IMPROVING ACTUARIAL RESERVE ANALYSIS THROUGH CLAIM-LEVEL PREDICTIVE ANALYTICS

2017 Spring Meeting

Presenters: Chris Gross

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Case Reserve Adequacy Example

Calendar Period	Open Count	Case Reserves	Average Case Reserve
8	564	4,954,014	8,784
9	568	6,198,630	10,913
10	649	5,347,576	8,240
11	674	6,067,343	9,002
12	543	5,313,733	9,786
13	590	5,666,509	9,604
14	631	6,927,816	10,979
15	731	7,125,765	9,748
16	590	6,493,882	11,007
17	697	7,773,533	11,153
18	660	7,021,701	10,639
19	678	5,778,941	8,524
20	528	5,795,591	10,976
21	541	5,268,996	9,739
22	941	7,110,736	7,557
23	823	6,631,955	8,058
24	707	5,615,405	7,943
25	842	7,115,139	8,450
26	954	7,139,176	**7,483**
Combined	12,911	119,346,440	9,244

Case Reserve Adequacy Example

Average Case Reserves	Age 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1								512			548	57,087									
2							13,168	43,387	118	4,486	467	13,320	11,290	458	1,041	5,517					
3						30,457	57,601	34,507	74,052	30,793	12,588	19,056	3,207	1,744	5,859	3,569	4,483	146	8,134		
4					6,030	32,481	64,389	53	255	24,697	8,981	19,703	19,144	2			6,580	10,847	24,711		
5				11,331	18,579	20,569	29,027	17,082	16,540	22,693	32,308	17,854	10,363	24,879	7,801	1,318	334	168,510			
6			13,606	17,543	12,071	17,182	12,122	13,483	18,534	13,056	9,569	10,769	9,117	14,123	28,212	3,422	1,248		37,824	9	6,939
7		8,083	11,215	7,118	9,795	13,921	7,462	7,789	6,464	8,385	16,903	6,925	4,454	11,053	5,285	5,810					
8	7,105	8,079	10,475	11,119	12,694	24,061	17,083	11,479	7,013	17,439	12,778	7,906	12,905	11,363	3,073	11,400	12,421	2,013	3,371		
9	7,425	9,161	8,555	15,436	6,572	15,662	24,329	13,195	19,990	24,451	1,223	23,073	11,437	4,161	22,349	14,575	10,715	56,507			
10	5,418	7,361	14,058	13,784	15,392	6,633	10,383	18,718	21,325	4,504	12,790	11,855	17,316	53,291	22,333	24,411	14,796				
11	6,023	7,660	12,017	13,242	22,099	11,470	12,114	14,543	4,401	6,422	23,625	9,392	16,623	1,797	17,284	20,446					
12	6,667	11,333	12,659	11,197	7,531	18,592	2,718	20,921	13,429	7,004	21,444	344	6,983	798	15,746						
13	5,647	8,594	10,021	23,137	15,536	11,719	12,401	4,044	7,681	55	33,349	14,686	54,026	3,709							
14	9,031	8,283	12,626	12,802	17,409	33,697	7,833	35,736	11,894	13,454	4,599	9,822	29,958								
15	7,333	12,039	8,452	30,860	12,491	32,925	27,371	13,483	18,818	16,353	34,826	19,515									
16	8,290	15,097	11,663	12,336	19,280	14,183	50,042	37,290	14,578	40,260	3,416										
17	8,292	14,563	12,252	31,963	15,778	15,291	15,324	14,548	15,318	15,589											
18	5,733	7,960	8,312	14,460	8,781	20,298	7,253	7,433	15,853												
19	6,172	8,008	8,994	17,823	17,125	17,383	17,468	8,057													
20	7,964	10,467	13,008	8,360	10,024	19,829	20,106														
21	5,695	7,318	9,937	14,810	19,155	12,661															
22	5,086	7,900	9,373	15,745	23,693																
23	5,595	7,308	8,055	**11,351**																	
24	6,293	9,071	**7,172**																		
25	5,207	**7,730**																			
26	**4,605**																				

Accident Period

Case Reserve Adequacy Example

Accident Period											
	9	7,425	9,161	8,555	15,436	6,572	15,662	24,329	13,195	19,990	24,451
	10	5,418	7,361	14,058	13,784	15,392	6,633	10,383	18,718	21,325	4,504
	11	6,023	7,660	12,017	13,242	22,099	11,470	12,114	14,543	4,401	6,422
	12	6,667	11,333	12,659	11,197	7,531	18,592	2,718	20,921	13,429	7,004
	13	5,647	8,594	10,021	23,137	15,536	11,719	12,401	4,044	7,681	55
	14	9,031	8,283	12,626	12,802	17,409	33,697	7,833	35,736	11,894	13,454
	15	7,333	12,039	8,452	30,860	12,491	32,925	27,371	13,483	18,818	16,353
	16	8,290	15,097	11,663	12,336	19,280	14,183	50,042	37,290	14,578	40,260
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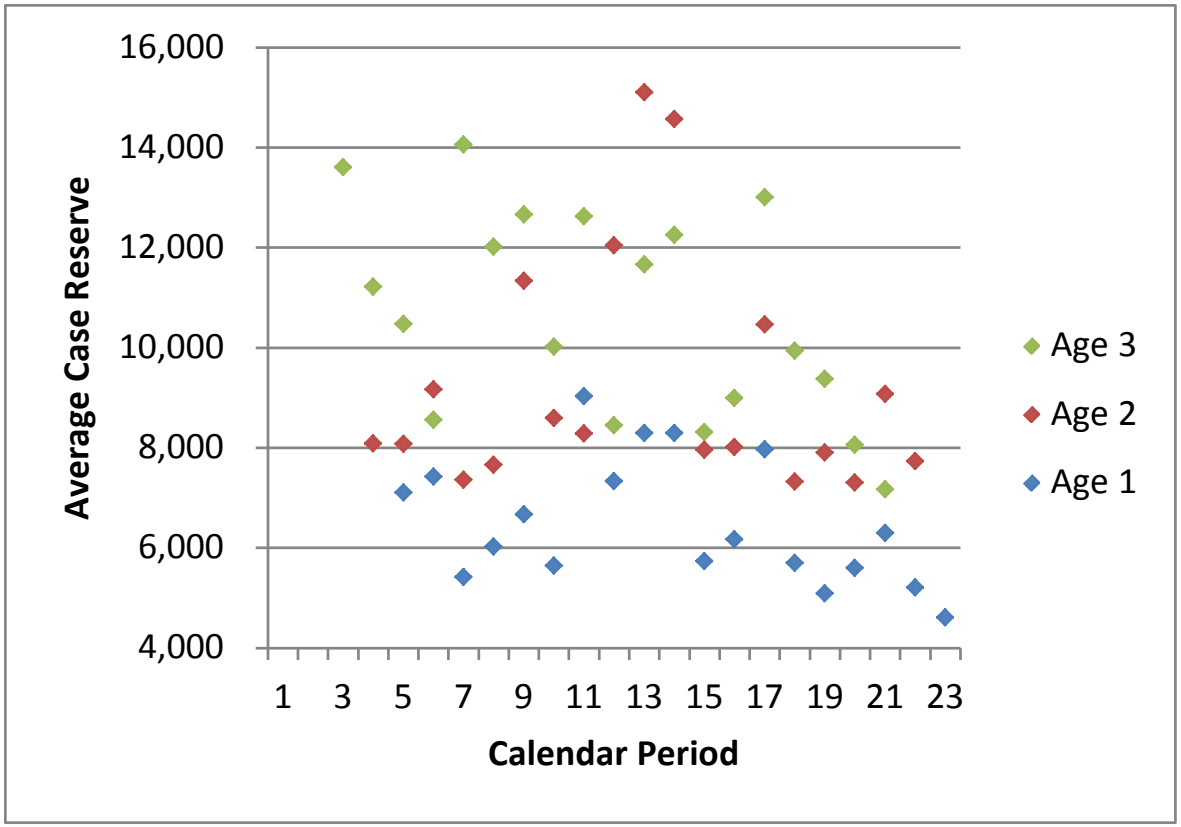
	24	6,293	9,071	**7,172**							
	25	5,207	**7,730**								
	26	**4,605**									

Case Reserve Adequacy Example

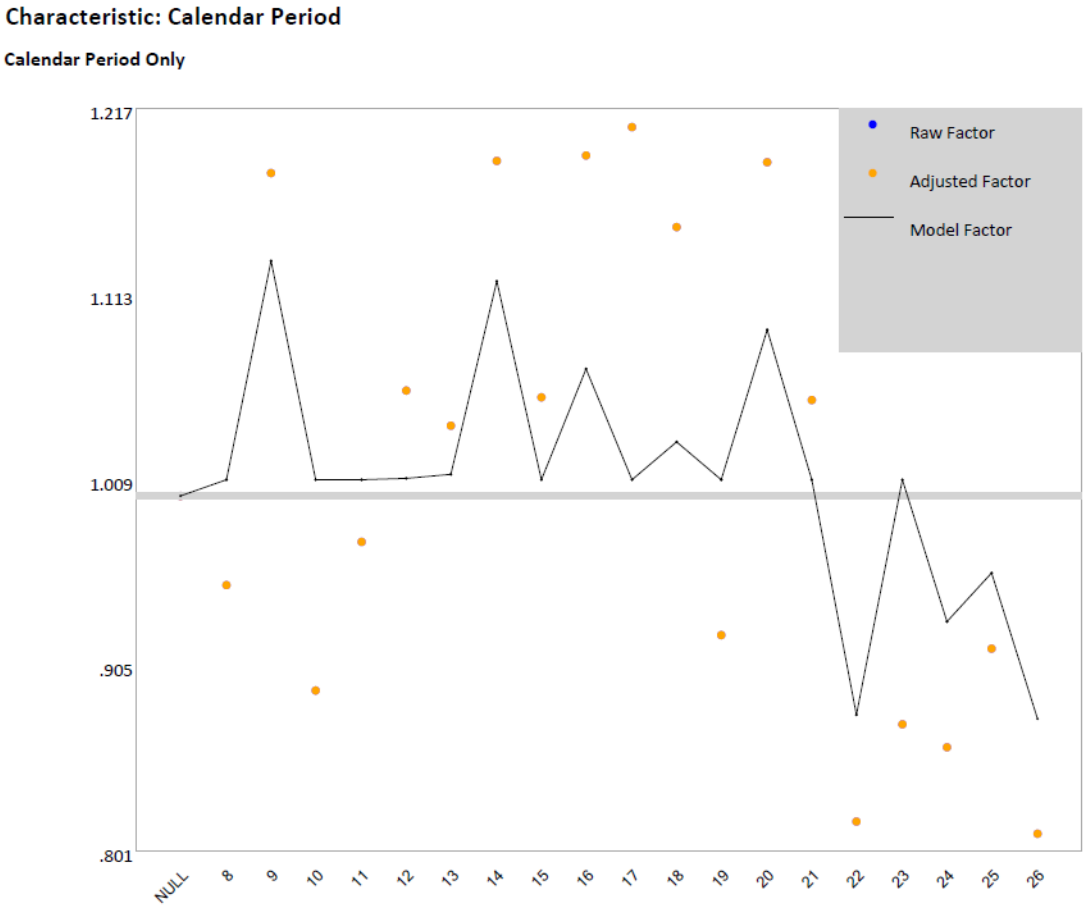


Case Reserve Adequacy Example

- 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**.

Case Reserve Adequacy Example

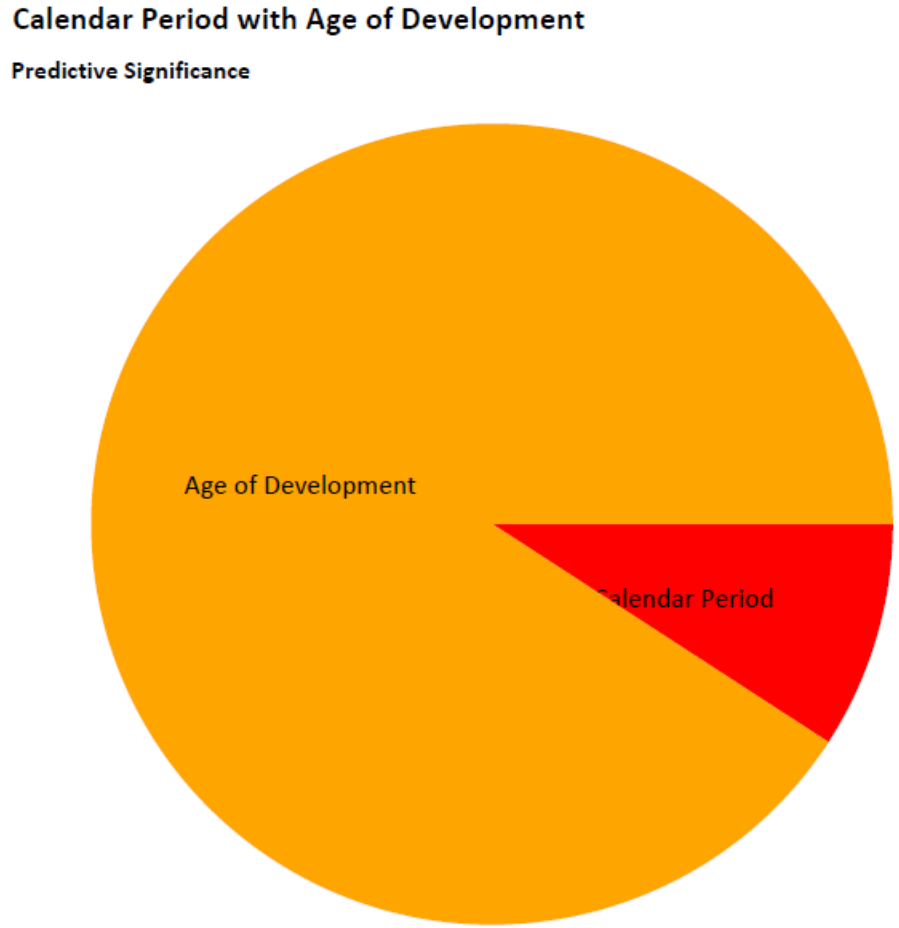
Same calendar period data, but include credibility (in this case based on rank based t-statistic of observations) and smoothing techniques.



