IMPROVING ACTUARIAL RESERVE ANALYSIS THROUGH CLAIM-LEVEL PREDICTIVE ANALYTICS

Predictive Modeling in Reserve Analysis

- It's all predictive modeling isn't it?
- This discussion refers to the what is commonly termed 'predictive modeling'- multivariate models, statistical rigor, etc.
- Emphasis in the past on pricing
- Reserving getting attention

Case Reserve Adequacy Example

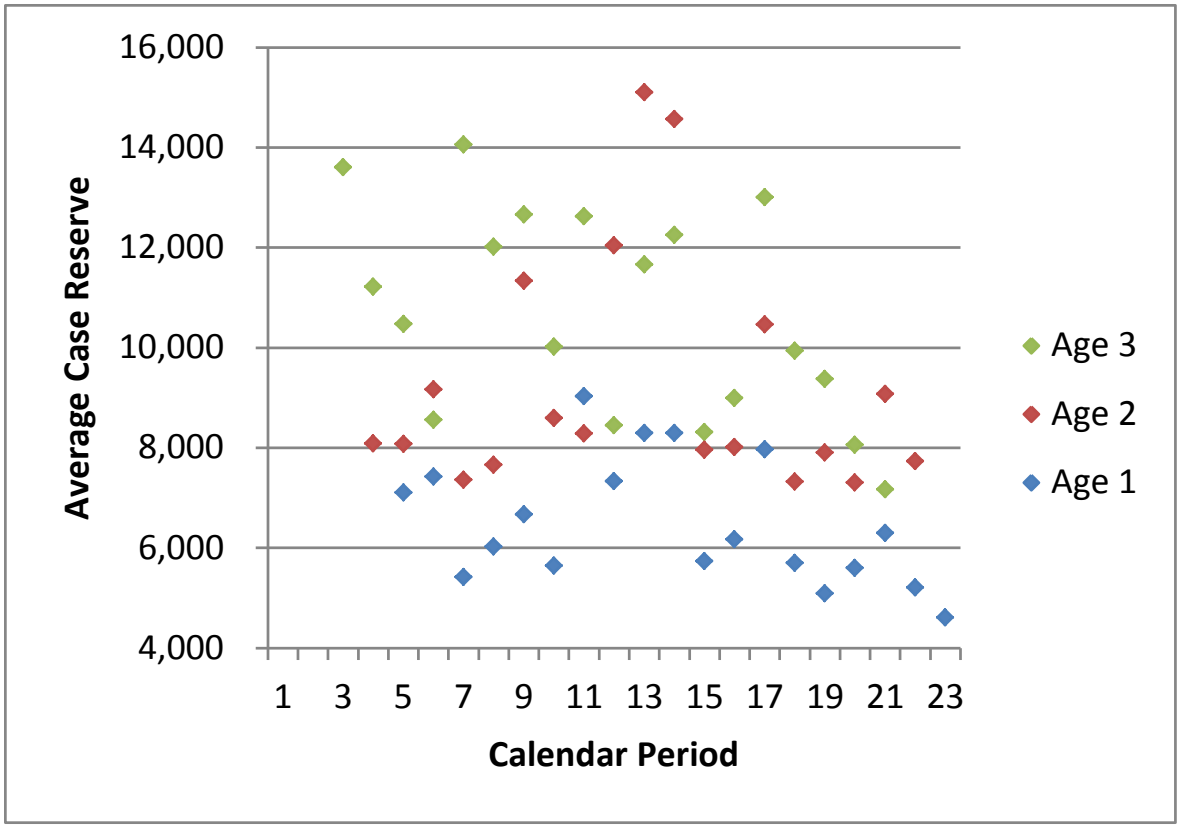
Calendar Period	Open Count	Case Reserves	Average Case Reserve
8	564	4,954,014	8,784
9	568	6,198,630	10,913
10	649	5,347,576	8,240
11	674	6,067,343	9,002
12	543	5,313,733	9,786
13	590	5,666,509	9,604
14	631	6,927,816	10,979
15	731	7,125,765	9,748
16	590	6,493,882	11,007
17	697	7,773,533	11,153
18	660	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

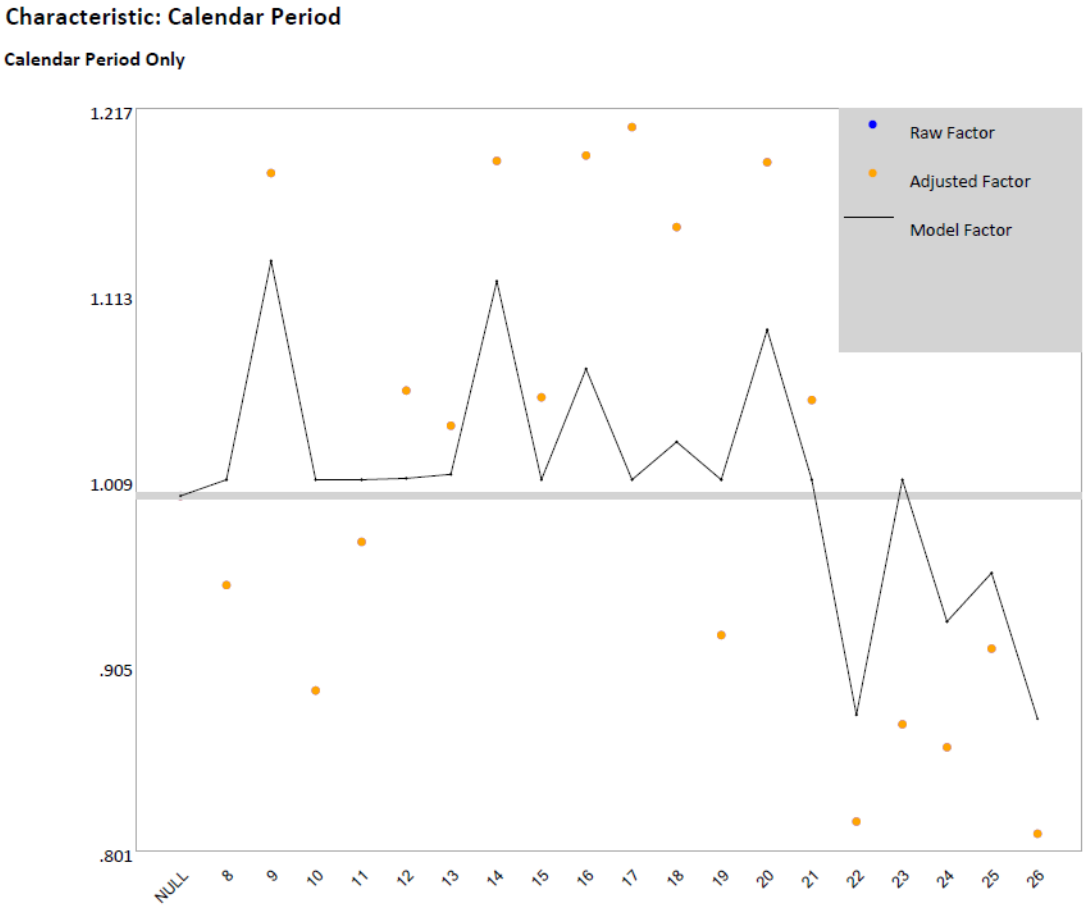


Case Reserve Adequacy Example

- 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

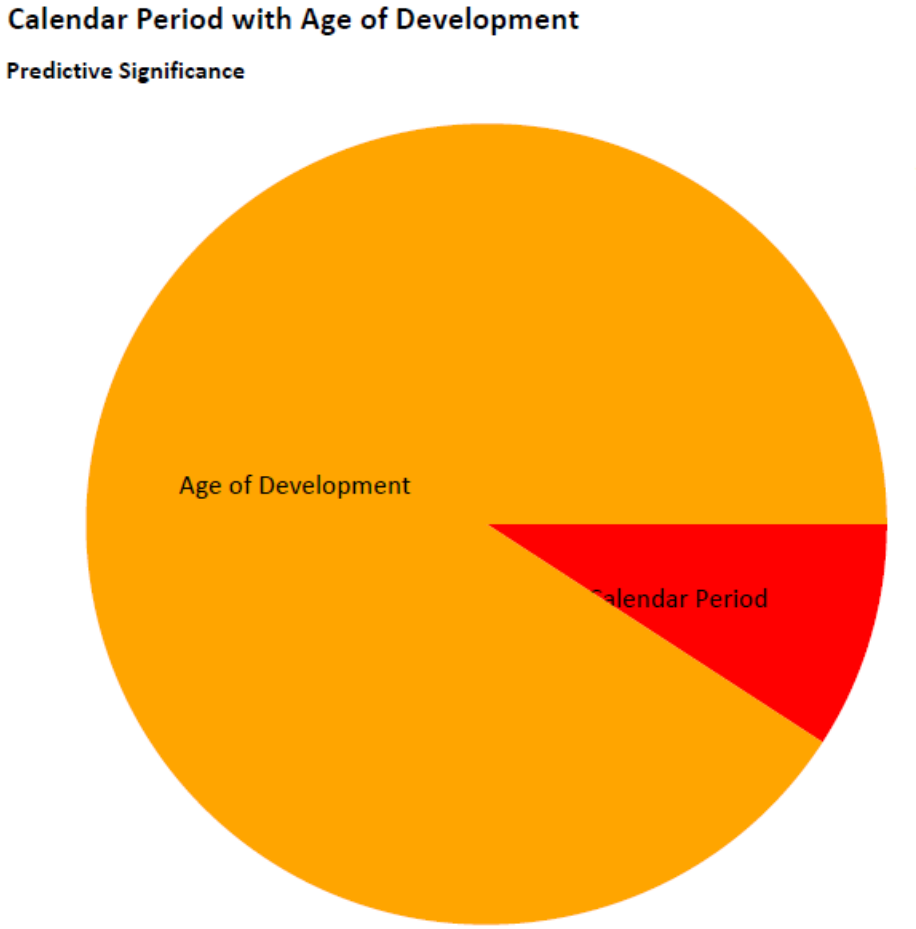
Same calendar period data, but include credibility (in this case based on rank based t-statistic of observations) and smoothing techniques.



Case Reserve Adequacy Example

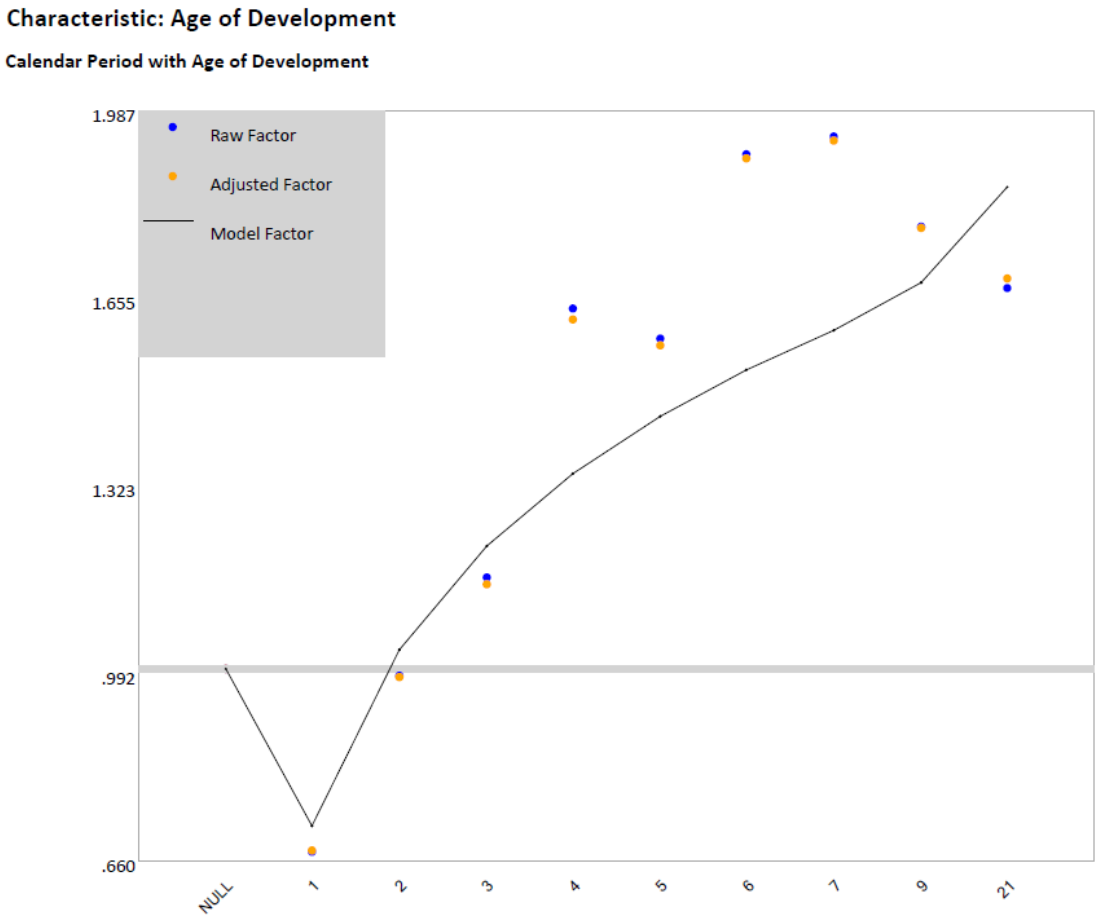
At the very least, the inclusion of Age of Development is appropriate in a predictive model of case reserves

In this case it is very predictive



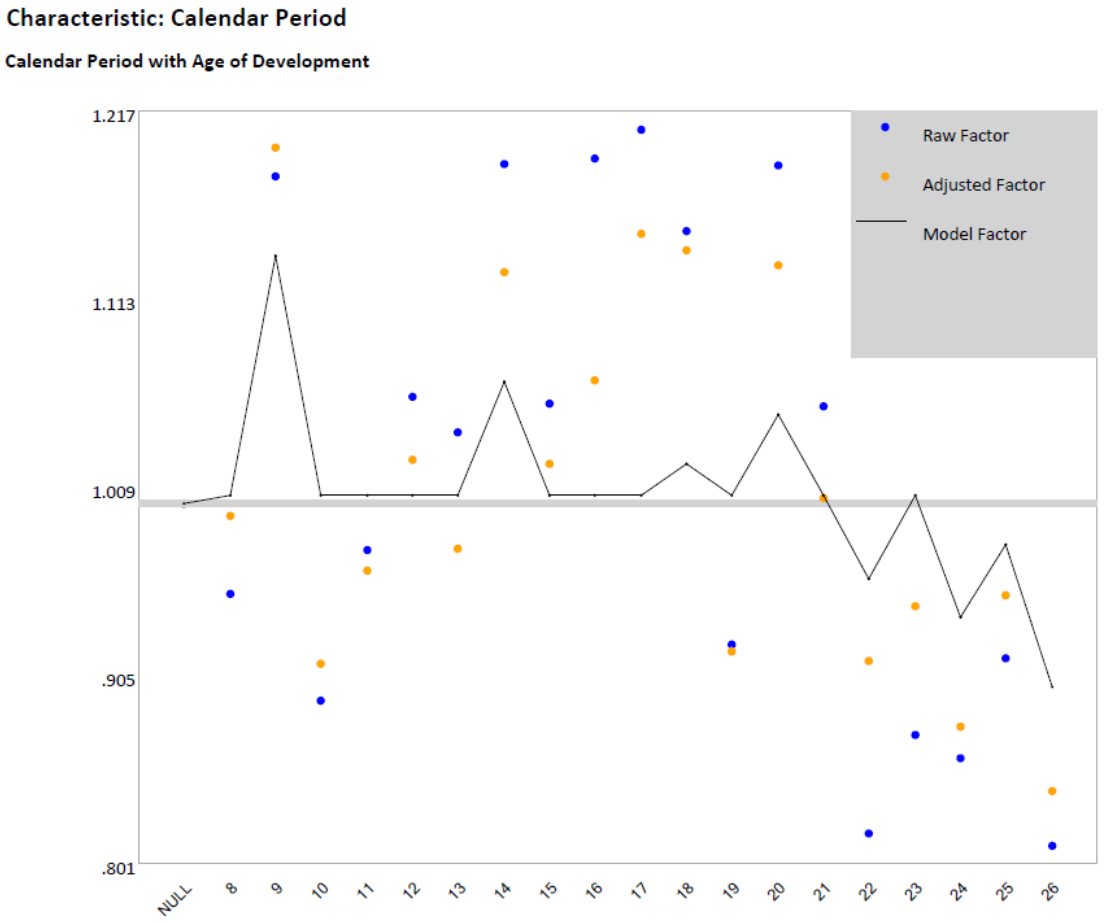
Case Reserve Adequacy Example

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



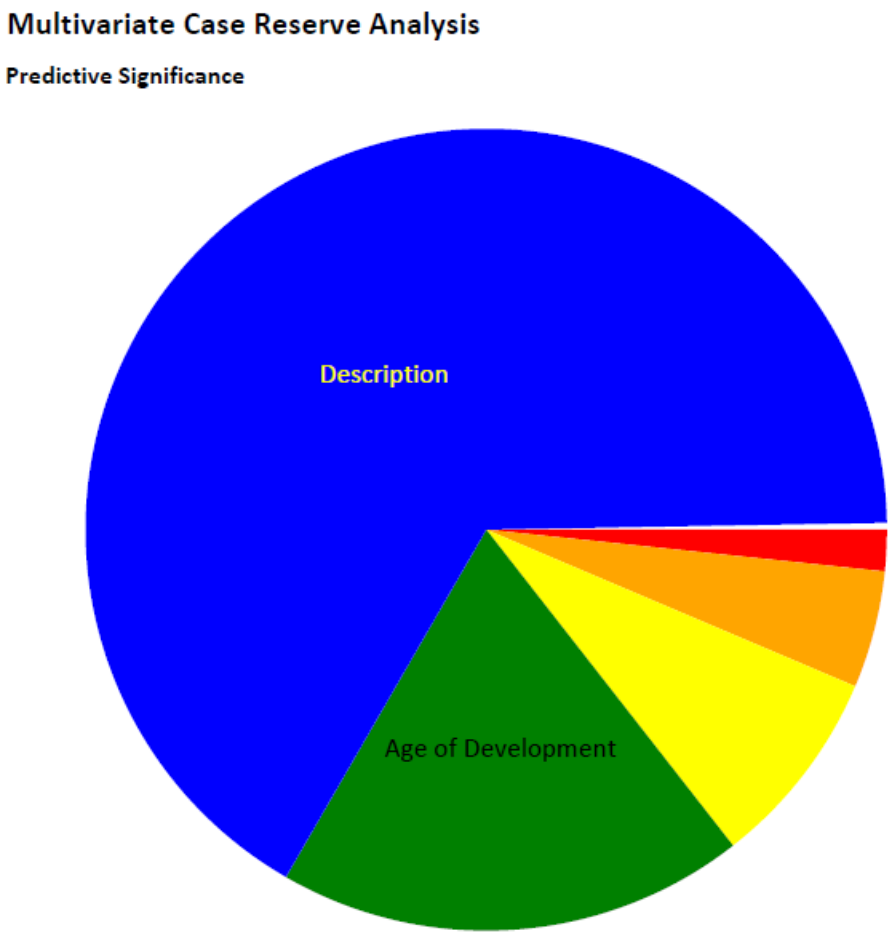
Case Reserve Adequacy Example

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.



