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IFRS 17 Risk Adjustments, and Risk Margins using the Cost-of-Capital approach: Estimating Future Capital Requirements

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GIRO 2017, Edinburgh

Agenda

- Part 1 – Techniques for risk adjustments using a risk measure applied to a given risk profile (ie distribution)

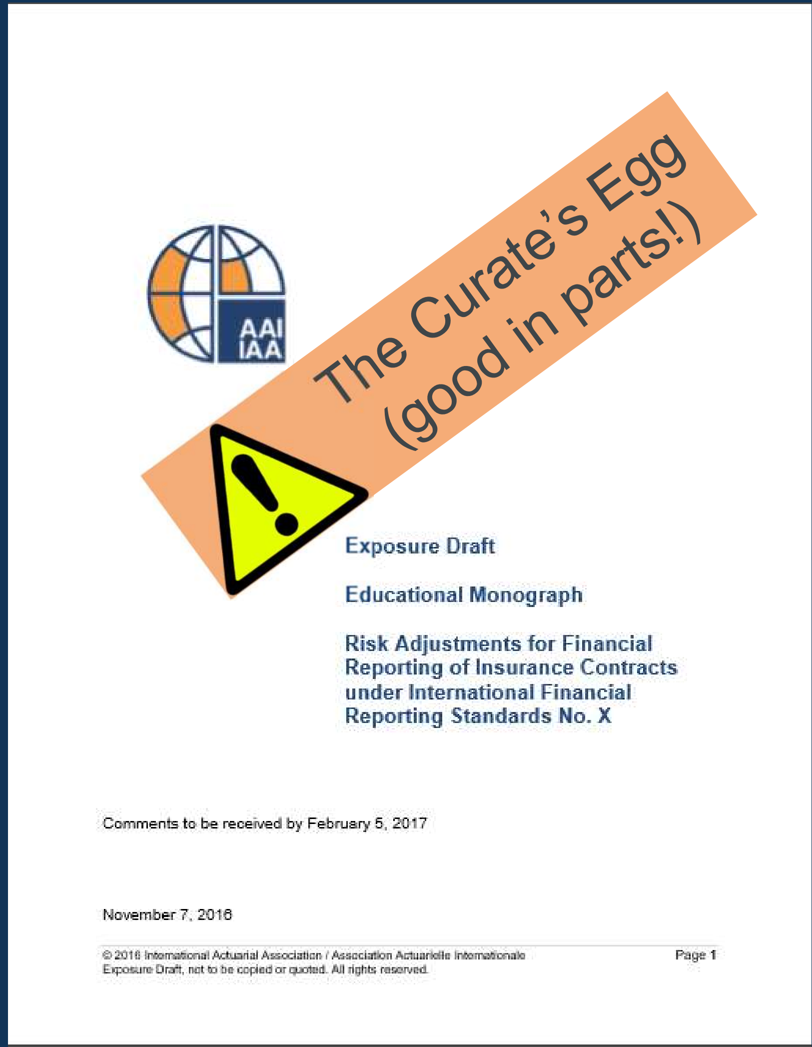
- Part 2 – The Cost-of-Capital approach for risk adjustments: obtaining future capital amounts given an opening capital amount

- Part 3 – Obtaining equivalence between the Cost-of-Capital approach, and approaches using a risk measure applied to a given risk profile

IFRS 17: Insurance Contracts

"IFRS 17 does not specify the estimation technique(s) used to determine the risk adjustment for non-financial risk." (B91)

"Paragraph 119 requires an entity that uses a technique other than the confidence level technique for determining the risk adjustment for non-financial risk to disclose the technique used and the confidence level corresponding to the results of that technique." (B92)



Exposure Draft

Educational Monograph

Risk Adjustments for Financial Reporting of Insurance Contracts under International Financial Reporting Standards No. X

Comments to be received by February 5, 2017

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IFRS 17 Risk Adjustment Methodology

- Four general methods have been proposed *:
  - Confidence level (Value at Risk)
  - Conditional Tail Expectation (Tail Value at Risk)
  - Proportional Hazards Transform (see IAA Monograph Section 3)
  - Cost-of-Capital
- Note: Wright (1997) proposed using Wang's proportional hazards transform for calculating a prudential margin (ie risk adjustment)
  - Wright, T.S. (1997). Probability Distribution of Outstanding Liability from Individual Payments Data. *Claims Reserving Manual, 2,* Institute of Actuaries

** See IAA Monograph, for example*

- The first three specify a risk measure applied to a risk profile (distribution)
- Unfortunately the risk profile is not defined
- Let's assume it is the distribution of discounted fulfilment cash flows
- This implies the traditional actuarial "ultimo" view over the lifetime of the liabilities, not the one year view of Solvency II
- The cost-of-capital method requires a basis for estimating initial capital requirements, and subsequent capital-requirements over the lifetime of the liabilities
  - It also requires a basis for the cost of capital rate, and yield curve for discounting the costs of capital
- The basis for capital requirements is not specified
  - Neither are the bases for cost-of-capital rate nor discount rate

IFRS 17 Risk Adjustment Methodology

- VaR, TVaR and PHT are related and all require the same risk profile (distribution). Once that risk profile is obtained, all can be calculated easily (in a simulation environment)
- All 3 can be expressed as a weighted average of the simulations, but with different weights
- Bootstrapping/MCMC techniques (with copulae for applying dependencies) are useful for obtaining the risk profile

- Given a simulated distribution with 10,000 simulations, sort the simulations in ascending order, then calculate a weighted average where:
  - VaR at a given percentile: there is a single weight at the simulation representing the percentile ("confidence") level, zero elsewhere.
  - TVaR at a given percentile: all simulations above the given percentile are given equal weight, with zero elsewhere.
  - PHT with a given parameter: each simulation has a different weight, where the weights are monotonically increasing
- The IFRS 17 risk adjustment is then the risk measure less the mean