Case Reserve Adequacy Example

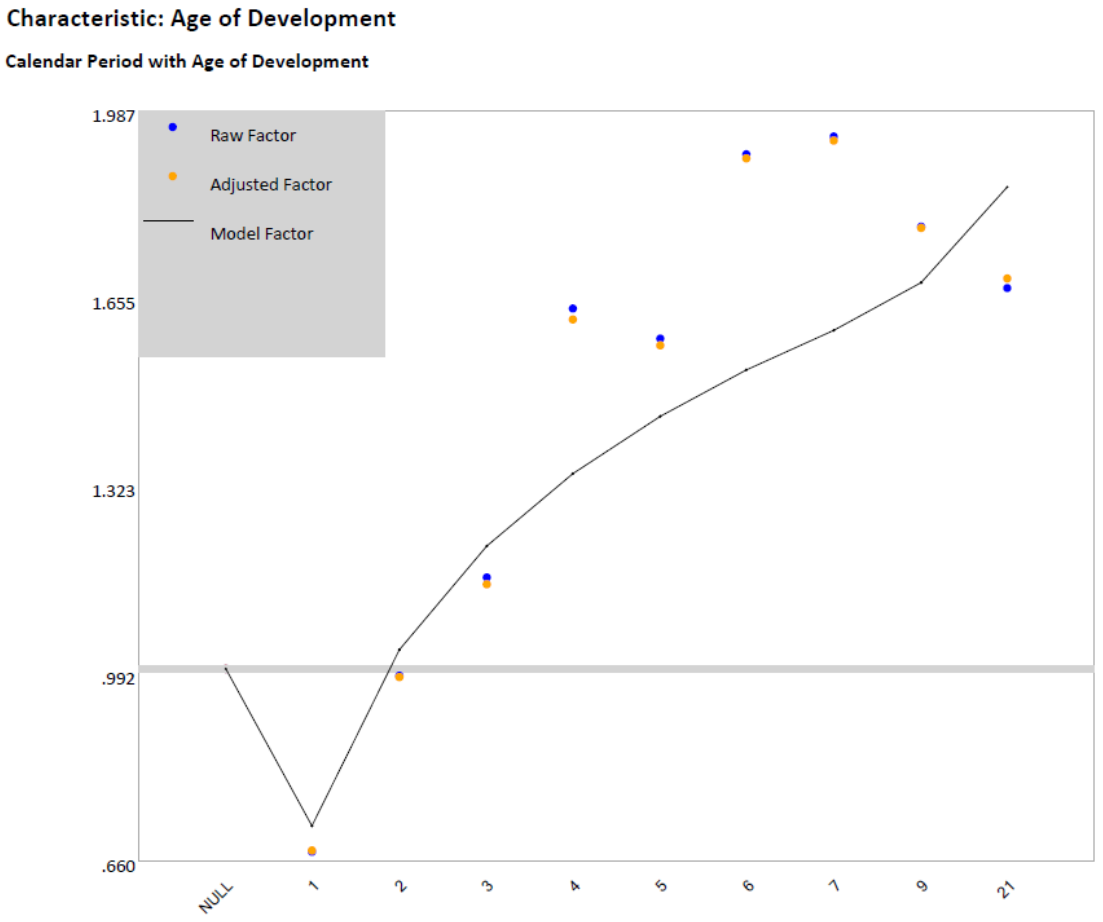
At the very least, the inclusion of Age of Development is appropriate in a predictive model of case reserves

In this case it is very predictive



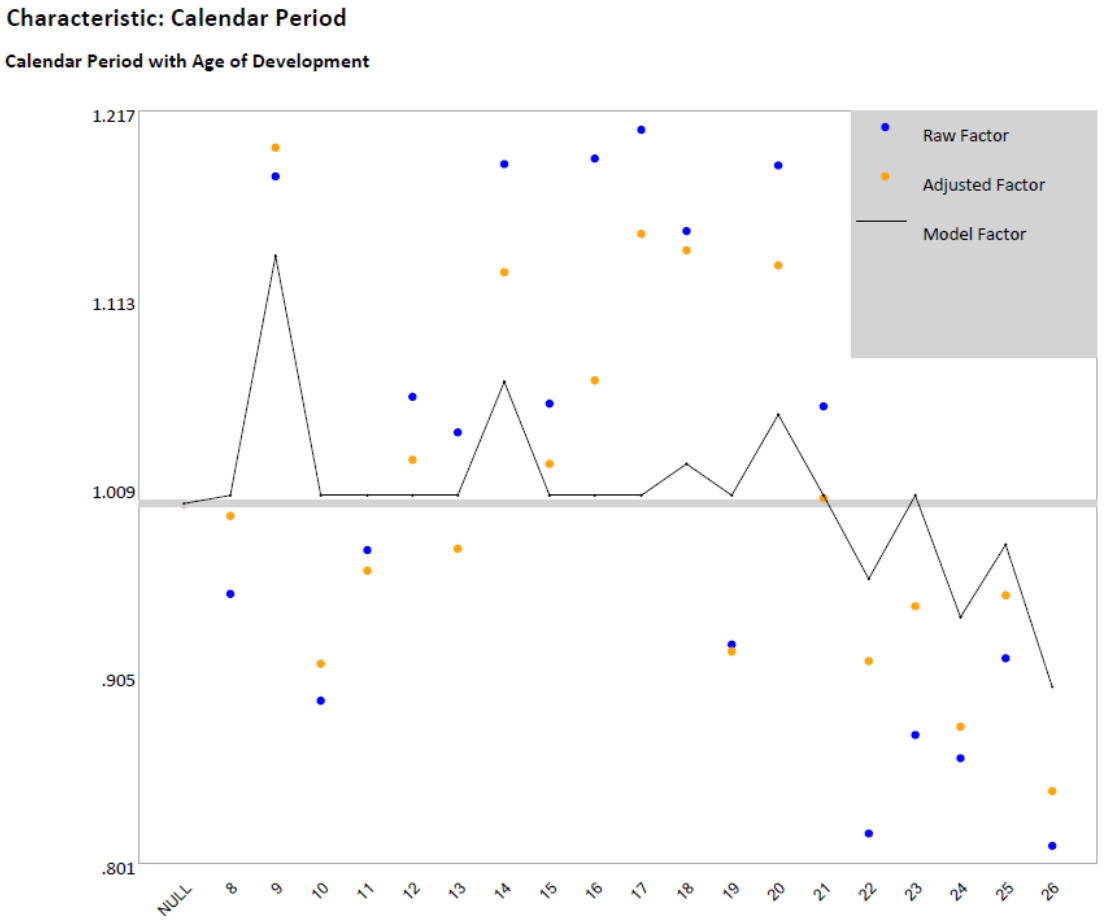
Case Reserve Adequacy Example

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



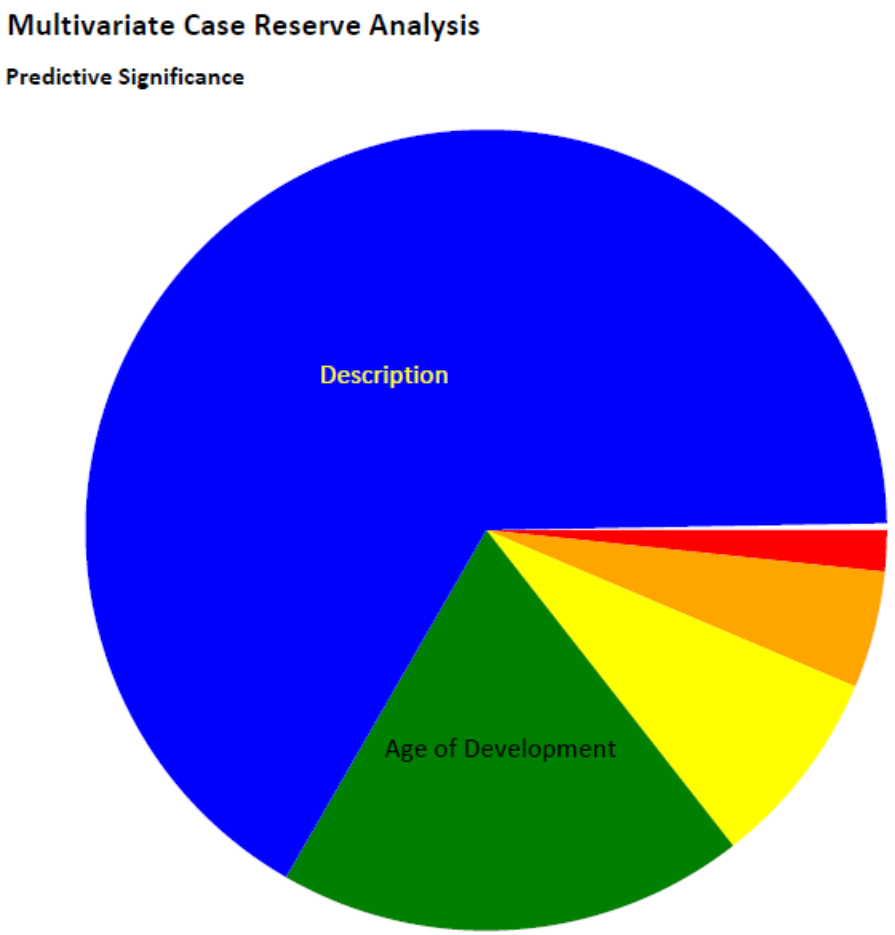
Case Reserve Adequacy Example

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.



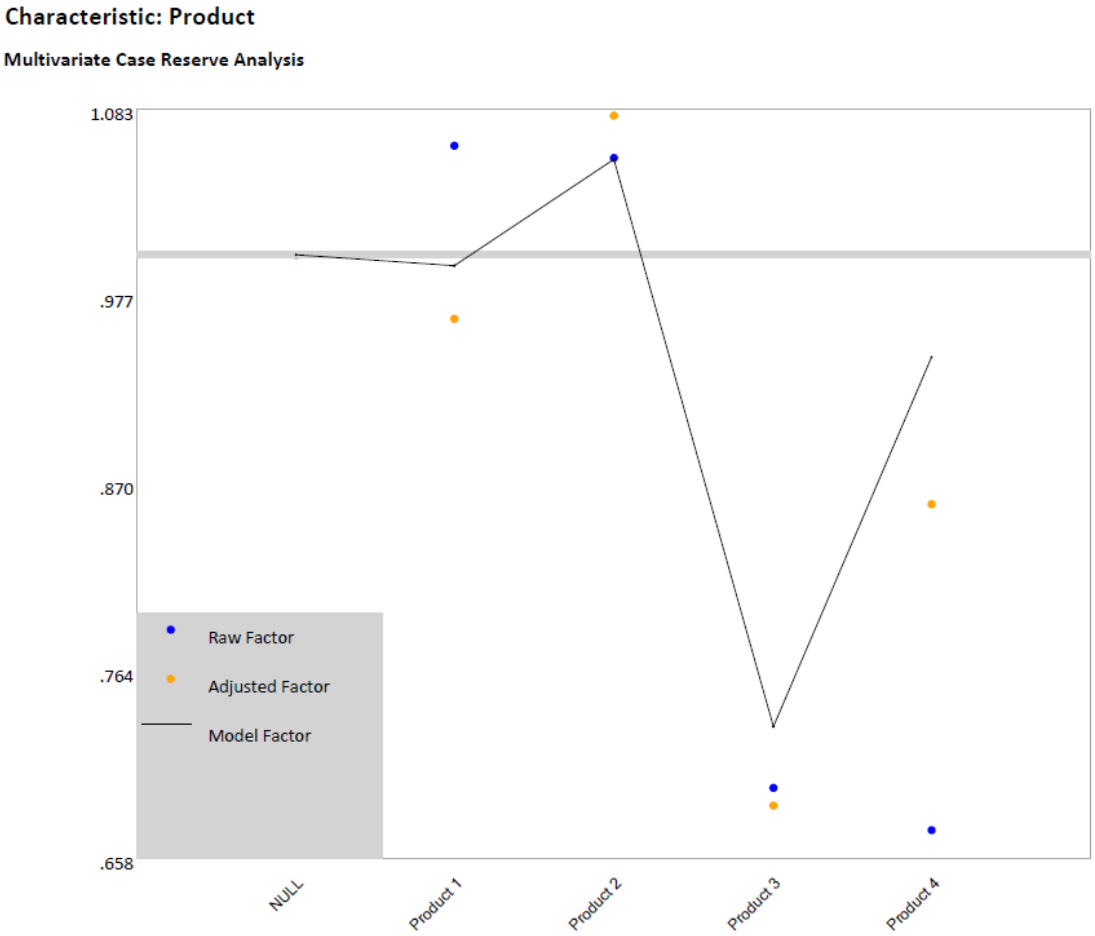
Case Reserve Adequacy Example

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



Case Reserve Adequacy Example

The policy form was also predictive.



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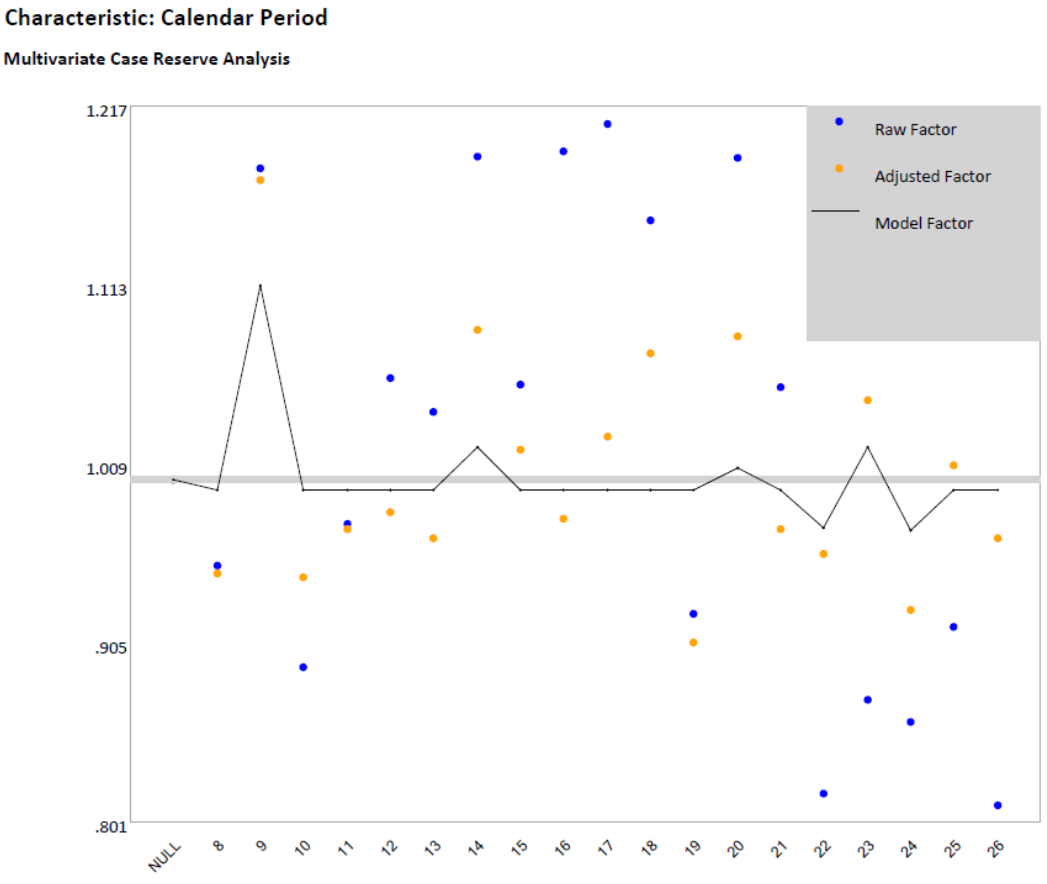
Case Reserve Adequacy Example