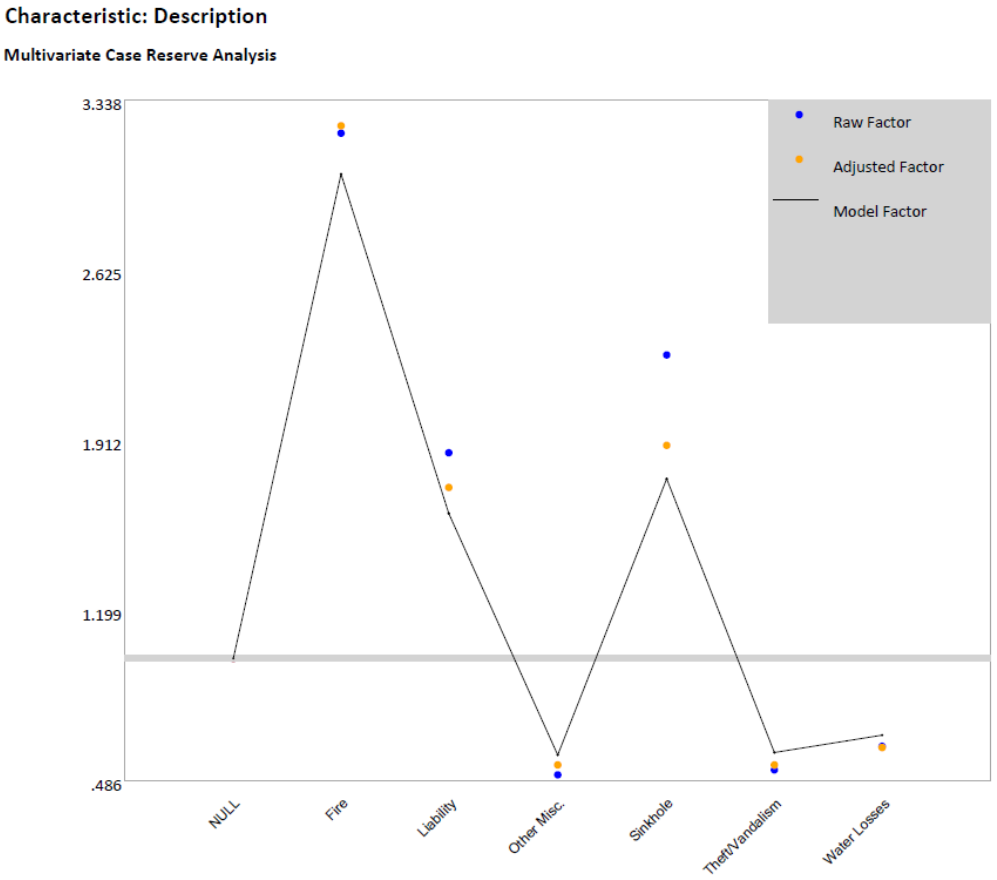
Case Reserve Adequacy Example

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



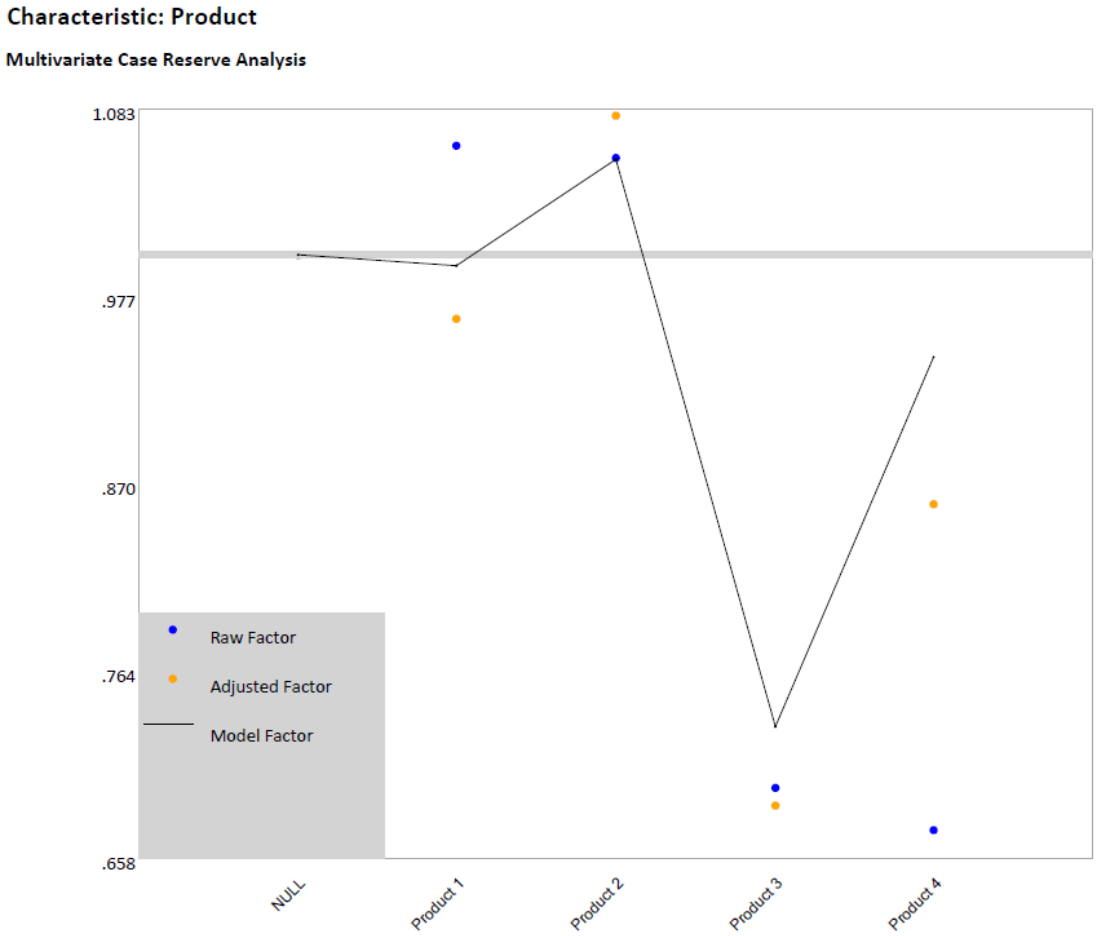
Case Reserve Adequacy Example

In this the cause of loss is very predictive of the case reserve amount.



Case Reserve Adequacy Example

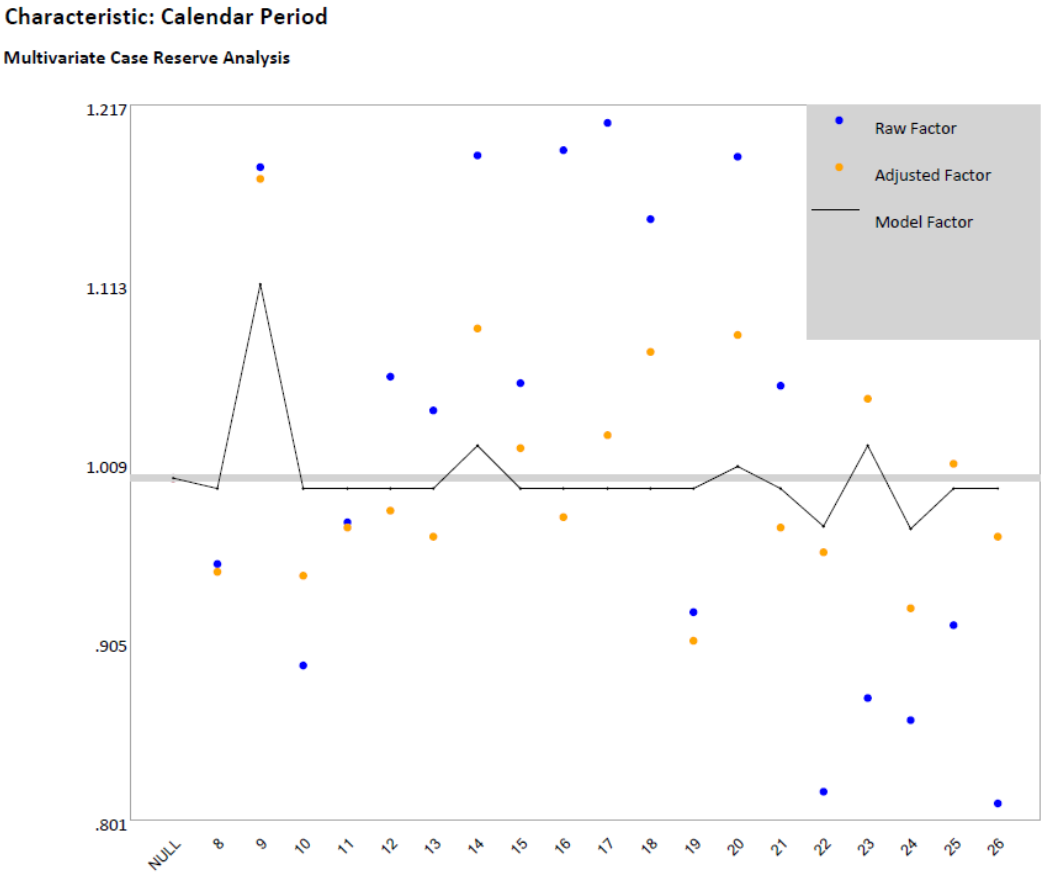
The policy form was also predictive.



Case Reserve Adequacy Example

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

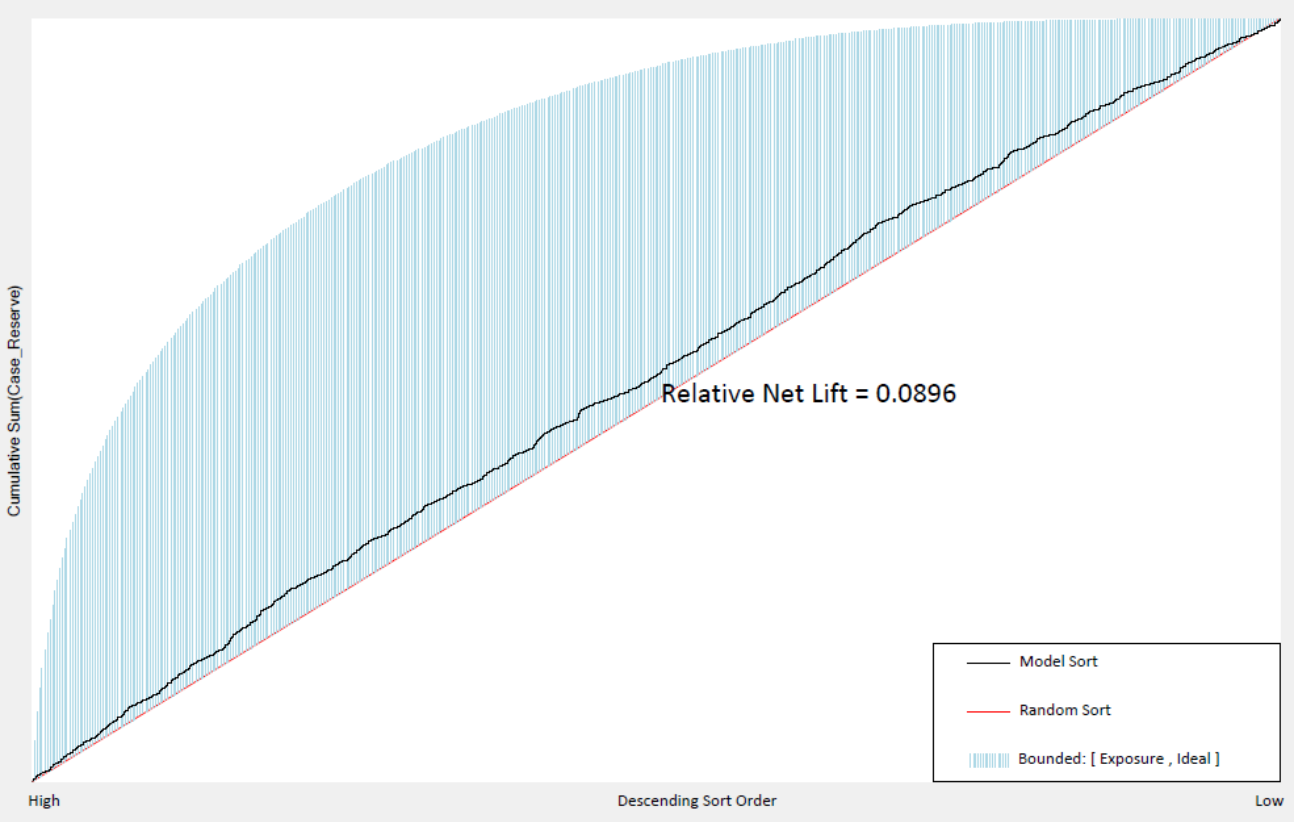
After adjusting for the other variables, there is much less evidence of a change in adequacy over time.



Case Reserve Adequacy Example

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

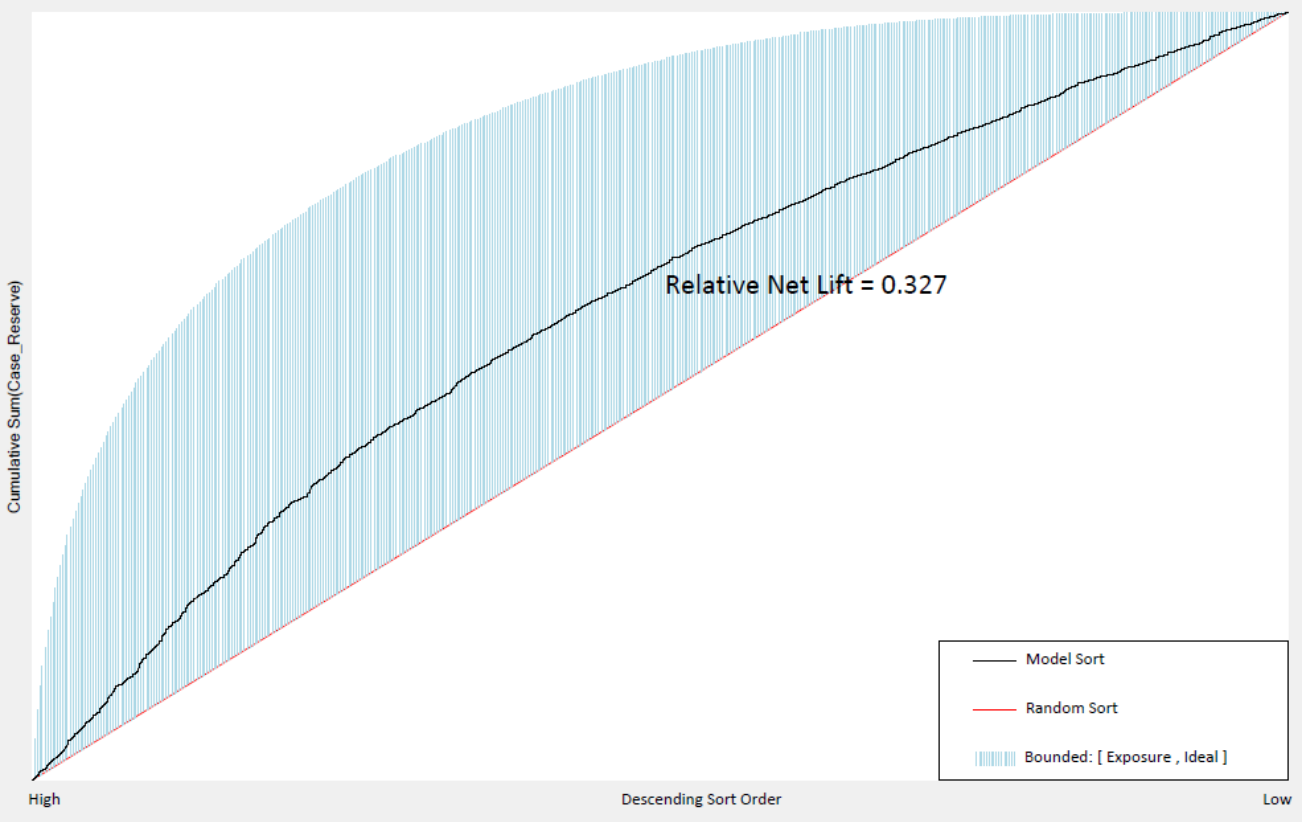
Calendar Period by itself, does little to describe the size of the case reserve in this example.



Case Reserve Adequacy Example

A lift chart using Calendar Period and Age of Development.