Mathematical Description of PHT Risk Measure

For a non-negative loss random variable X, with survival function $S(X)$ such that

$$S_X(u) = Pr\{X > u\} = 1 - Pr\{X \leq u\}$$

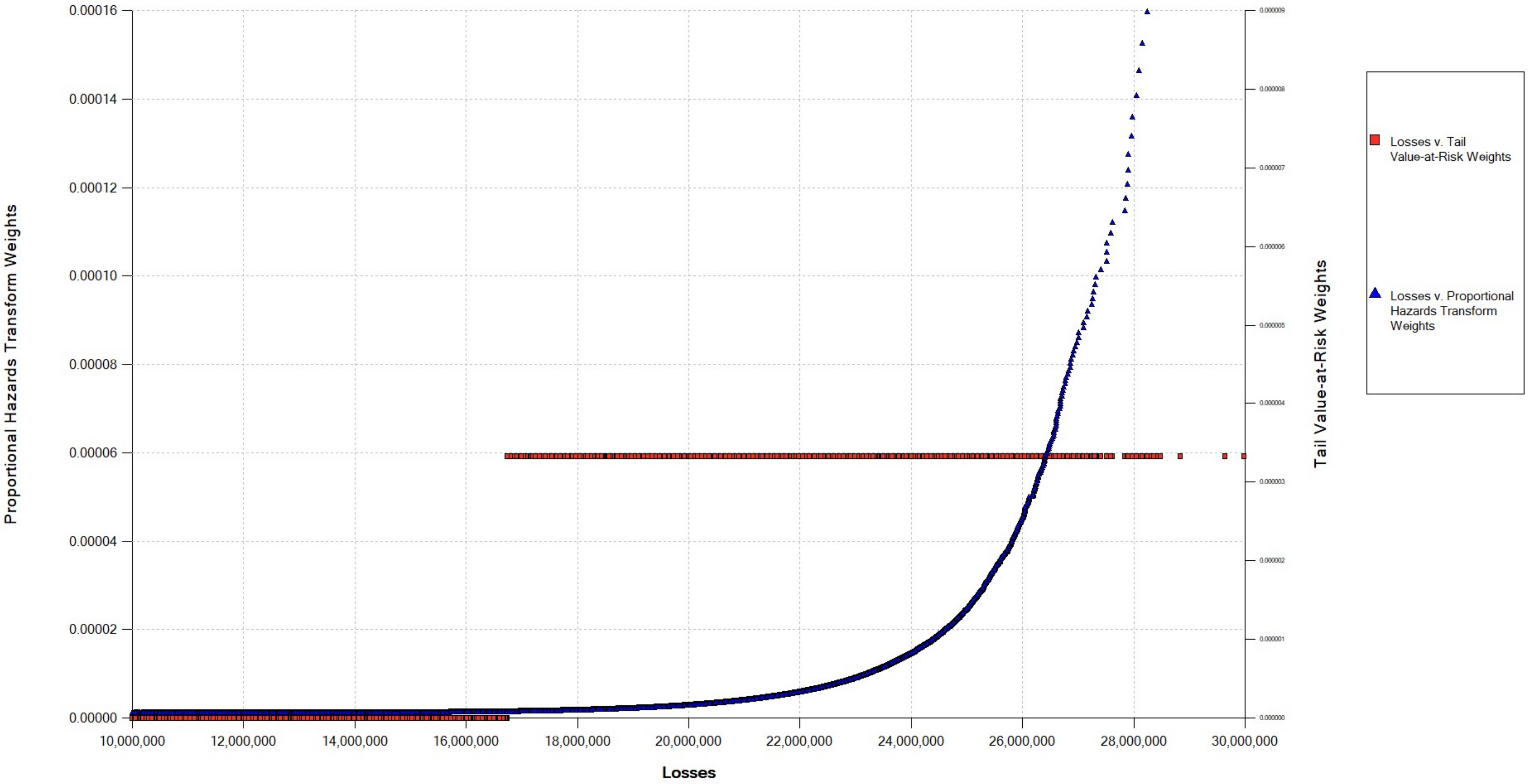
Then $E[X] = \int_0^\infty S_X(u)du$

The *PH-mean* with parameter ρ is given by $H_\rho(X)$ where

$$H_\rho(X) = \int_0^\infty [S_X(u)]^{1/\rho} du \qquad \text{(for } \rho \geq 1\text{)}$$

where the *PH-mean* refers to the expected value under the transformed distribution.