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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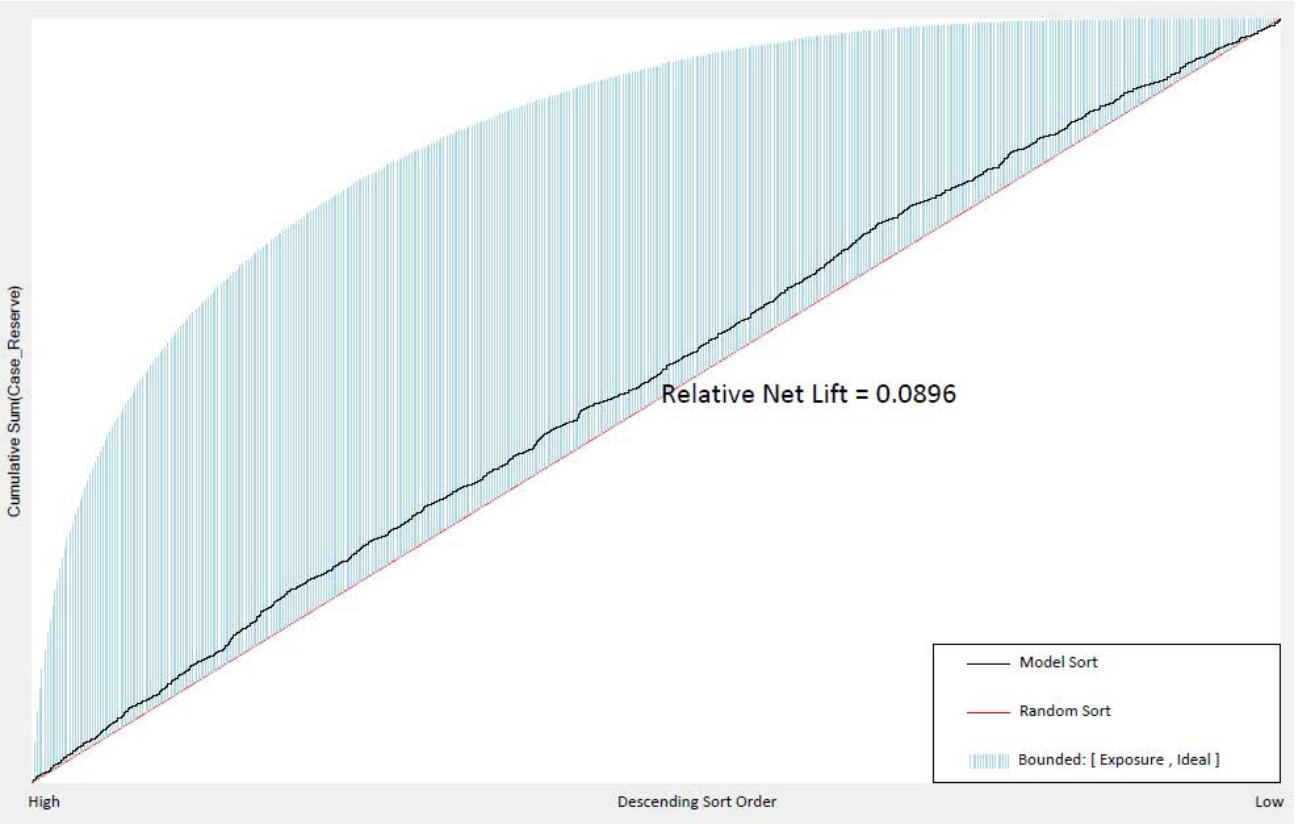
Case Reserve Adequacy Example

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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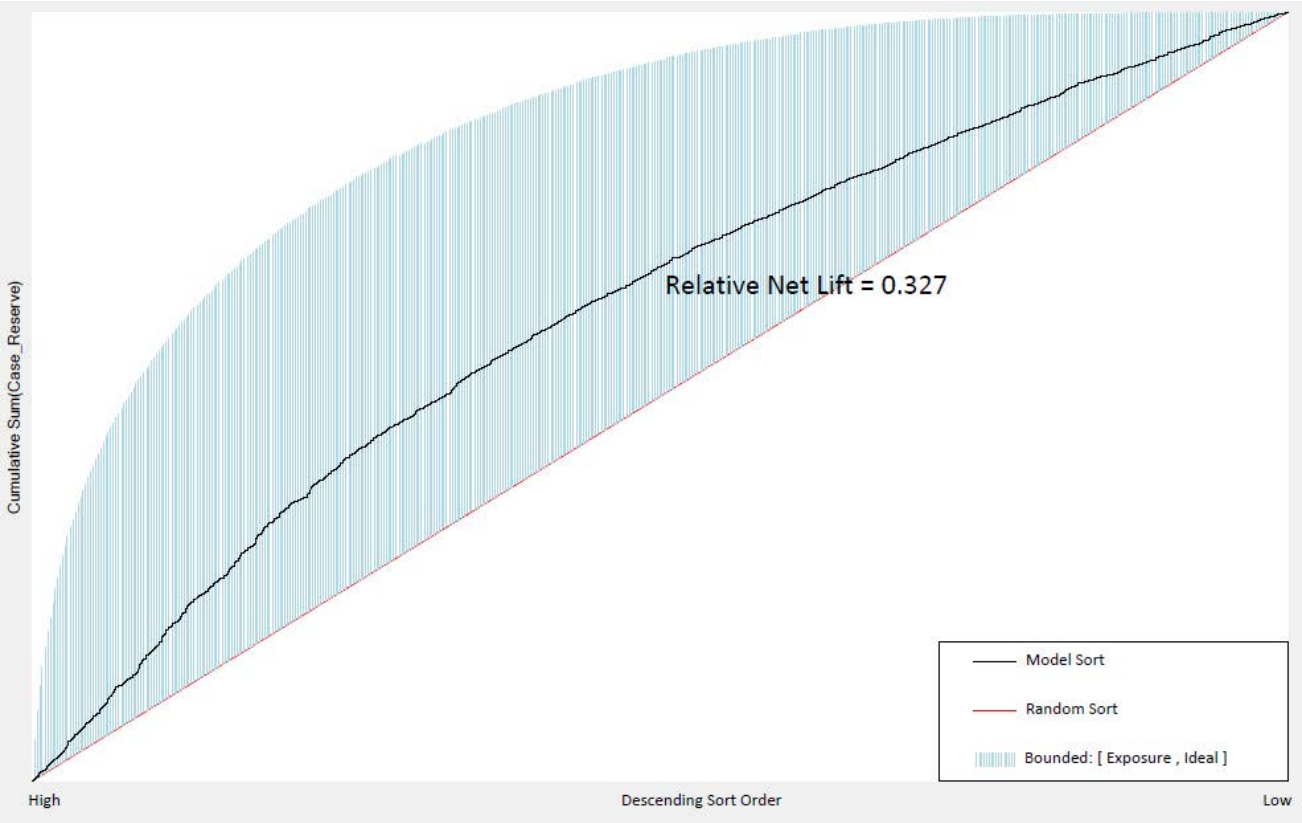
Case Reserve Adequacy Example

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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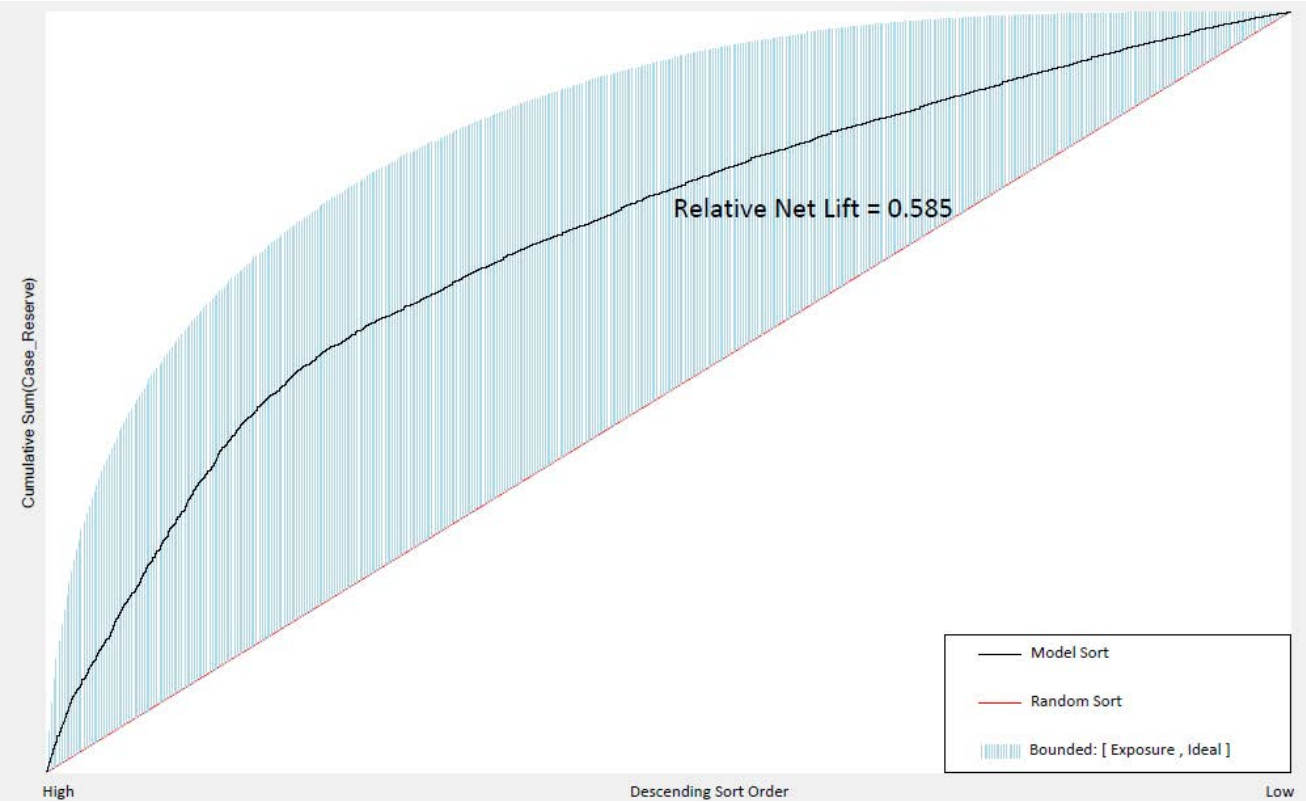
Case Reserve Adequacy Example

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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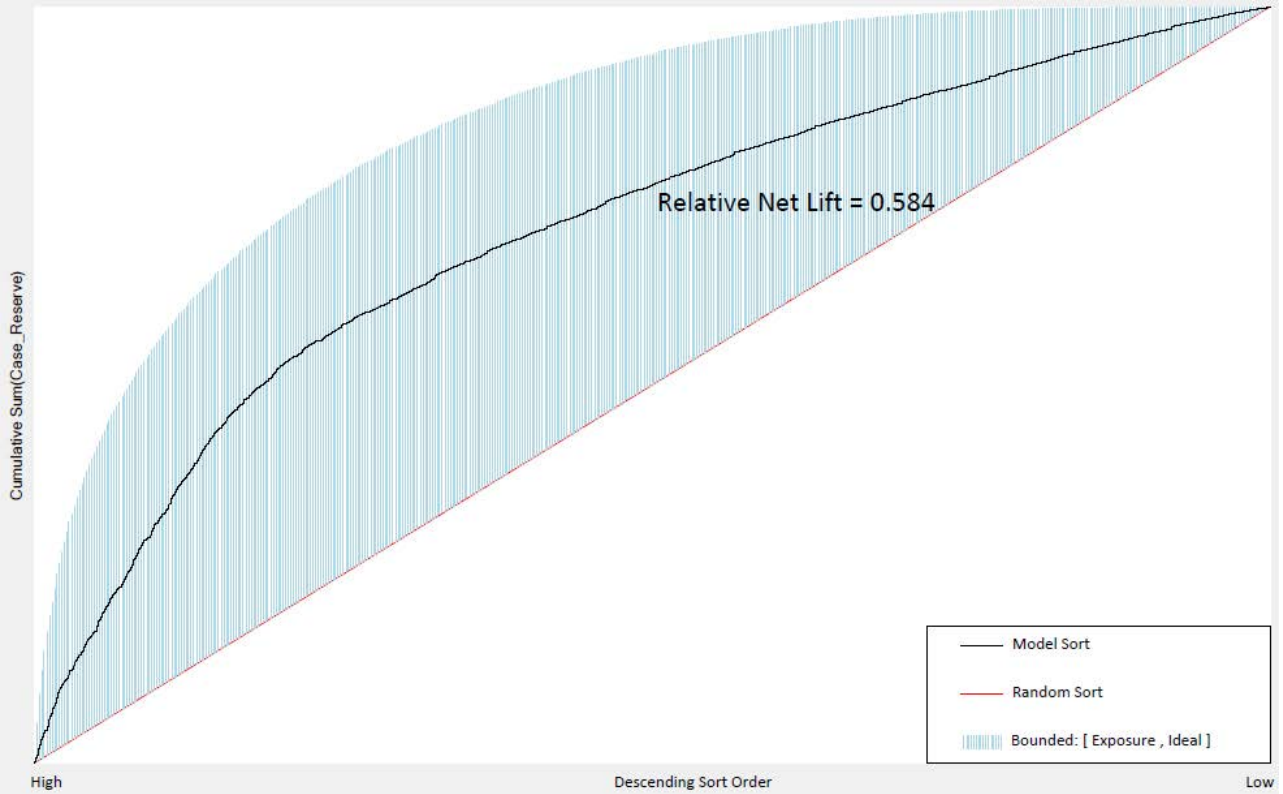
Case Reserve Adequacy Example