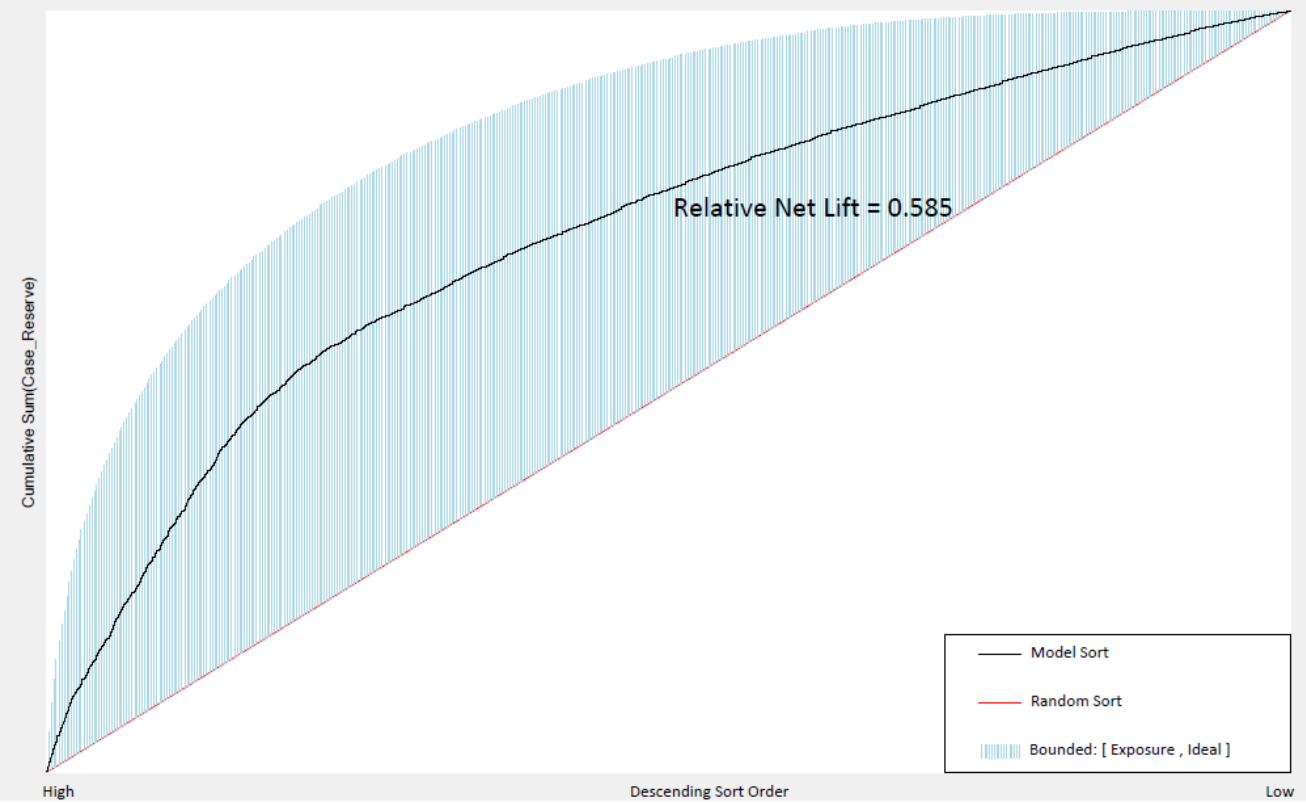
This model does a considerably better job of describing case reserve size. (Hence our use of average case triangles)



Case Reserve Adequacy Example

This lift chart includes the impact of other variables.

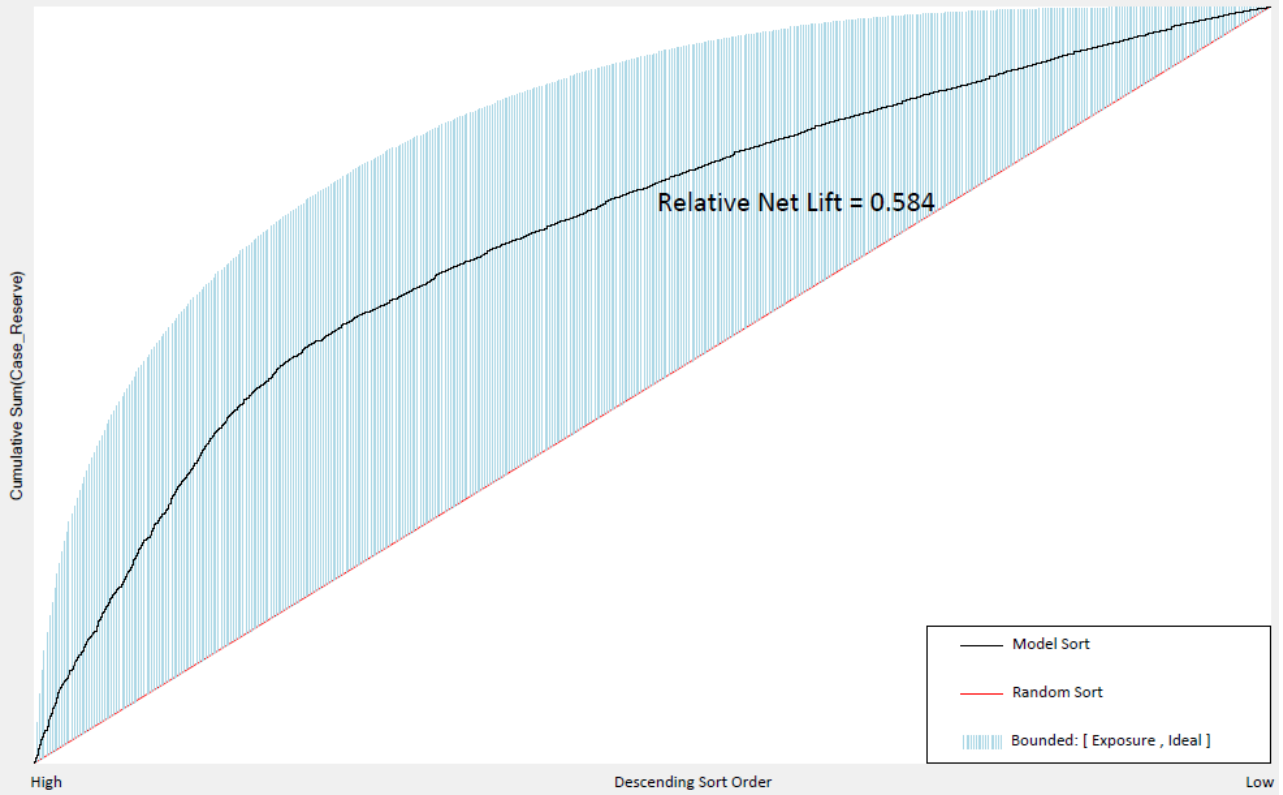
Adding variables like cause of loss results in a **much** better model of case reserves.



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.



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.

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

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

Challenges

- Same as with P&C reserving in general
  - Loss development occurs over time, mature periods are old
  - Immature claims contain information
- Many facets of loss development
- Helpful to concentrate on a single time-step (e.g. beginning of quarter to end of quarter)

Data

Financial Data

- Beginning Case Reserve
- Ending Case Reserve
- Payment in Period

Timing Data

- Accident Quarter
- Report Quarter
- Valuation Quarter

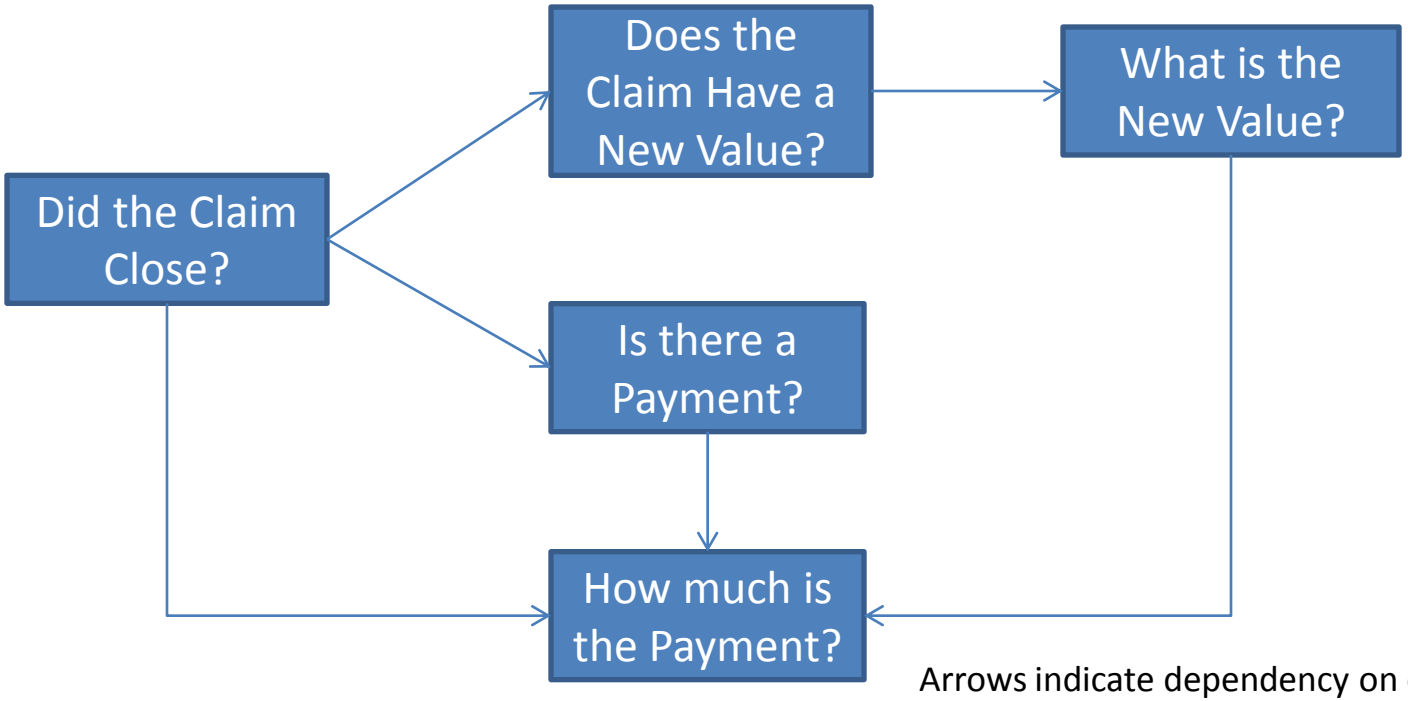
Exposure Characteristics

- Type
- Product
- ZIP Code

Claim Characteristics

- Loss Cause
- Loss Cause - Detail

Claim activity from the beginning of the quarter to the end of the quarter

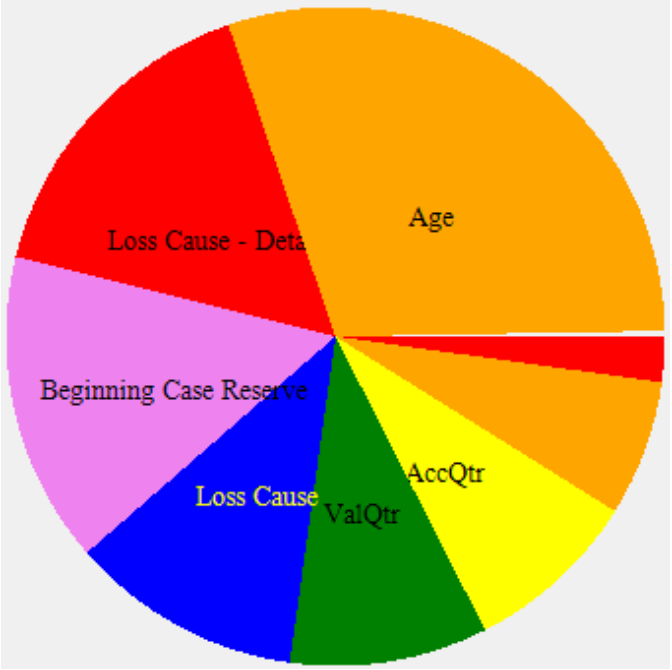


Arrows indicate dependency on other results

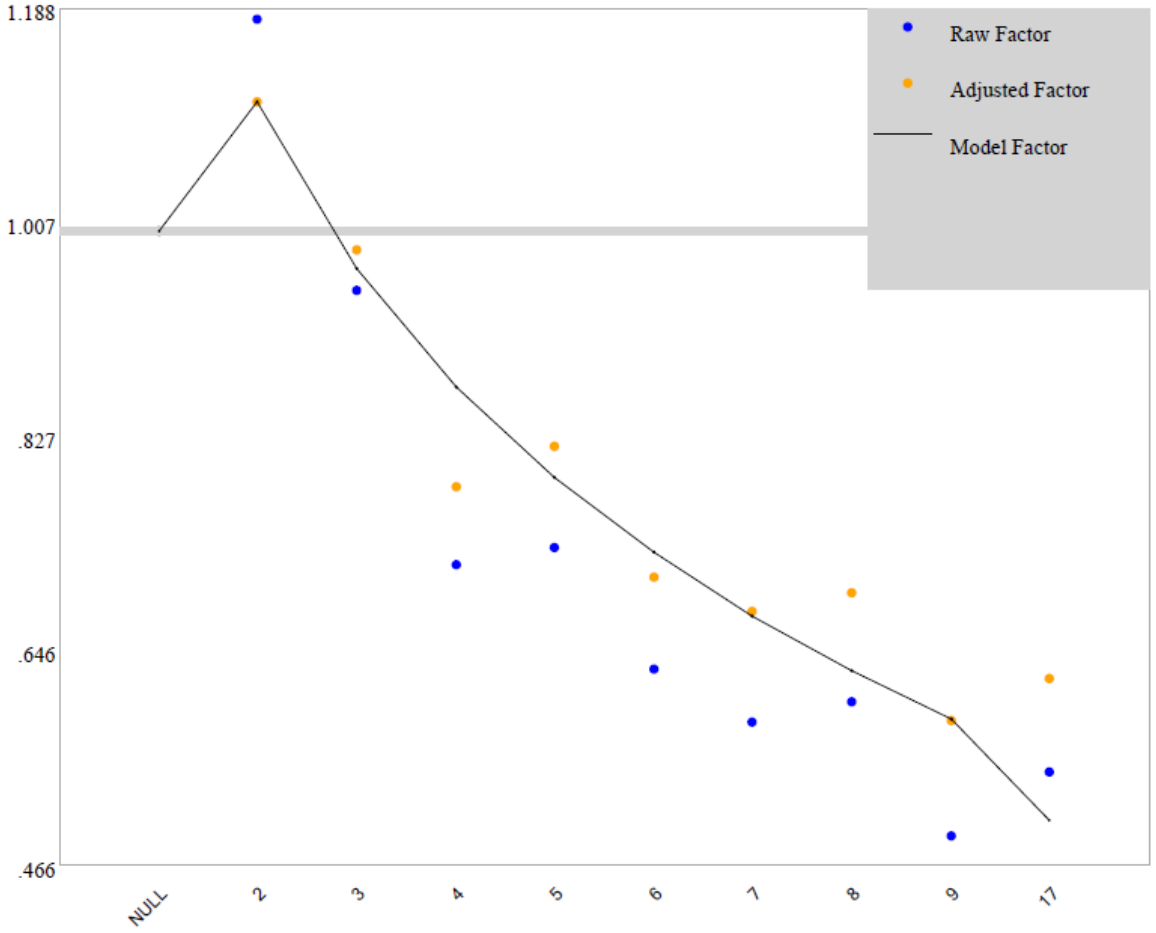
A number of available claim or exposure characteristics may have predictive value for any of these questions.

Probability of a Claim Closing

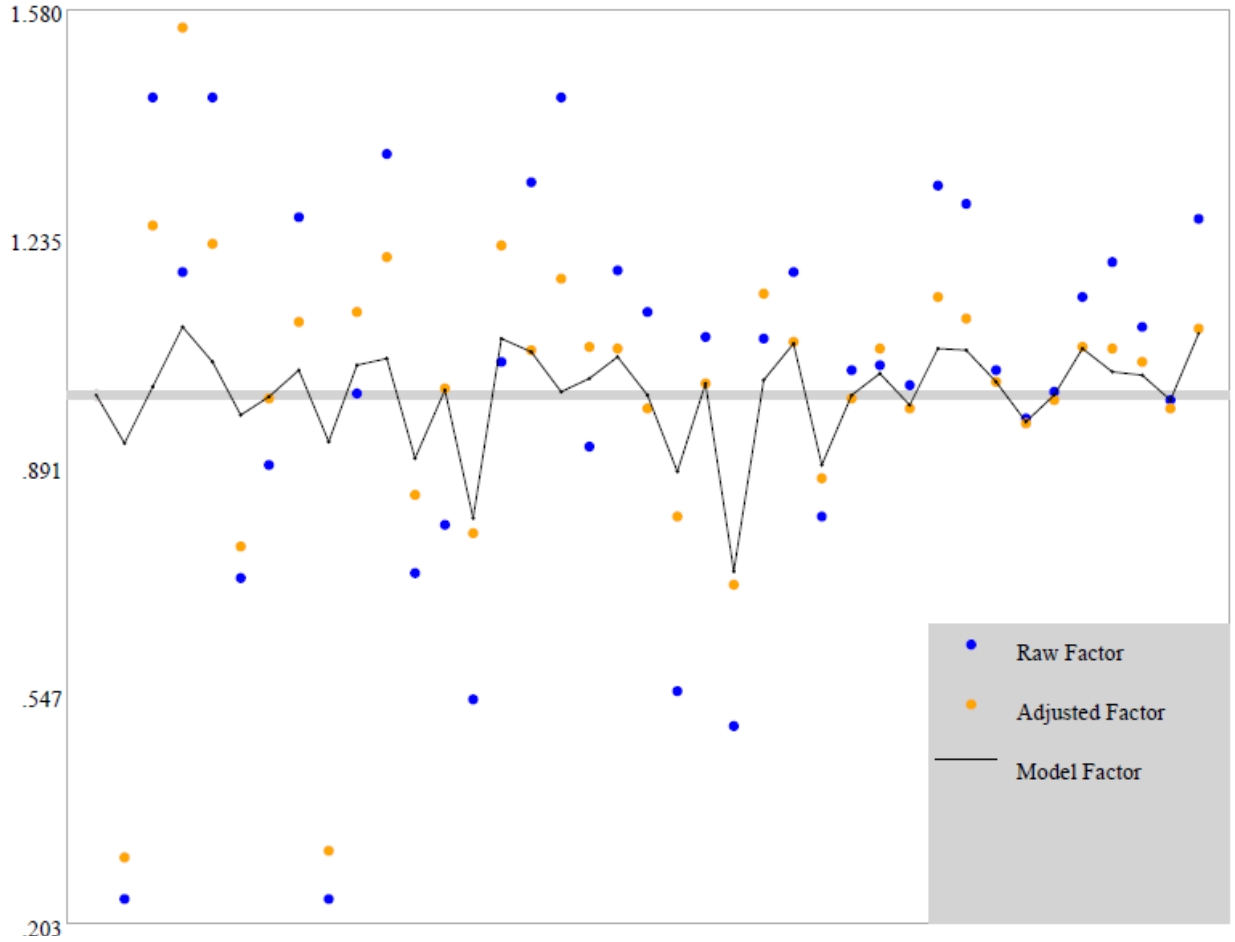
- Base probability of 71%
- Modification of this probability by various claim characteristic values that were found to have predictive value



