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Juggling uncertainty the actuary's part to play

19 Sep 2012

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The 1 year view of reserving risk:
The “actuary-in-the-box” vs emergence patterns

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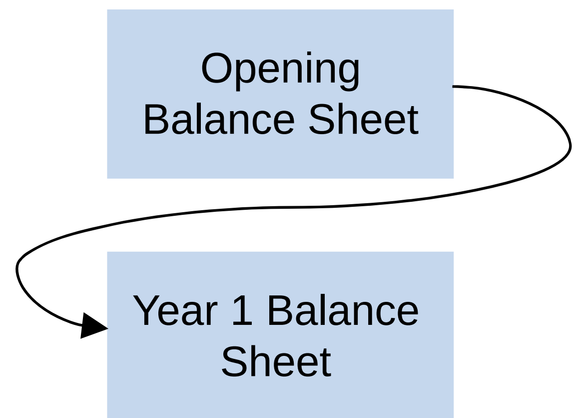
19 Sep 2012

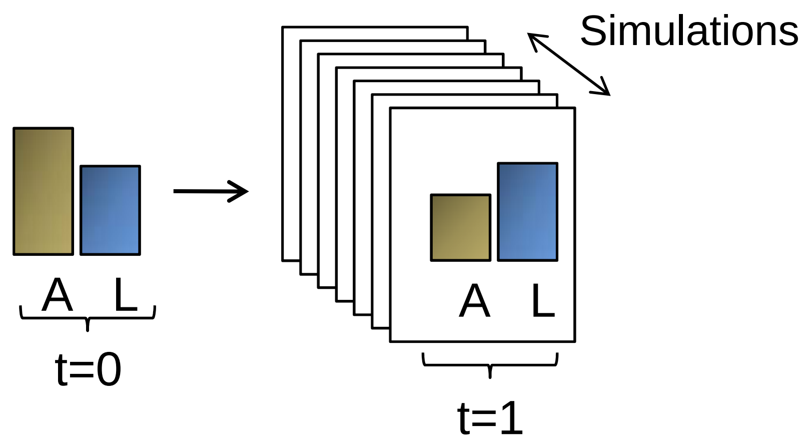
Agenda

- Background to the 1 year view of reserve risk
- Characteristics of the "actuary-in-the-box" approach
- Emergence pattern methods as an alternative
- Calibrating emergence patterns from the "actuary-in-the-box" approach
- Characteristics of two emergence pattern approaches
- Benchmarking emergence patterns from industry data
- Data Analysis
- Final Considerations

A Projected Balance Sheet View

- From Article 101, the SCR is calculated from a distribution of net assets over a 1 year time horizon
- When projecting Balance Sheets for solvency, we have an opening balance sheet with expected outstanding liabilities
- The bulk of those liabilities are the “reserves” (provisions) set aside to pay unsettled claims that have arisen on policies sold in the past
- We then project one year forwards, simulating the payments that emerge in the year, and require a closing balance sheet, with (simulated) expected outstanding liabilities conditional on the payments in the year, together with the market value of assets at the end of the year





Reserve Risk under Solvency II…

It’s all about the CDR*…

* a.k.a. the Run-off Result

The one-year run-off result (undiscounted)

(The view of profit or loss on reserves after one year)

- For a particular origin year, let:
  - The opening reserve estimate be R_0
  - The expected reserve estimate after one year be R_1
  - The payments in the year be C_1
  - The run-off result (claims development result) be CDR_1
- Then

$$CDR_1 = R_0 - C_1 - R_1 = U_0 - U_1$$

  - Where the opening estimate of ultimate claims and the expected ultimate after one year are U_0, U_1

The One-year view of Reserve Risk

Why do we want it? A view from the industry

- Fit in with theoretical Solvency II requirements
- Avoid excessive capital requirements
- May want to reflect ultimo view in ORSA, but don't want to contaminate regulatory capital
- More IMAP requirements if we don't!
- Potentially adds value to validation: actual versus expected

The One-year view of Reserve Risk

How do we measure it?

- Don’t bother?
  - Just use “perfect foresight” (the traditional actuarial “lifetime” view)
- Use analytic (formula based) approaches
  - Based only on data, eg QIS 5 USP Method 1
  - Based on a model and data, *eg* Merz-Wuthrich formula (used in QIS 5 USP Methods 2 & 3)
- Use simulation based approaches
  - Actuary-in-the-box
  - Emergence patterns
- Use Hindsight re-estimation

The One-year view of Reserve Risk

(The view of profit or loss on reserves after one year)

- Merz & Wuthrich (2008) derived analytic formulae for the standard deviation of the claims development result after one year assuming:
  - The opening reserves were set using the pure chain ladder model (no tail)
  - Claims develop in the year according to the assumptions underlying Mack's model
  - Reserves are set after one year using the pure chain ladder model (no tail)
  - The mathematics is quite challenging.

- The M&W method is gaining popularity, but has limitations. What if:
  - We need a tail factor to extrapolate into the future?
  - Mack's model is not used – other assumptions are used instead?
  - We want another risk measure, not just a standard deviation (*eg* VaR @ 99.5%)?
  - We want a distribution of the CDR?

Merz & Wuthrich (2008)

Data Triangle

Accident Year	12m	24m	36m	48m	60m	72m	84m	96m	108m
0	2,202,584	3,210,449	3,468,122	3,545,070	3,621,627	3,644,636	3,669,012	3,674,511	3,678,633
1	2,350,650	3,553,023	3,783,846	3,840,067	3,865,187	3,878,744	3,898,281	3,902,425	
2	2,321,885	3,424,190	3,700,876	3,798,198	3,854,755	3,878,993	3,898,825		
3	2,171,487	3,165,274	3,395,841	3,466,453	3,515,703	3,548,422			
4	2,140,328	3,157,079	3,399,262	3,500,520	3,585,812				
5	2,290,664	3,338,197	3,550,332	3,641,036					
6	2,148,216	3,219,775	3,428,335						
7	2,143,728	3,158,581							
8	2,144,738								

Merz & Wuthrich (2008)

Prediction errors

	Analytic Prediction Errors	
Accident Year	1 Year Ahead CDR	Mack Ultimate
0	0	0
1	567	567
2	1,488	1,566
3	3,923	4,157
4	9,723	10,536
5	28,443	30,319
6	20,954	35,967
7	28,119	45,090
8	53,320	69,552
Total	81,080	108,401

Expressed as a percentage of the opening reserves, this forms a basis of the reserve risk parameter under Solvency II (QIS 5 Technical Specification)

The one-year run-off result in a simulation model

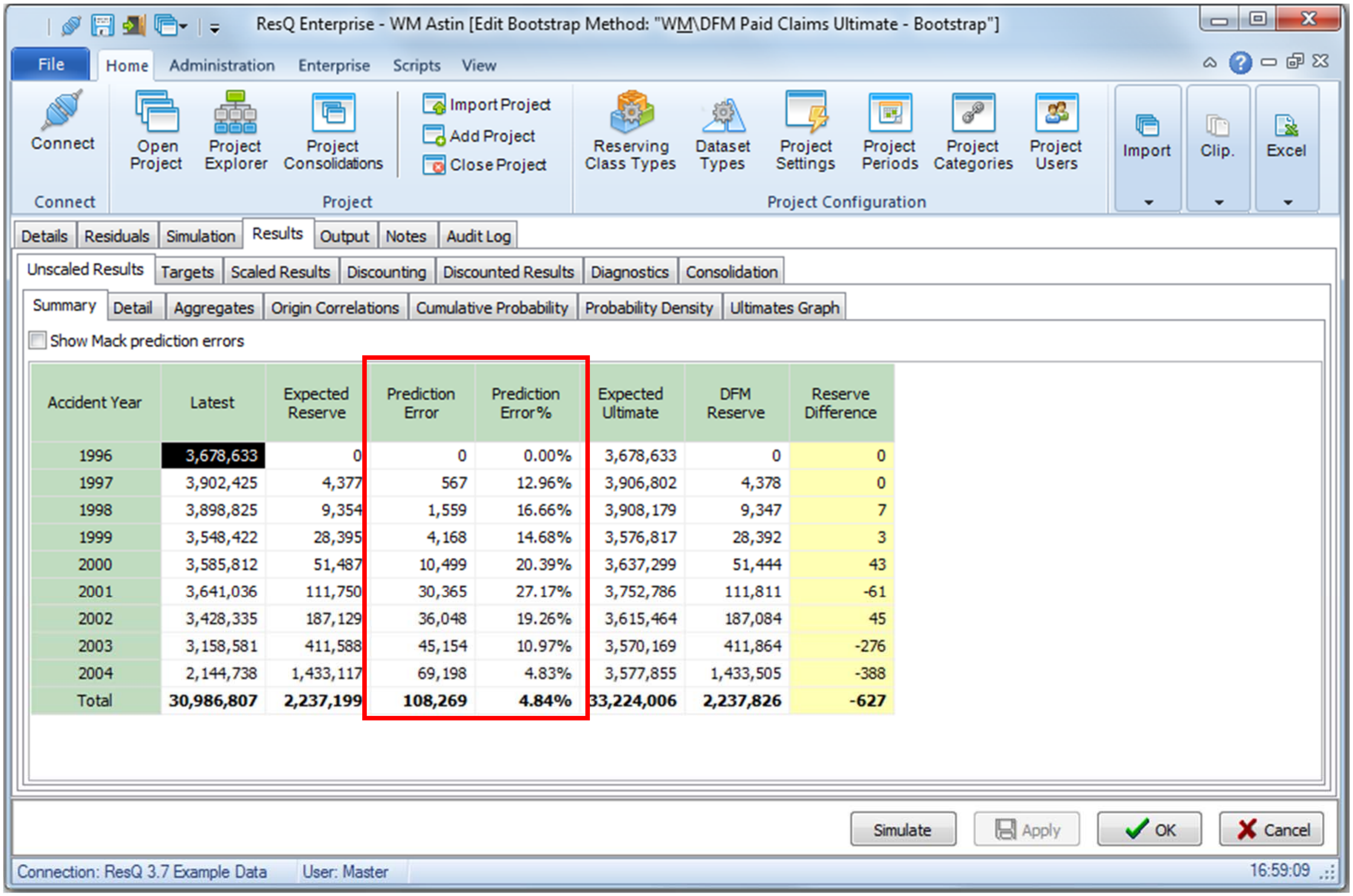
- For a particular origin year, let:
  - The opening reserve estimate be R_0
  - The expected reserve estimate after one year be $R_1^{(i)}$
  - The payments in the year be $C_1^{(i)}$
  - The run-off result (claims development result) be $CDR_1^{(i)}$
- Then

$$CDR_1^{(i)} = R_0 - C_1^{(i)} - R_1^{(i)} = U_0 - U_1^{(i)}$$

  - Where the opening estimate of ultimate claims and the expected ultimate after one year are $U_0, U_1^{(i)}$
  - for each simulation i