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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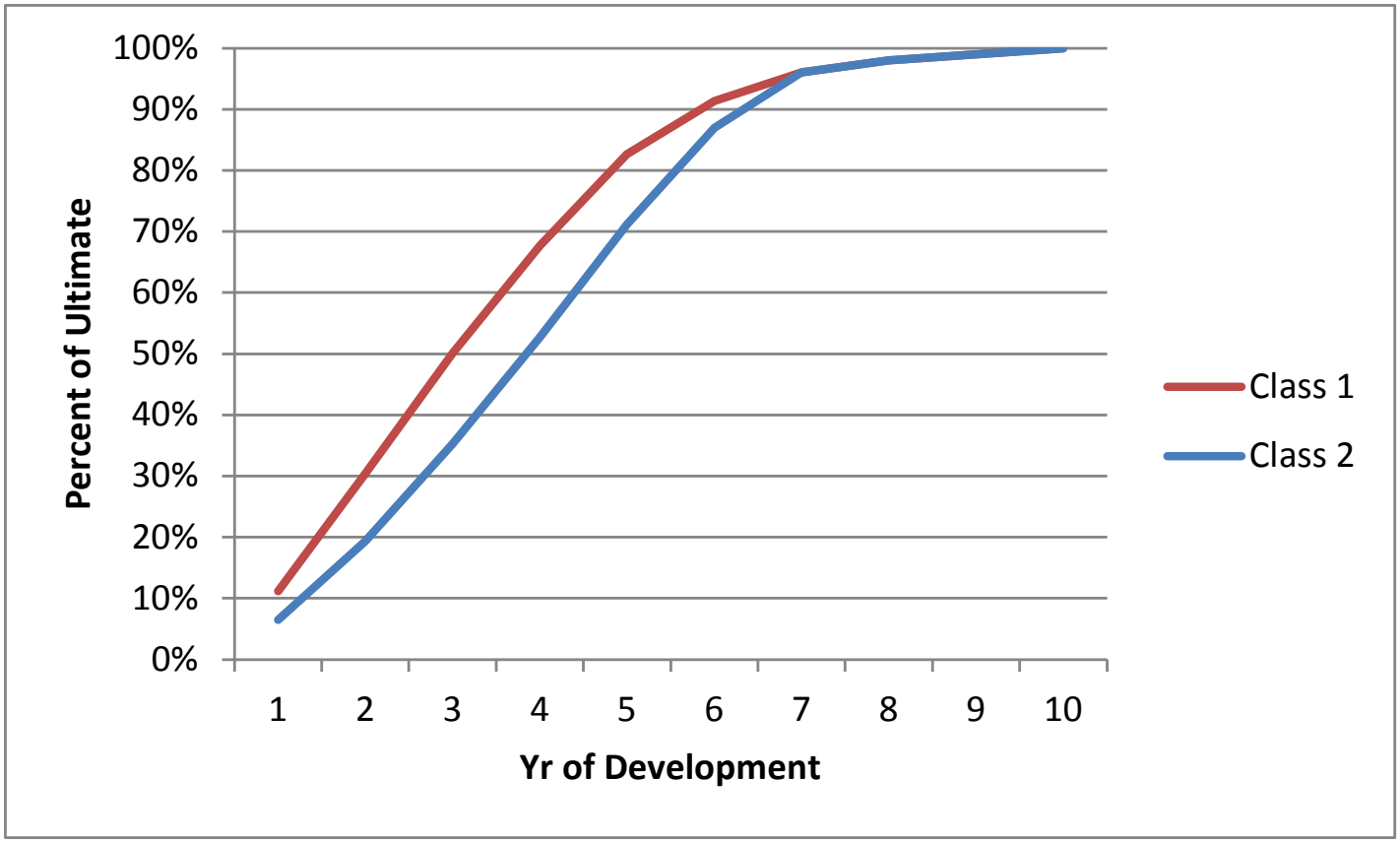
The Mix Problem… An Example

- 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

Different Development



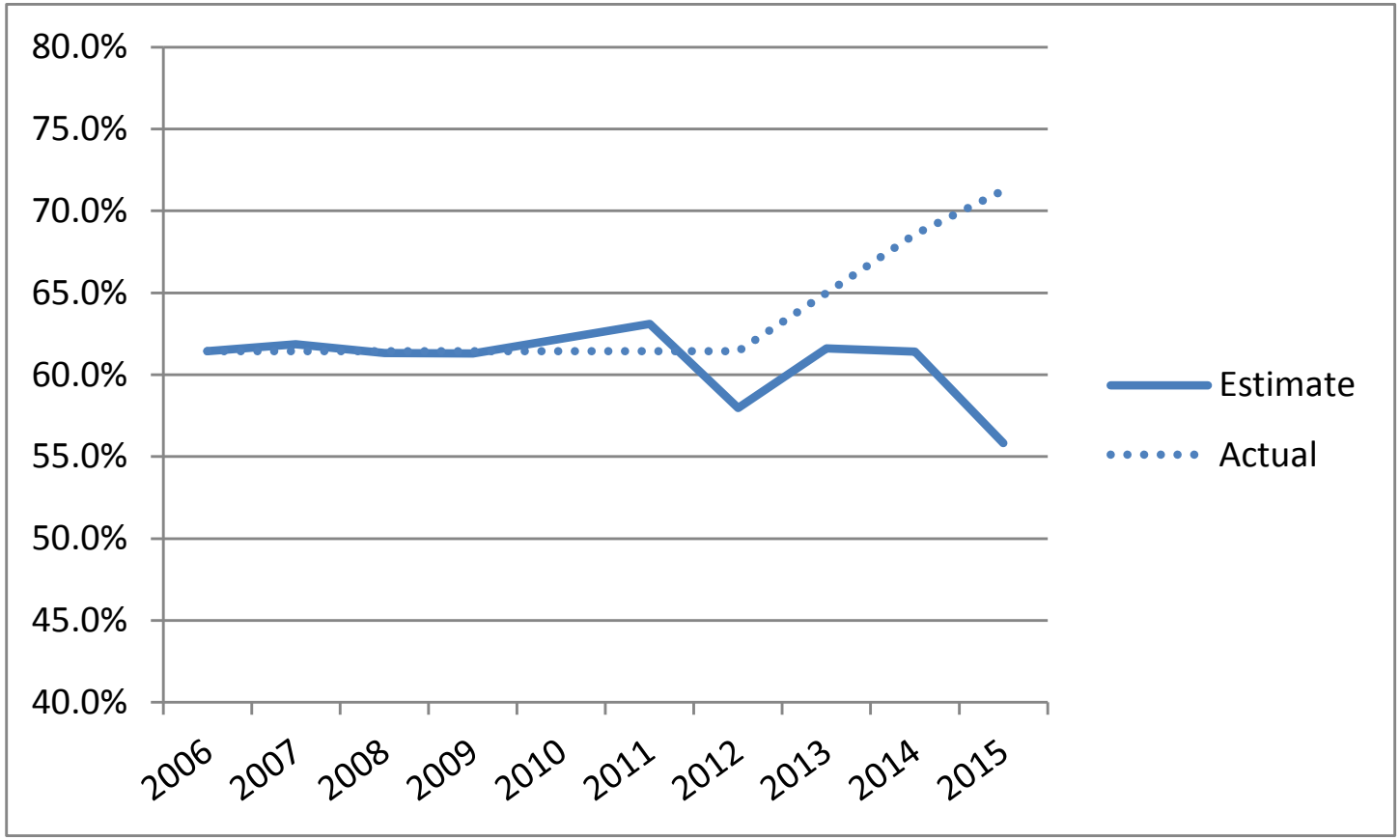
The Triangle

		Loss as of:									
Year	Premium	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									

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

True Loss Ratio vs Estimate



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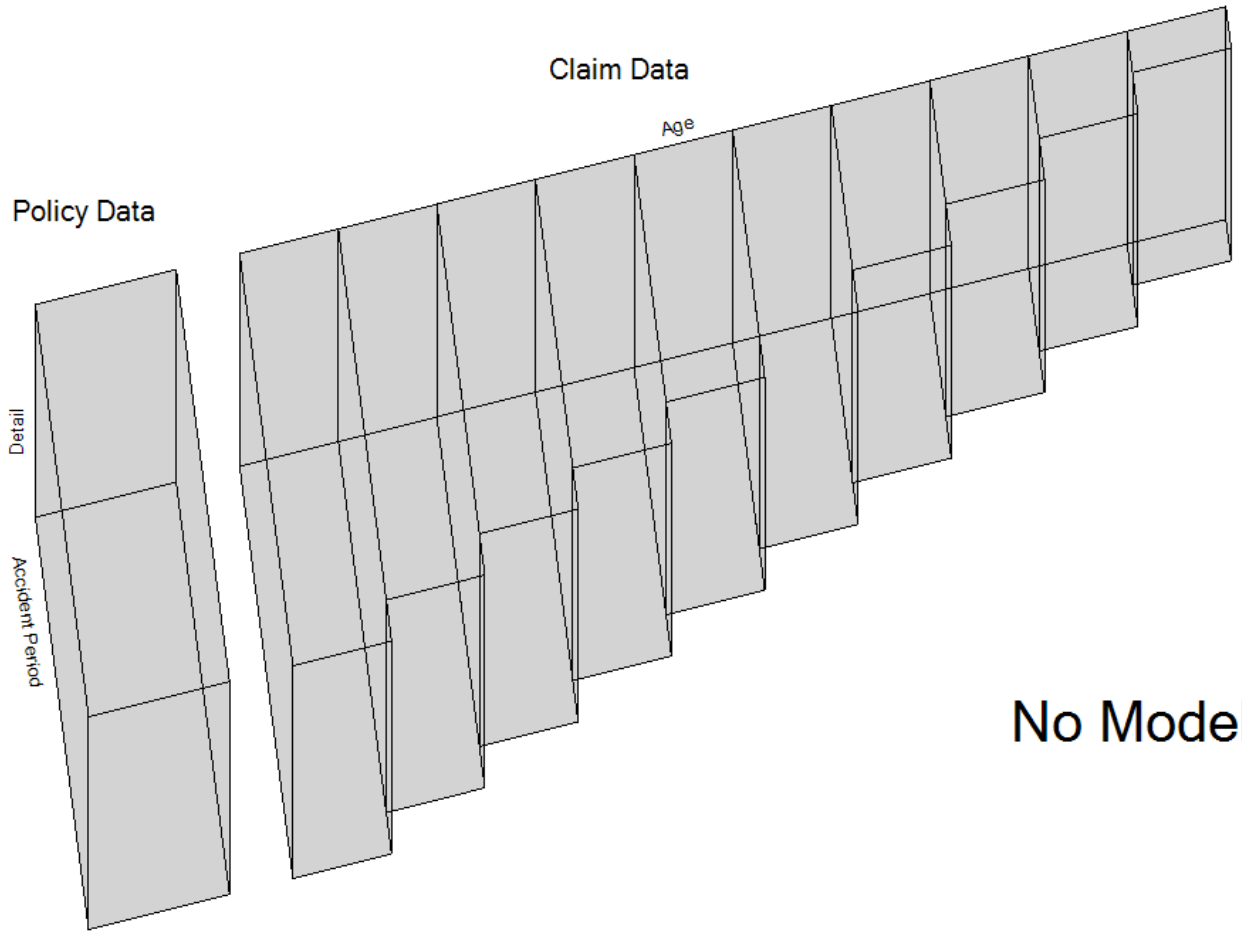
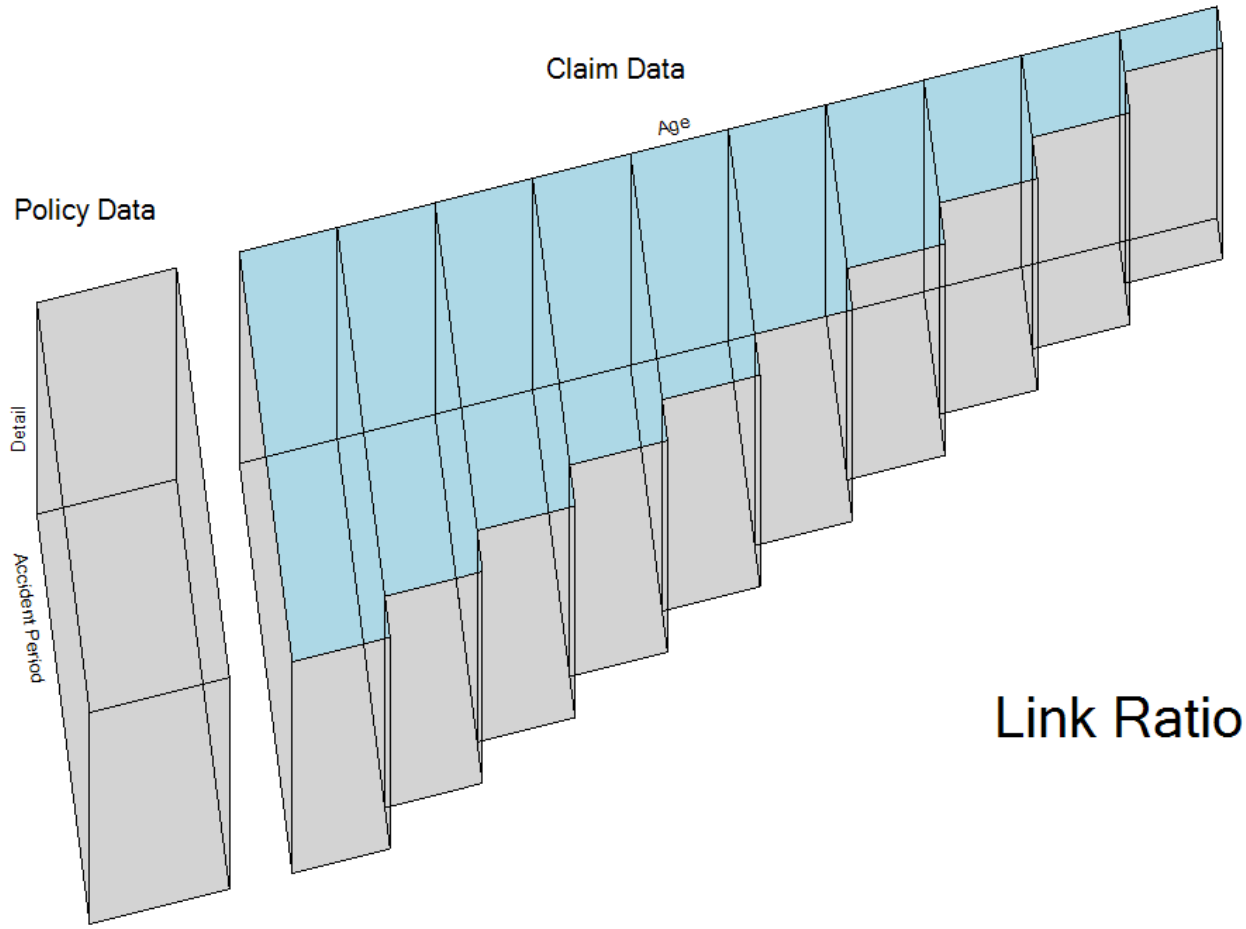
Potential Differences