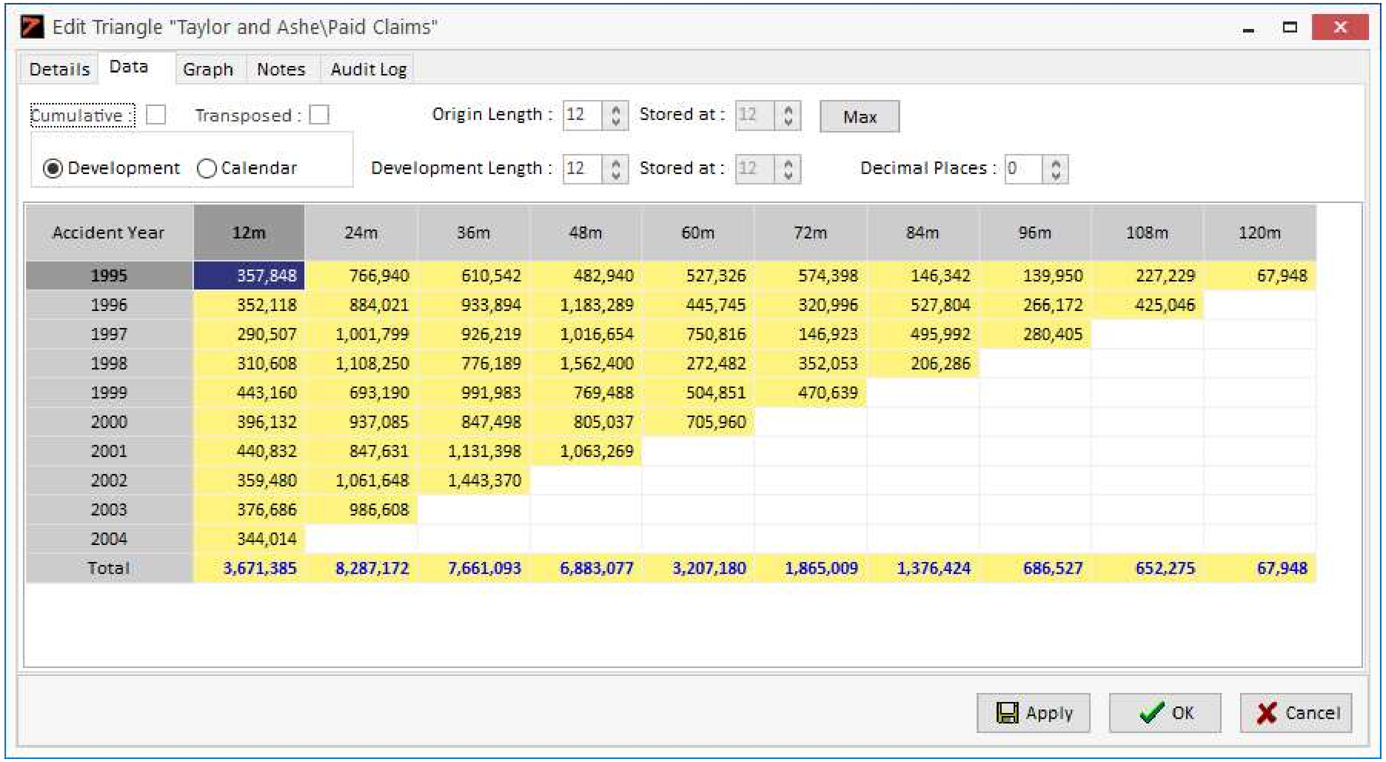
PHT and TVaR Weights against Value



VaR, TVaR and PHT: Characteristics

- Value at Risk
  - VaR is from a single simulation. As such, it could be subject to considerable volatility (especially at higher percentiles). Some users take an average of a few values either side.
  - Has a range from the minimum to the maximum simulated values
  - Some commentators observe that VaR does not adequately pick up skewness/extremes
  - VaR is NOT a coherent risk measure, and does not obey the sub-additivity property, so it is not generally useful for allocations to lower levels
- Tail Value at Risk
  - Uses equal weights above a given percentile level
  - Potentially better at catching skewness/extremes
  - Note it is still an *equal* weight above a given percentile
  - Has a range from the mean to the maximum simulated value
  - TVaR is a coherent risk measure, and as such obeys the sub-additivity property, so is potentially useful for allocations to lower levels
- Proportional Hazards Transform
  - Uses increasing weights across all simulations
  - Better at catching skewness/extremes
  - Has a range from the mean to the maximum simulated value
  - PHT is a coherent risk measure, and as such obeys the sub-additivity property, so is potentially useful for allocations to lower levels

Example: Taylor and Ashe Data



Accident Year	12m	24m	36m	48m	60m	72m	84m	96m	108m	120m
1995	357,848	766,940	610,542	482,940	527,326	574,398	146,342	139,950	227,229	67,948
1996	352,118	884,021	933,894	1,183,289	445,745	320,996	527,804	266,172	425,046	
1997	290,507	1,001,799	926,219	1,016,654	750,816	146,923	495,992	280,405		
1998	310,608	1,108,250	776,189	1,562,400	272,482	352,053	206,286			
1999	443,160	693,190	991,983	769,488	504,851	470,639				
2000	396,132	937,085	847,498	805,037	705,960					
2001	440,832	847,631	1,131,398	1,063,269						
2002	359,480	1,061,648	1,443,370							
2003	376,686	986,608								
2004	344,014									
Total	3,671,385	8,287,172	7,661,093	6,883,077	3,207,180	1,865,009	1,376,424	686,527	652,275	67,948

- Apply standard chain ladder model, no tail
- Bootstrap Mack's model*
- 500,000 simulations
- Parametric bootstrapping with gamma estimation and process distributions

** England, PD and Verrall, RJ (2006).*

For ease of exposition, we only consider the distribution of outstanding losses. We do not consider other elements of the fulfilment cash flows, nor unexpired exposures

Example: Taylor and Ashe Data
Undiscounted Results

Edit Bootstrap Method: "Taylor and Ashe\DFM Paid Claims Ultimate - Bootstrap Mack Discounted"

Details | Residuals | Simulation | Results | Output | Notes | Audit Log

Unscaled Results | Targets | Scaled Results | Discounting | Discounted Results | Diagnostics | Consolidation

Summary | Detail | Cashflow Summary | Cashflow Detail | Aggregates | Origin Correlations | Cumulative Probability | Probability Density | Reserve Development | Ultimates Graph

☑ Show Mack prediction errors

Accident Year	Latest	Expected Reserve	Prediction Error	Prediction Error%	Expected Ultimate	DFM Reserve	Reserve Difference	Mack Prediction Error	Mack Prediction Error%	Bootstrap - Mack Pred. Error	Bootstrap - Mack Pred. Error%
1995	3,901,463	0	0	0.00%	3,901,463	0	0	0	79.82%	0	-79.82%
1996	5,339,085	94,595	75,648	79.97%	5,433,680	94,634	-39	75,535	79.82%	113	0.15%
1997	4,909,315	469,236	121,622	25.92%	5,378,551	469,511	-275	121,699	25.92%	-77	0.00%
1998	4,588,268	709,804	133,411	18.80%	5,298,072	709,638	166	133,549	18.82%	-137	-0.02%
1999	3,873,311	984,792	261,311	26.53%	4,858,103	984,889	-97	261,406	26.54%	-95	-0.01%
2000	3,691,712	1,418,769	410,643	28.94%	5,110,481	1,419,459	-690	411,010	28.96%	-367	-0.01%
2001	3,483,130	2,178,778	557,417	25.58%	5,661,908	2,177,641	1,137	558,317	25.64%	-900	-0.05%
2002	2,864,498	3,920,657	875,944	22.34%	6,785,155	3,920,301	356	875,328	22.33%	617	0.01%
2003	1,363,294	4,279,332	971,783	22.71%	5,642,626	4,278,972	359	971,258	22.70%	525	0.01%
2004	344,014	4,625,888	1,366,322	29.54%	4,969,902	4,625,811	77	1,363,155	29.47%	3,167	0.07%
Total	**34,358,090**	**18,681,850**	**2,450,608**	**13.12%**	**53,039,940**	**18,680,856**	**994**	**2,447,095**	**13.10%**	**3,513**	**0.02%**

Simulate | Apply | OK | Cancel

Example: Taylor and Ashe Data
Discounted @ 3%

Edit Bootstrap Method: "Taylor and Ashe\DFM Paid Claims Ultimate - Bootstrap Mack Discounted"

Details | Residuals | Simulation | Results | Output | Notes | Audit Log

Unscaled Results | Targets | Scaled Results | Discounting | Discounted Results | Diagnostics | Consolidation

Summary | Detail | Cashflow Summary | Cashflow Detail | Aggregates | Origin Correlations | Cumulative Probability | Probability Density | Reserve Development | Ultimates Graph