ResQ Example

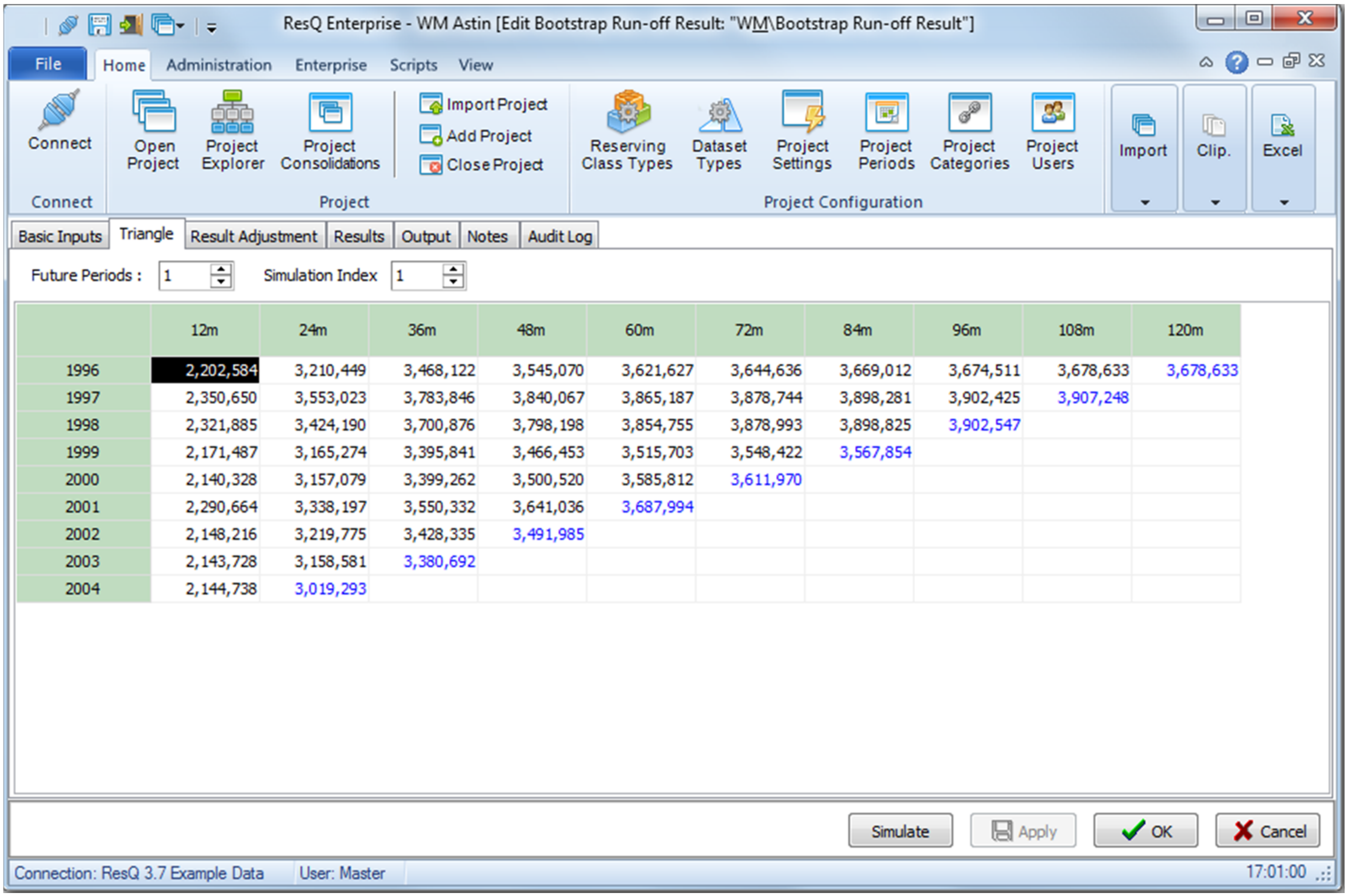
Bootstrap Results Summary – “Ultimo” perspective



Accident Year	Latest	Expected Reserve	Prediction Error	Prediction Error%	Expected Ultimate	DFM Reserve	Reserve Difference
1996	3,678,633	0	0	0.00%	3,678,633	0	0
1997	3,902,425	4,377	567	12.96%	3,906,802	4,378	0
1998	3,898,825	9,354	1,559	16.66%	3,908,179	9,347	7
1999	3,548,422	28,395	4,168	14.68%	3,576,817	28,392	3
2000	3,585,812	51,487	10,499	20.39%	3,637,299	51,444	43
2001	3,641,036	111,750	30,365	27.17%	3,752,786	111,811	-61
2002	3,428,335	187,129	36,048	19.26%	3,615,464	187,084	45
2003	3,158,581	411,588	45,154	10.97%	3,570,169	411,864	-276
2004	2,144,738	1,433,117	69,198	4.83%	3,577,855	1,433,505	-388
Total	**30,986,807**	**2,237,199**	**108,269**	**4.84%**	**33,224,006**	**2,237,826**	**-627**

ResQ Example

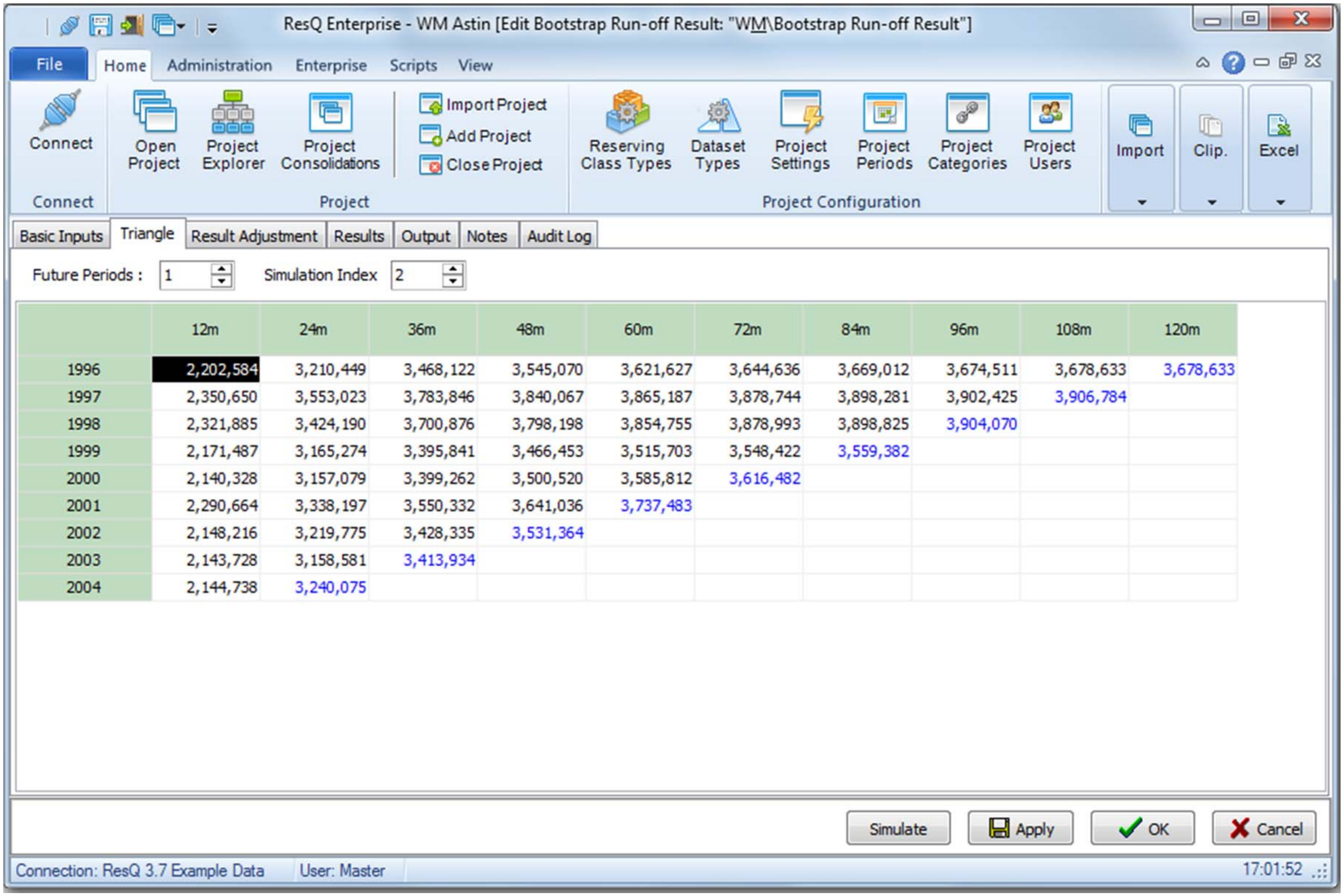
1 Year ahead – Simulation 1



	12m	24m	36m	48m	60m	72m	84m	96m	108m	120m
1996	2,202,584	3,210,449	3,468,122	3,545,070	3,621,627	3,644,636	3,669,012	3,674,511	3,678,633	3,678,633
1997	2,350,650	3,553,023	3,783,846	3,840,067	3,865,187	3,878,744	3,898,281	3,902,425	3,907,248	
1998	2,321,885	3,424,190	3,700,876	3,798,198	3,854,755	3,878,993	3,898,825	3,902,547		
1999	2,171,487	3,165,274	3,395,841	3,466,453	3,515,703	3,548,422	3,567,854			
2000	2,140,328	3,157,079	3,399,262	3,500,520	3,585,812	3,611,970				
2001	2,290,664	3,338,197	3,550,332	3,641,036	3,687,994					
2002	2,148,216	3,219,775	3,428,335	3,491,985						
2003	2,143,728	3,158,581	3,380,692							
2004	2,144,738	3,019,293								