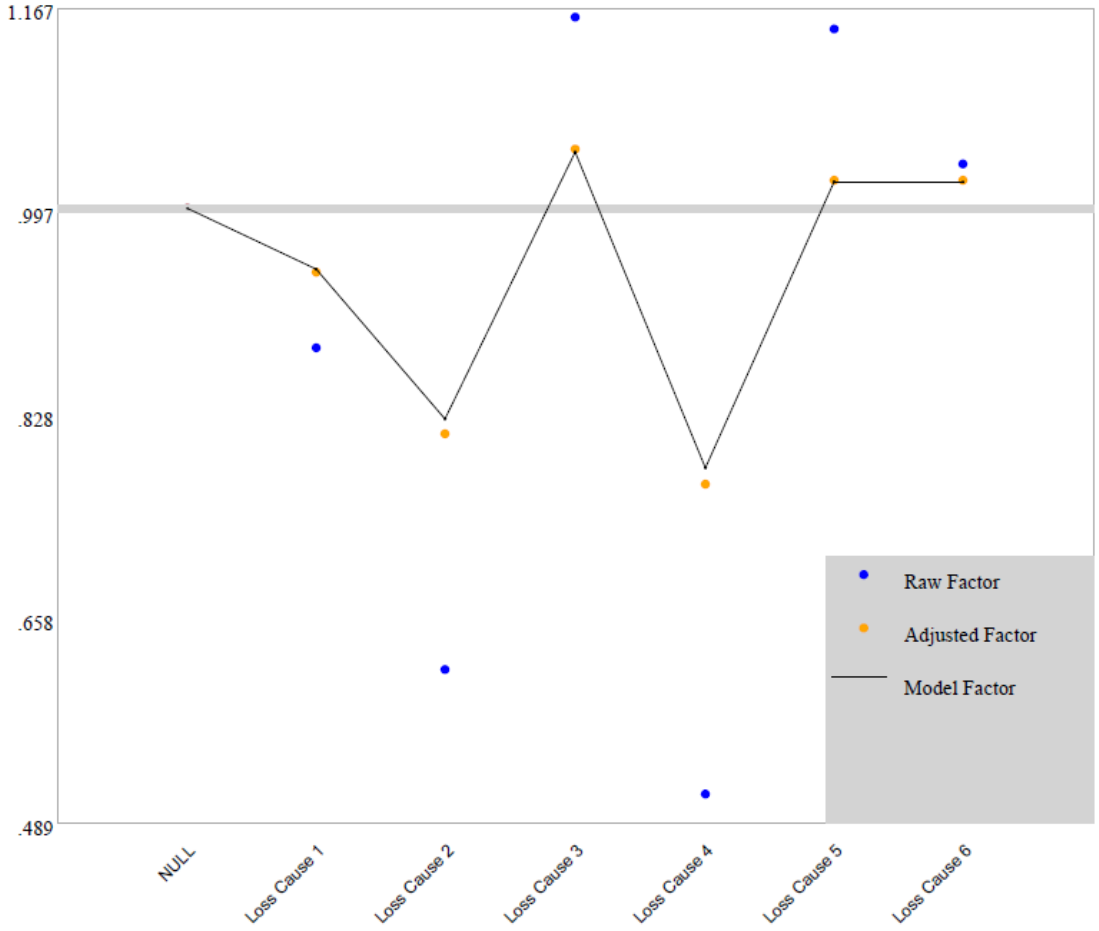
Close Probability – Claim Age



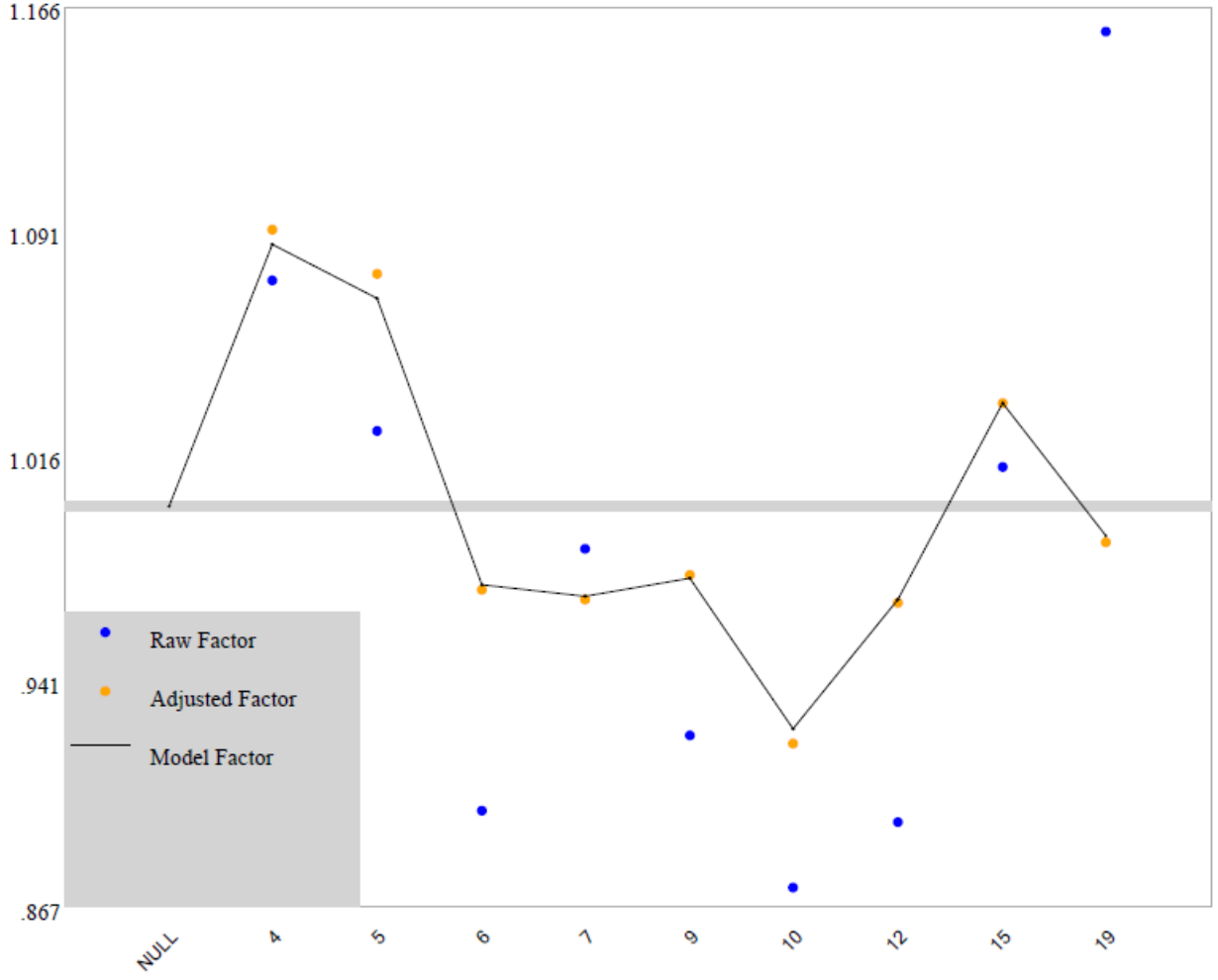
Close Probability – Loss Cause (detailed)



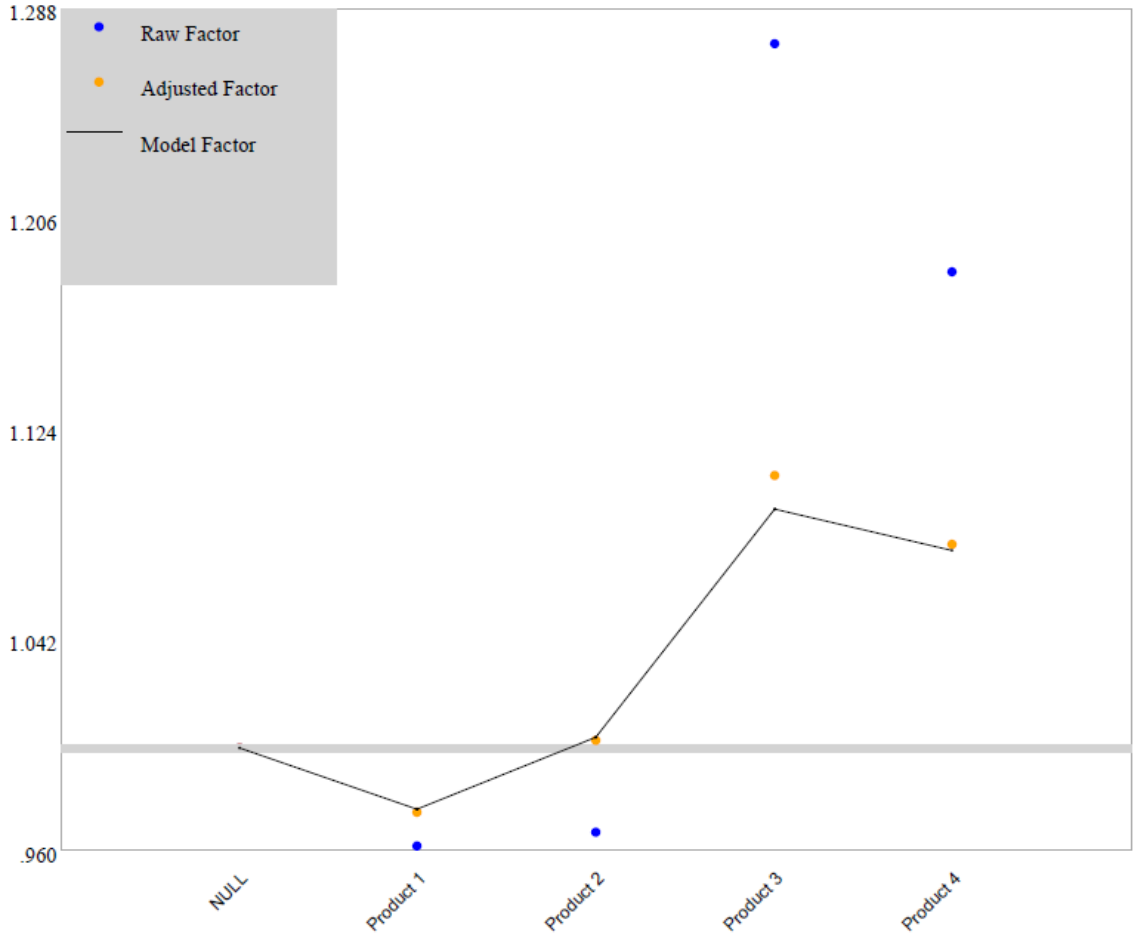
Close Probability – Loss Cause



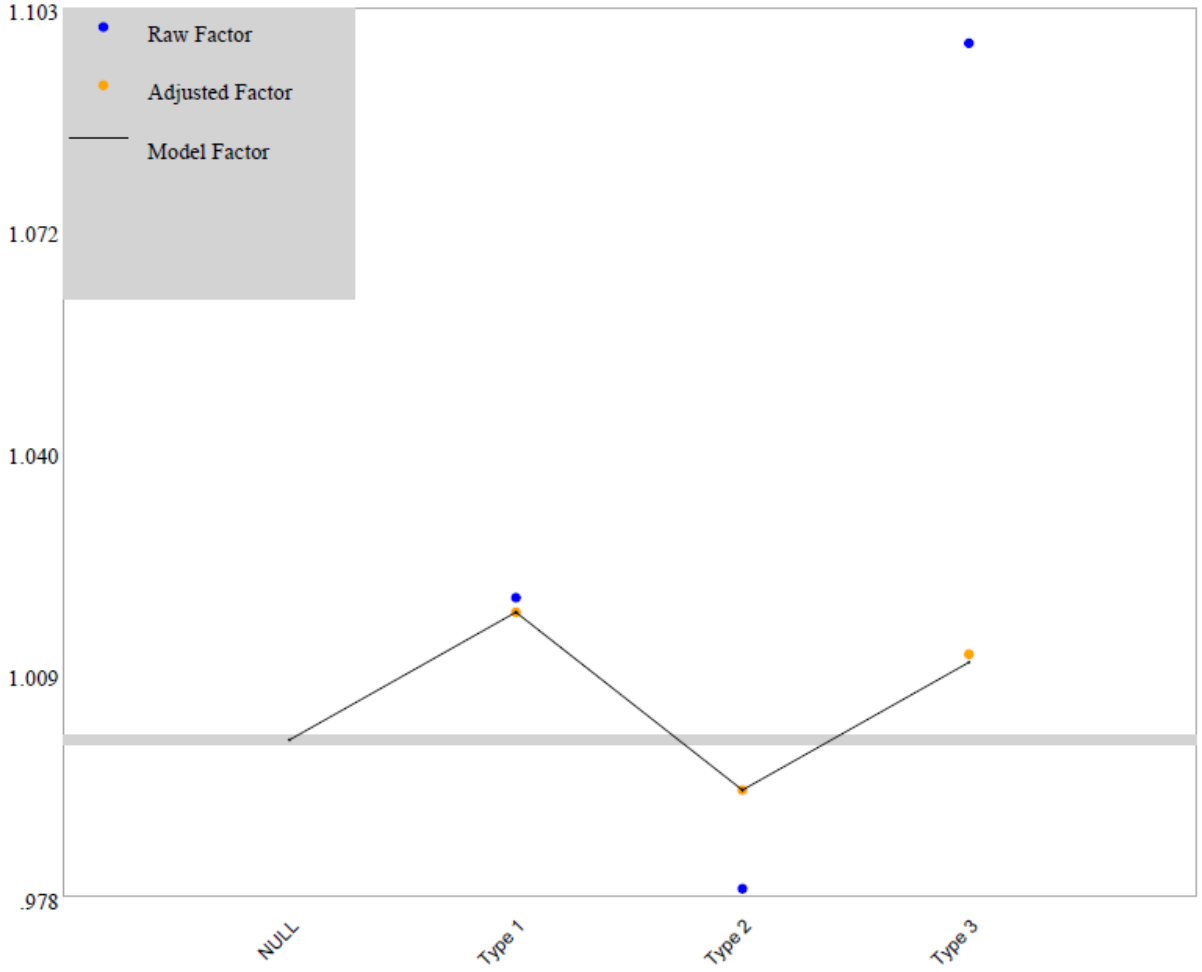
Close Probability – Accident Quarter



Close Probability - Product

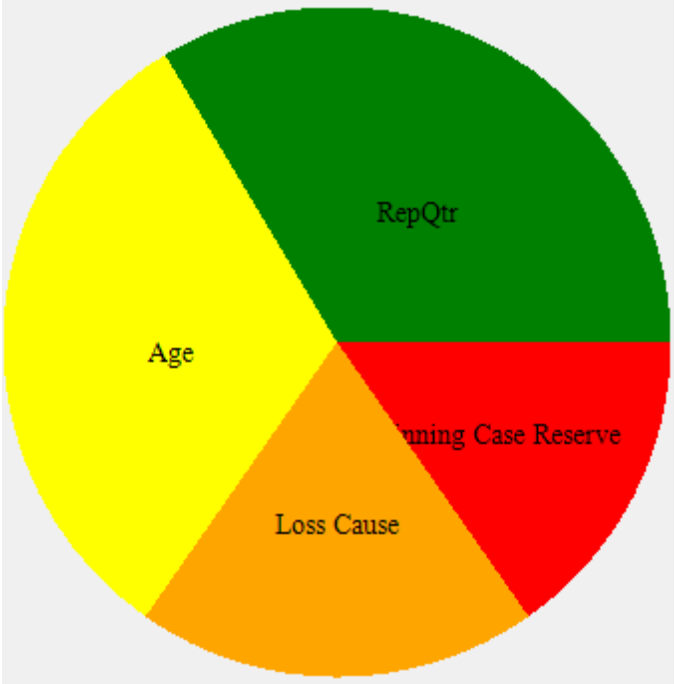


Close Probability - Type

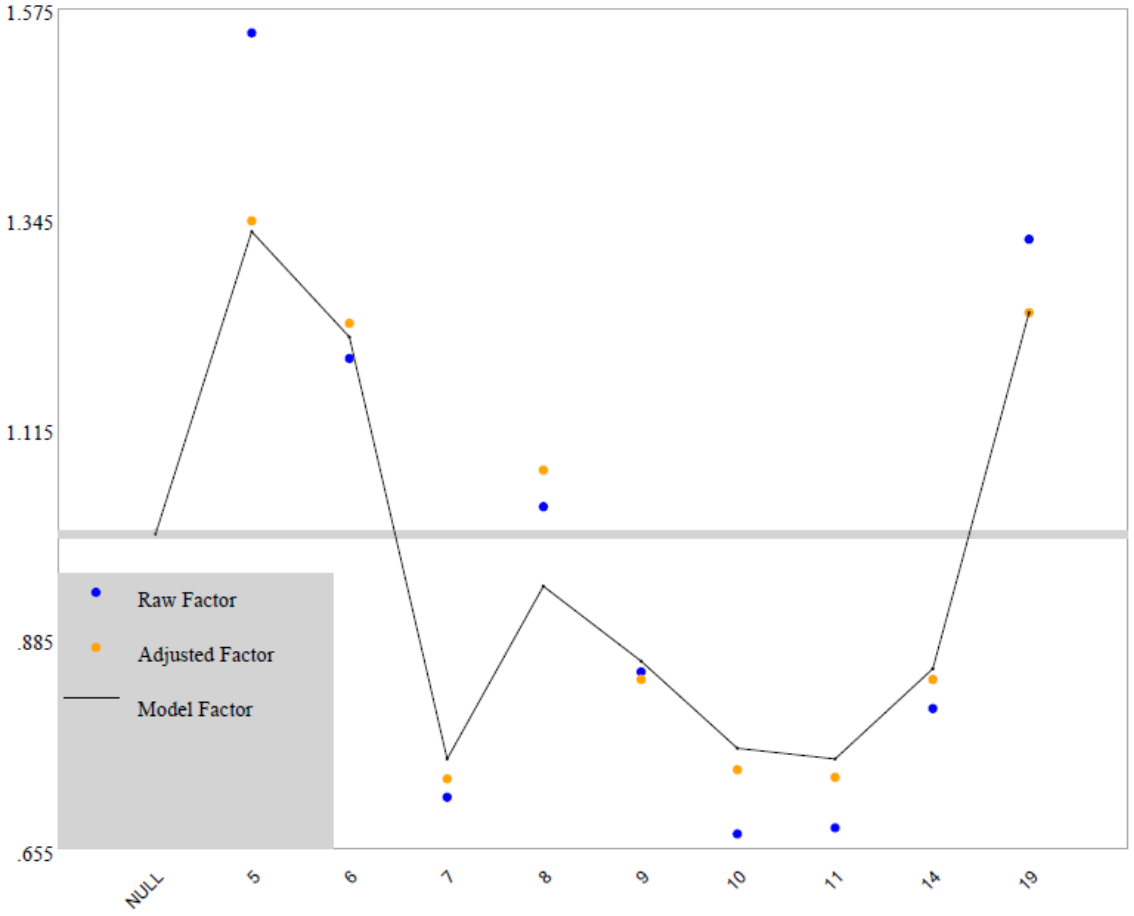


Probability of Change in Value (Given Not Closed)