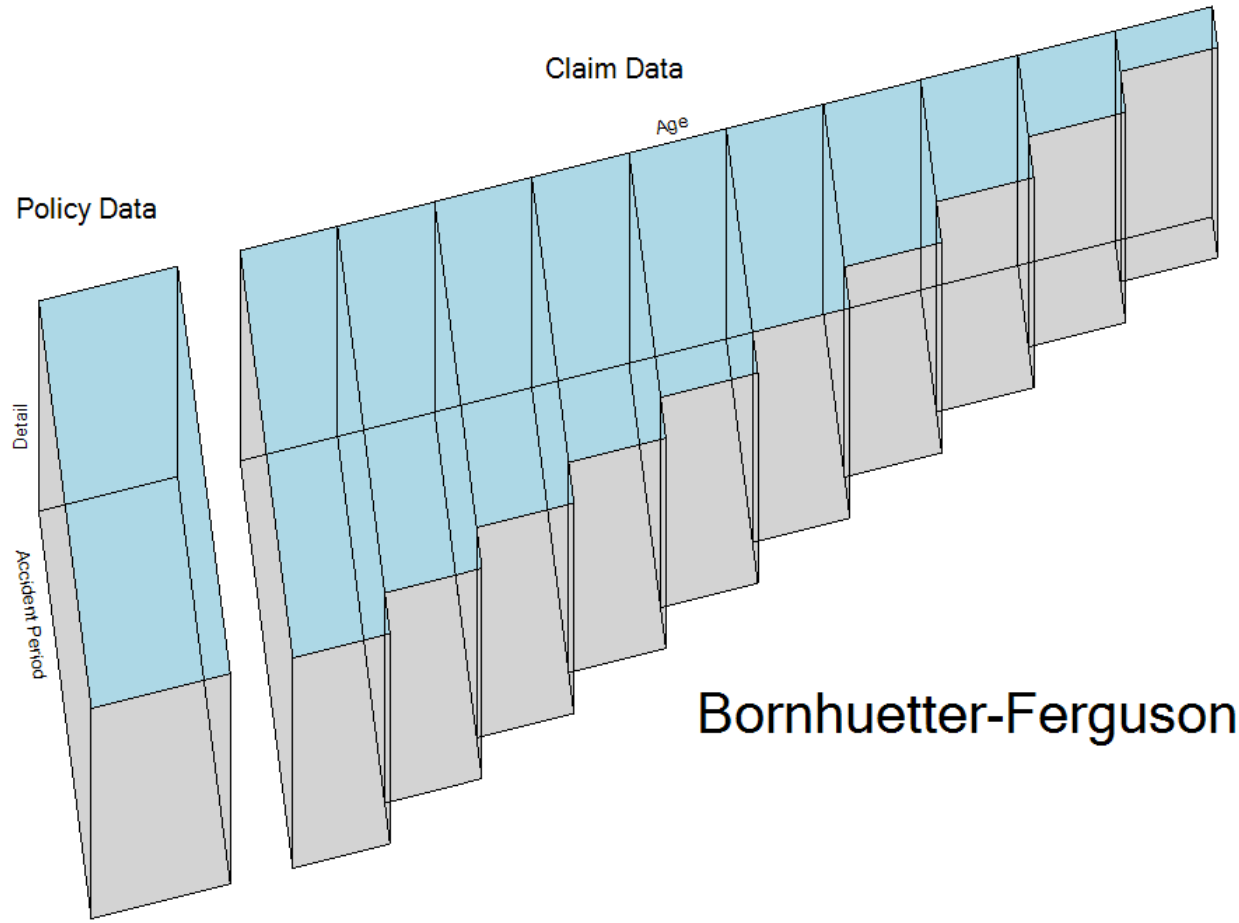
- Industry classification
- Geography
- Deductible/Limit Profile
- Size of account
- Type of Claims
- Etc.