☐ Show Mack prediction errors

Accident Year	Latest	Expected Reserve	Prediction Error	Prediction Error%	Expected Ultimate	DFM Reserve	Reserve Difference
1995	3,901,463	0	0	0.00%	3,901,463	0	0
1996	5,339,085	93,207	74,539	79.97%	5,432,292	94,634	-1,427
1997	4,909,315	459,668	118,489	25.78%	5,368,983	469,511	-9,843
1998	4,588,268	683,549	127,119	18.60%	5,271,817	709,638	-26,089
1999	3,873,311	937,568	252,569	26.94%	4,810,879	984,889	-47,320
2000	3,691,712	1,334,743	393,455	29.48%	5,026,455	1,419,459	-84,716
2001	3,483,130	2,033,670	526,120	25.87%	5,516,800	2,177,641	-143,970
2002	2,864,498	3,656,588	819,346	22.41%	6,521,086	3,920,301	-263,713
2003	1,363,294	3,956,230	893,241	22.58%	5,319,524	4,278,972	-322,742
2004	344,014	4,227,221	1,239,600	29.32%	4,571,235	4,625,811	-398,589
Total	**34,358,090**	**17,382,445**	**2,249,658**	**12.94%**	**51,740,535**	**18,680,856**	**-1,298,410**

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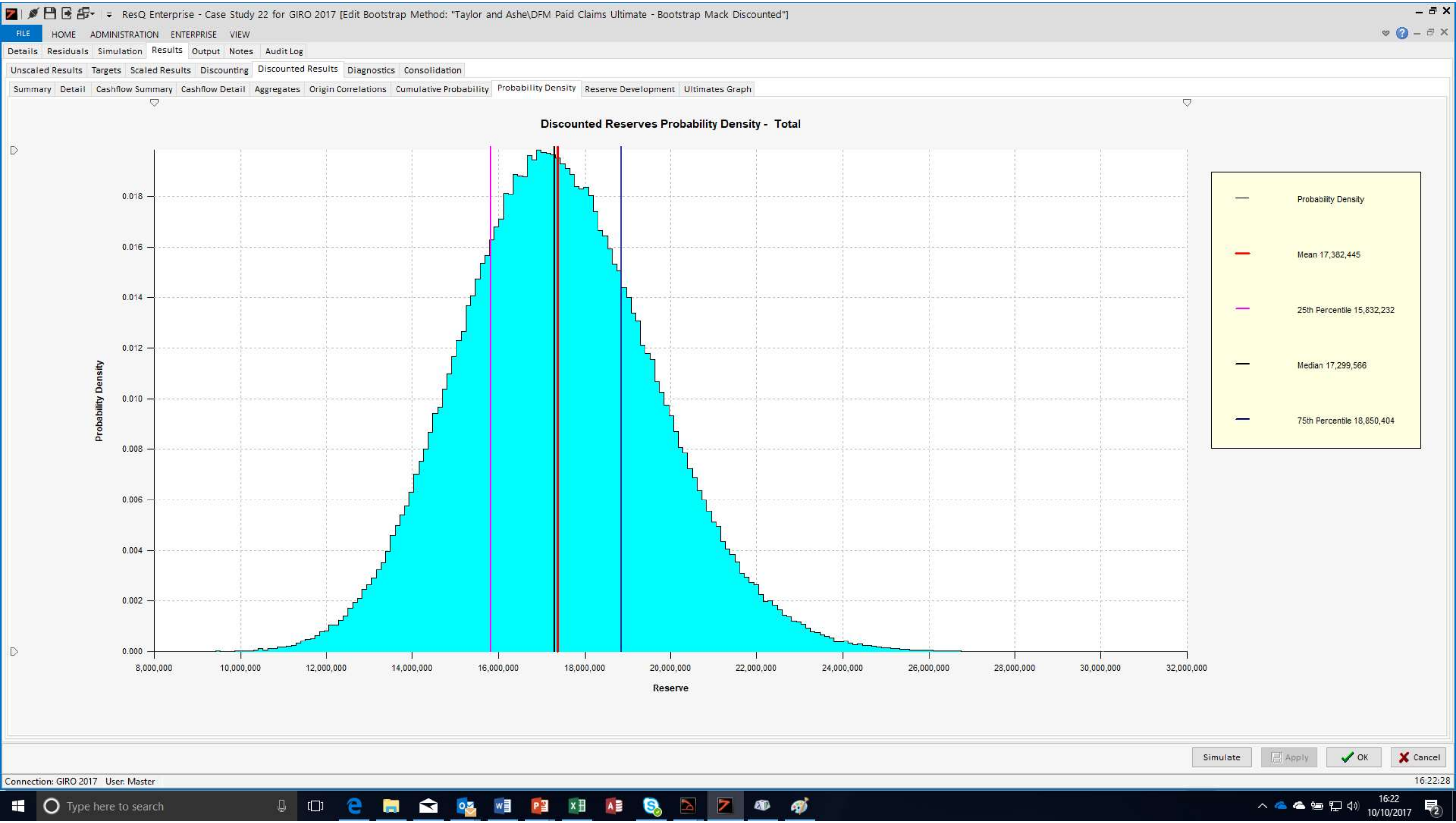
ResQ Enterprise - Case Study 22 for GIRO 2017 [Edit Bootstrap Method: "Taylor and Ashe\DFM Paid Claims Ultimate - Bootstrap Mack Discounted"]
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Residuals
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Results
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Audit Log
Unscaled Results
Targets
Scaled Results
Discounting
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Diagnostics
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Summary
Detail
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VaR, TVaR and PHT: Example

	Value at Risk	Tail Value at Risk	Proportional Hazards Transform
Risk Tolerance *	75.00%	40.00%	1.85
Best Estimate (Disc)	17,382,445	17,382,445	17,382,445
Risk Adjustment	1,467,959	1,431,203	1,456,272
Total	18,850,404	18,813,648	18,838,717
Risk Adjustment %	8.45%	8.23%	8.38%