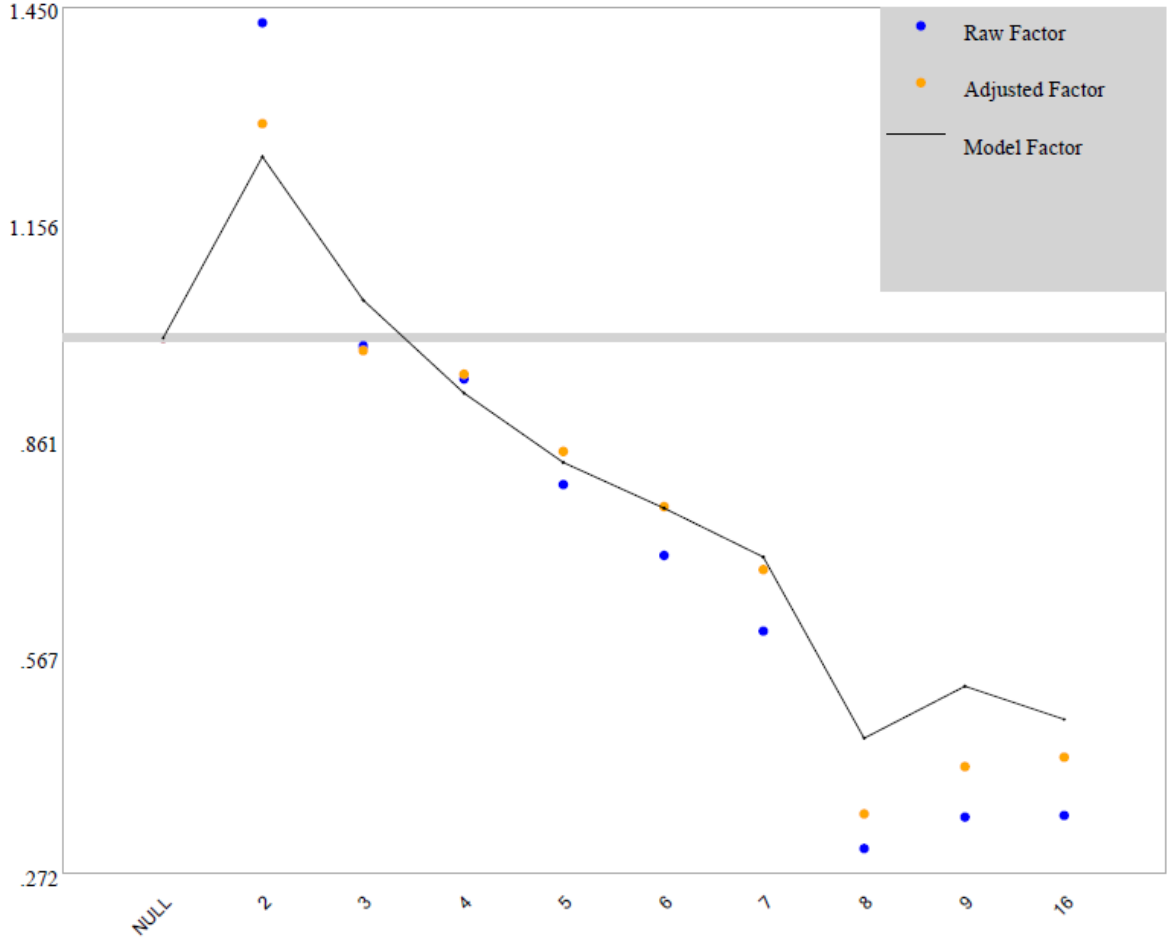
- Base probability of 37%
- 4 characteristics found to be predictive



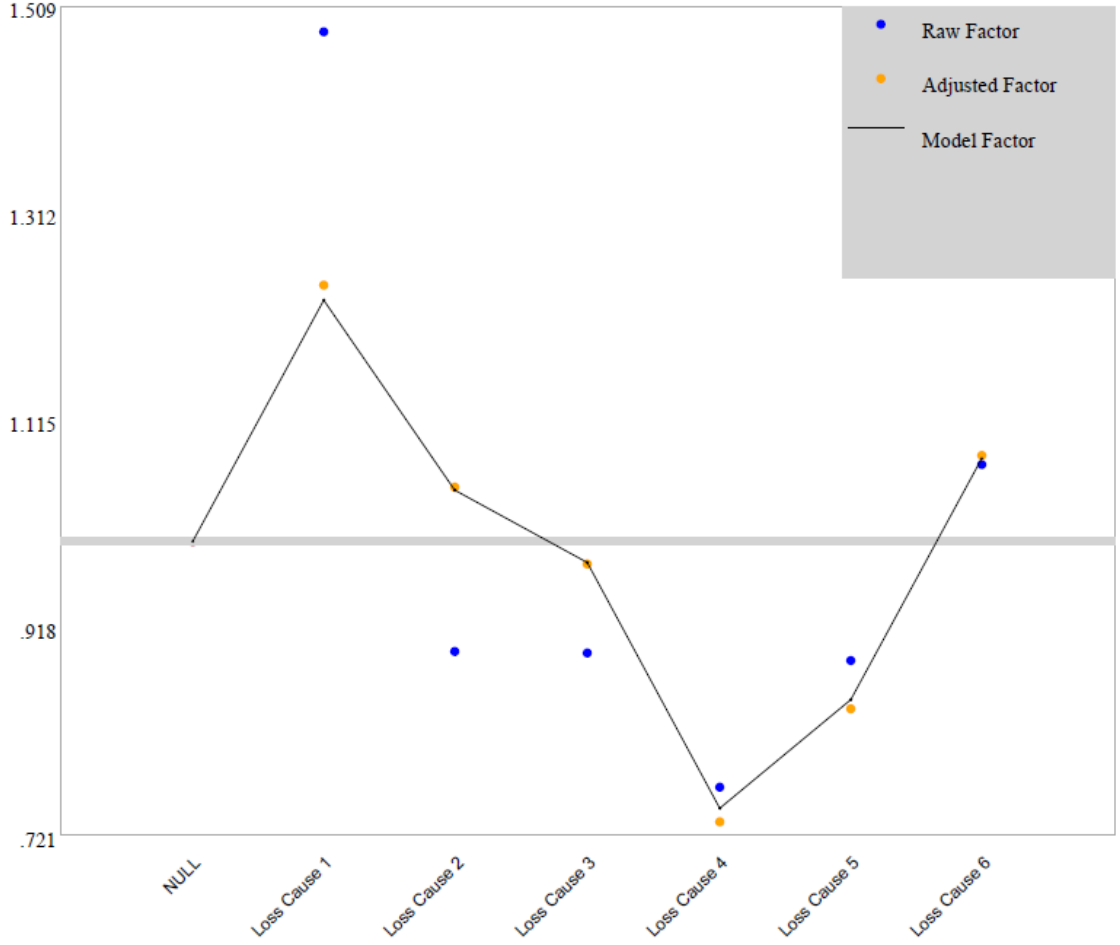
Change Probability – Reported Quarter



Change Probability – Claim Age

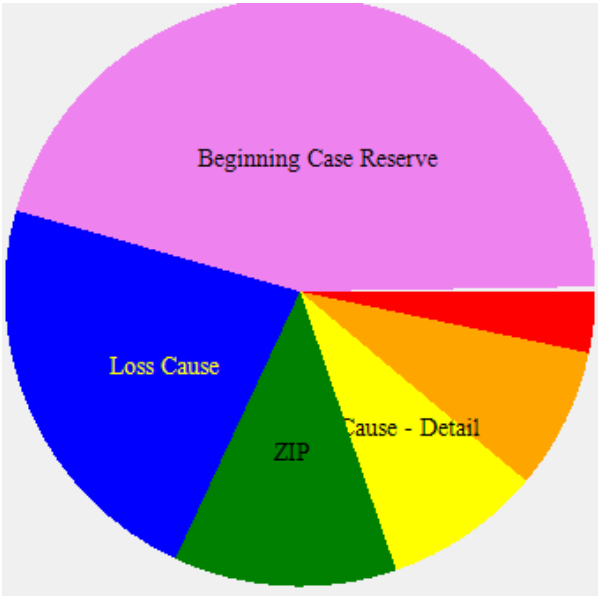


Change Probability – Loss Cause

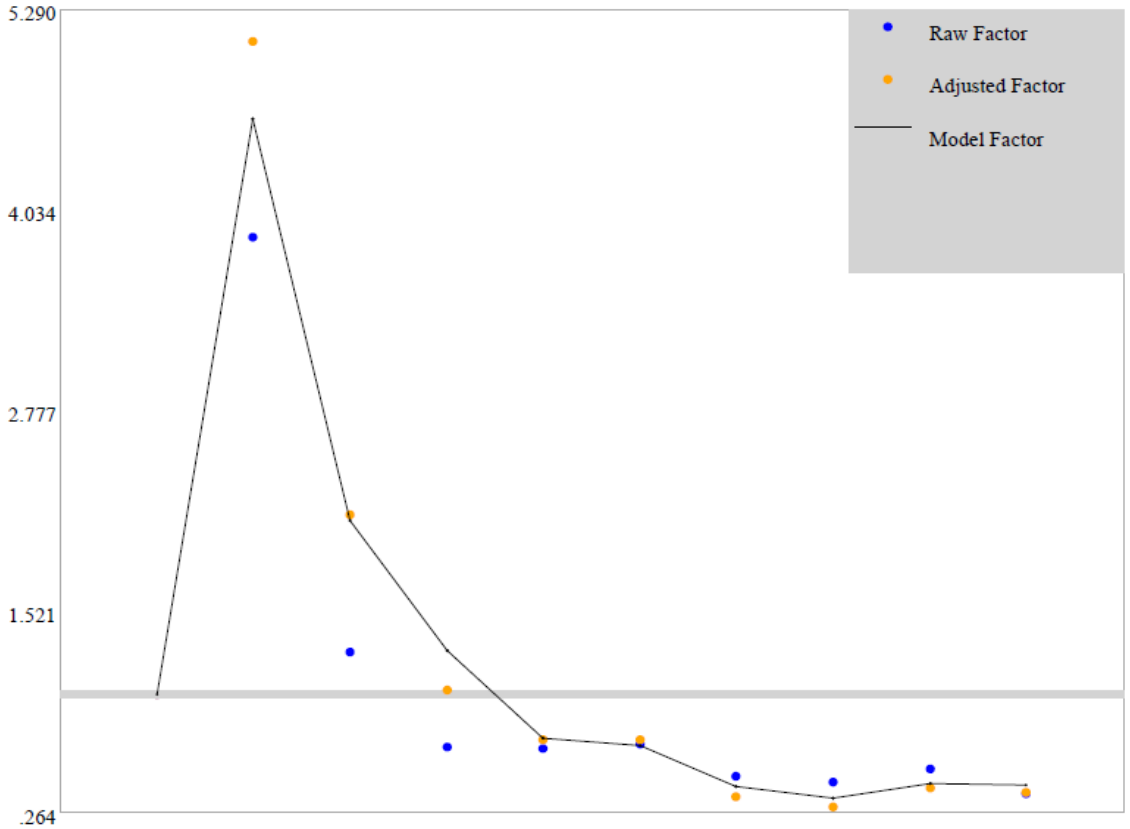


New Claim Value (Given Changed but Not Closed)

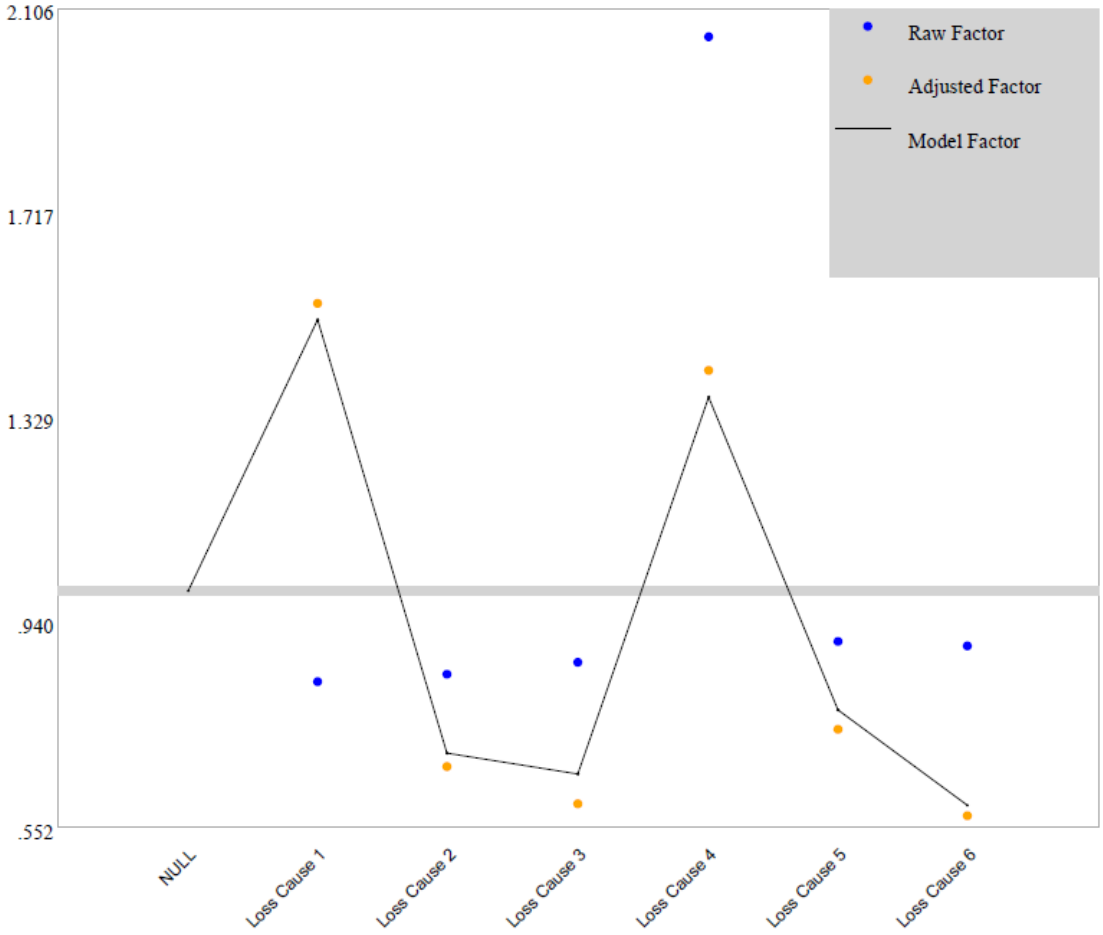
- Base factor of 1.98 to beginning case reserve
- Modification to this linear relationship, as well as five additional predictive characteristics



