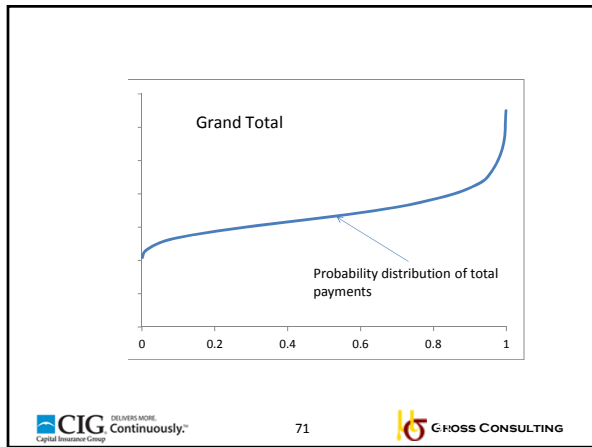
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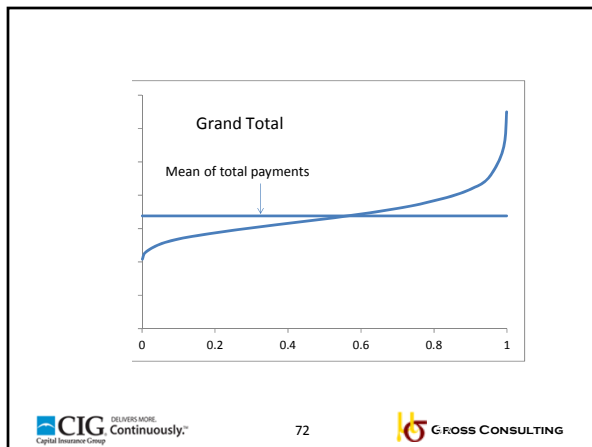
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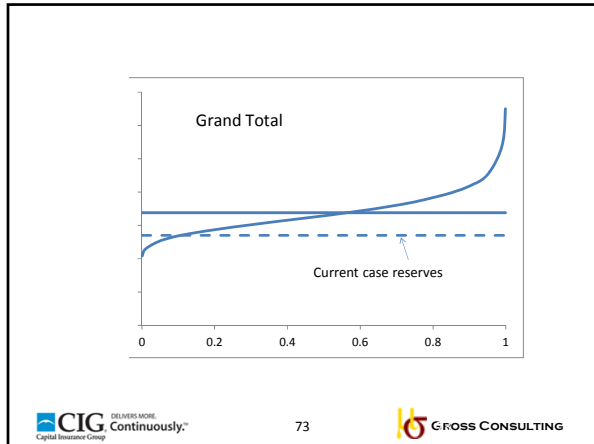
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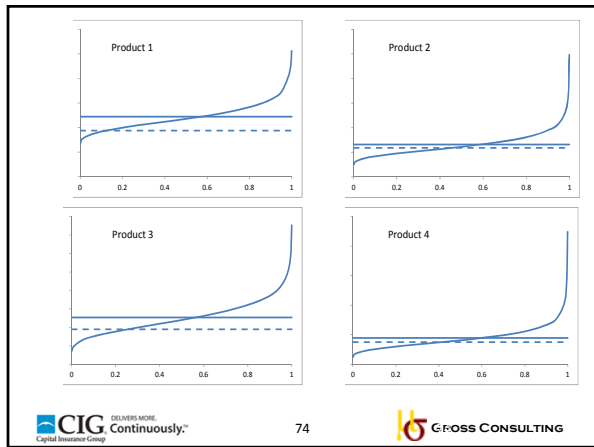
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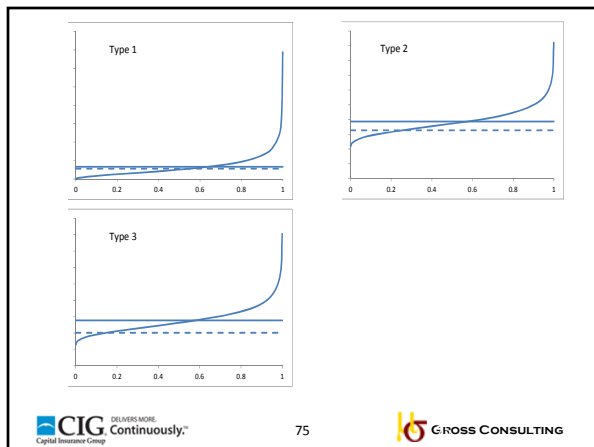
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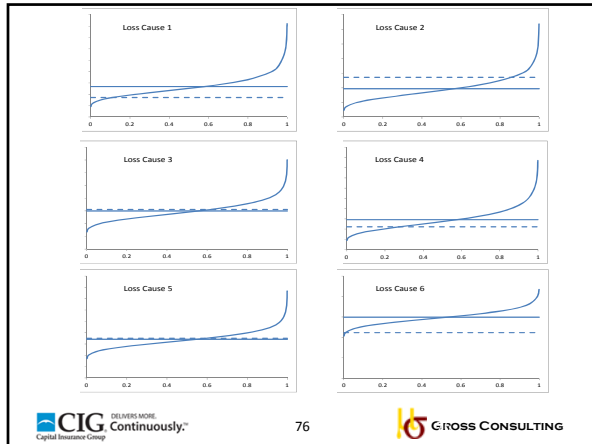
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## Emergence

- After simulating claim development to ultimate, model emergence
- Frequency
- Severity
- Report Lag

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## Emergence Simulation

- Use written policies (w/ characteristics) simulate remaining emergence.
- Generating loss date within this process allows accident period calculations
- Also get losses associated with unearned premium
- Inforce loss ratio distribution.

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## Conclusion

- There is a wealth of data available to use when developing estimates of reserves
- Triangles, while useful, obscure much of the information
- By applying predictive modeling techniques, we can develop a much more comprehensive understanding of loss development
- Simulation can be useful for developing the reserve estimates from such models
- There are significant collateral benefits to other actuarial areas such as pricing

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