** Risk tolerances selected to give approximately similar results only*

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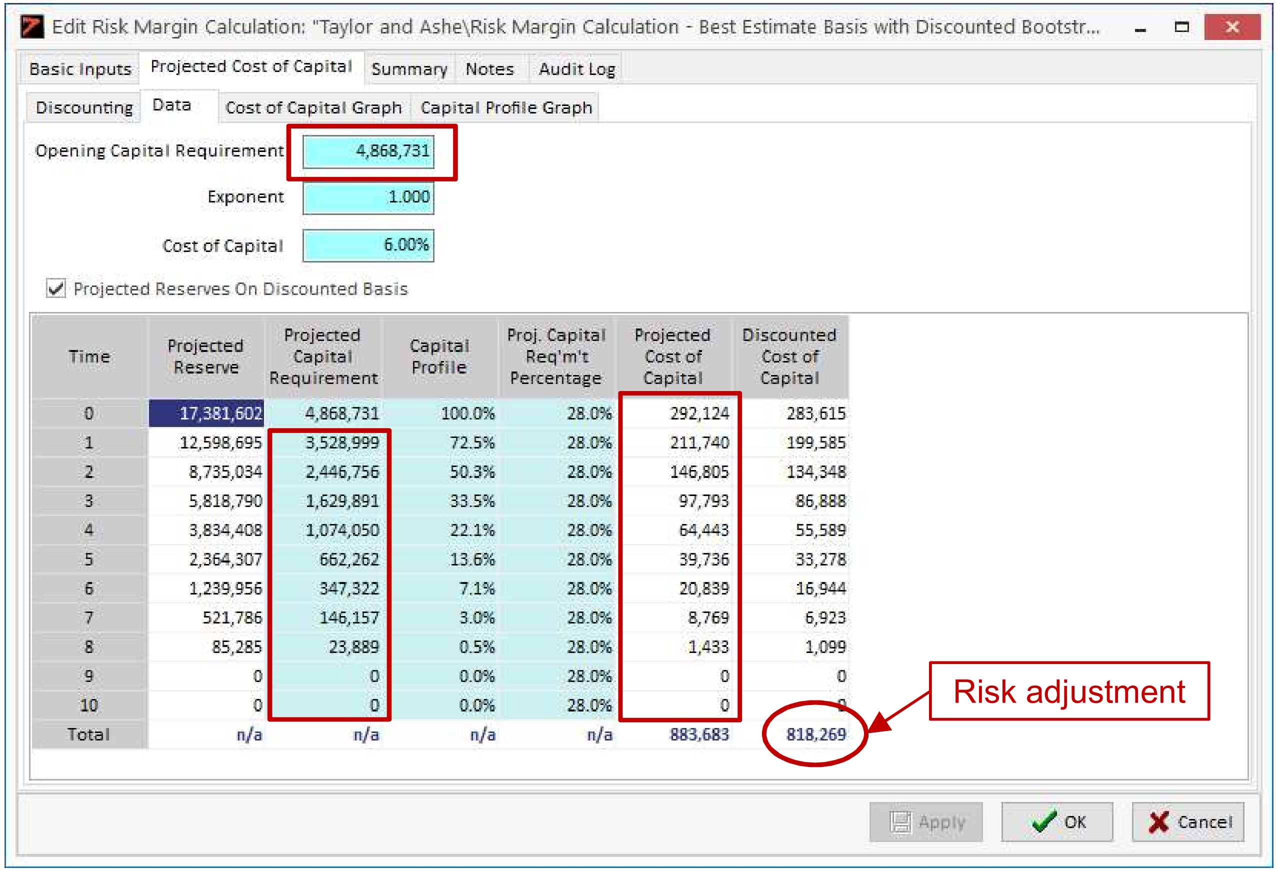
Cost-of-Capital Risk Adjustment/Margins

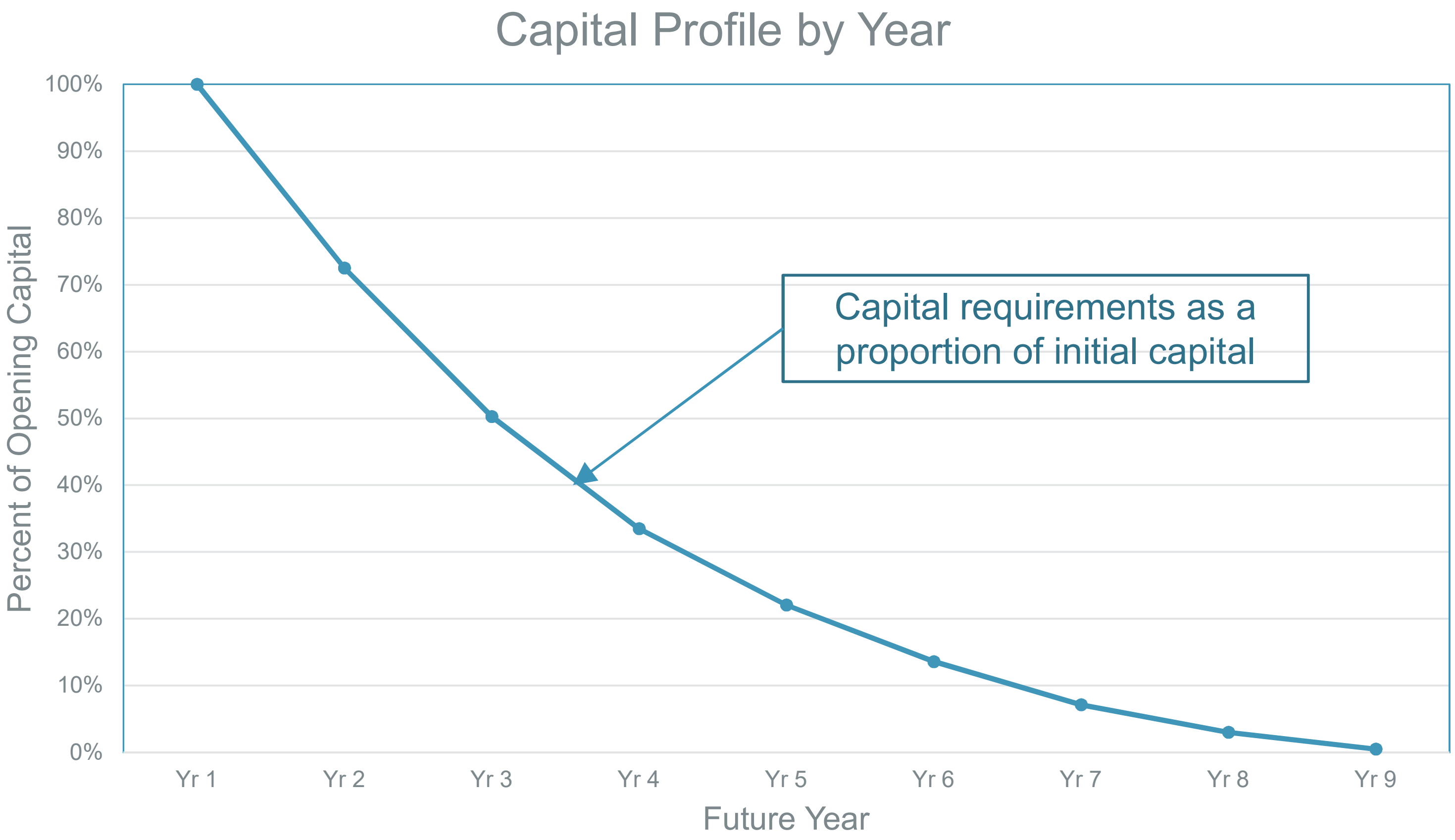
Cost-of-Capital Risk Margins: Example

1. Obtain opening capital requirement
2. Obtain future capital requirements
3. Multiply by assumed cost-of-capital rate (above risk-free rate) to give projected cost-of-capital
4. Discount and sum