ResQ Example

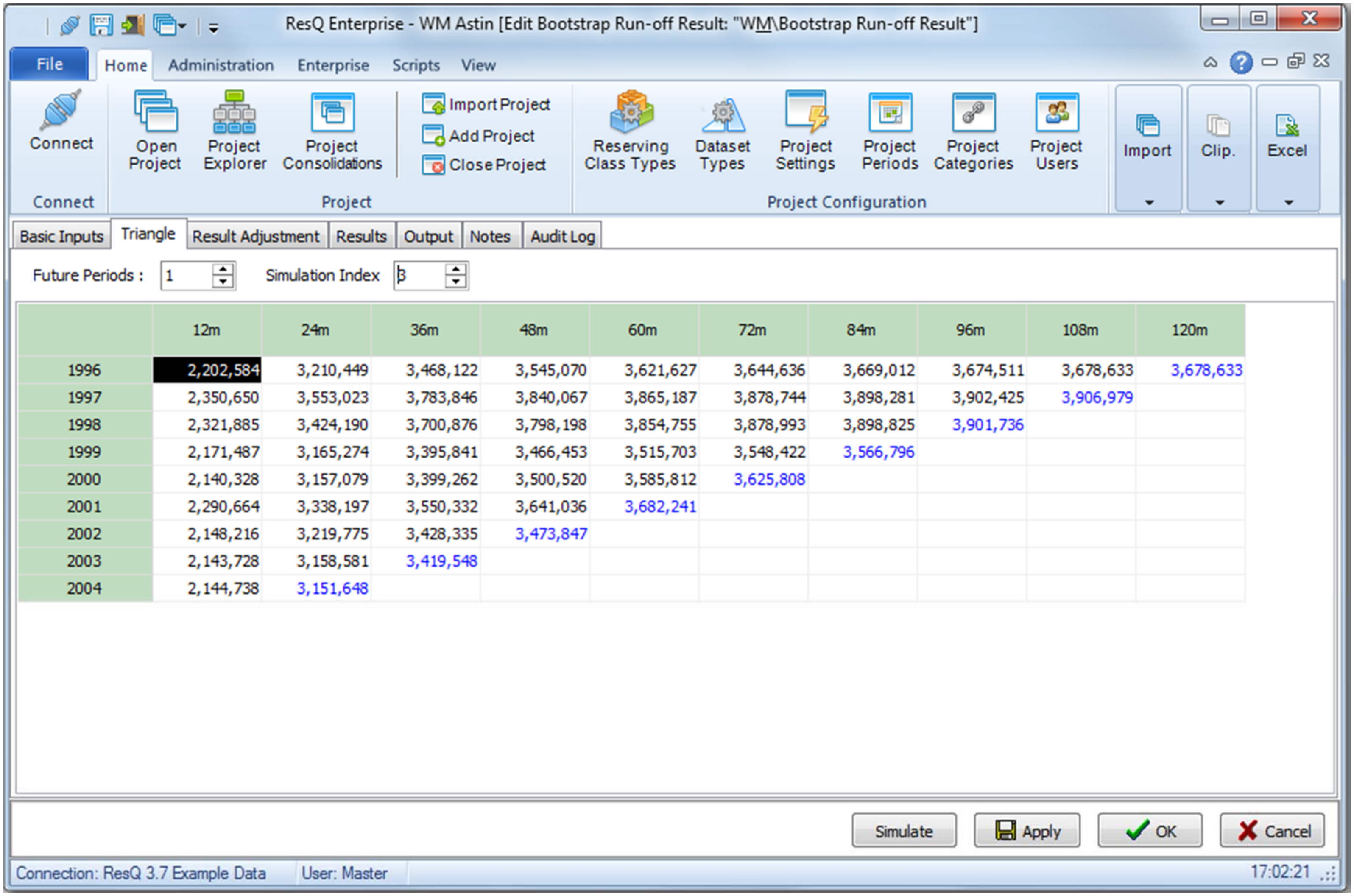
1 Year ahead – Simulation 2



	12m	24m	36m	48m	60m	72m	84m	96m	108m	120m
1996	2,202,584	3,210,449	3,468,122	3,545,070	3,621,627	3,644,636	3,669,012	3,674,511	3,678,633	3,678,633
1997	2,350,650	3,553,023	3,783,846	3,840,067	3,865,187	3,878,744	3,898,281	3,902,425	3,906,784	
1998	2,321,885	3,424,190	3,700,876	3,798,198	3,854,755	3,878,993	3,898,825	3,904,070		
1999	2,171,487	3,165,274	3,395,841	3,466,453	3,515,703	3,548,422	3,559,382			
2000	2,140,328	3,157,079	3,399,262	3,500,520	3,585,812	3,616,482				
2001	2,290,664	3,338,197	3,550,332	3,641,036	3,737,483					
2002	2,148,216	3,219,775	3,428,335	3,531,364						
2003	2,143,728	3,158,581	3,413,934							
2004	2,144,738	3,240,075								

ResQ Example

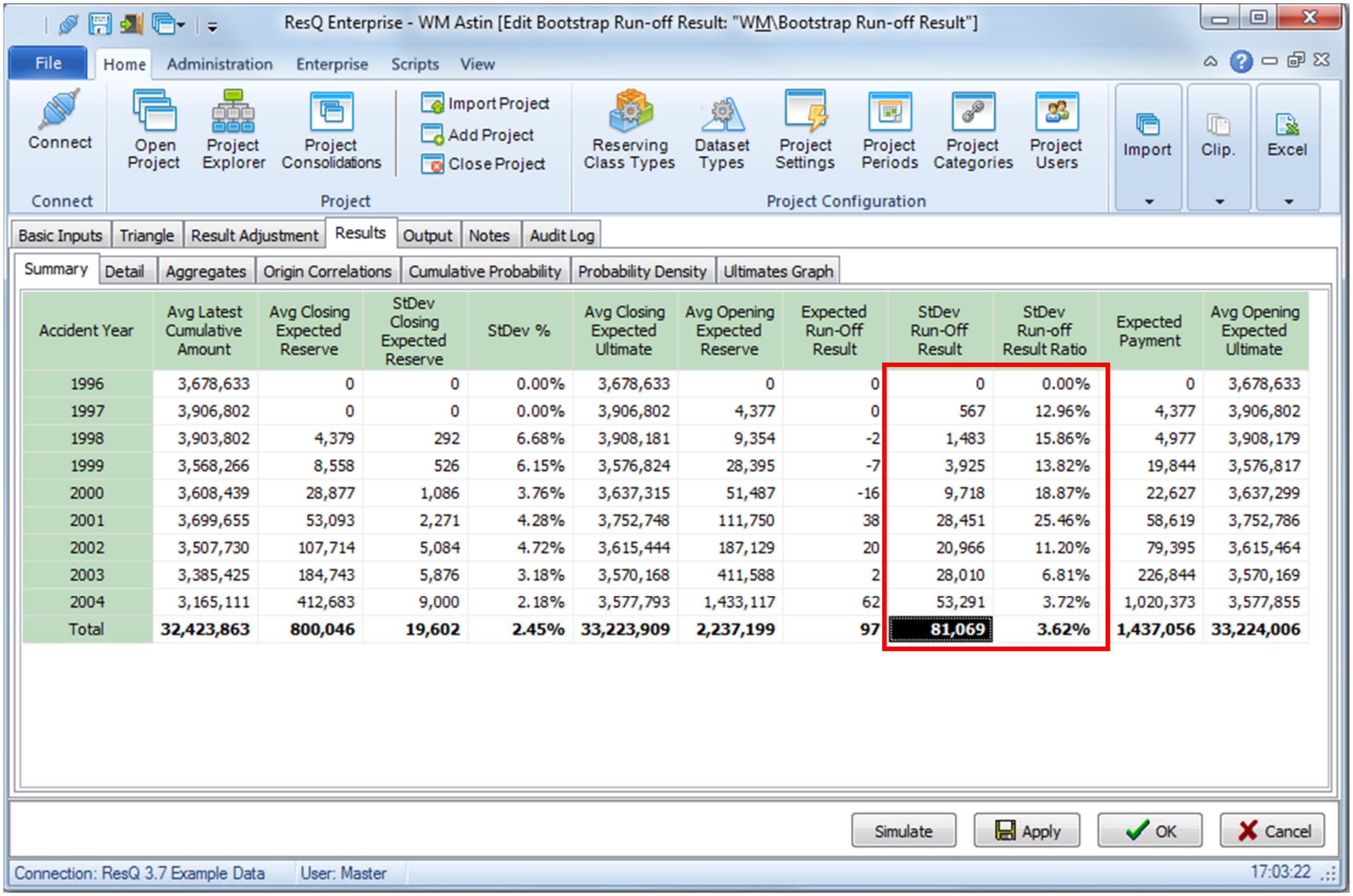
1 Year ahead – Simulation 3



	12m	24m	36m	48m	60m	72m	84m	96m	108m	120m
1996	2,202,584	3,210,449	3,468,122	3,545,070	3,621,627	3,644,636	3,669,012	3,674,511	3,678,633	3,678,633
1997	2,350,650	3,553,023	3,783,846	3,840,067	3,865,187	3,878,744	3,898,281	3,902,425	3,906,979	
1998	2,321,885	3,424,190	3,700,876	3,798,198	3,854,755	3,878,993	3,898,825	3,901,736		
1999	2,171,487	3,165,274	3,395,841	3,466,453	3,515,703	3,548,422	3,566,796			
2000	2,140,328	3,157,079	3,399,262	3,500,520	3,585,812	3,625,808				
2001	2,290,664	3,338,197	3,550,332	3,641,036	3,682,241					
2002	2,148,216	3,219,775	3,428,335	3,473,847						
2003	2,143,728	3,158,581	3,419,548							
2004	2,144,738	3,151,648								

ResQ Example

Bootstrap Run-off Results Summary – 1 year perspective



Accident Year	Avg Latest Cumulative Amount	Avg Closing Expected Reserve	StDev Closing Expected Reserve	StDev %	Avg Closing Expected Ultimate	Avg Opening Expected Reserve	Expected Run-Off Result	StDev Run-Off Result	StDev Run-off Result Ratio	Expected Payment	Avg Opening Expected Ultimate
1996	3,678,633	0	0	0.00%	3,678,633	0	0	0	0.00%	0	3,678,633
1997	3,906,802	0	0	0.00%	3,906,802	4,377	0	567	12.96%	4,377	3,906,802
1998	3,903,802	4,379	292	6.68%	3,908,181	9,354	-2	1,483	15.86%	4,977	3,908,179
1999	3,568,266	8,558	526	6.15%	3,576,824	28,395	-7	3,925	13.82%	19,844	3,576,817
2000	3,608,439	28,877	1,086	3.76%	3,637,315	51,487	-16	9,718	18.87%	22,627	3,637,299
2001	3,699,655	53,093	2,271	4.28%	3,752,748	111,750	38	28,451	25.46%	58,619	3,752,786
2002	3,507,730	107,714	5,084	4.72%	3,615,444	187,129	20	20,966	11.20%	79,395	3,615,464
2003	3,385,425	184,743	5,876	3.18%	3,570,168	411,588	2	28,010	6.81%	226,844	3,570,169
2004	3,165,111	412,683	9,000	2.18%	3,577,793	1,433,117	62	53,291	3.72%	1,020,373	3,577,855
Total	**32,423,863**	**800,046**	**19,602**	**2.45%**	**33,223,909**	**2,237,199**	**97**	**81,069**	**3.62%**	**1,437,056**	**33,224,006**

Merz & Wuthrich (2008)