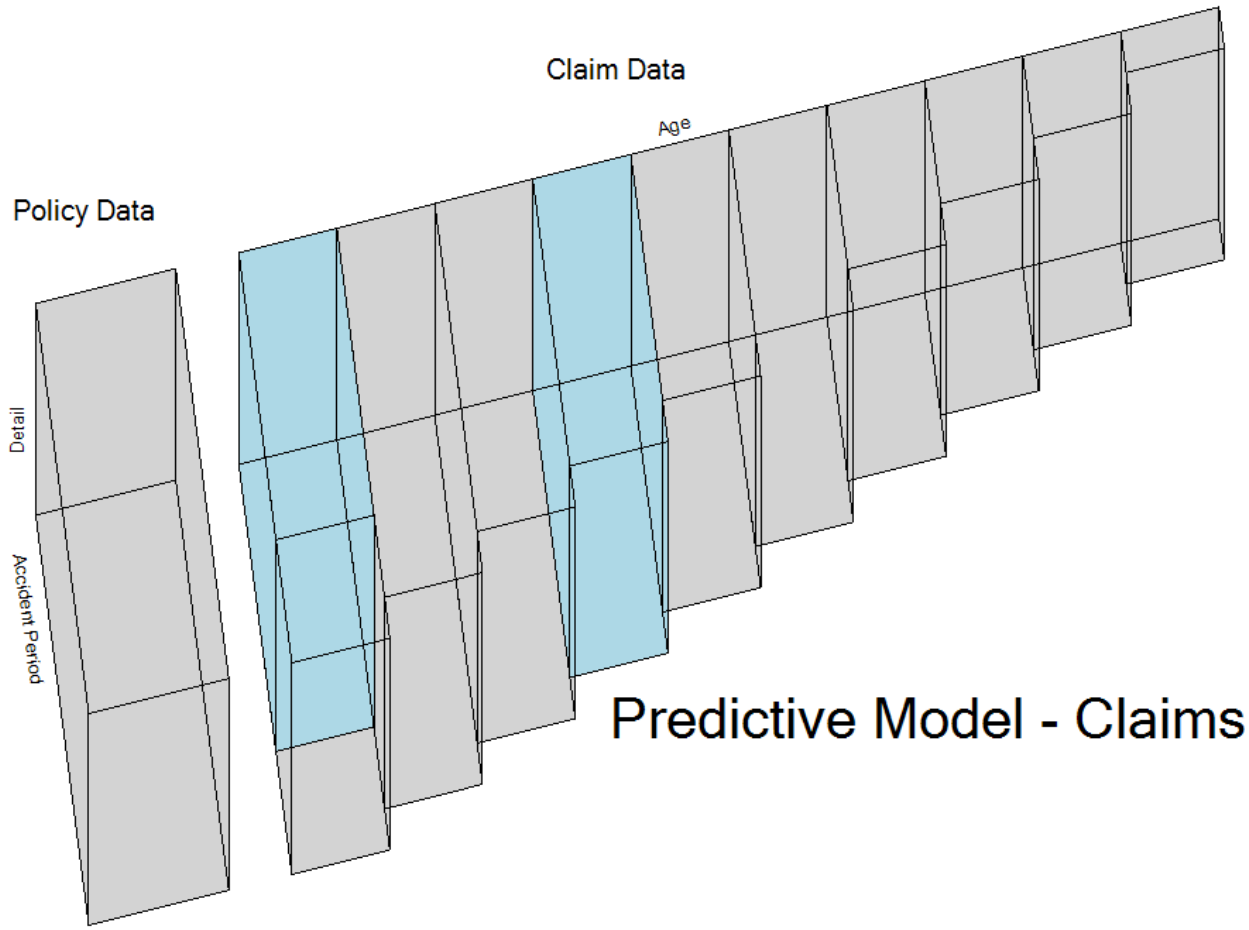


No Model

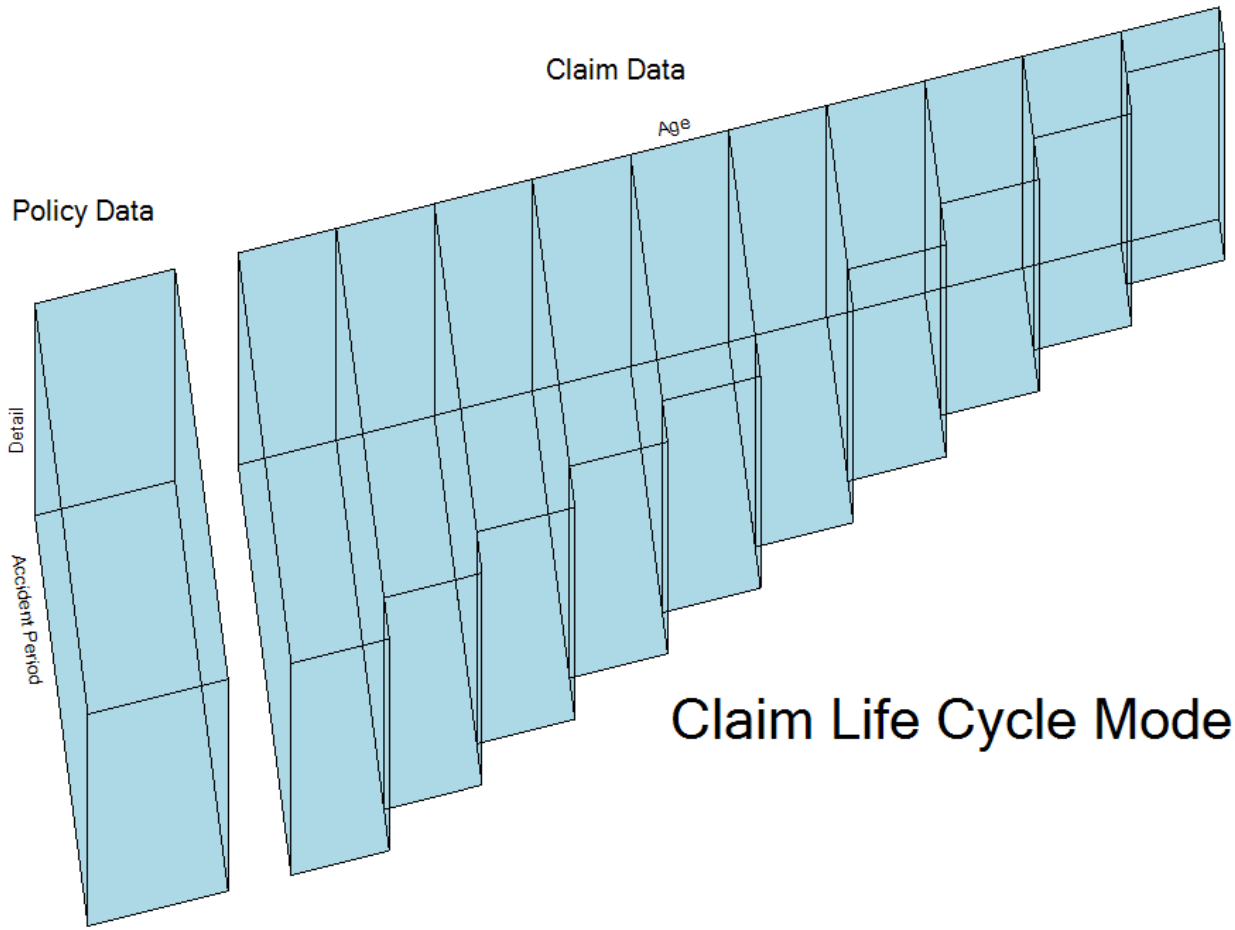


Link Ratio


Claim Data
Age
Policy Data
Detail
Accident Period
Bornhuetter-Ferguson



Predictive Model - Claims

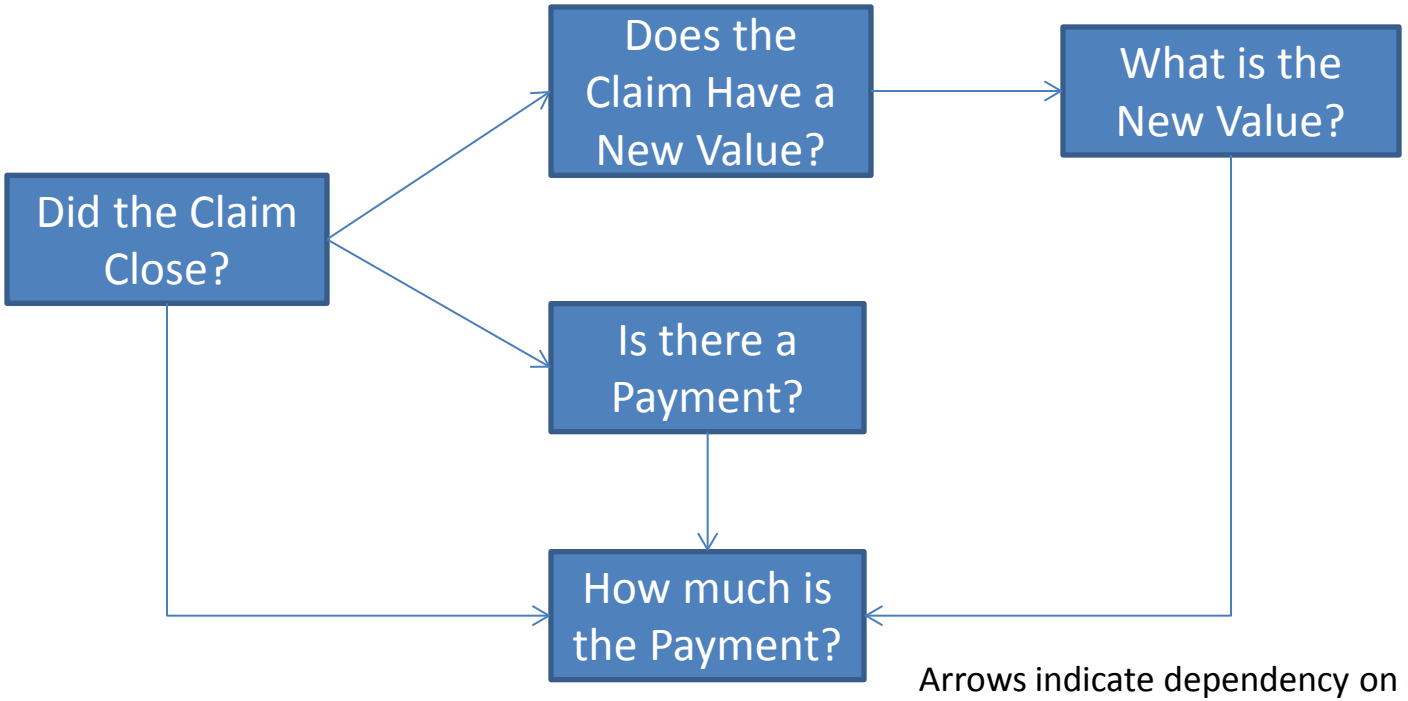


Claim Life Cycle Model

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

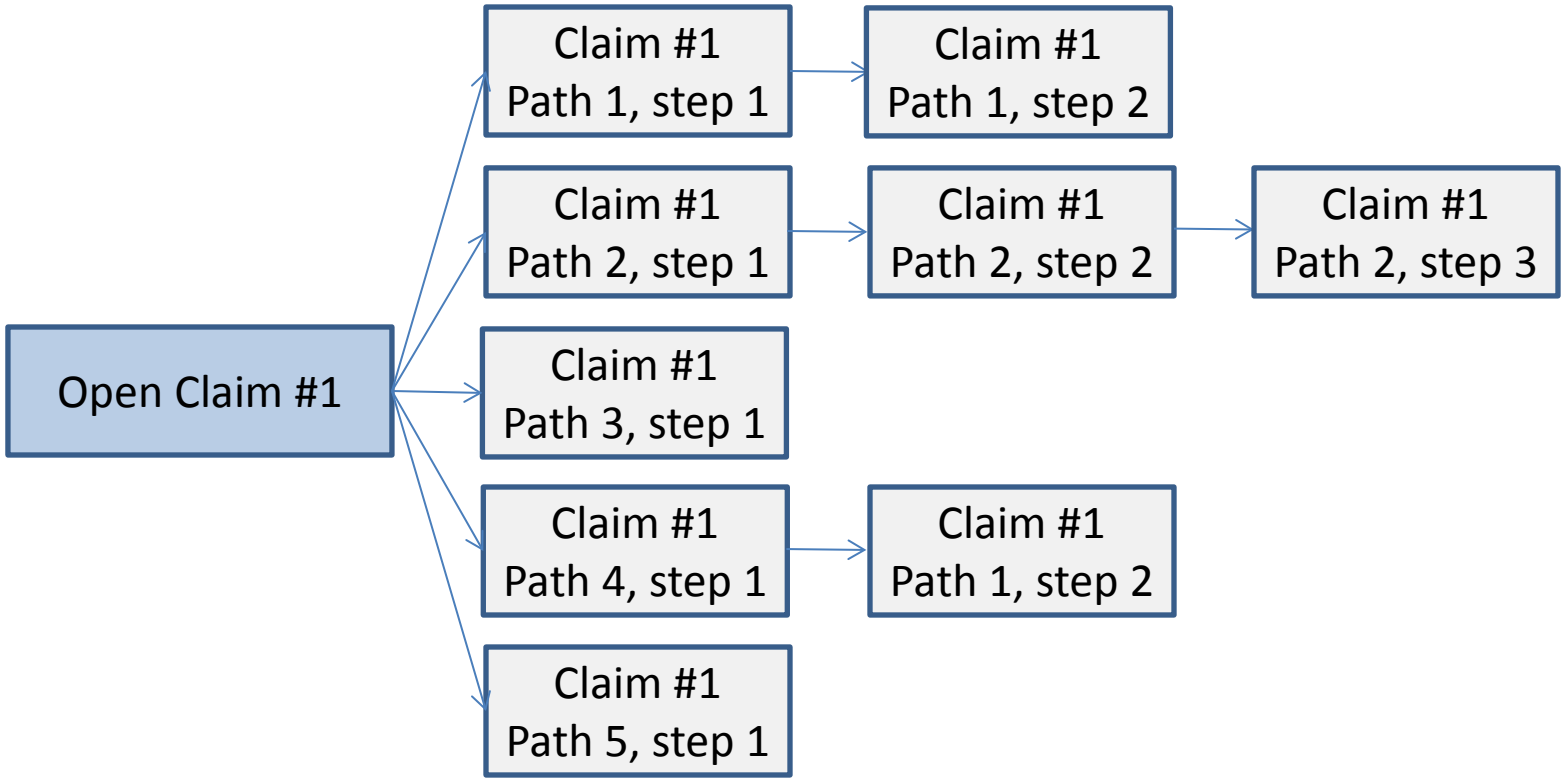
Claim Development



Arrows indicate dependency on other results

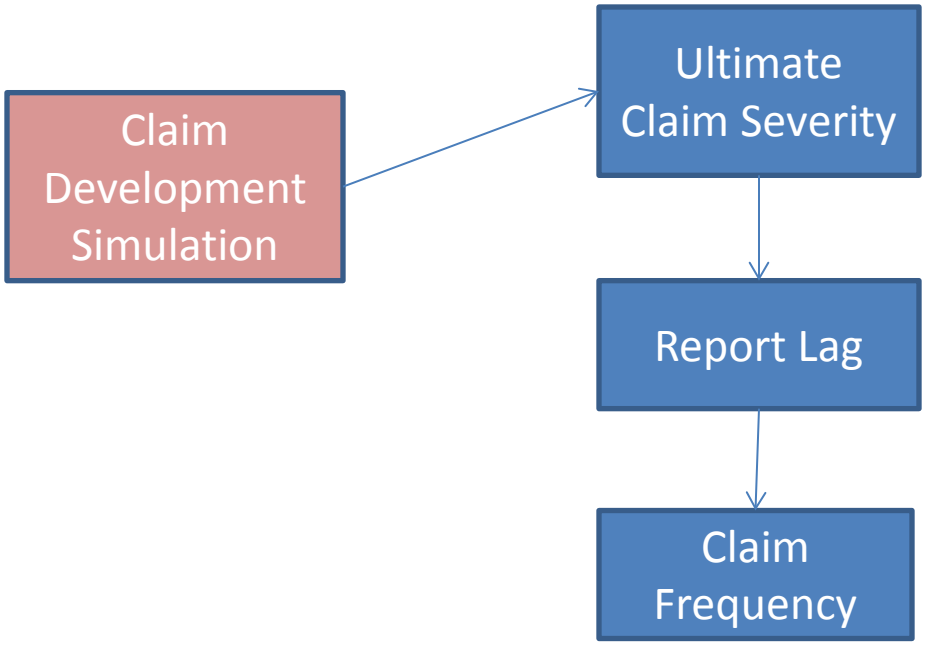
A number of available claim or exposure characteristics may have predictive value for any of these questions.

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.

Claim Emergence



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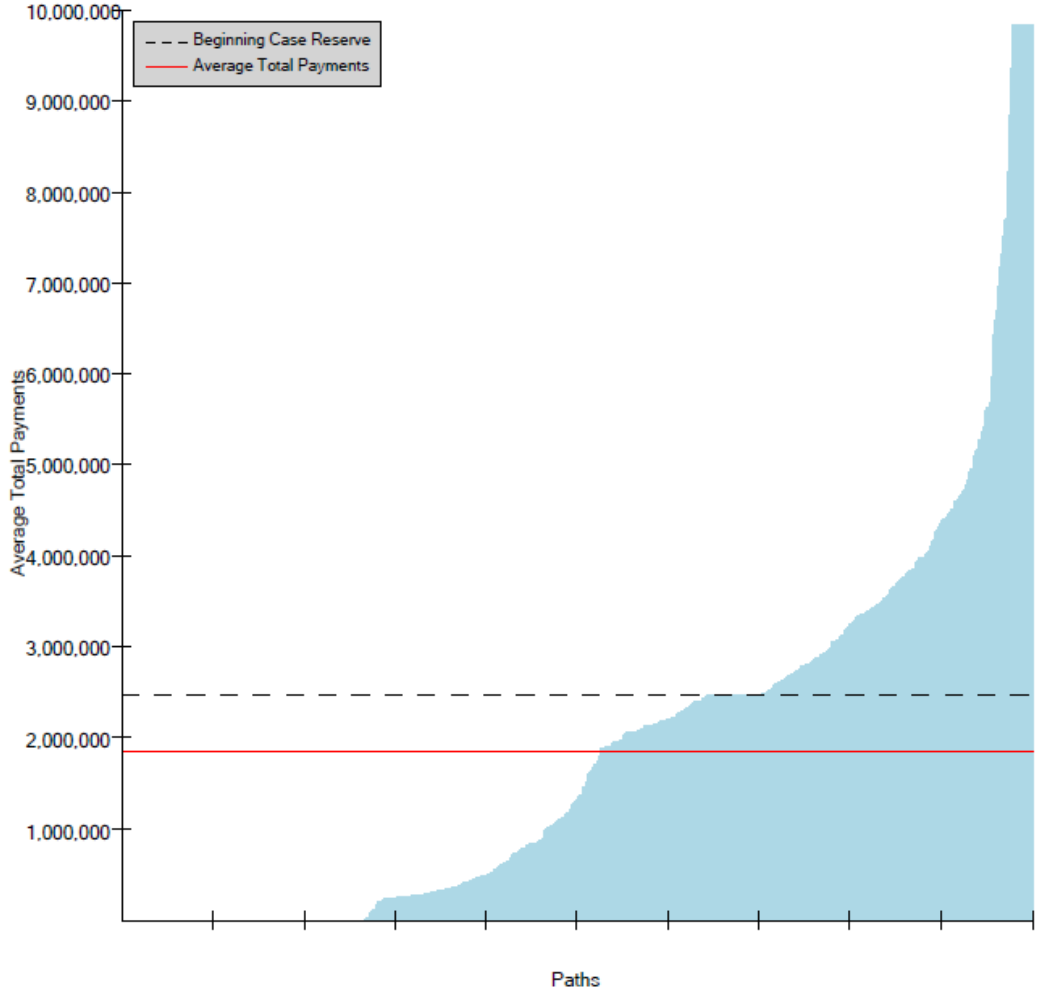
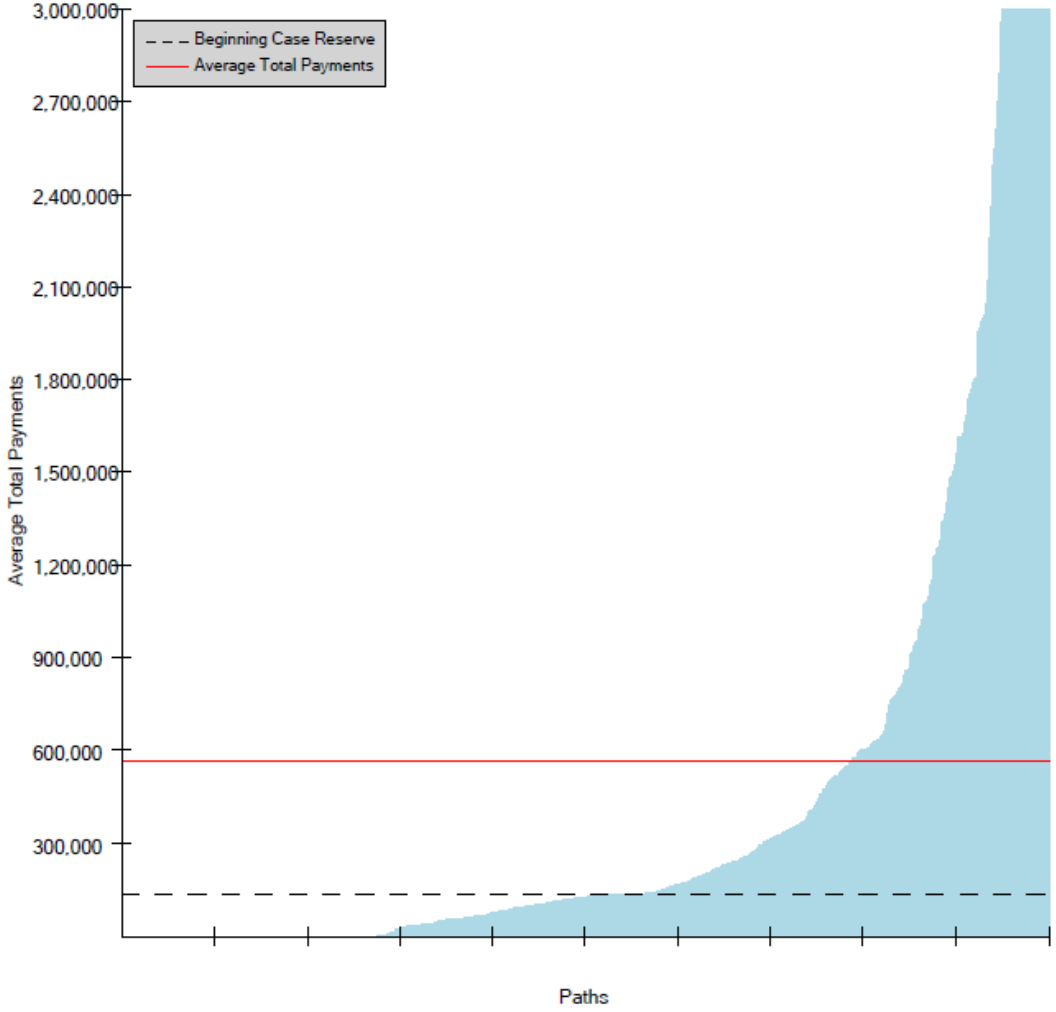
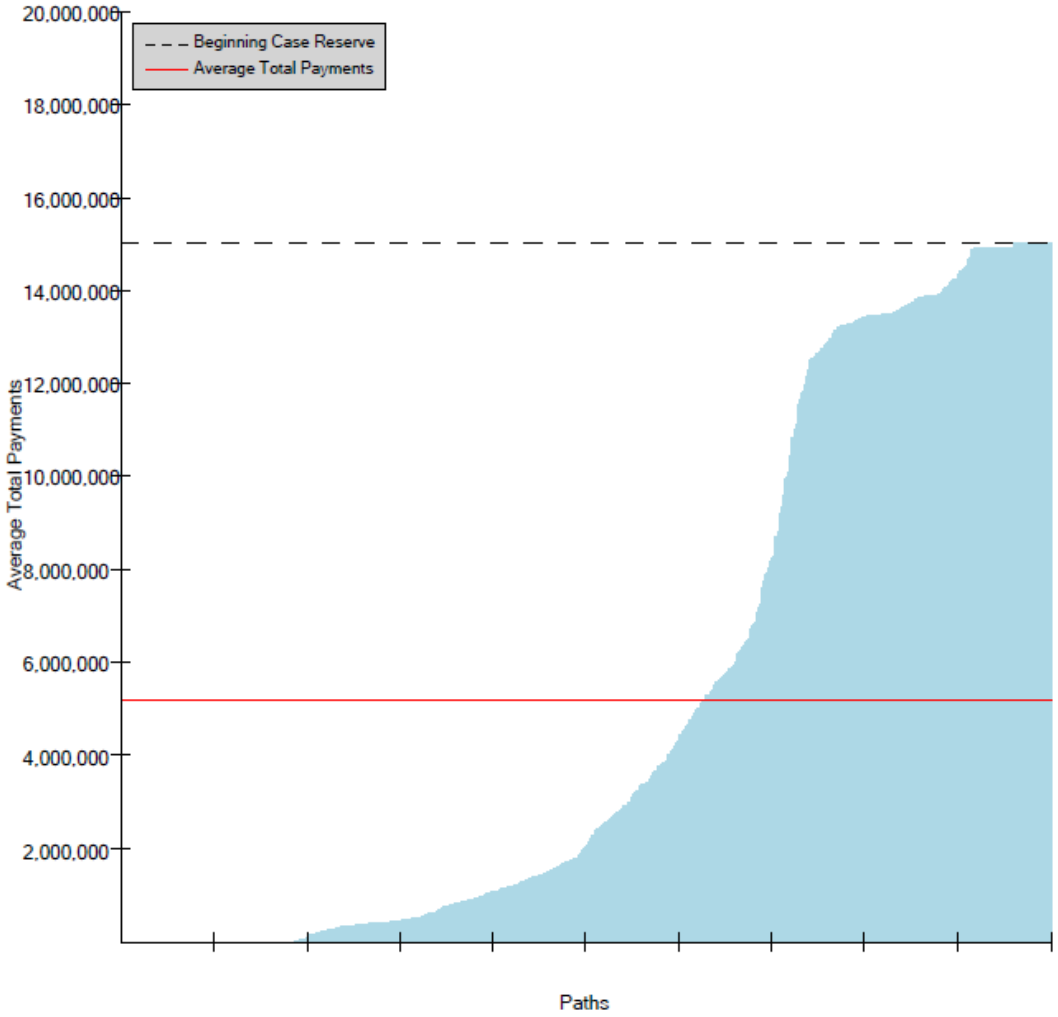
Claim 1