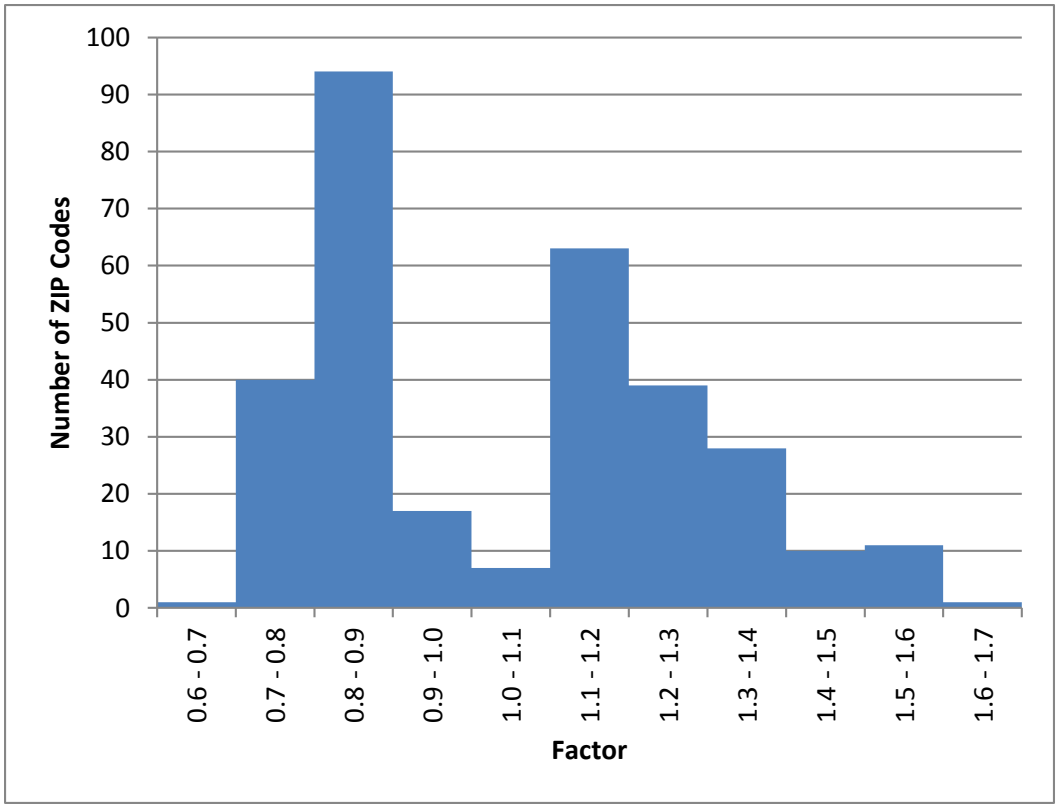
New Claim Value - Case Reserve



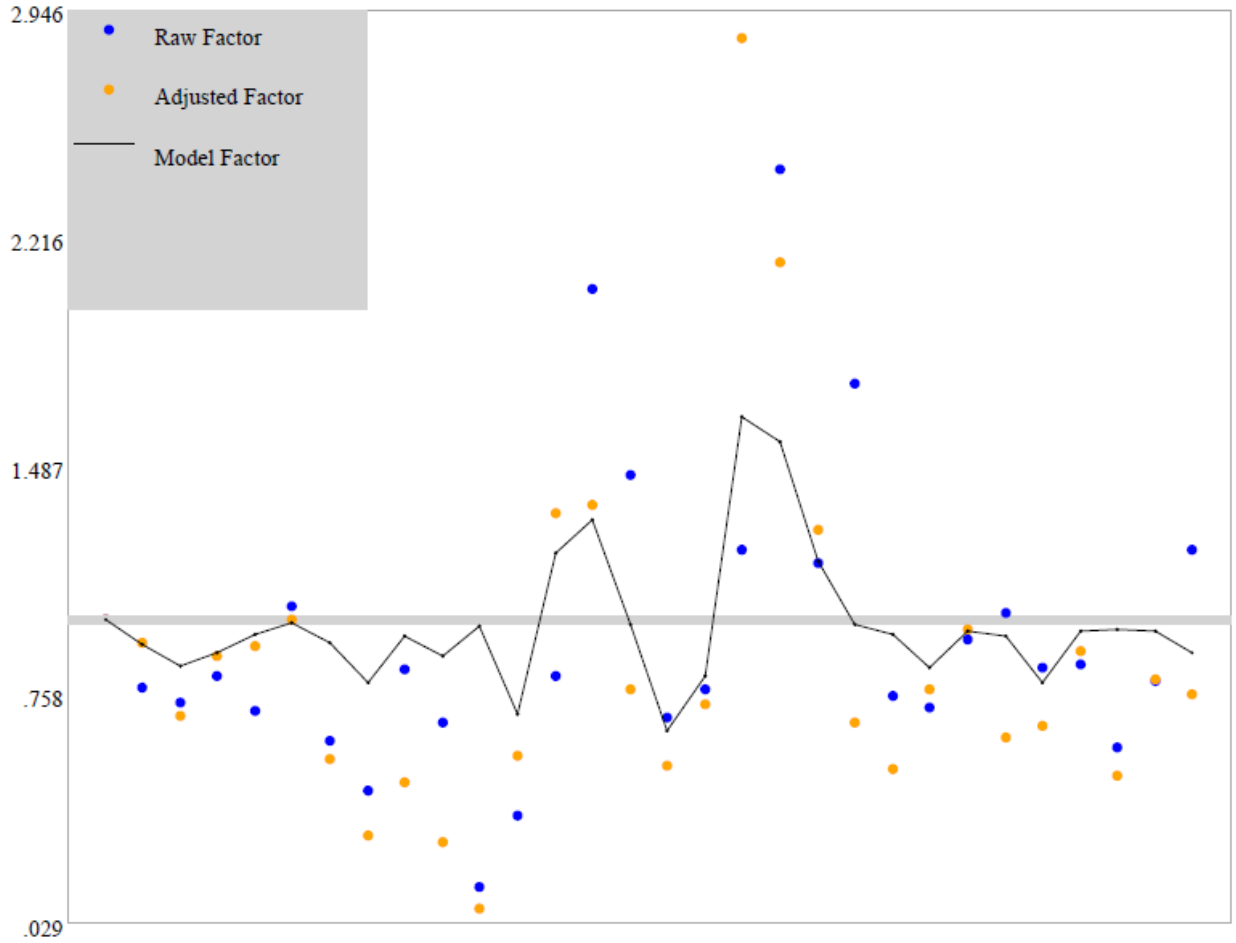
New Claim Value – Loss Cause



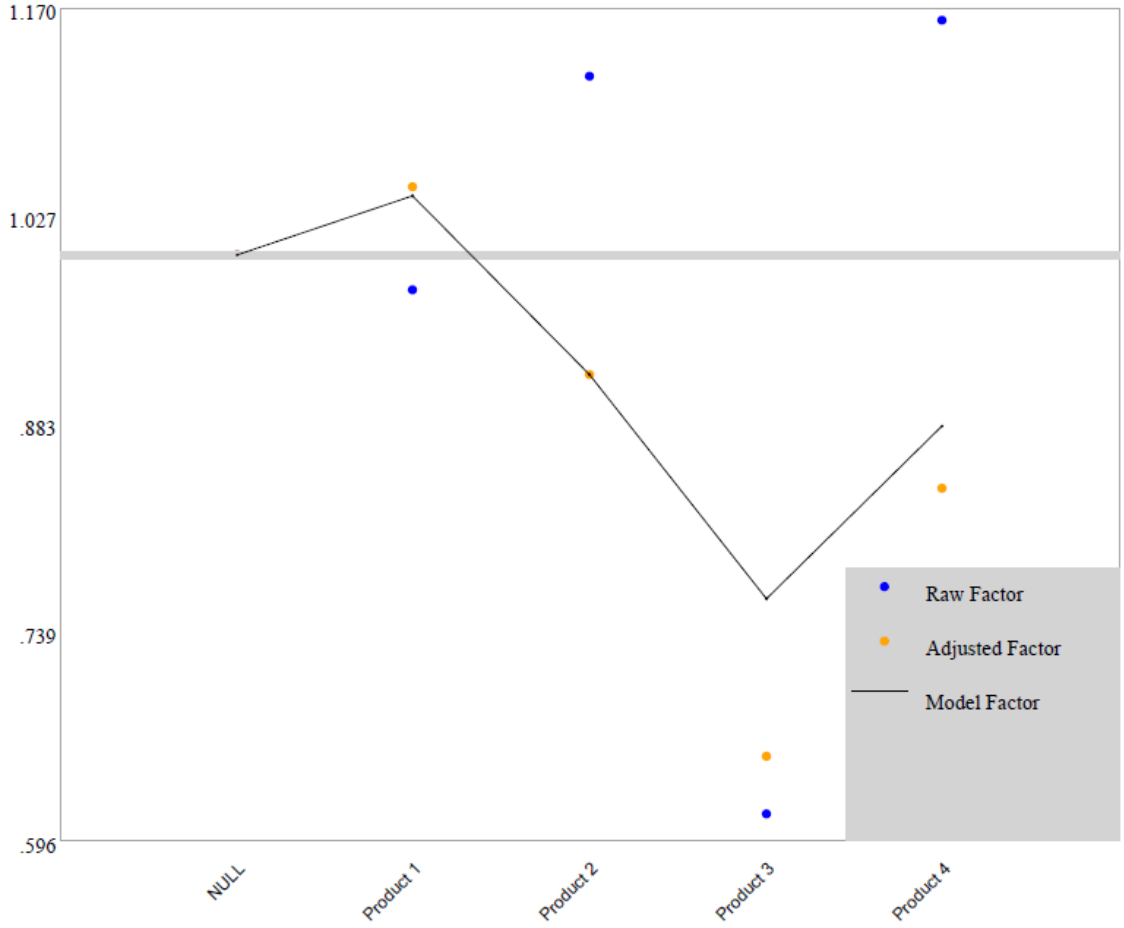
New Claim Value – ZIP Code



New Claim Value- Loss Cause (Detail)



New Claim Value - Product



Bringing it together

- Simulation can be used to project activity in the next quarter
- It is necessary to project not only the predictive relationships, but also the residual error term.
- Chain through quarters using information from the previous simulated quarter.
- Store results, preferably at the claim level.

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

Simulating Change in Value

- Could use distributional form
- Unlikely to be described well by a few parameters
- Sampling of actual errors has the potential to more faithfully reproduce the true distributions(s)
- Sampling introduces challenges with regard to multivariate analysis

Why Sample?

- Distributional forms too limiting.
- Differentiation of variability and distribution across risks.
- Thin data for specific combinations of variables.

Process

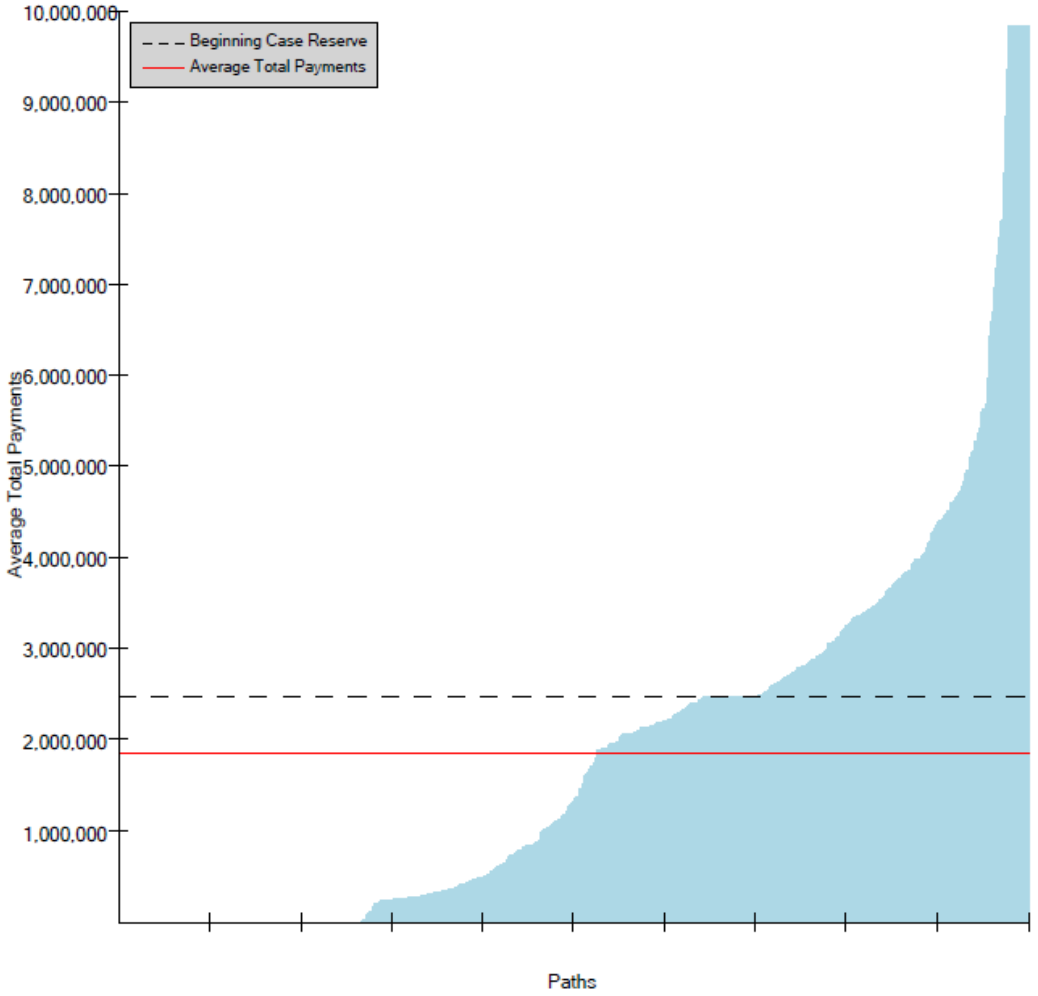
- Develop your multivariate model
- Measure errors using out-of-sample data
- Decompose the errors into characteristic components
- Simulate by sampling from these components
- Calibrate to aggregate measure(s)

Residual Decomposition

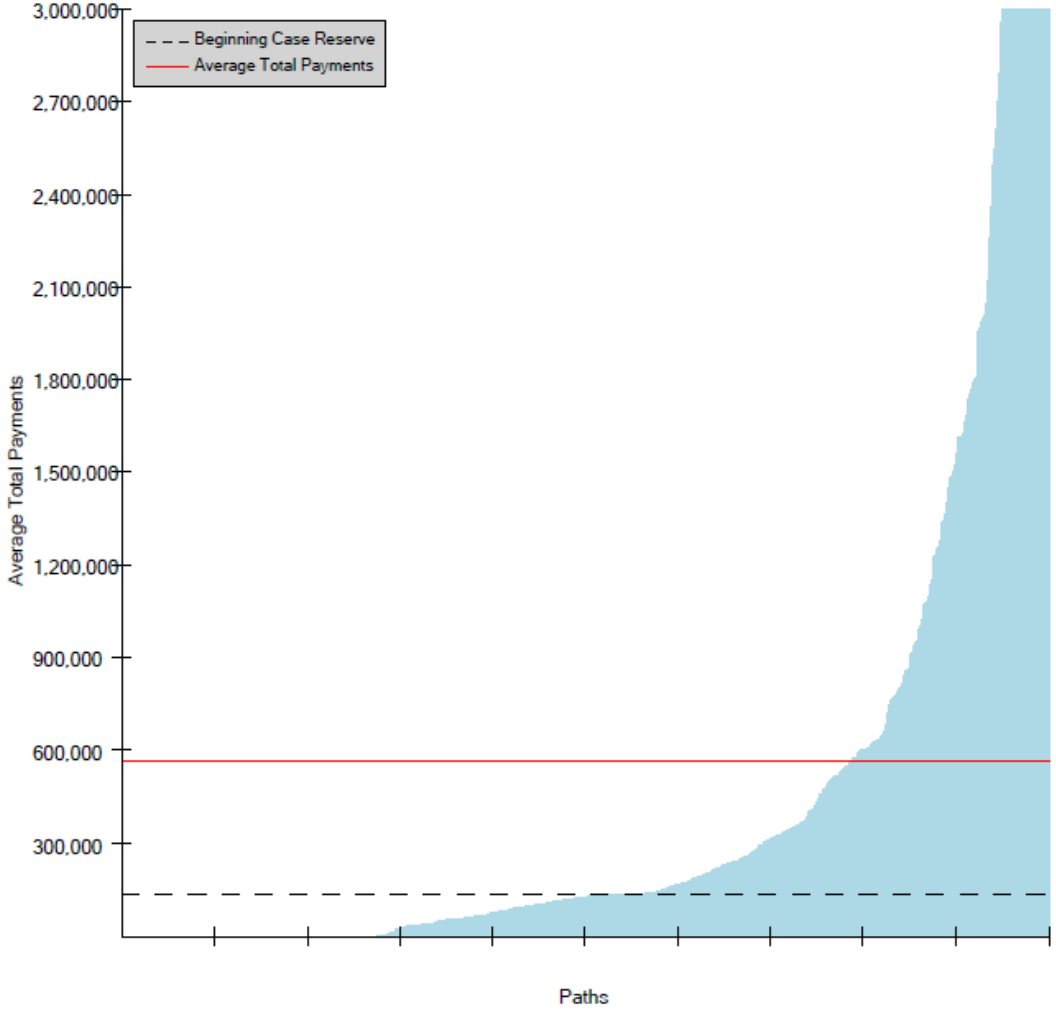
- Need to assign the residual to various dimensions (at the record level)
- Proportionality to mean factor
- Decomposed factors need to reflect the fact that they will be recombined randomly – otherwise variability will be understated.

$$decomposed\ residual\ factor_i = \left(\frac{Actual}{Modeled}\right)^{\left(|\ln(f_i)|\,/\,\sum|\ln(f)|\right)^{.5}}$$