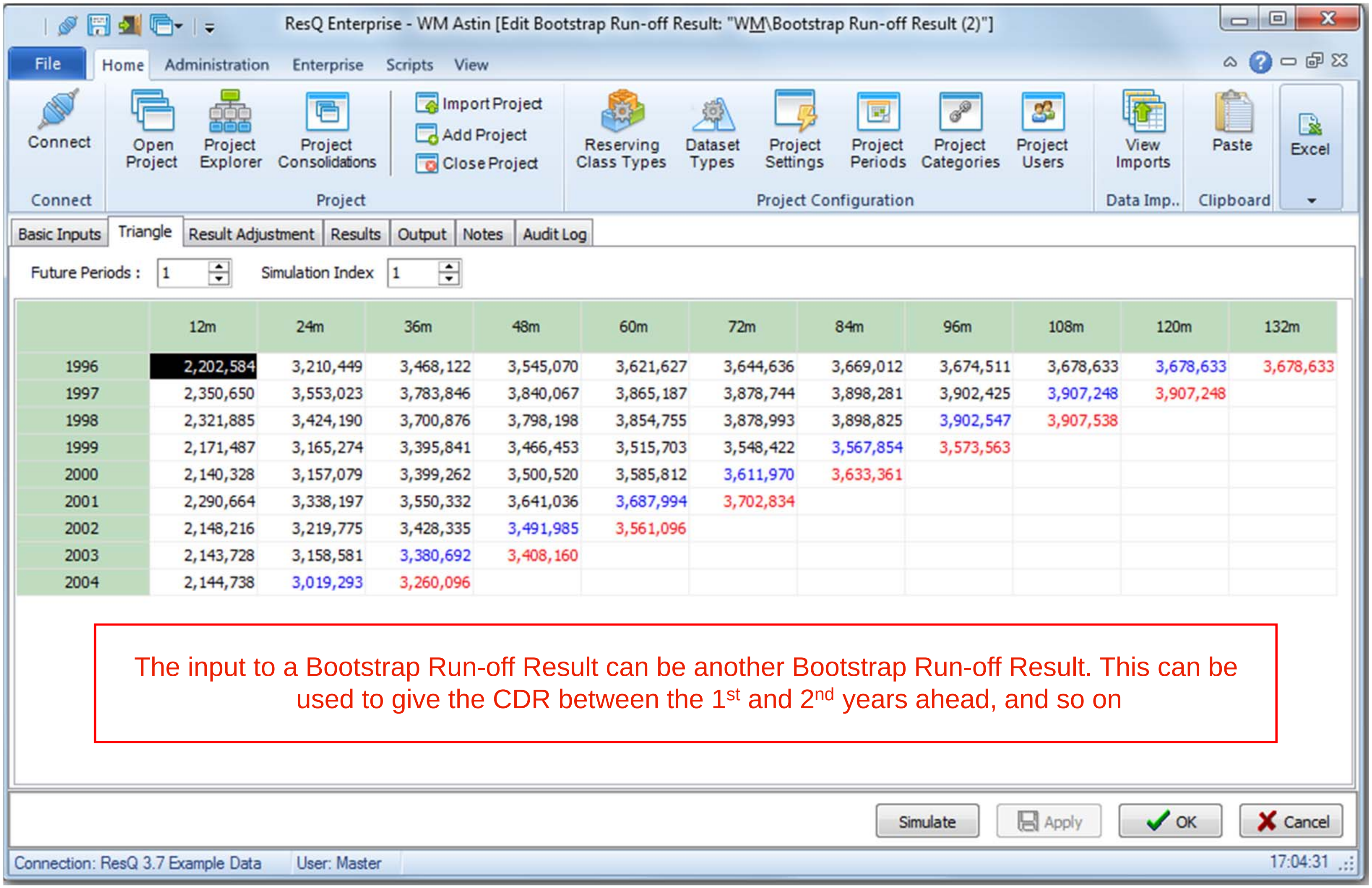
Analytic vs Simulated: Summary

	Analytic		Simulated	
	Prediction Errors		Prediction Errors	
Accident Year	1 Year Ahead CDR	Mack Ultimate	1 Year Ahead CDR	Mack Ultimate
0	0	0	0	0
1	567	567	567	567
2	1,488	1,566	1,483	1,559
3	3,923	4,157	3,925	4,168
4	9,723	10,536	9,718	10,499
5	28,443	30,319	28,451	30,365
6	20,954	35,967	20,966	36,048
7	28,119	45,090	28,010	45,154
8	53,320	69,552	53,291	69,198
Total	81,080	108,401	81,069	108,269

We can develop simulation based models that are analogous to their analytic counterparts

ResQ Example

Cascading Bootstrap Run-off Results

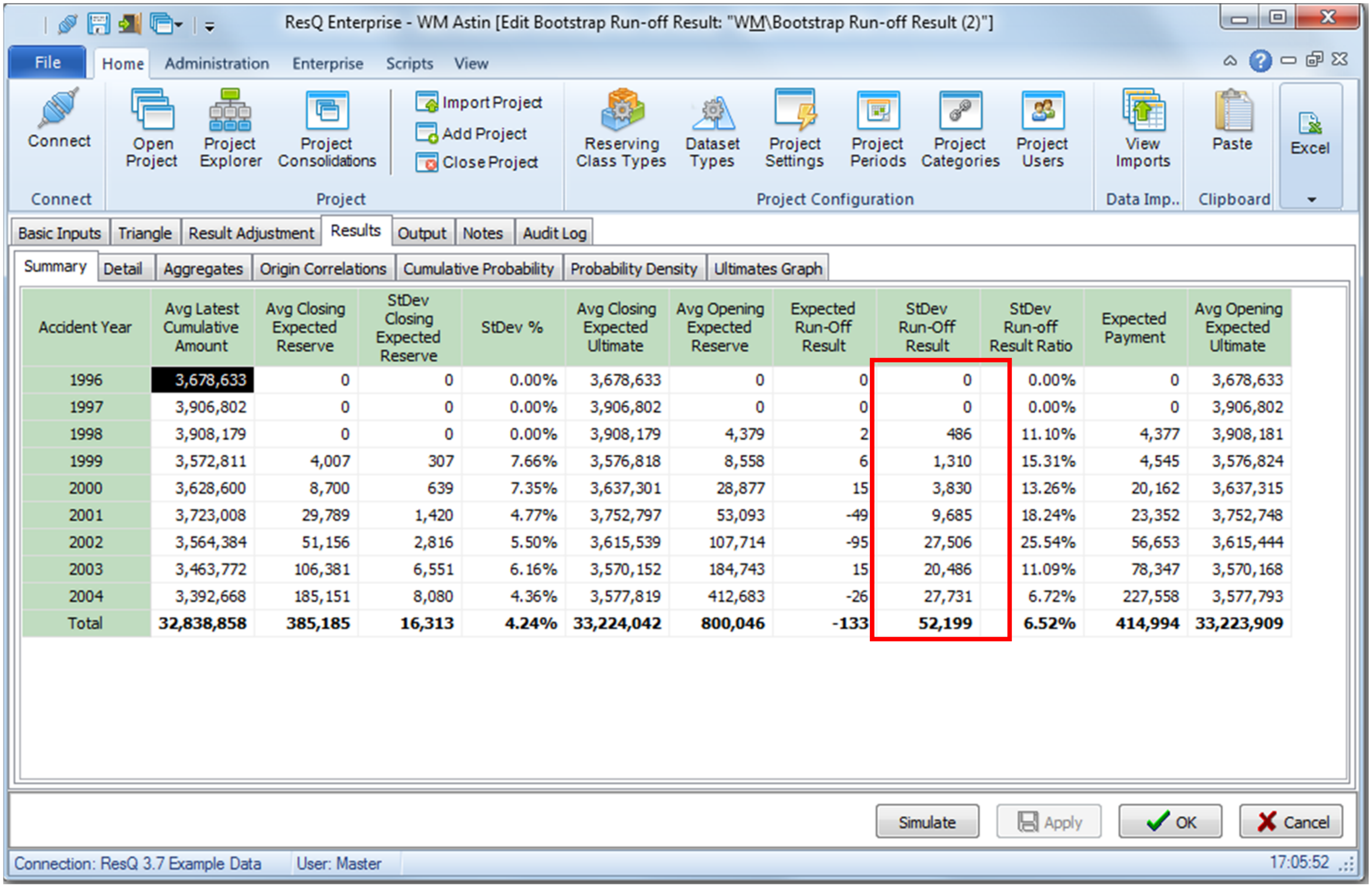


	12m	24m	36m	48m	60m	72m	84m	96m	108m	120m	132m
1996	2,202,584	3,210,449	3,468,122	3,545,070	3,621,627	3,644,636	3,669,012	3,674,511	3,678,633	3,678,633	3,678,633
1997	2,350,650	3,553,023	3,783,846	3,840,067	3,865,187	3,878,744	3,898,281	3,902,425	3,907,248	3,907,248	
1998	2,321,885	3,424,190	3,700,876	3,798,198	3,854,755	3,878,993	3,898,825	3,902,547	3,907,538		
1999	2,171,487	3,165,274	3,395,841	3,466,453	3,515,703	3,548,422	3,567,854	3,573,563			
2000	2,140,328	3,157,079	3,399,262	3,500,520	3,585,812	3,611,970	3,633,361				
2001	2,290,664	3,338,197	3,550,332	3,641,036	3,687,994	3,702,834					
2002	2,148,216	3,219,775	3,428,335	3,491,985	3,561,096						
2003	2,143,728	3,158,581	3,380,692	3,408,160							
2004	2,144,738	3,019,293	3,260,096								

The input to a Bootstrap Run-off Result can be another Bootstrap Run-off Result. This can be used to give the CDR between the 1st and 2nd years ahead, and so on

ResQ Example

Cascading Bootstrap Run-off Results



Accident Year	Avg Latest Cumulative Amount	Avg Closing Expected Reserve	StDev Closing Expected Reserve	StDev %	Avg Closing Expected Ultimate	Avg Opening Expected Reserve	Expected Run-Off Result	StDev Run-Off Result	StDev Run-off Result Ratio	Expected Payment	Avg Opening Expected Ultimate
1996	3,678,633	0	0	0.00%	3,678,633	0	0	0	0.00%	0	3,678,633
1997	3,906,802	0	0	0.00%	3,906,802	0	0	0	0.00%	0	3,906,802
1998	3,908,179	0	0	0.00%	3,908,179	4,379	2	486	11.10%	4,377	3,908,181
1999	3,572,811	4,007	307	7.66%	3,576,818	8,558	6	1,310	15.31%	4,545	3,576,824
2000	3,628,600	8,700	639	7.35%	3,637,301	28,877	15	3,830	13.26%	20,162	3,637,315
2001	3,723,008	29,789	1,420	4.77%	3,752,797	53,093	-49	9,685	18.24%	23,352	3,752,748
2002	3,564,384	51,156	2,816	5.50%	3,615,539	107,714	-95	27,506	25.54%	56,653	3,615,444
2003	3,463,772	106,381	6,551	6.16%	3,570,152	184,743	15	20,486	11.09%	78,347	3,570,168
2004	3,392,668	185,151	8,080	4.36%	3,577,819	412,683	-26	27,731	6.72%	227,558	3,577,793
Total	**32,838,858**	**385,185**	**16,313**	**4.24%**	**33,224,042**	**800,046**	**-133**	**52,199**	**6.52%**	**414,994**	**33,223,909**

Multiple 1 yr ahead CDRs

An interesting result

- Creating cascading CDRs over all years gives the following results:

Accident Year	Number of years ahead								Sqrt(Sum of Squares)	Mack Ultimate
	1 Yr	2 Yrs	3 Yrs	4 Yrs	5 Yrs	6 Yrs	7 Yrs	8 Yrs		
1	0	0	0	0	0	0	0	0	-	0
2	567	0	0	0	0	0	0	0	567	567
3	1,483	486	0	0	0	0	0	0	1,561	1,559
4	3,925	1,310	433	0	0	0	0	0	4,160	4,168
5	9,718	3,830	1,285	425	0	0	0	0	10,533	10,499
6	28,451	9,685	3,824	1,276	425	0	0	0	30,327	30,365
7	20,966	27,506	9,364	3,683	1,223	410	0	0	36,042	36,048
8	28,010	20,486	27,001	9,237	3,619	1,211	404	0	45,093	45,154
9	53,291	27,731	20,146	26,593	9,101	3,609	1,200	400	69,422	69,198
Total	81,069	52,199	38,463	28,972	10,107	3,887	1,282	400	108,327	108,269
	56.01%	79.23%	91.83%	98.99%	99.86%	99.98%	100.00%	100.00%	Cumulative Risk Emergence (Variance)	

- The sum of the variances of the repeated 1 yr ahead CDRs (over all years) equals the variance over the lifetime of the liabilities
- This means that we expect the risk under the 1 year view to be lower than the standard “ultimo” perspective

Actuary-in-the-box issues

- The “Actuary-in-the-box” method is not without its difficulties:
  - What if you’ve applied a lot of judgement?
  - What if the claims triangle is sparse, or very volatile?
  - What if you have no claims triangle?
  - What if you used a parametric model?
- In addition, actuary-in-the-box is fairly computationally expensive in simulation models
- It may be harder than ultimo bootstrapping to produce sensible results for some triangles
- So we need simpler alternatives:
  - Simply allow the “ultimo” variability to emerge steadily over time?