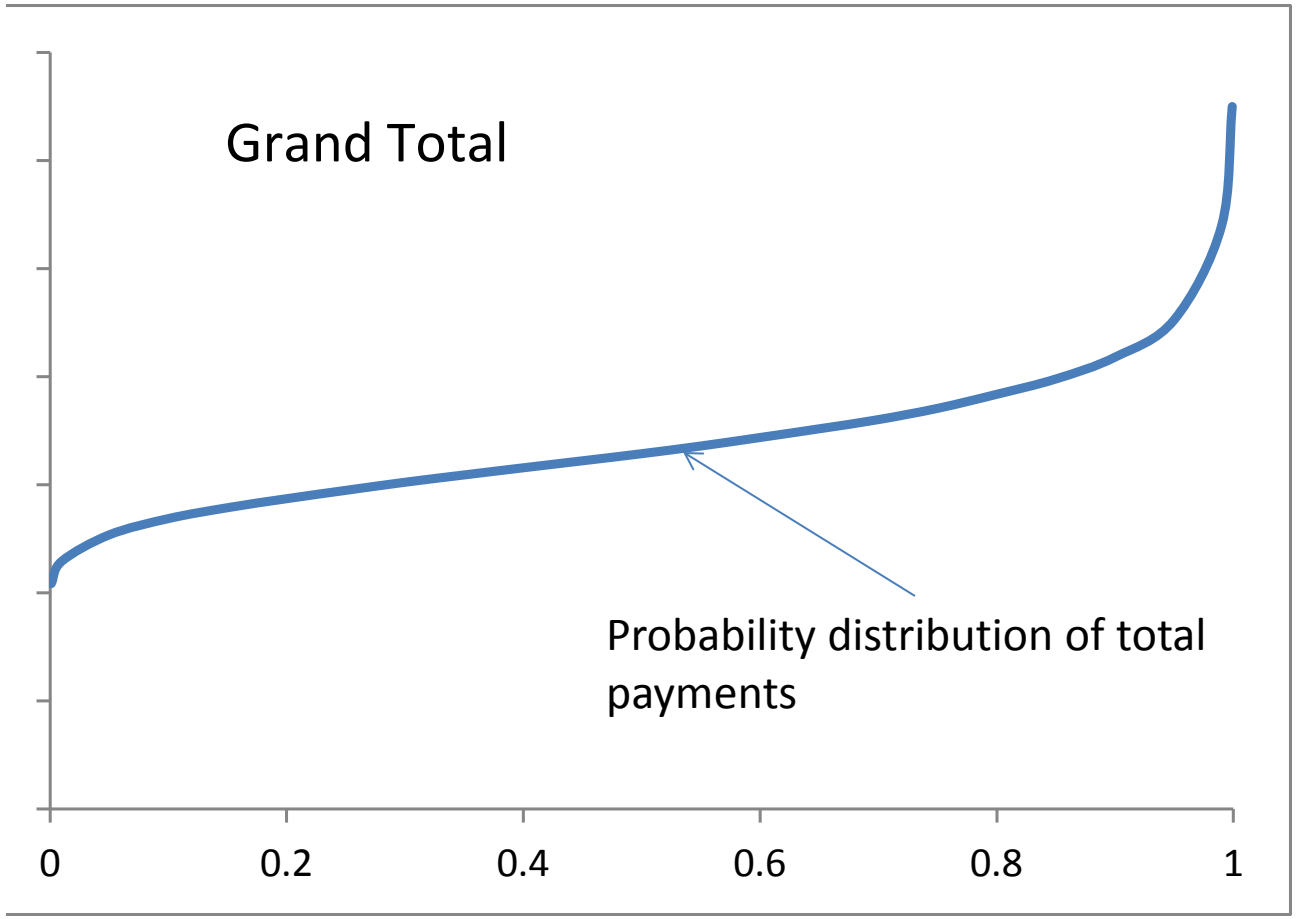

Beginning Case Reserve
Average Total Payments
10,000,000
9,000,000
8,000,000
7,000,000
6,000,000
5,000,000
4,000,000
3,000,000
2,000,000
1,000,000
Average Total Payments
Paths

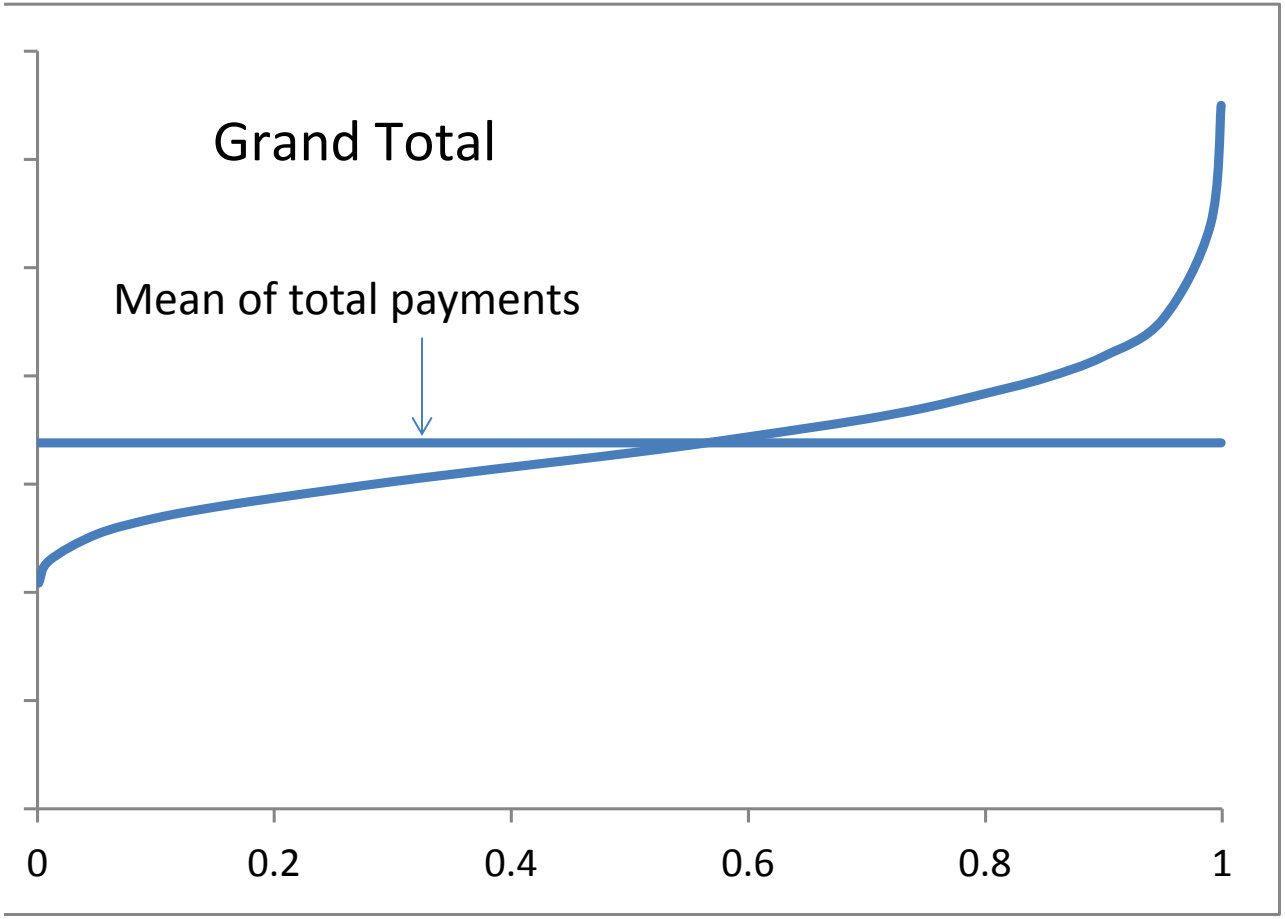
Claim 2

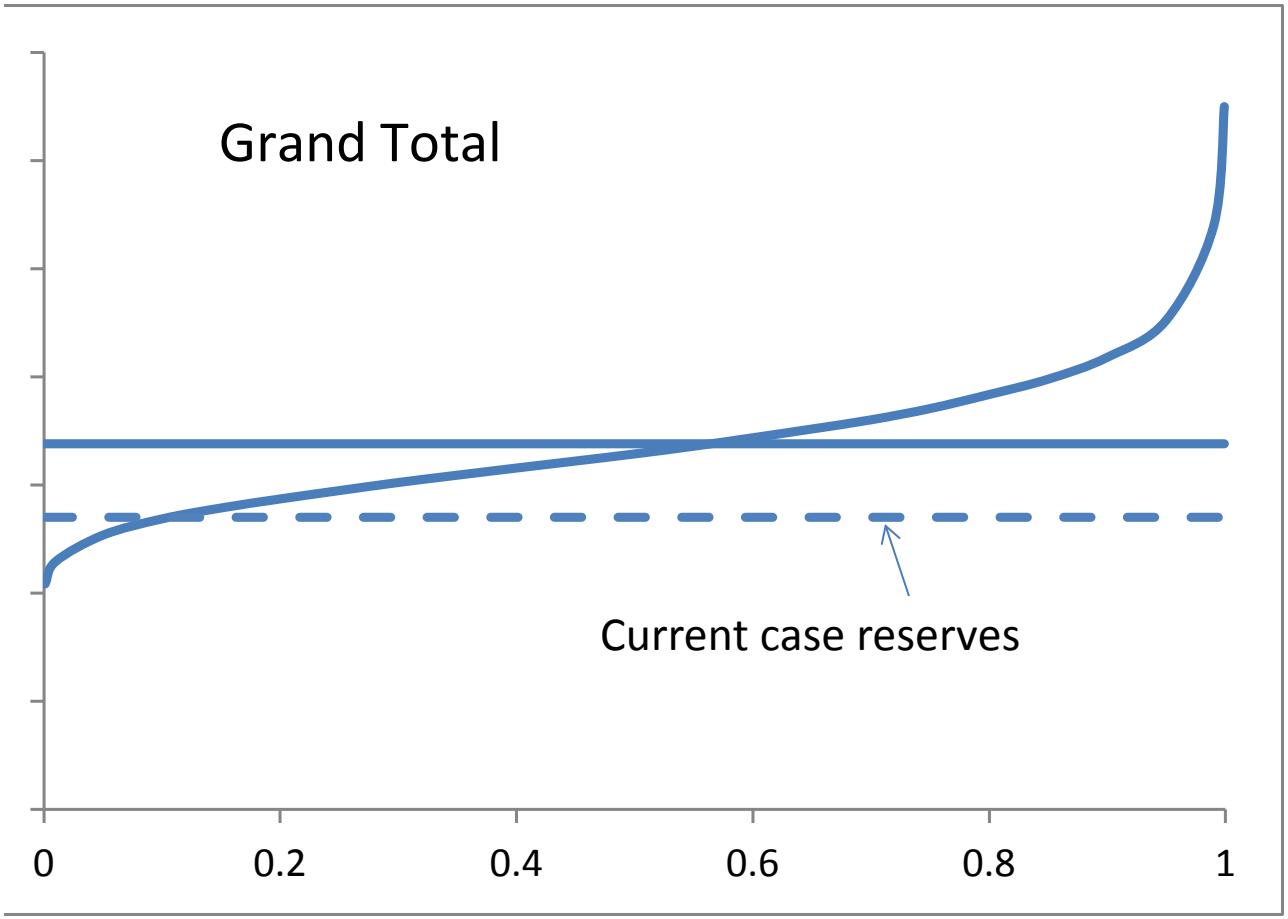

Beginning Case Reserve
Average Total Payments
3,000,000
2,700,000
2,400,000
2,100,000
1,800,000
1,500,000
1,200,000
900,000
600,000
300,000
Average Total Payments
Paths

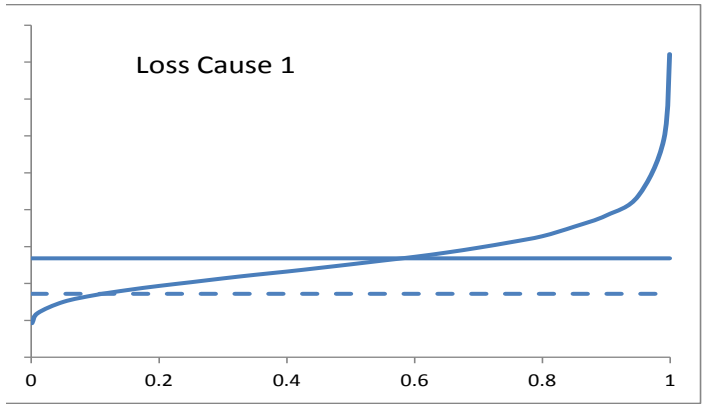
Claim 3

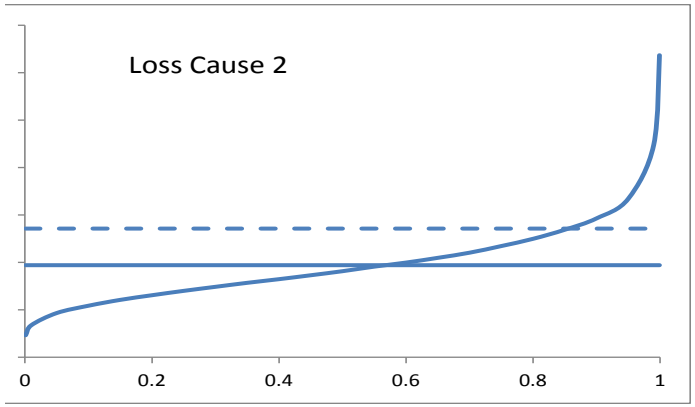

Beginning Case Reserve
Average Total Payments
20,000,000
18,000,000
16,000,000
14,000,000
12,000,000
10,000,000
8,000,000
6,000,000
4,000,000
2,000,000
Average Total Payments
Paths