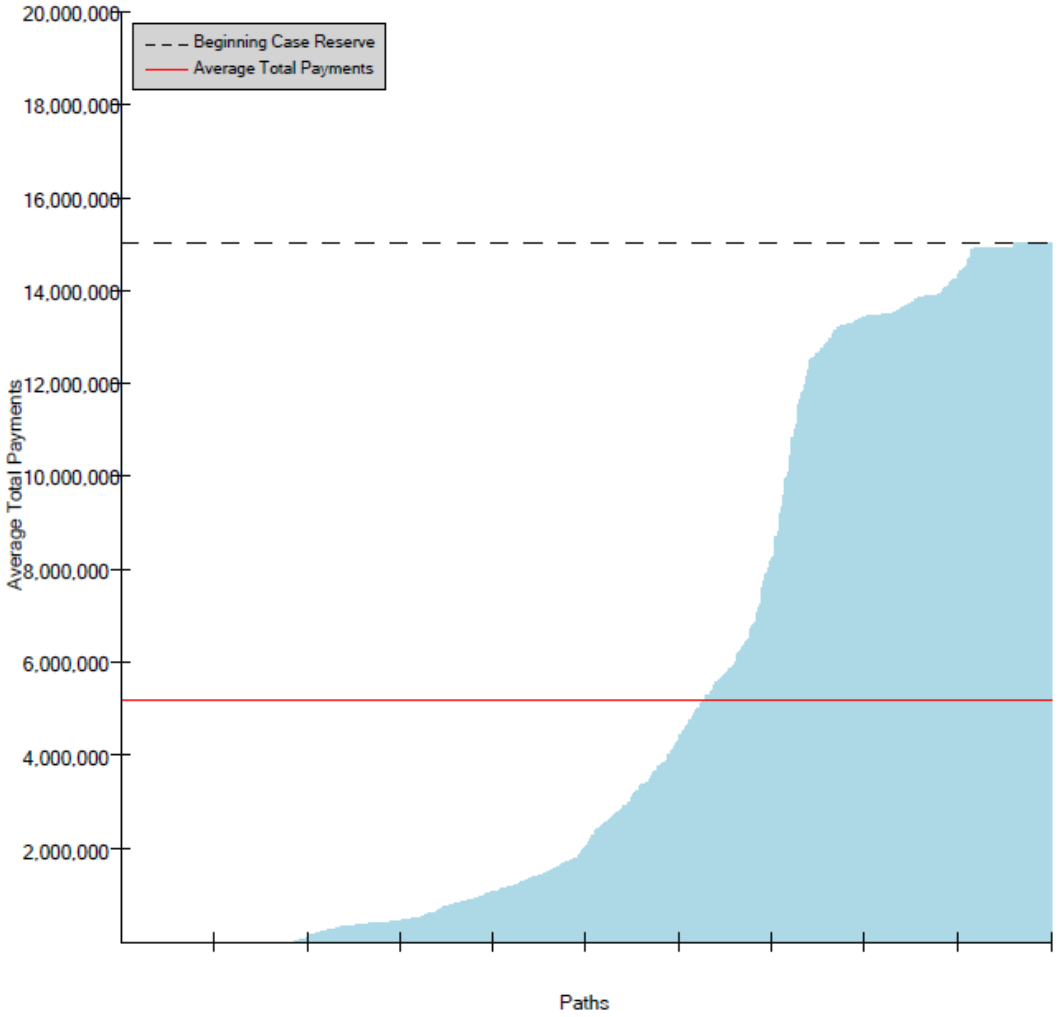
Claim 1

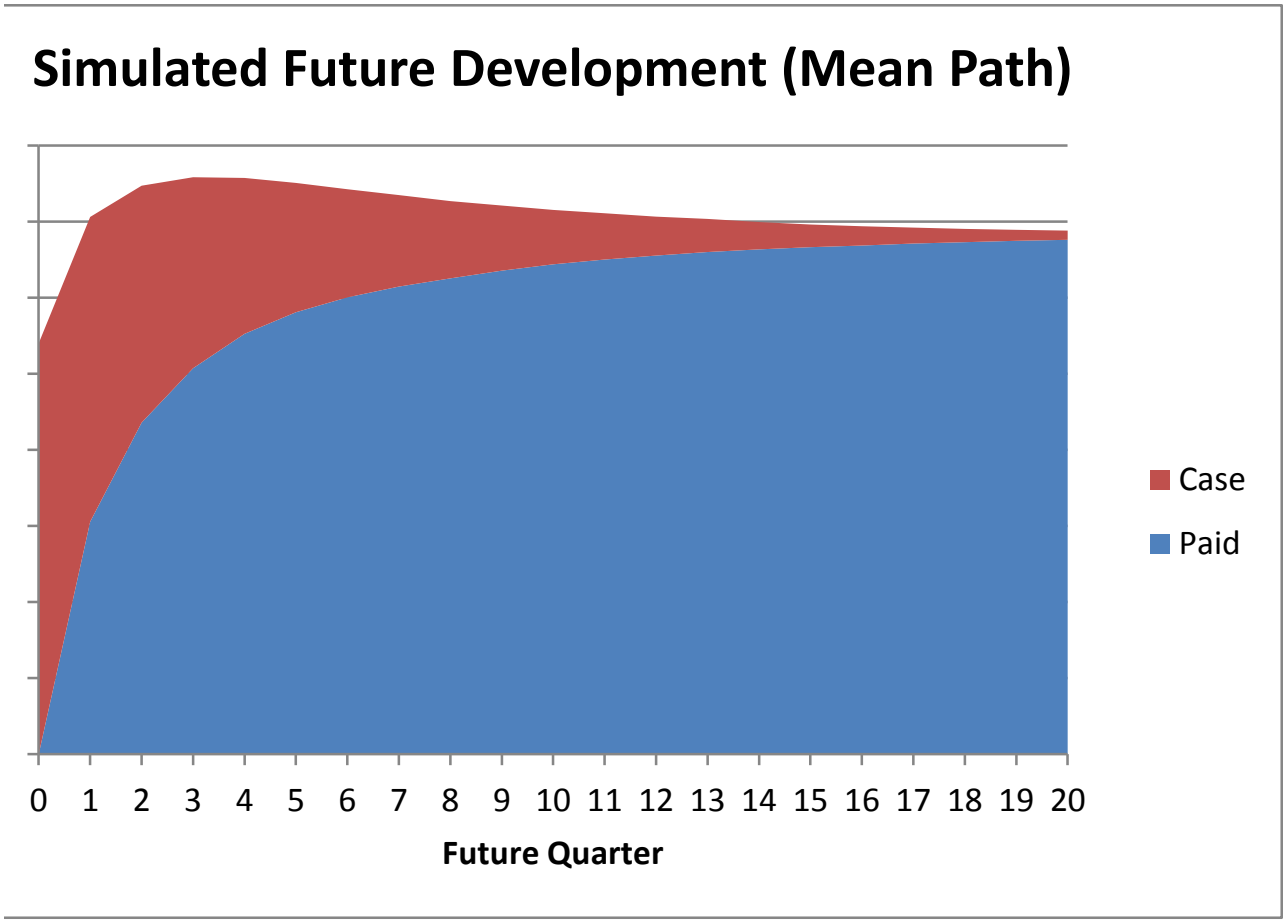

Beginning Case Reserve
Average Total Payments
10,000,000
9,000,000
8,000,000
7,000,000
6,000,000
5,000,000
4,000,000
3,000,000
2,000,000
1,000,000
Average Total Payments
Paths

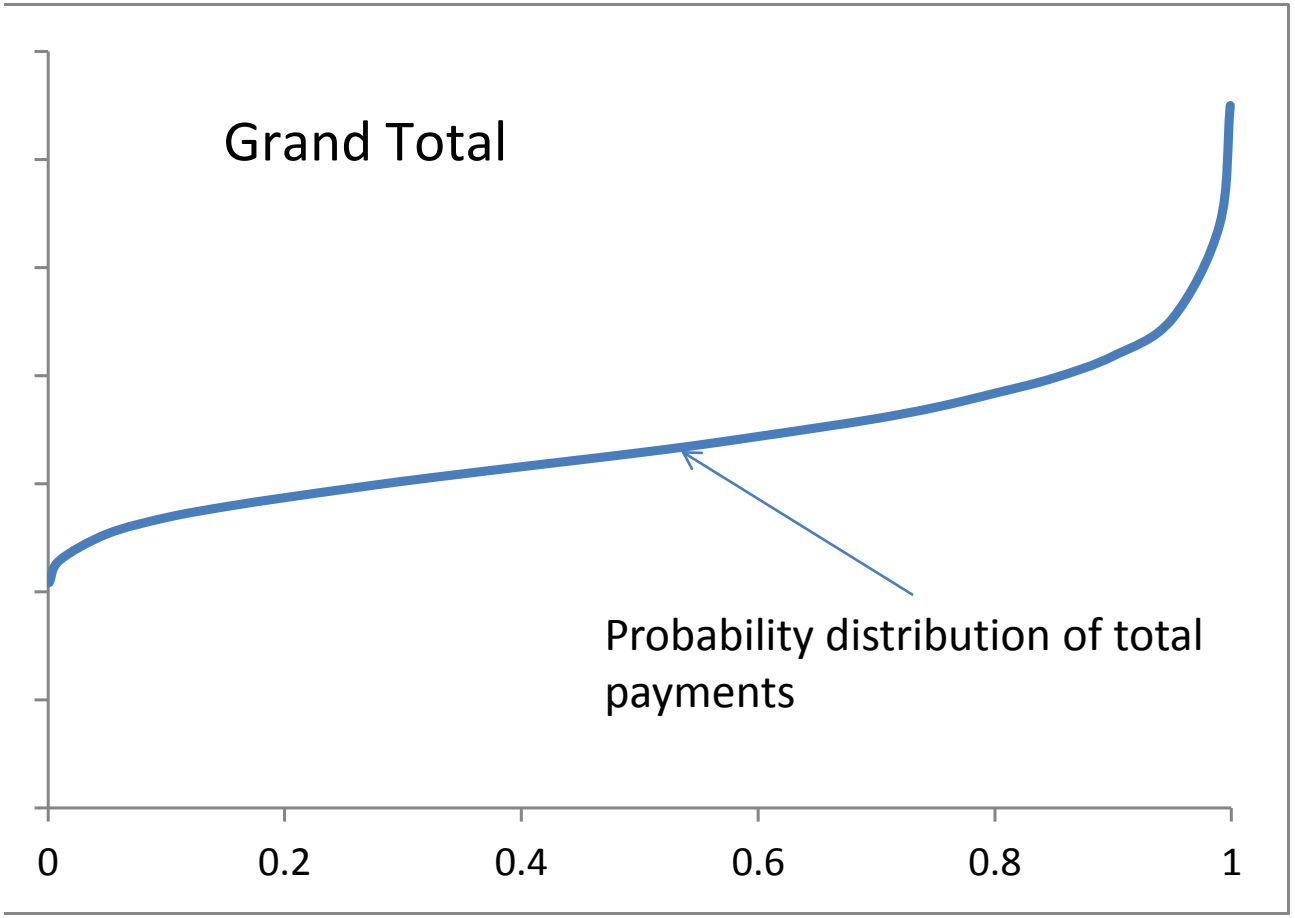
Claim 2

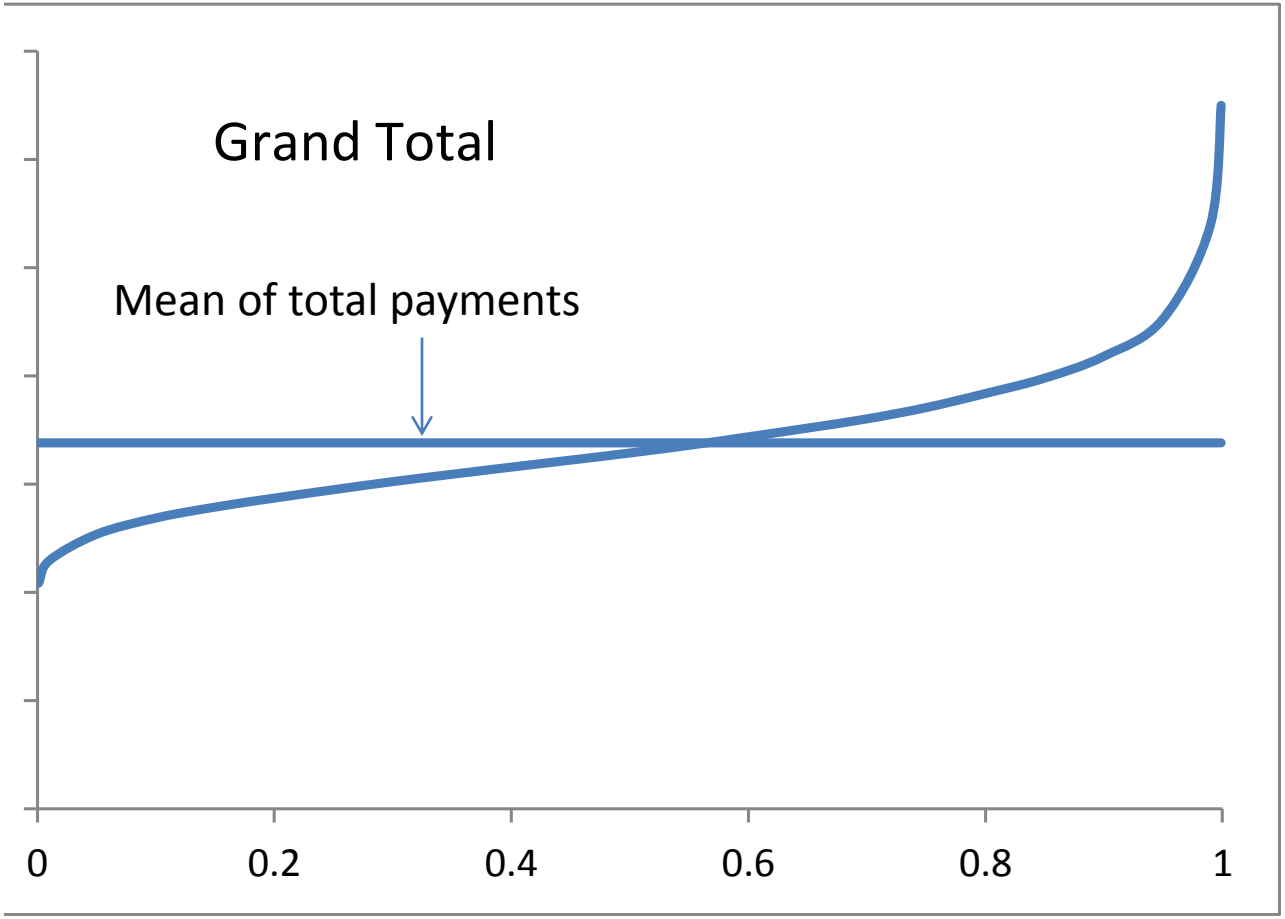

Beginning Case Reserve
Average Total Payments
3,000,000
2,700,000
2,400,000
2,100,000
1,800,000
1,500,000
1,200,000
900,000
600,000
300,000
Average Total Payments
Paths

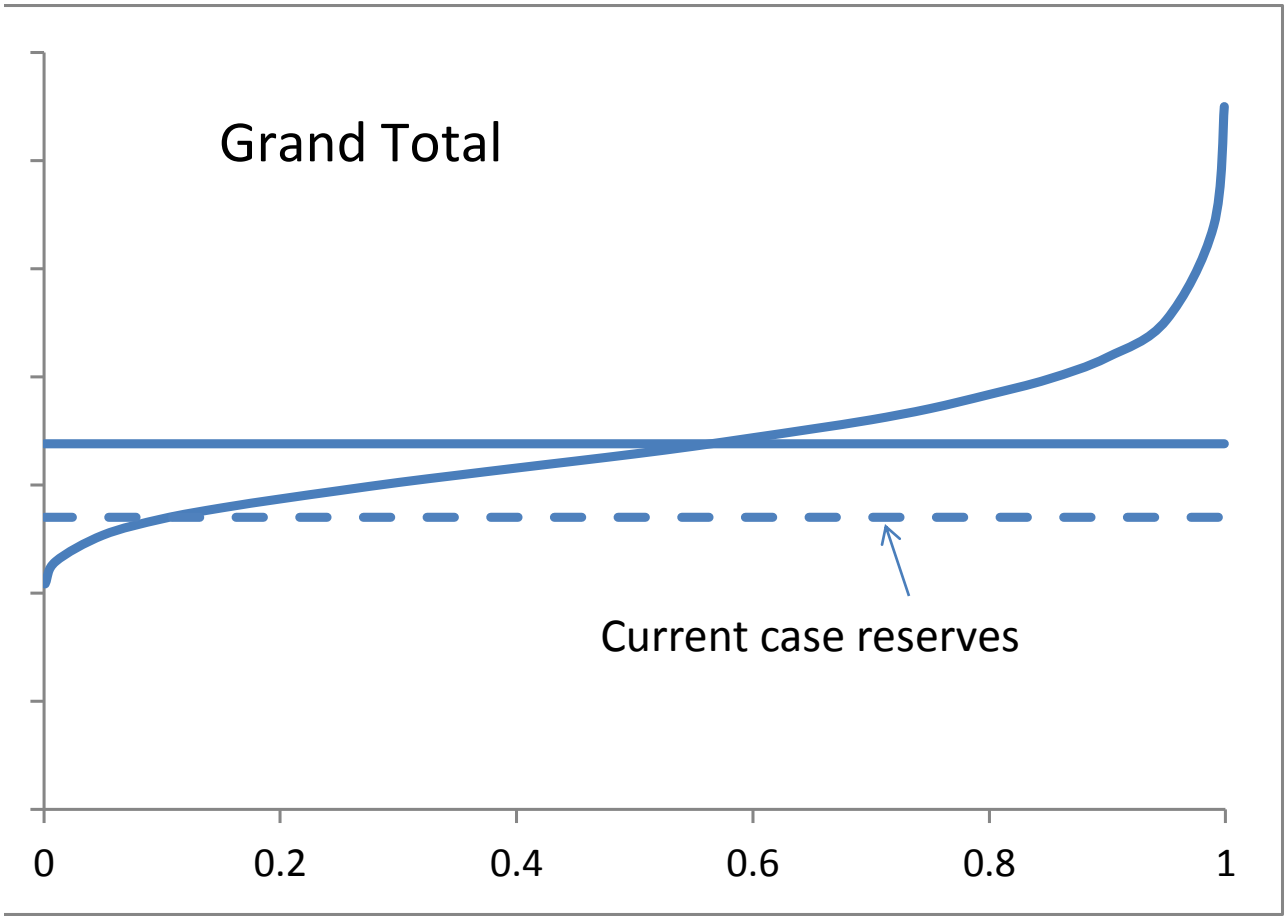
Claim 3

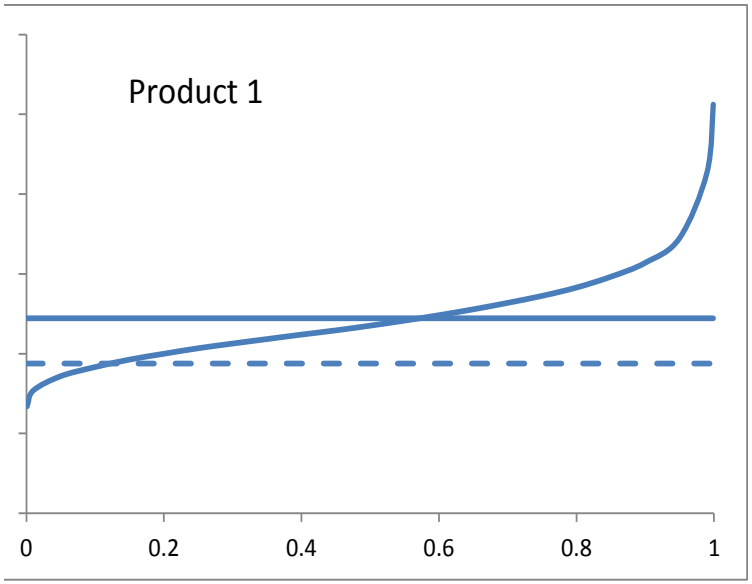

Beginning Case Reserve
Average Total Payments
20,000,000
18,000,000
16,000,000
14,000,000
12,000,000
10,000,000
8,000,000
6,000,000
4,000,000
2,000,000
Average Total Payments
Paths