Time	Projected Reserve	Projected Capital Requirement	Capital Profile	Proj. Capital Req'm't Percentage	Projected Cost of Capital	Discounted Cost of Capital
0	17,381,602	4,868,731	100.0%	28.0%	292,124	283,615
1	12,598,695	3,528,999	72.5%	28.0%	211,740	199,585
2	8,735,034	2,446,756	50.3%	28.0%	146,805	134,348
3	5,818,790	1,629,891	33.5%	28.0%	97,793	86,888
4	3,834,408	1,074,050	22.1%	28.0%	64,443	55,589
5	2,364,307	662,262	13.6%	28.0%	39,736	33,278
6	1,239,956	347,322	7.1%	28.0%	20,839	16,944
7	521,786	146,157	3.0%	28.0%	8,769	6,923
8	85,285	23,889	0.5%	28.0%	1,433	1,099
9	0	0	0.0%	28.0%	0	0
10	0	0	0.0%	28.0%	0	0
Total	n/a	n/a	n/a	n/a	883,683	818,269

The Capital Profile
"Best estimate" basis



Cost-of-Capital Risk Margins
Obtaining the opening capital requirement

- Method 1: Use a simulation based capital model
  - Under Solvency II, this is for running off the existing reserves, and unexpired exposures, ignoring asset risk
- Method 2: For Solvency II, use the Standard Formula
  - Again, this is for running off the existing reserves, and unexpired exposures, ignoring asset risk
- Method 3: Use a risk measure applied to the distribution of the profit/loss on reserves over a 1 yr period
  - Eg. For Solvency II, VaR @ 99.5% applied to the distribution of the claims development result (CDR)
- Method 4: Use a risk measure applied to the distribution of outstanding future cash flows over their lifetime
  - Eg. VaR at a high percentile applied to the distribution of the outstanding future cash-flows

Cost-of-Capital Risk Margins:
Obtaining the future capital requirements

- Method 1: Use a simulation based capital model
  - Run the model repeatedly, changing the assumptions as the reserves run-off
- Method 2: For Solvency II, use the Standard Formula
  - Again, apply the formula repeatedly, changing the assumptions as the reserves run-off
- Method 3: Use a proxy
  - Eg given an initial capital amount, calculate future capital requirements in proportion to the development of the "best estimate"

- PRA Supervisory Statement SS5/14 (April 2014):
  - *"Firms should not approximate the future Solvency Capital Requirements used to calculate the risk margin as proportional to the projected best estimate unless this has been shown not to lead to a material misstatement of technical provisions."*
- Some companies make an arbitrary adjustment to increase capital as a percentage of reserves as the reserves run-off
  - Is there a good basis for such an adjustment?

The One-Year Ahead Run-off Result
(Undiscounted)

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

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

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

Obtaining future capital requirements

So what is a good approximation?

- Merz-Wüthrich (2008): Prediction error of the claims development result (CDR)
  - Derived formulae for the standard deviation of the profit/loss over a one year horizon
  - Used the same assumptions as Mack's model over the lifetime of the liabilities
  - Useful for Solvency II
- Merz-Wüthrich (2014): The full picture
  - Extended their formulae to give the standard deviation of the profit/loss over a sequence of one year horizons until the liabilities are extinguished
  - Allows the lifetime view to be partitioned into a sequence of 1 year views, which is a fascinating result
- M-W considered setting capital (hence risk margins) using SD or Variance risk measures, and compared to the "best estimate" approximation
- They provided a "risk margin" profile, showing how a sequence of risk margins would deteriorate over time under the three approaches
- But VaR @ 99.5% is more appropriate under Solvency II
- Unfortunately the M-W formulae only consider the SD of the CDR, so what do we do?
- Simulate, and use the "actuary-in-the-box" approach recursively.

Description of the "Actuary-in-the-box" approach

1. Given the opening reserve triangle, simulate all future claim payments to ultimate using bootstrap (or Bayesian MCMC) techniques.

2. Now forget that we have already simulated what the future holds.

3. Move one year ahead. Augment the opening reserve triangle by one diagonal, that is, by the simulated payments from step 1 in the next calendar year only. An actuary only sees what emerges in the year.

4. For each simulation, estimate the (expected) outstanding liabilities, conditional only on what has emerged to date. (The future is still "unknown").

5. A reserving methodology is required for each simulation – an "actuary-in-the-box" is required*. We call this re-reserving.

6. For each simulation, calculate the difference between the estimated ultimate claims one-year ahead and the estimated ultimate claims at the start of the year. This is called the claims development result (a.k.a. the run-off result, or simply profit/loss on the reserves)

** The term "actuary-in-the-box" was coined by Esbjörn Ohlsson*

The Run-Off Result Using Bootstrapping

- Note that with the “Actuary-in-the-box” approach, we have a causal chain:

- The “actuary-in-the-box” uses the same settings for re-reserving as the original model at the start of the chain, allowing the method to be generalised beyond the chain ladder model used by Merz-Wüthrich (and also giving a distribution of the CDR, not just a standard deviation)

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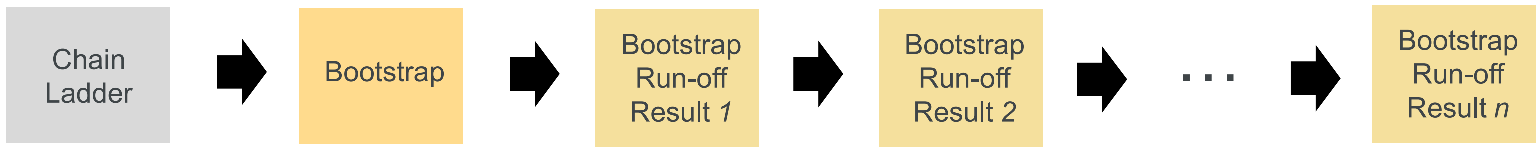
Example

10 October 2017

Recursive Run-Off Results Using Bootstrapping

- The Actuary-in-the-box process can be repeated at future time horizons beyond 1 year:



- We can collect the standard deviations of the CDRs for each year ahead, and create a full table across all future years. This leads to an interesting result (for the chain ladder model)…