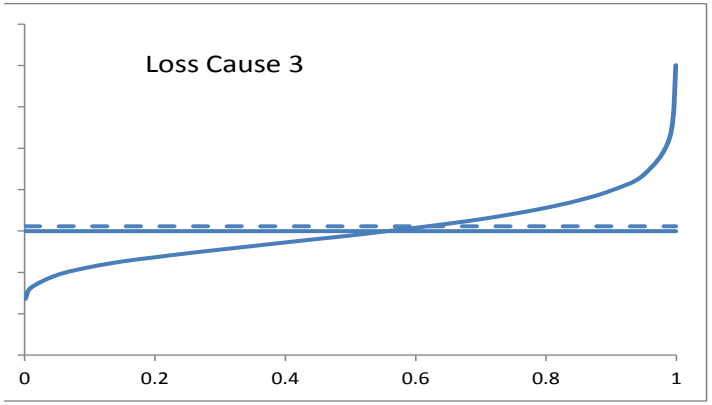

Grand Total
Probability distribution of total payments
0
0.2
0.4
0.6
0.8
1

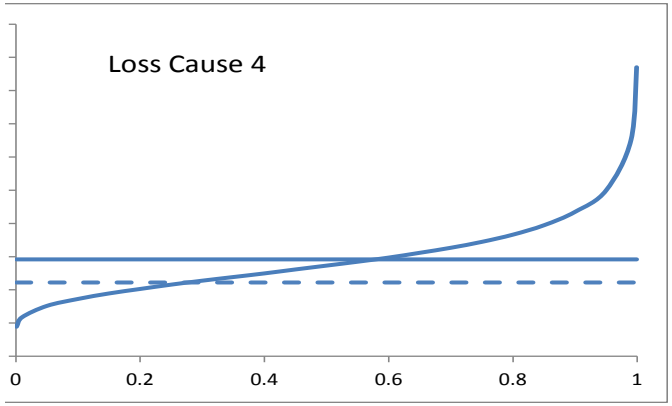

Grand Total
Mean of total payments
0
0.2
0.4
0.6
0.8
1

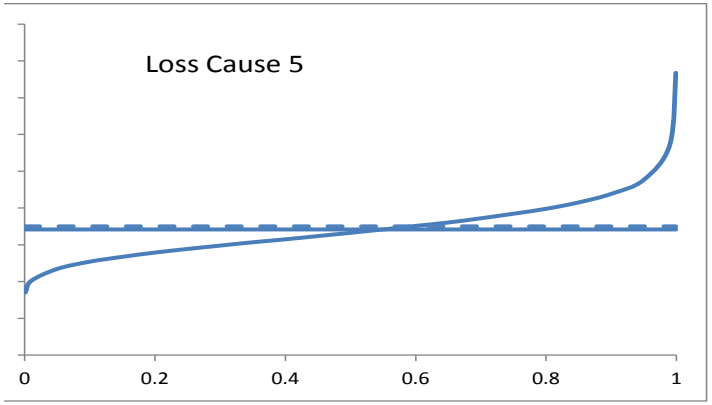

Grand Total
Current case reserves
0
0.2
0.4
0.6
0.8
1

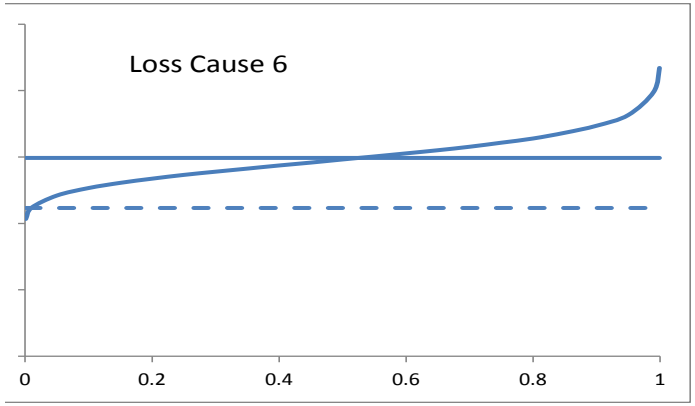

Loss Cause 1
0
0.2
0.4
0.6
0.8
1


Loss Cause 2
0
0.2
0.4
0.6
0.8
1


Loss Cause 3
0
0.2
0.4
0.6
0.8
1


Loss Cause 4
0
0.2
0.4
0.6
0.8
1


Loss Cause 5
0
0.2
0.4
0.6
0.8
1


Loss Cause 6
0
0.2
0.4
0.6
0.8
1

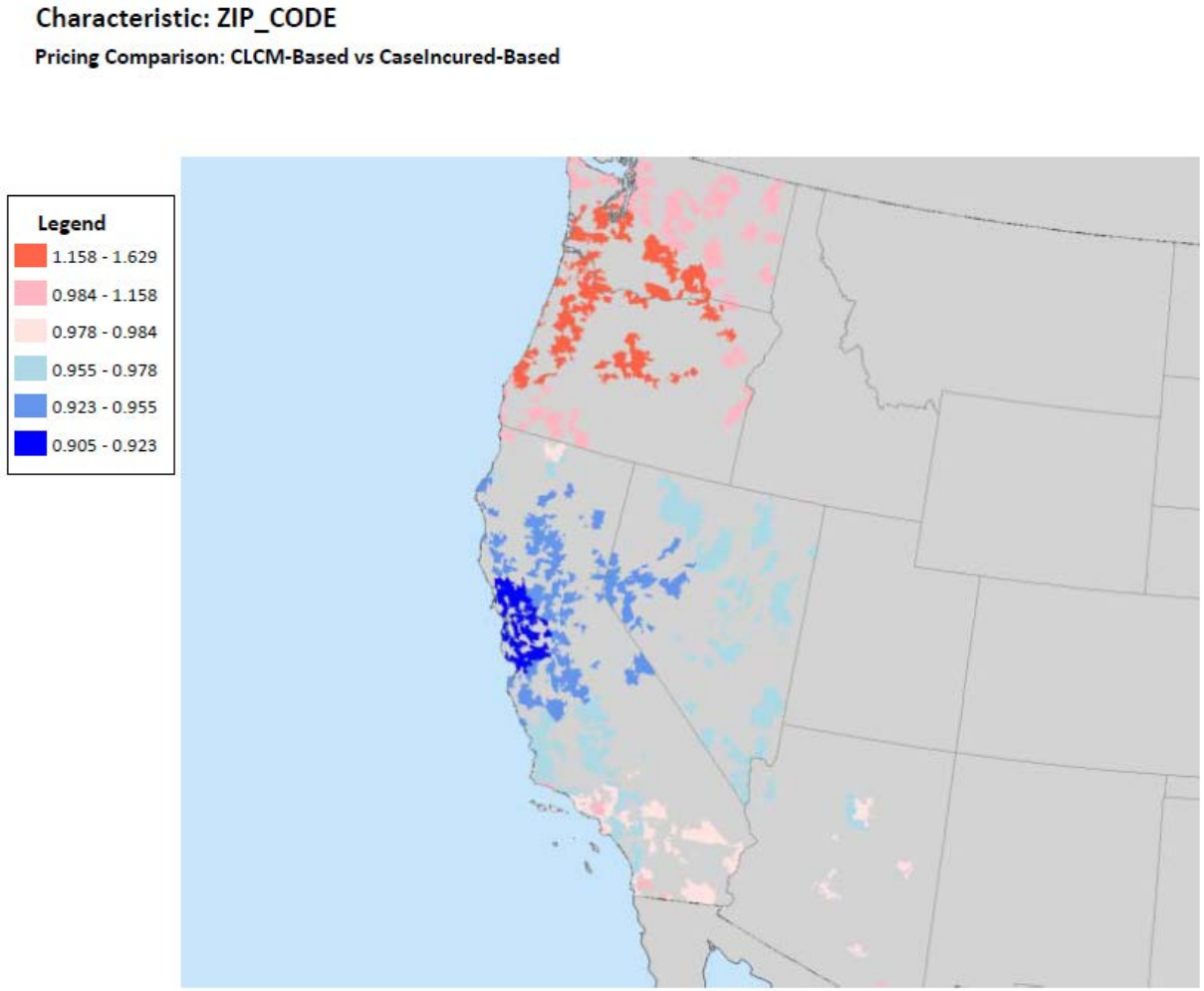
Why do it?

- 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

Uses

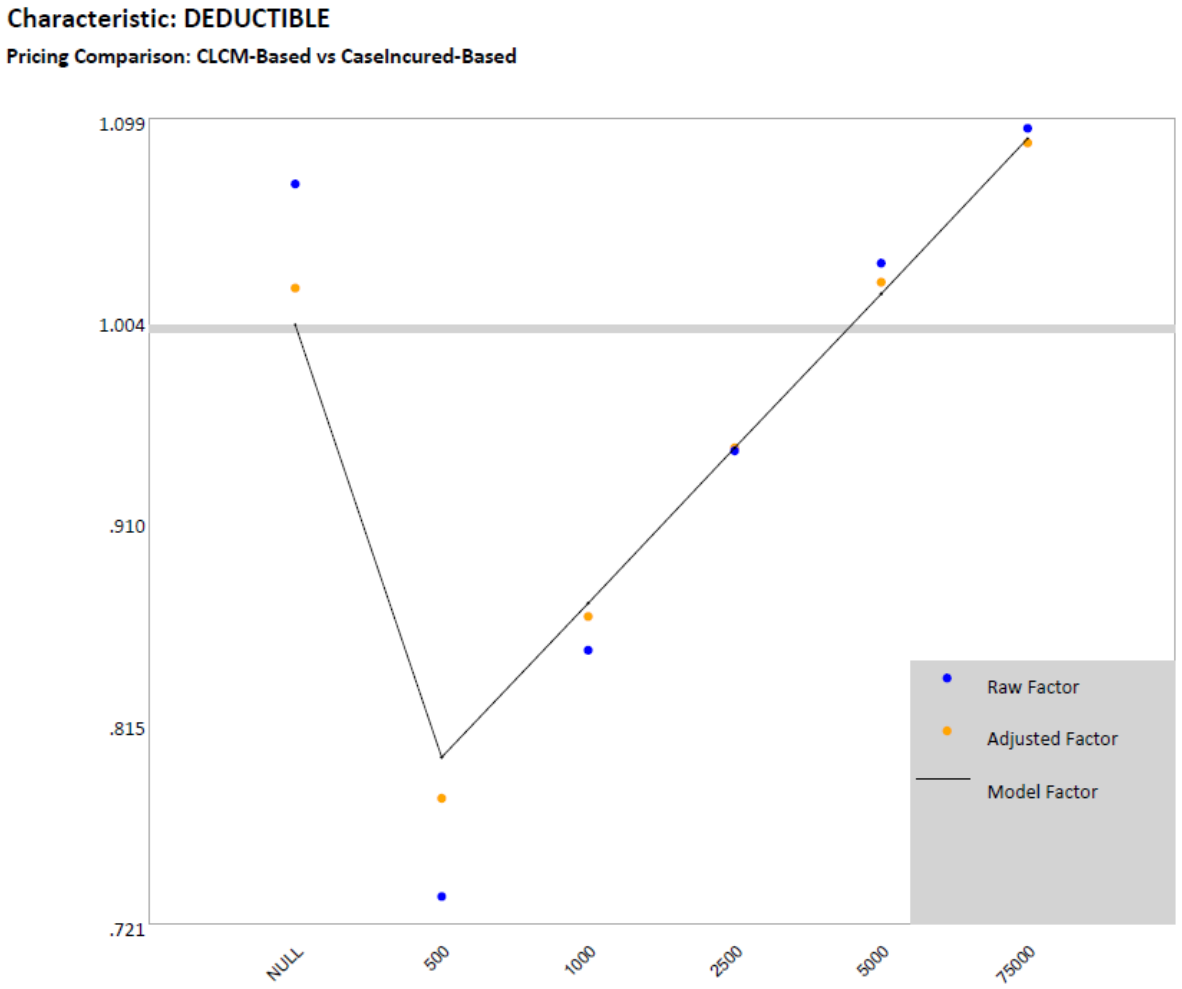
- Reserve Analysis
- Claim management
- Pricing Analysis
- Underwriting Management
- Risk Management
- Reinsurance

Case Study – Selected Highlights

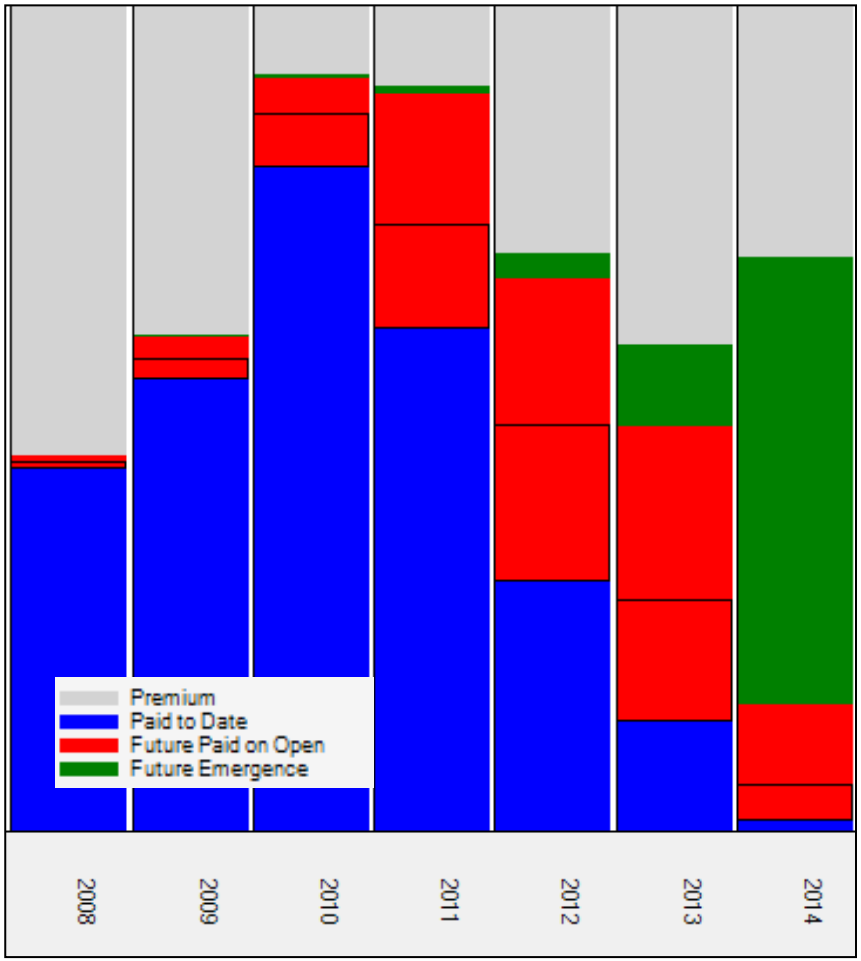


Gross Consulting

Case Study– Selected Highlights



Case Study– Selected Highlights



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Conclusion

- There is a wealth of data available to use when developing estimates of reserves
- Triangles obscure much of the information, and will not identify problems with mix shifts until it is too late.
- 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