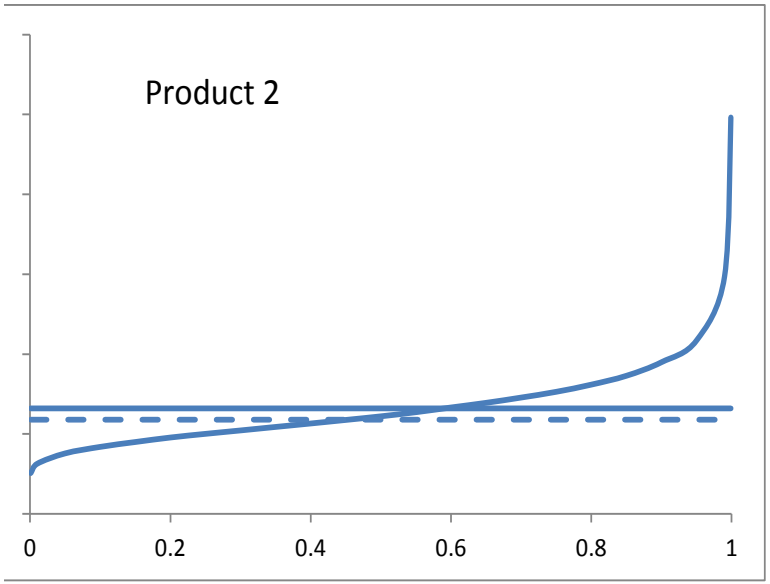

Simulated Future Development (Mean Path)
Case
Paid
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
Future Quarter

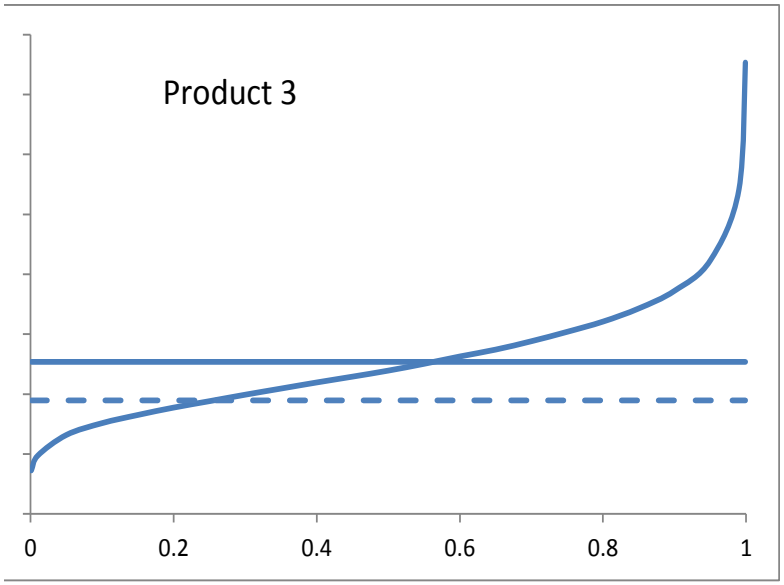

Grand Total
Probability distribution of total payments
0
0.2
0.4
0.6
0.8
1

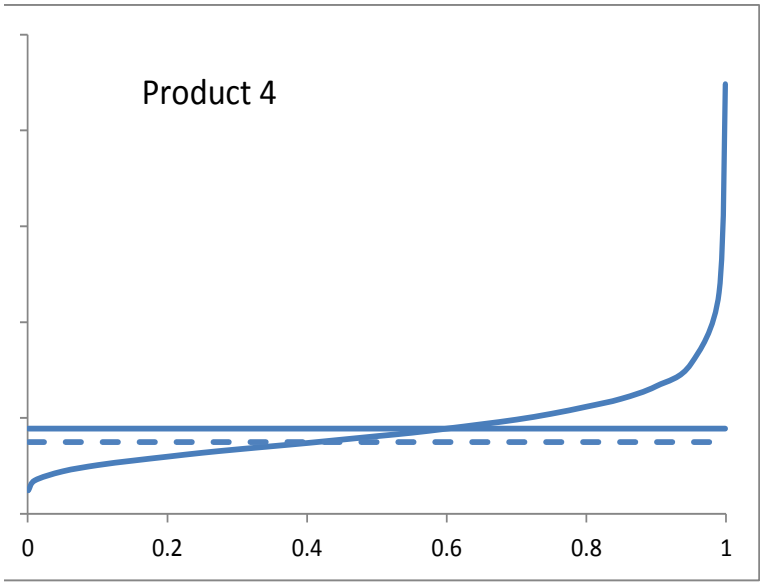

Grand Total
Mean of total payments
0
0.2
0.4
0.6
0.8
1

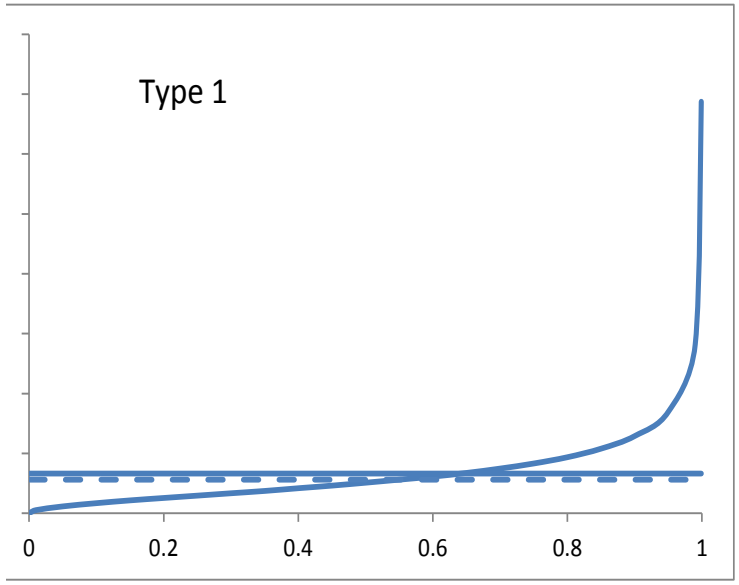

Grand Total
Current case reserves
0
0.2
0.4
0.6
0.8
1

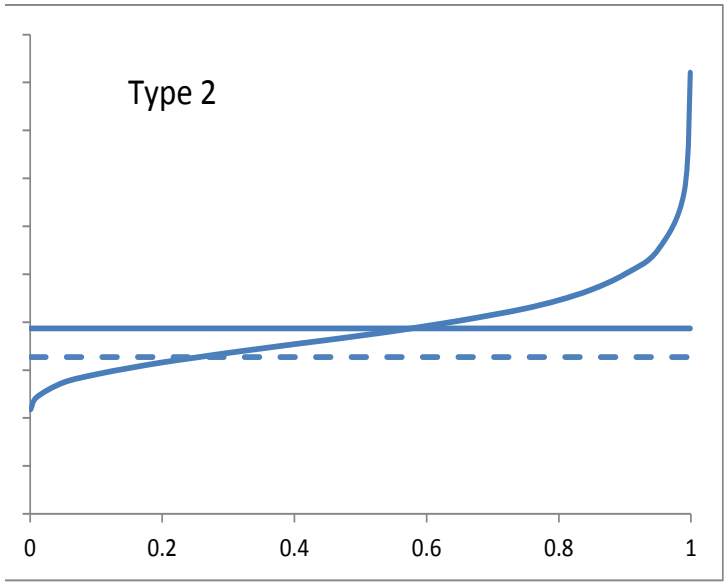

Product 1
0
0.2
0.4
0.6
0.8
1

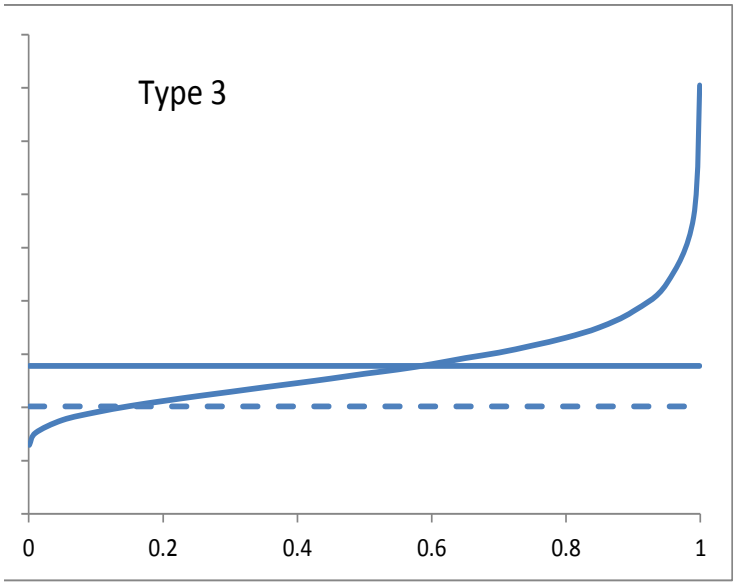

Product 2
0
0.2
0.4
0.6
0.8
1

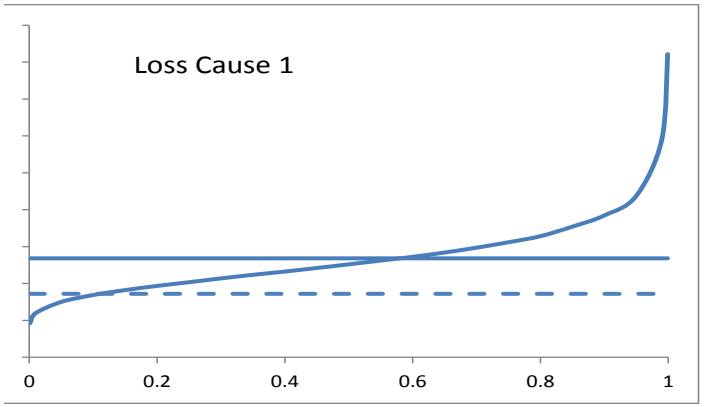

Product 3
0
0.2
0.4
0.6
0.8
1

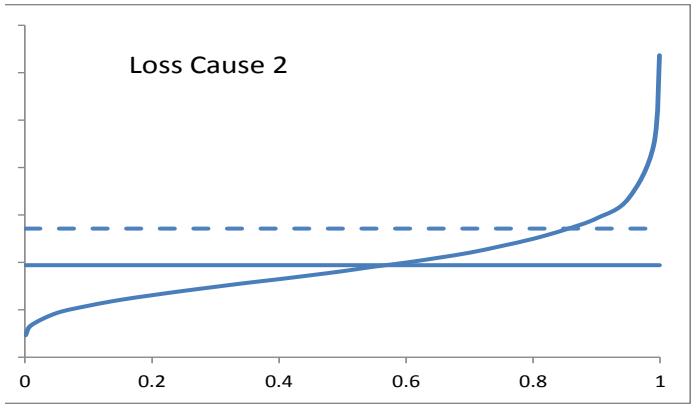

Product 4
0
0.2
0.4
0.6
0.8
1

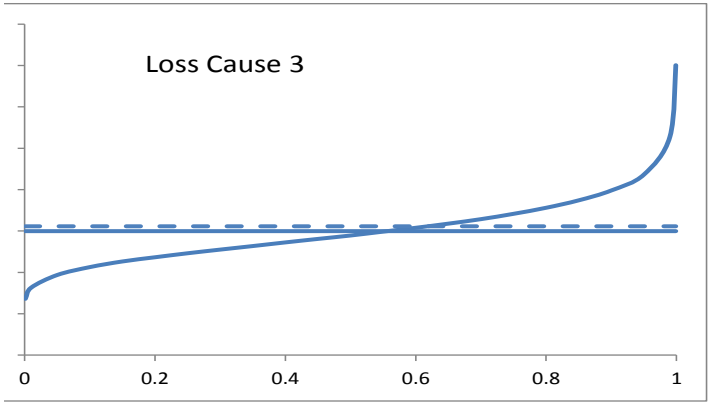

Type 1
0
0.2
0.4
0.6
0.8
1

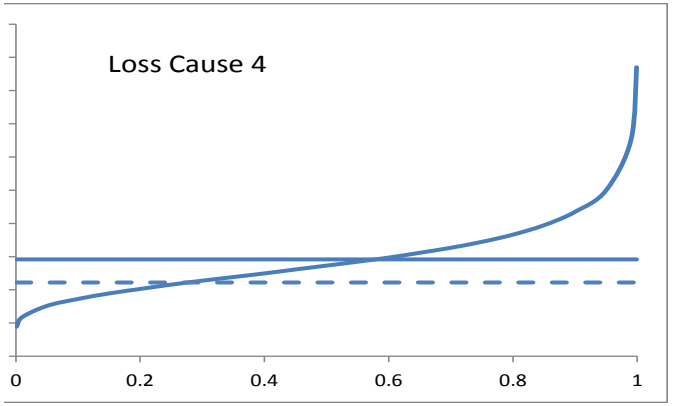

Type 2
0
0.2
0.4
0.6
0.8
1

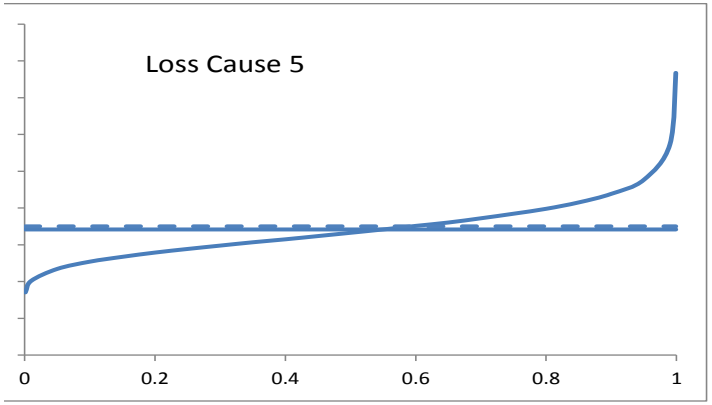

Type 3
0
0.2
0.4
0.6
0.8
1

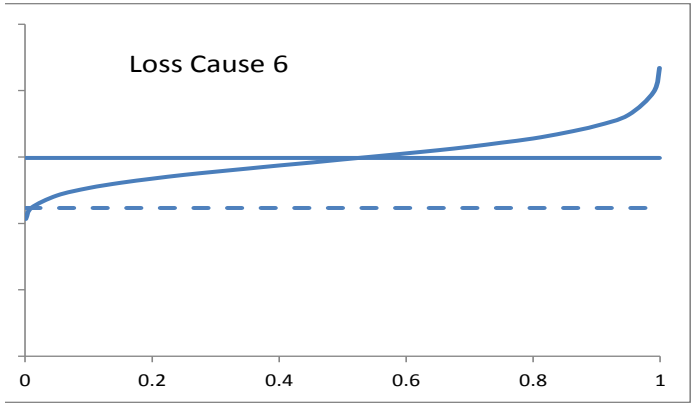

Loss Cause 1
0
0.2
0.4
0.6
0.8
1


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

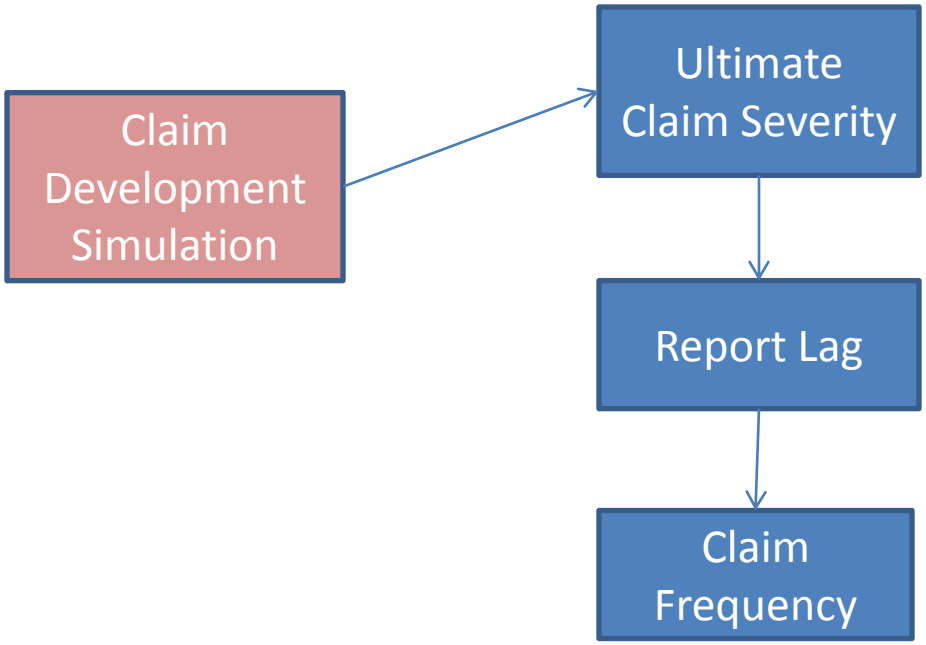

Loss Cause 5
0
0.2
0.4
0.6
0.8
1


Loss Cause 6
0
0.2
0.4
0.6
0.8
1

Emergence

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

Claim Emergence



Arrows indicate dependency on other results

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

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.

Discussion of Additional Complexity

- Relationship between Loss and ALAE
- Re-opened claims
- Changing claim characteristics
- Salvage & Subrogation

Uses

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