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Example

Results from Applying the M-W Formulae

Standard deviation of a sequence of 1 Yr ahead CDRs

	Future Period									
Accident Period	FY 1	FY 2	FY 3	FY 4	FY 5	FY 6	FY 7	FY 8	FY 9	Sqrt(Sum of Squares)	Mack St. Err.
AY 1											
AY 2	75,535									75,535	75,535
AY 3	105,309	60,996								121,698	121,699
AY 4	79,846	91,093	56,232							133,549	133,549
AY 5	235,115	60,577	82,068	51,474						261,407	261,406
AY 6	318,427	233,859	57,825	82,433	51,999					411,009	411,010
AY 7	361,089	328,989	243,412	59,162	85,998	54,343				558,317	558,317
AY 8	629,681	391,249	359,352	266,320	64,443	94,166	59,533			875,328	875,328
AY 9	588,662	554,574	344,763	318,493	236,576	56,543	83,645	52,965		971,258	971,258
AY 10	1,029,925	538,726	511,118	317,142	293,978	218,914	51,661	77,317	49,055	1,363,155	1,363,155
Total	**1,778,968**	**1,177,727**	**885,178**	**607,736**	**428,681**	**267,503**	**128,557**	**96,764**	**49,055**	**2,447,095**	**2,447,095**

Results from Applying the “Actuary-in-the-Box”

Standard deviation of a sequence of 1 Yr ahead CDRs

	Future Period										
Accident Period	FY 1	FY 2	FY 3	FY 4	FY 5	FY 6	FY 7	FY 8	FY 9	Sqrt(Sum of Squares)	Mack St. Err.
AY 1											
AY 2	75,648									75,648	75,648
AY 3	105,367	60,886								121,694	121,622
AY 4	80,004	91,037	56,196							133,590	133,411
AY 5	235,031	60,605	82,136	51,474						261,359	261,311
AY 6	318,042	233,925	57,922	82,621	52,036					410,805	410,643
AY 7	360,456	328,504	243,435	59,163	86,055	54,250				557,632	557,417
AY 8	630,439	392,007	360,203	266,596	64,500	94,216	59,698			876,666	875,944
AY 9	588,080	554,967	345,154	318,752	237,005	56,679	83,682	53,065		971,475	971,783
AY 10	1,031,456	540,295	513,208	318,563	294,733	219,839	52,058	77,578	49,241	1,366,395	1,366,322
Total	**1,779,509**	**1,179,316**	**887,310**	**609,061**	**430,002**	**268,439**	**128,951**	**97,085**	**49,241**	**2,449,725**	**2,450,608**

Results Comparison

Ratio of simulation based SD and formula based SD

Accident Period	Future Period FY 1	FY 2	FY 3	FY 4	FY 5	FY 6	FY 7	FY 8	FY 9	Sqrt(Sum of Squares)	Mack St. Err.
AY 1											
AY 2	100.2%									100.2%	100.2%
AY 3	100.1%	99.8%								100.0%	99.9%
AY 4	100.2%	99.9%	99.9%							100.0%	99.9%
AY 5	100.0%	100.0%	100.1%	100.0%						100.0%	100.0%
AY 6	99.9%	100.0%	100.2%	100.2%	100.1%					100.0%	99.9%
AY 7	99.8%	99.9%	100.0%	100.0%	100.1%	99.8%				99.9%	99.8%
AY 8	100.1%	100.2%	100.2%	100.1%	100.1%	100.1%	100.3%			100.2%	100.1%
AY 9	99.9%	100.1%	100.1%	100.1%	100.2%	100.2%	100.0%	100.2%		100.0%	100.1%
AY 10	100.1%	100.3%	100.4%	100.4%	100.3%	100.4%	100.8%	100.3%	100.4%	100.2%	100.2%
Total	**100.0%**	**100.1%**	**100.2%**	**100.2%**	**100.3%**	**100.3%**	**100.3%**	**100.3%**	**100.4%**	**100.1%**	**100.1%**

Results from Applying the “Actuary-in-the-Box”

Value at Risk @ 99.5% of 1 Yr ahead CDRs

(Obtained using minus the 0.5th percentile of the distribution of the CDR at each time period)

Accident Period	Future Period FY 1	FY 2	FY 3	FY 4	FY 5	FY 6	FY 7	FY 8	FY 9
AY 1									
AY 2	195,445								
AY 3	274,132	157,161							
AY 4	208,646	237,838	145,347						
AY 5	622,286	157,868	215,113	134,032					
AY 6	847,663	619,676	150,891	215,088	134,798				
AY 7	963,673	875,128	641,692	153,812	224,561	140,861			
AY 8	1,707,440	1,054,445	962,241	707,010	169,250	248,062	156,094		
AY 9	1,619,833	1,520,197	929,218	860,693	633,913	149,633	220,954	139,089	
AY 10	2,993,318	1,522,633	1,434,921	880,000	811,236	603,022	140,511	209,369	132,721
Total	**4,868,731**	**3,161,151**	**2,376,627**	**1,626,023**	**1,144,731**	**717,806**	**338,957**	**257,370**	**132,721**

An advantage of the simulation approach is that we have a full distribution of the CDRs, from which we can obtain any statistic of interest.

A further advantage is that the procedure can be generalised beyond the chain ladder model

Setting Capital and Obtaining a “Capital Profile”