Alternatives to the “actuary-in-the-box”:

Emergence patterns

- What do we do when bootstrapping is not appropriate (and hence the “actuary-in-the-box” cannot be used), or the “actuary-in-the-box” fails?
- Well, we know that we expect the “ultimo” (lifetime) volatility to emerge over time, so if we have an estimate of the “ultimo” volatility, then we can create approaches that allow it to emerge using an “emergence pattern”

Alternatives to the "actuary-in-the-box":

Emergence patterns based on Ultimates

- If, for a particular origin period:
  - We have a distribution of the ultimate cost of claims $\tilde{U}_0$ at time zero
  - Then let $U_1^{(i)} = \alpha \tilde{U}_0^{(i)} + (1-\alpha) E\left[\tilde{U}_0\right]$
  - and $CDR_1^{(i)} = U_0 - U_1^{(i)}$ where $U_0 = E\left[\tilde{U}_0\right]$
  - The CDR then becomes a function of *α* and the SD of the CDR can be controlled using *α*
  - Note: each origin period has a different value of *α*
  - We call *α* an "emergence factor", and the set of alphas an "emergence pattern"

Alternatives to the “actuary-in-the-box”:

Emergence patterns: Notes

- The method relies on having a distribution of the ultimate cost of claims under the “lifetime” view
- Each origin period has a different value of α, depending on how developed it is
- The pattern is expressed by development period, since a tail may be required. Each origin period is associated with only one development period
- If $\alpha = 1$, the SDs of the CDRs will be maximised and will match the “lifetime” view
- If $\alpha = 0$, the SD of the CDRs will be zero
- The calibration problem is finding appropriate values of α

Calibrating the emergence pattern

Where the "actuary-in-the-box" approach is possible

- Given the SDs of the 1 year ahead CDR by origin period using the "actuary-in-the-box" approach, find α such that the SDs of the CDR using the emergence pattern approach are the same
- For a single origin period, it is straightforward to show that $\alpha = \dfrac{SD\left[CDR_1^{AIB}\right]}{SD\left[\tilde{U}_0\right]}$
- But the dependencies between origin periods are different using the emergence pattern approach relative to the "actuary-in-the-box"
  - If α is calibrated to the origin period SDs, the SD of the total CDR will be different
  - An alternative is to adjust the αs until the SD of the total CDR matches
- (Calibration alternatives based on a sequence of 1 year ahead views are possible)

Taylor & Ashe Data

Prediction errors

	Prediction Errors	
Accident Year	**1 Year Ahead CDR**	**Mack Ultimate**
1	0	0
2	76,210	76,210
3	106,164	122,494
4	80,585	133,428
5	231,538	257,706
6	318,598	409,466
7	360,036	554,675
8	627,638	878,730
9	586,187	963,470
10	1,030,989	1,357,727
Total	1,776,119	2,444,130

Taylor & Ashe Data

"Actuary-in-the-box" vs Emergence patterns based on Ultimates

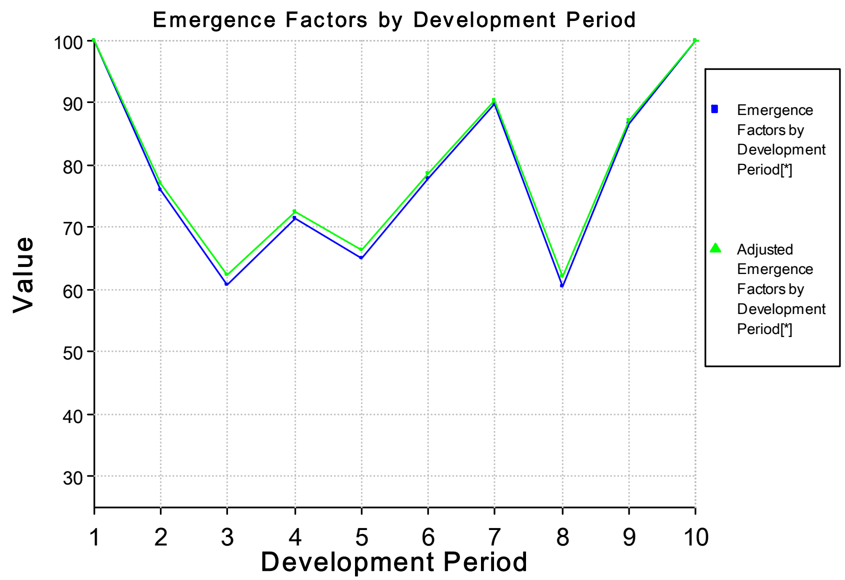
SDs of 1 Yr ahead CDRs

		Emergence Patterns			
Accident Year	**Actuary-in-the-box**	**100%**	**0%**	**Calibrated (unadjusted)**	**Calibrated (adjusted)**
1	0	0	0	0	0
2	76,210	76,210	0	76,210	76,210
3	106,164	122,494	0	106,164	106,836
4	80,585	133,428	0	80,585	82,759
5	231,538	257,706	0	231,538	232,614
6	318,598	409,466	0	318,598	322,337
7	360,036	554,675	0	360,036	368,044
8	627,638	878,730	0	627,638	637,968
9	586,187	963,470	0	586,187	601,710
10	1,030,989	1,357,727	0	1,030,989	1,044,432
Total	1,776,119	2,444,130	0	1,747,742	1,776,119

Taylor & Ashe Data

"Actuary-in-the-box" vs Emergence patterns based on Ultimates

	Emergence Pattern	
Development Period	Unadjusted	Adjusted
1	100.0	100.0
2	75.9	76.9
3	60.8	62.5
4	71.4	72.6
5	64.9	66.4
6	77.8	78.7
7	89.8	90.3
8	60.4	62.0
9	86.7	87.2
10	100.0	100.0



Note: In a standard analysis, we only have data to calibrate from development period 2. The value of 100% at development period 1 was chosen arbitrarily. This can be discussed further.

Emergence Patterns based on Ultimates

Pros and Cons

- Pro: Very easy to calibrate
- Con: Can result in negative expected reserves one year ahead for some simulations, for example

Expected Opening Ultimate	100	
Simulation *n*		
Perfect Foresight Opening Ultimate	180	
Cumulative Claims at end of Year	170	
Emergence Factor (alpha)	0.75	
Closing Booked Ultimate	160	= 0.75 x 180 + 0.25 x 100
Claims Development Result	-60	= 100 - 160
Closing Booked Reserve	-10	= 160 - 170

Alternatives to the "actuary-in-the-box":

Emergence patterns based on Reserves

- For example, if for a particular origin period:
  - We have a distribution of the outstanding liabilities L_0 at time zero
  - with payments in each future year $C_1, \ldots, C_n$ such that $L_0 = \sum_{k=1}^{n} C_k$
  - Then let $R_1^{(i)} = \beta \left(L_0^{(i)} - C_1^{(i)} \right) + (1 - \beta) E \left[L_0 - C_1 \right]$
  - and $CDR_1^{(i)} = R_0 - C_1^{(i)} - R_1^{(i)}$
  - The CDR then becomes a function of β and the SD of the CDR can be controlled using β
  - Note: each origin period has a different value of β
  - We call β an "emergence factor", and the set of alphas an "emergence pattern"

Calibrating the emergence pattern

Where the "actuary-in-the-box" approach is possible

- Given the SDs of the 1 year ahead CDR by origin period using the "actuary-in-the-box" approach, find β such that the SDs of the CDR using the emergence pattern approach are the same
- This is not as straightforward as finding α for the method based on Ultimates

- The dependencies between origin periods are different using the emergence pattern approach relative to the "actuary-in-the-box"
  - If β is calibrated to the origin period SDs, the SD of the total CDR will be different
  - An alternative is to adjust the βs until the SD of the total CDR matches
- (Calibration alternatives based on a sequence of 1 year ahead views are possible)

Taylor & Ashe Data

"Actuary-in-the-box" vs Emergence patterns based on Reserves

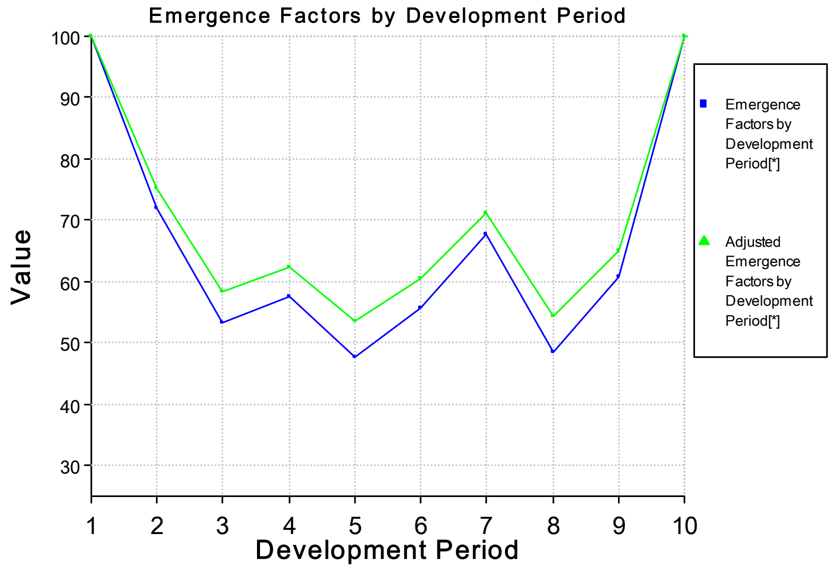
SDs of 1 Yr ahead CDRs

		Emergence Patterns			
Accident Year	**Actuary-in-the-box**	**100%**	**0%**	**Calibrated (unadjusted)**	**Calibrated (adjusted)**
1	0	0	0	0	0
2	76,210	76,210	76,210	76,210	76,210
3	106,164	122,494	94,487	106,164	107,712
4	80,585	133,428	53,001	80,585	85,910
5	231,538	257,706	195,521	231,538	234,236
6	318,598	409,466	247,200	318,598	327,732
7	360,036	554,675	250,906	360,036	379,593
8	627,638	878,730	376,752	627,638	654,312
9	586,187	963,470	240,217	586,187	627,309
10	1,030,989	1,357,727	246,658	1,030,989	1,067,405
Total	1,776,119	2,444,130	660,304	1,694,736	1,776,119

Taylor & Ashe Data

"Actuary-in-the-box" vs Emergence patterns based on Reserves

Development Period	Emergence Pattern Unadjusted	Adjusted
1	100.0	100.0
2	72.1	75.2
3	53.3	58.5
4	57.6	62.3
5	47.6	53.5
6	55.7	60.6
7	67.6	71.3
8	48.6	54.3
9	60.7	65.1
10	100.0	100.0



Note: In a standard analysis, we only have data to calibrate from development period 2. The value of 100% at development period 1 was chosen arbitrarily. This can be discussed further.

Calibrating the emergence pattern

Where the "actuary-in-the-box" approach is NOT possible

- When bootstrapping has not been used, or the "actuary-in-the-box" method fails, what emergence pattern should be used?
- This is difficult in the absence of an alternative method.
- In practice, either use 100% (*ie* go straight to ultimate), or use an appropriate benchmark
- Using benchmarks:
  - Find a suitable benchmark triangle where the "actuary-in-the-box" approach can be used
  - Calibrate an emergence pattern to the SDs of the CDRs given by the "actuary-in-the-box" approach
  - Apply the benchmark emergence pattern

Using Benchmarks

- The obvious question when using benchmarks is “Which benchmark is appropriate?”
- For emergence patterns, does it matter too much?
  - Do short tailed lines etc exhibit similar patterns?
  - How stable are the patterns in practice?
  - Do emergence patterns for different lines of business display common characteristics?
- To assist answer these (and other) questions, we took some publicly available data, and calibrated emergence patterns using a simple underlying model

Data Analysis

We used publically available paid claims triangles:
Schedule P – 2011 loss triangles

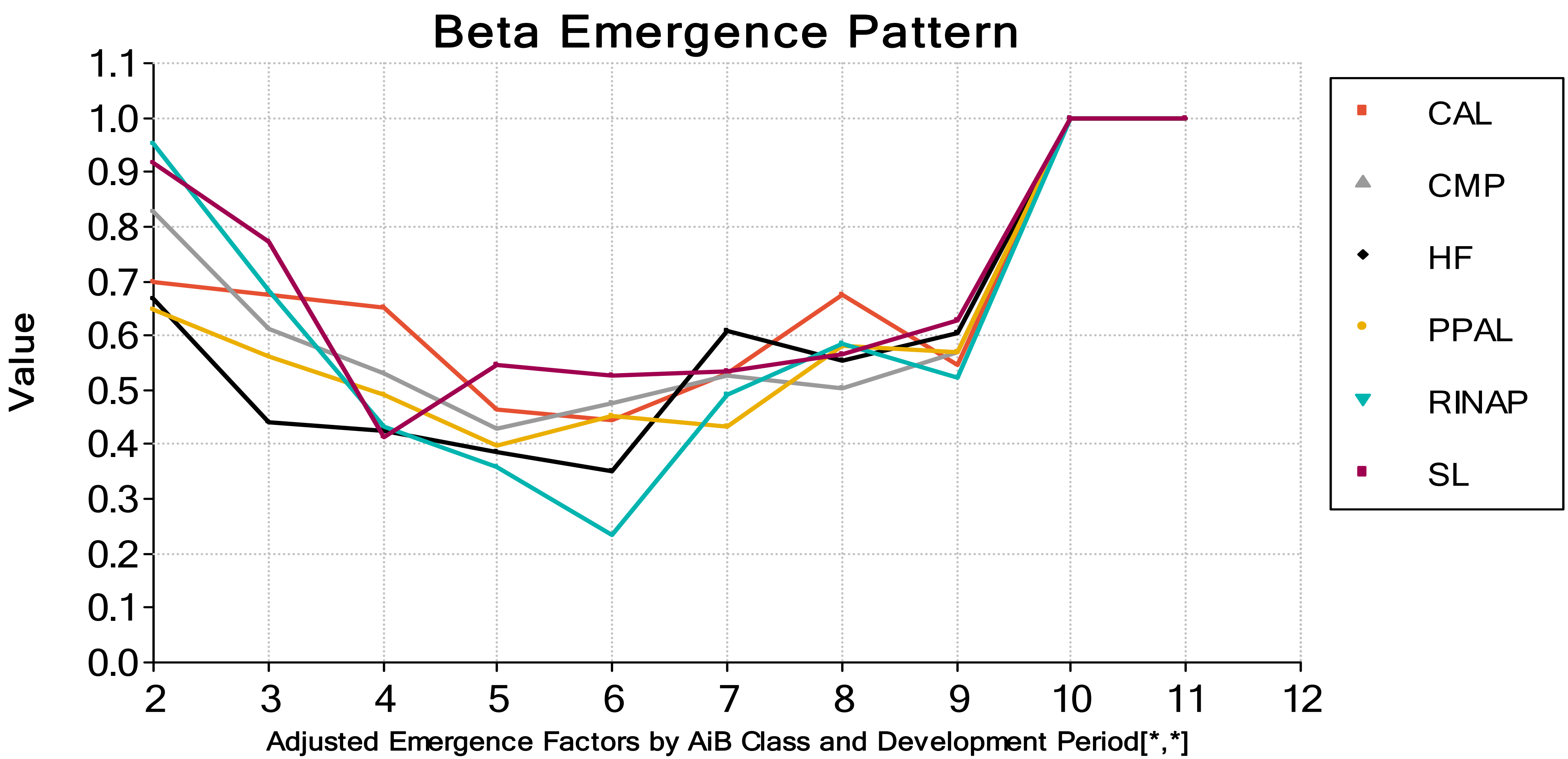
Schedule P data

		Duration	Volatility	Opening Reserves in USD bn
HF	Homeowner & Farmowners	1.4	5%	23.1
PPAL	Private Passenger Auto Liability	2.1	1%	76.4
SL	Special Liability	2.4	11%	4.7
RINAP	Reinsurance: Nonproportional Assumed Property	2.4	24%	7.6
Int	International	2.5	55%	0.2
RINAF	Reinsurance: Nonproportional Assumed Financial	2.6	67%	0.1
CMP	Commercial Multiple Peril	2.6	5%	33.2
CAL	Commercial Auto Liability	3.0	2%	21.2
WC	Workers' Compensation	3.2	3%	49.1
MPLCM	Medical Professional Liability - Claim Made	3.9	4%	11.1
OLO	Other Liability: Occurrence	3.9	6%	32.4
RINAL	Reinsurance: Nonproportional Assumed Liability	4.0	24%	6.8
PLCM	Product Liability: Claims Made	4.2	22%	0.9
OLCM	Other Liability: Claims Made	4.2	5%	30.5
PLO	Product Liability: Occurrence	5.3	9%	6.2
MPLO	Medical Professional Liability - Occurrence	5.3	13%	4.5

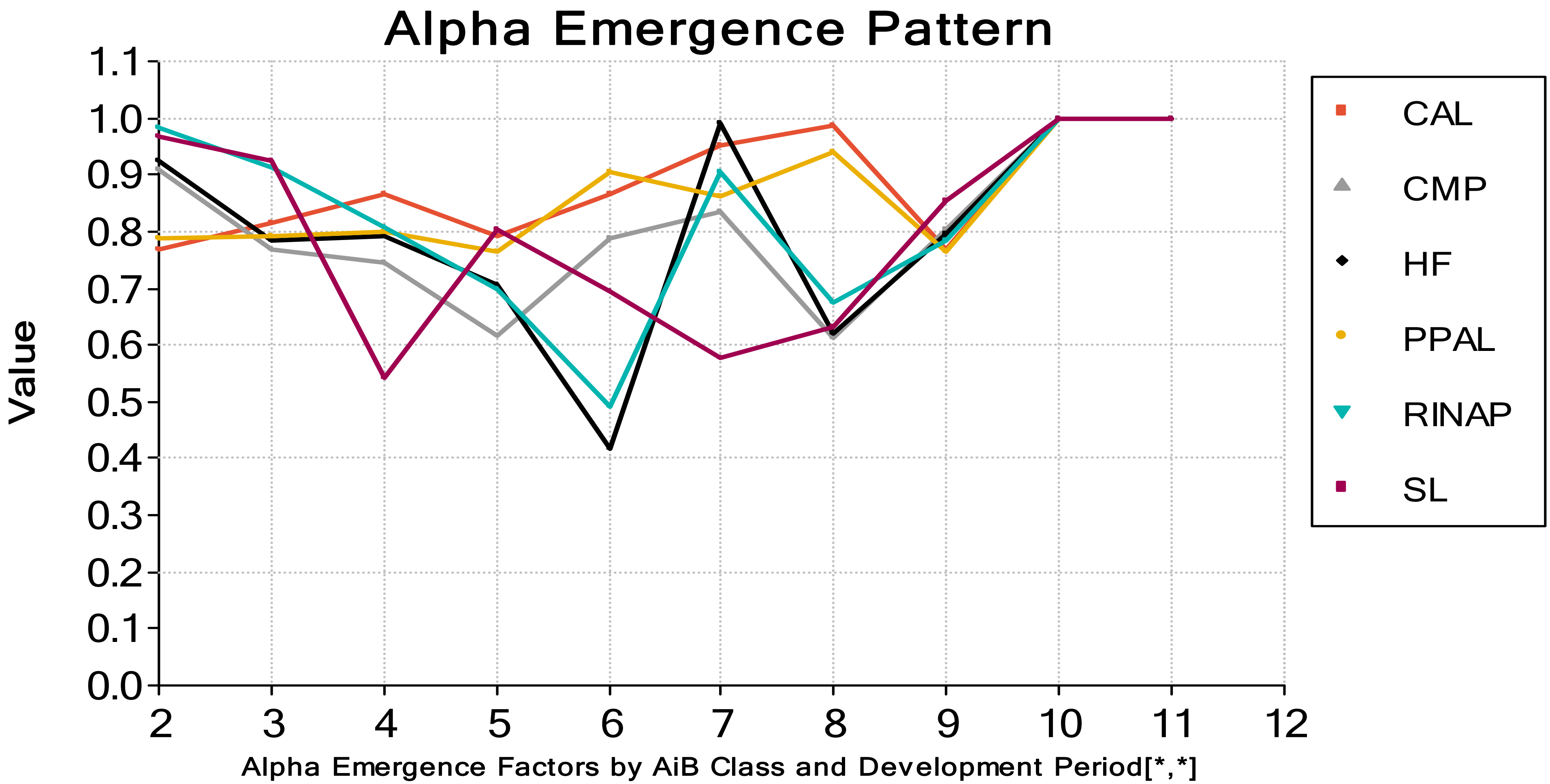
Models used

- For each paid claims triangle we fit four models:
  - Bootstrap
    - Mack and ODP (with varying scale parameters)
    - No curve fit (ie chain ladder model only)
  - Actuary-in-the-Box
    - With and without Bornhuetter-Ferguson adjustment for all origin years (where BF priors equal expected Ultimates from the Bootstrap results)
  - For each model we calculate the following emergence factors
    - Adjusted betas
    - Adjusted alphas

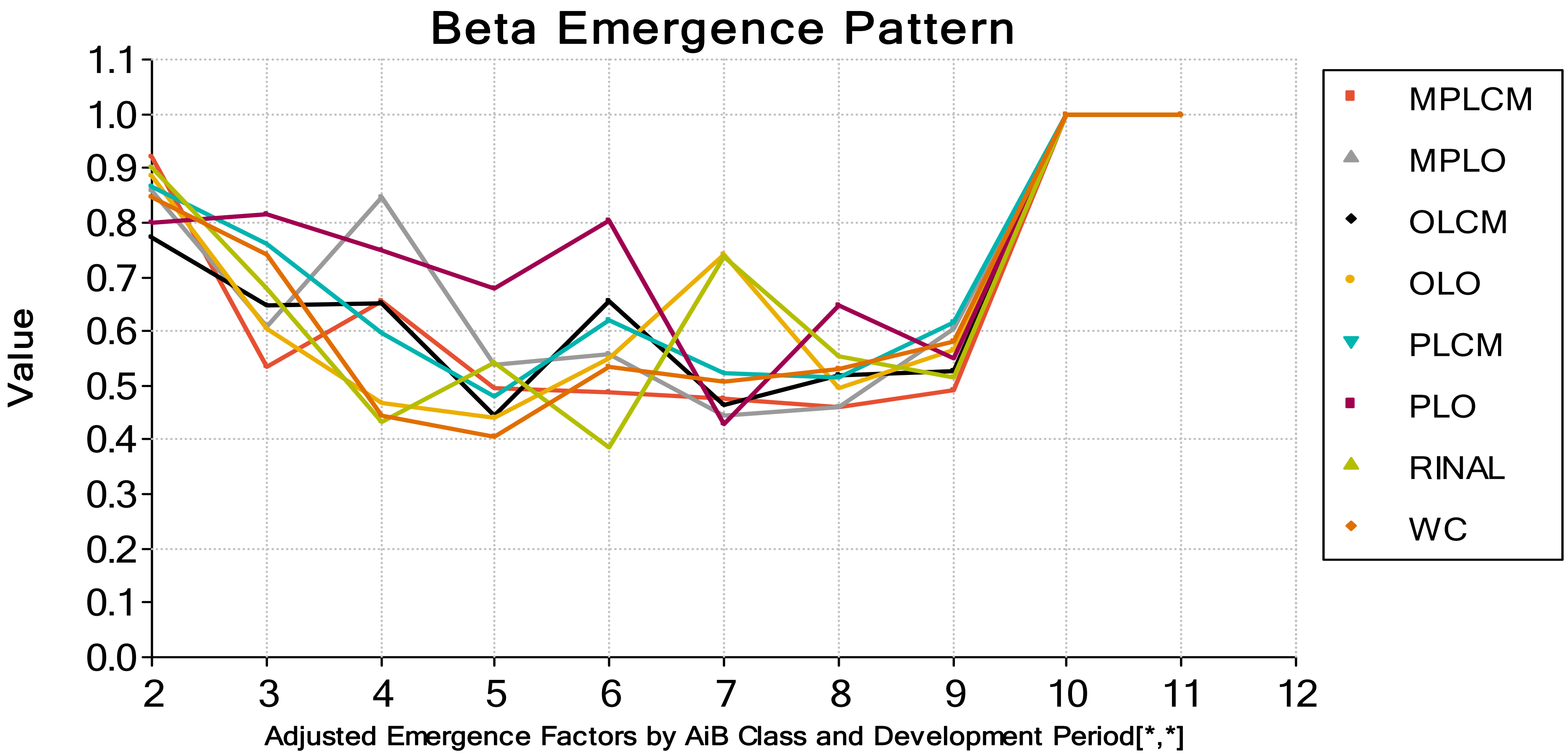
Schedule P – short tail lines – no BF



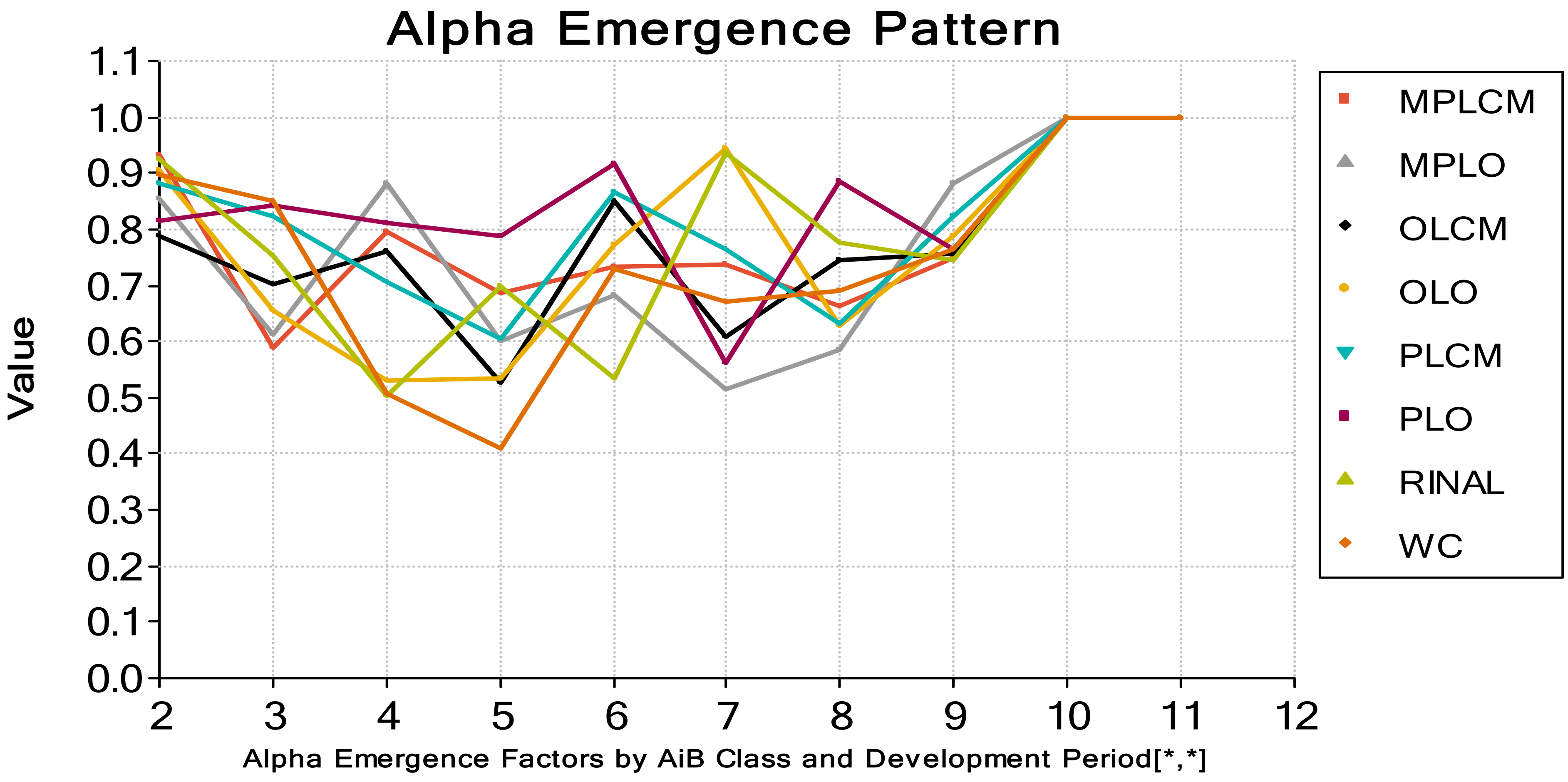
Schedule P – short tail lines – no BF



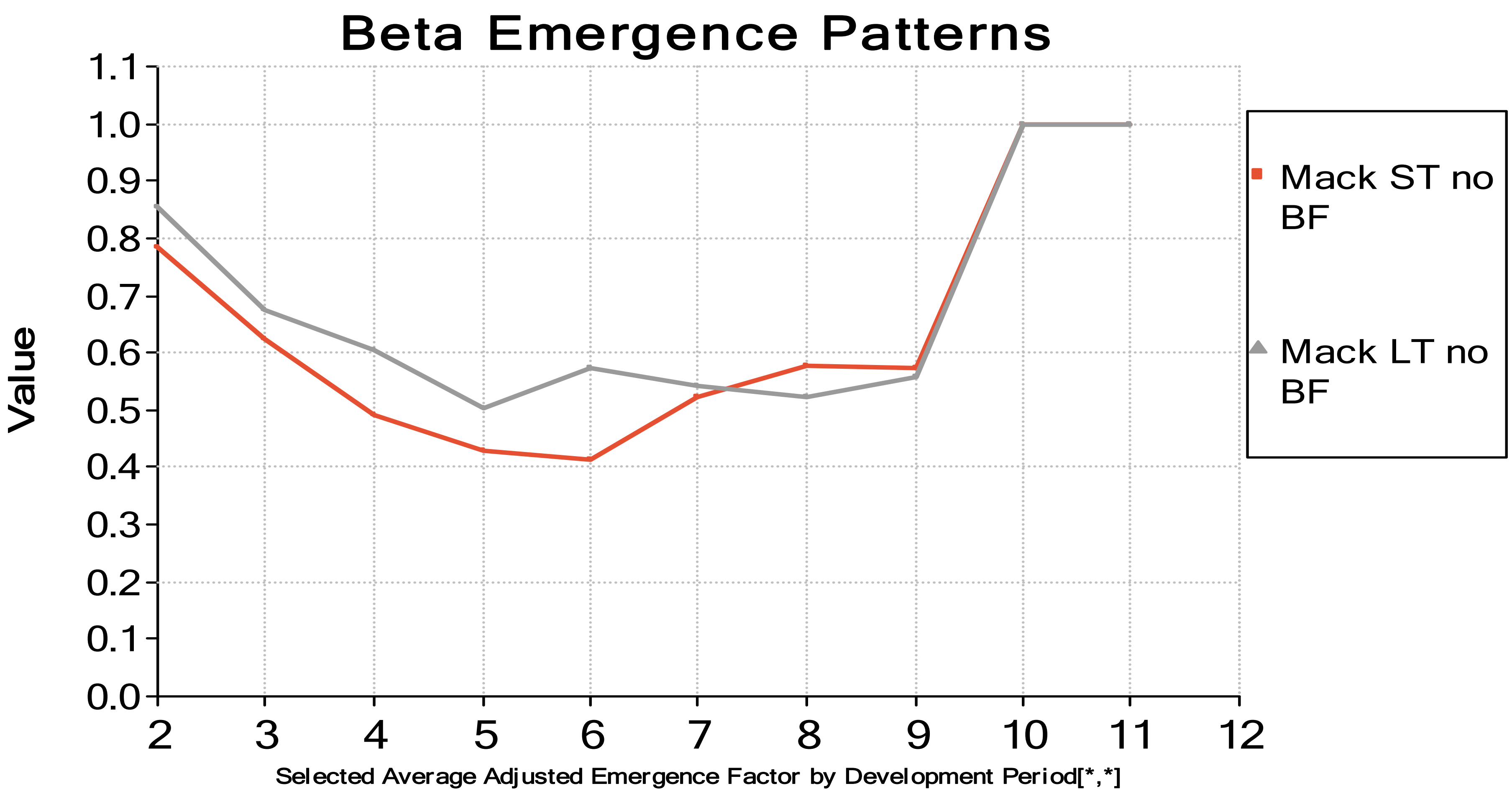
Schedule P – long tail lines – no BF



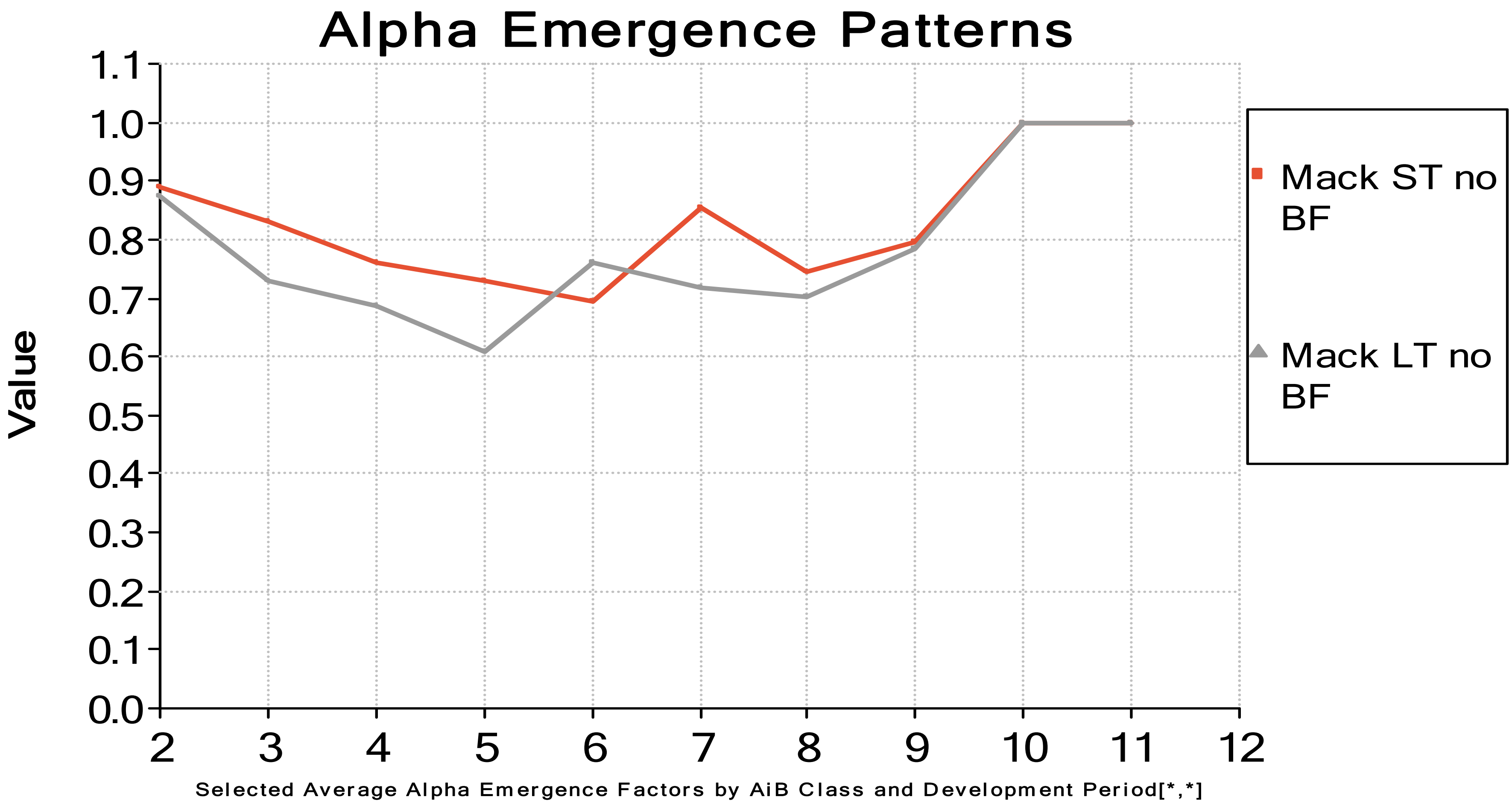
Schedule P – long tail lines – no BF



Schedule P – short tail v long tail – no BF



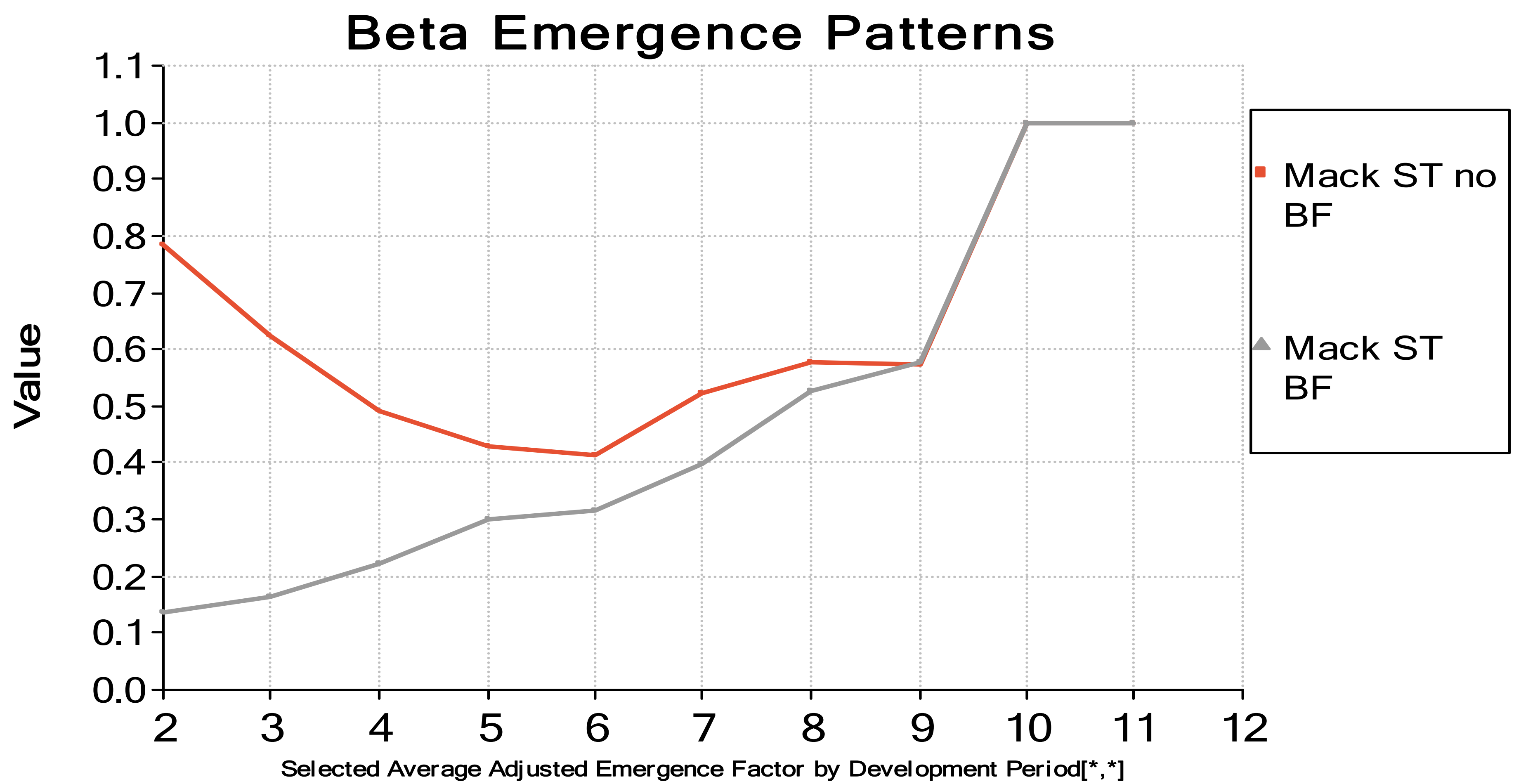
Schedule P – short tail v long tail – no BF



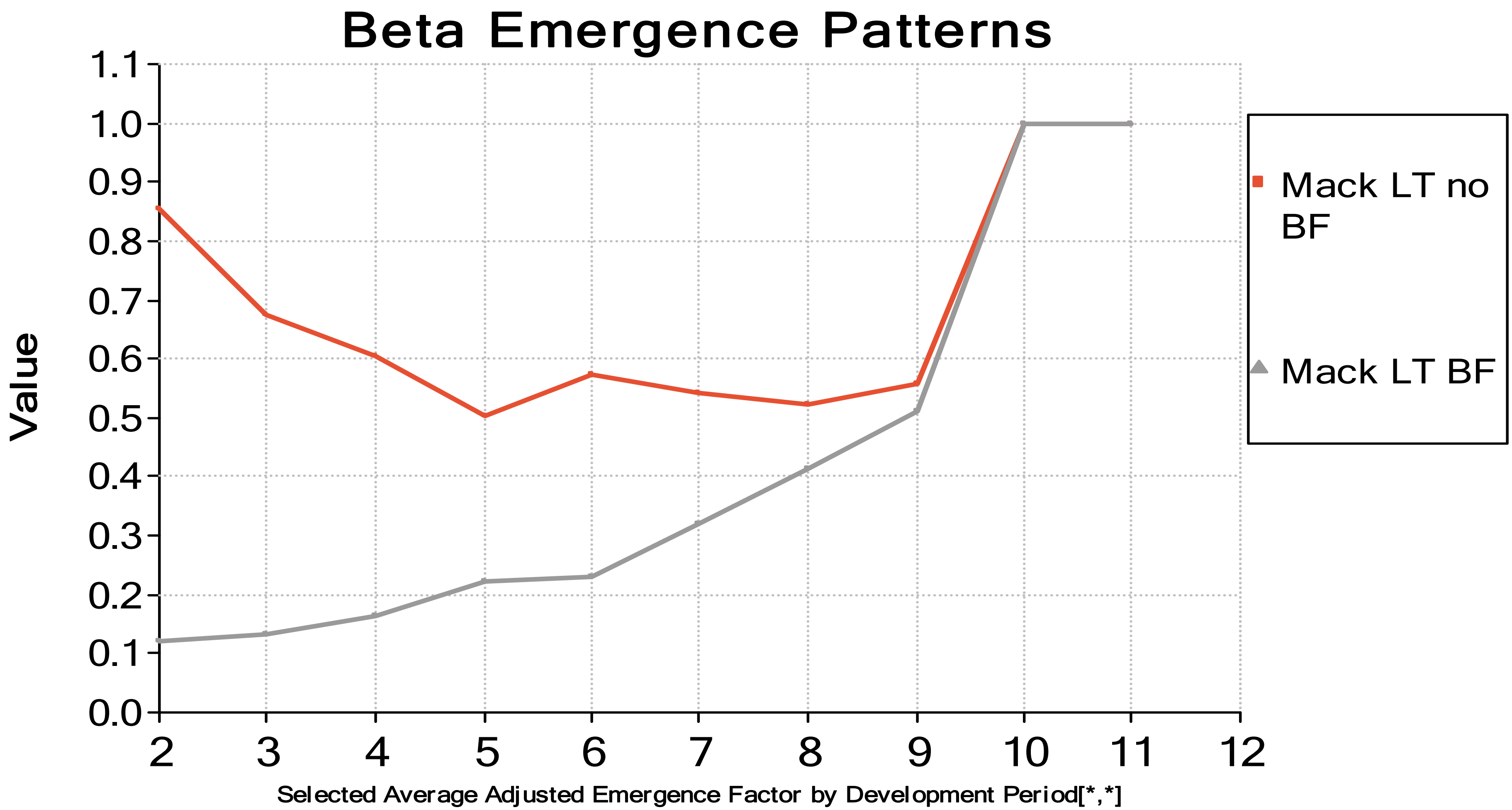
Rank correlations: duration v emergence factor (Mack)

Development Period	Beta		Alpha	
	BF	no BF	BF	no BF
2	-20%	15%	-94%	-38%
3	-29%	28%	-89%	-39%
4	-50%	67%	-76%	8%
5	-62%	60%	-78%	-45%
6	-58%	75%	-8%	28%
7	-60%	-32%	-66%	-54%
8	-80%	-41%	-14%	2%
9	-70%	-22%	-25%	-17%

Schedule P – short tail – BF v no BF



Schedule P – long tail – BF v no BF



Summary of Observations

- Beta patterns are smoother than alpha patterns
- Beta patterns show clearer relationships (see below) than alpha patterns
- Without BF adjustment
  - Beta patterns show clear U shape
  - Longer tail lines tend to have higher values
- With BF adjustment
  - Pattern starts low and increases with the development period
  - Longer tail lines tend to have lower values
- Patterns with and without the BF adjustment converge

Industry view: Why would you use emergence patterns?

- When AiB doesn’t work
- Data
- Expert judgement
- Dependencies
- Single method
- Other risks
- Consistency
- Transparency and communication
- Model efficiency

Reserve Risk under Solvency II…

Actually, it's not all about the CDR…

Other considerations

Reserve setting and re-reserving for technical liabilities

At each accounting date the following balance / reserves for future cashflows are required:

- Gross Outstanding Claims Provisions
  - Claims;
  - Premiums;
  - Expenses;
- RI Outstanding Claims Provisions
  - Claims;
  - Premiums;
  - Expenses
- Bad Debt Outstanding Claims Provisions

- Gross Premium Provisions
  - Claims;
  - Premiums;
  - Expenses;
- RI Premium Provisions
  - Claims;
  - Premiums;
  - Expenses
- Bad Debt Premium Provisions

Questions or comments?

Expressions of individual views by members of The Actuarial Profession and its staff are encouraged.

The views expressed in this presentation are those of the presenters.