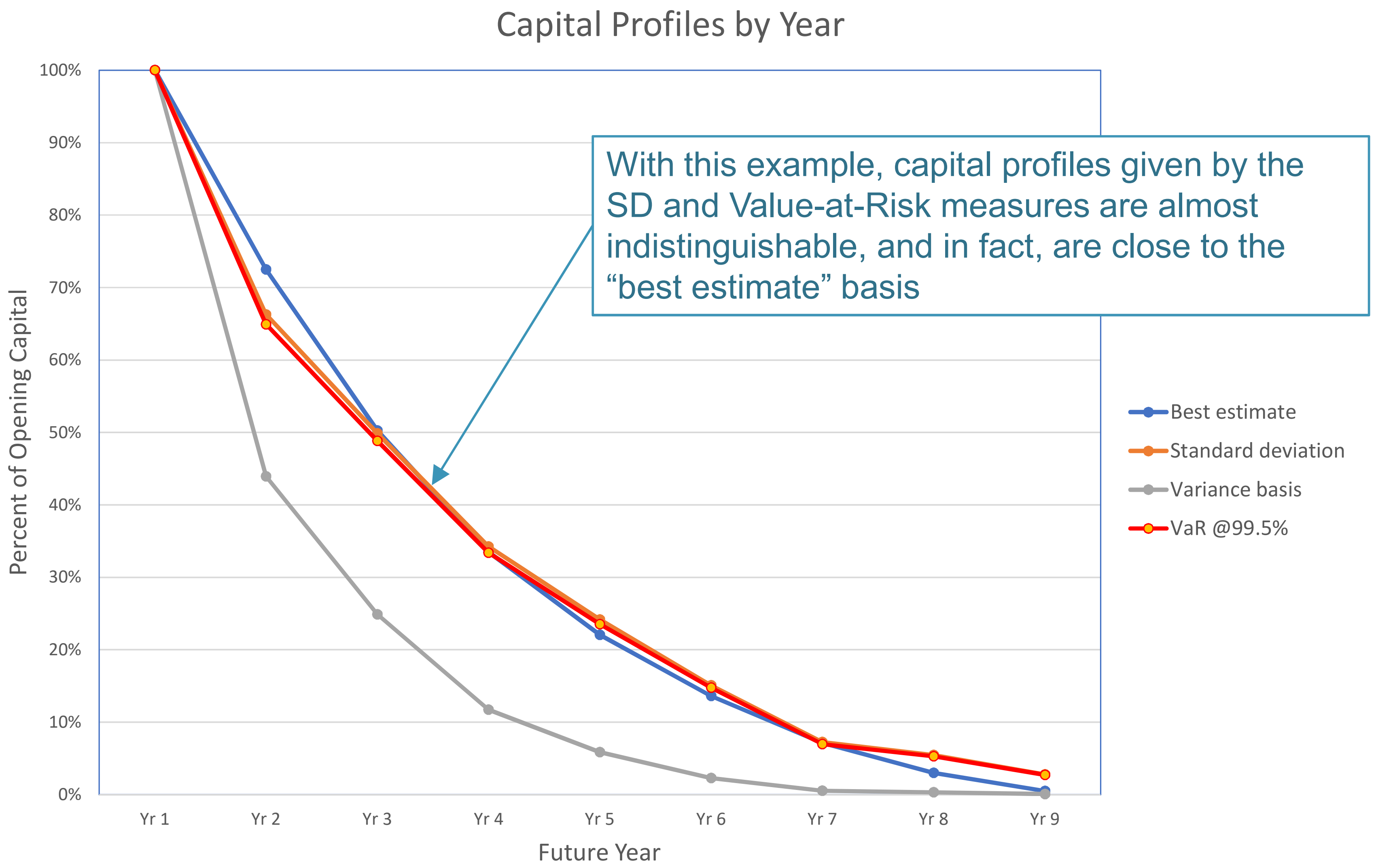
- From a theoretical perspective, setting capital requires 4 items:
  - Risk profile
  - Risk measure
  - Risk tolerance criterion
  - Time horizon
- For example, given a distribution of profit/loss over one year (or beyond):
  - Value at Risk @ *y*%
  - Multiple k_1 of standard deviation
  - Multiple k_2 of variance
  - *Etc*
- Or replace distribution of profit/loss with distribution of net assets
- (Merz-Wüthrich (2014) used multiples of SD and variance applied to the distribution of the CDR)

Obtaining a “Capital Profile”

Capital Amounts *	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5	Yr 6	Yr 7	Yr 8	Yr 9
Best Estimate	4,868,731	3,528,999	2,446,755	1,629,891	1,074,050	662,262	347,322	146,157	23,889
Standard deviation	4,868,731	3,226,604	2,427,678	1,666,389	1,176,485	734,447	352,811	265,624	134,725
Variance	4,868,731	2,138,334	1,210,505	570,344	284,287	110,791	25,566	14,492	3,728
VaR @99.5%	4,868,731	3,161,151	2,376,627	1,626,023	1,144,731	717,806	338,957	257,370	132,721

Capital Profile	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5	Yr 6	Yr 7	Yr 8	Yr 9
Best Estimate	100%	72%	50%	33%	22%	14%	7%	3%	0%
Standard deviation	100%	66%	50%	34%	24%	15%	7%	5%	3%
Variance	100%	44%	25%	12%	6%	2%	1%	0%	0%
VaR @99.5%	100%	65%	49%	33%	24%	15%	7%	5%	3%

** Opening capital for ‘best estimate’ basis set to be same as VaR @ 99.5%. Multiples of SD and Variance set to give same opening capital as VaR @ 99.5%, however, the mutipliers are irrelevant since they cancel when creating the ‘capital profile’*



With this example, capital profiles given by the SD and Value-at-Risk measures are almost indistinguishable, and in fact, are close to the "best estimate" basis

Cost-of-Capital Risk Margin

‘Best Estimate’ Basis

Edit Risk Margin Calculation: "Taylor and Ashe\Risk Margin Calculation - Best Estimate Basis"

Basic Inputs | Projected Cost of Capital | Summary | Notes | Audit Log

Discounting | Data | Cost of Capital Graph | Capital Profile Graph

Opening Capital Requirement: 4,868,731

Exponent: 1.000

Cost of Capital: 6.00%

☑ Projected Reserves On Discounted Basis

Time	Projected Reserve	Projected Capital Requirement	Capital Profile	Proj. Capital Req'm't Percentage	Projected Cost of Capital	Discounted Cost of Capital
0	17,381,602	4,868,731	100.0%	28.0%	292,124	283,615
1	12,598,695	3,528,999	72.5%	28.0%	211,740	199,585
2	8,735,034	2,446,756	50.3%	28.0%	146,805	134,348
3	5,818,790	1,629,891	33.5%	28.0%	97,793	86,888
4	3,834,408	1,074,050	22.1%	28.0%	64,443	55,589
5	2,364,307	662,262	13.6%	28.0%	39,736	33,278
6	1,239,956	347,322	7.1%	28.0%	20,839	16,944
7	521,786	146,157	3.0%	28.0%	8,769	6,923
8	85,285	23,889	0.5%	28.0%	1,433	1,099
9	0	0	0.0%	28.0%	0	0
10	0	0	0.0%	28.0%	0	0
Total	n/a	n/a	n/a	n/a	883,683	818,269

Apply | OK | Cancel

Cost-of-Capital Risk Margin

Standard Deviation Basis

Edit Risk Margin Calculation: "Taylor and Ashe\Risk Margin Calculation - St Dev Basis"

Basic Inputs | Projected Cost of Capital | Summary | Notes | Audit Log

Discounting | Data | Cost of Capital Graph | Capital Profile Graph

Opening Capital Requirement: 4,868,731

Exponent: 1.000

Cost of Capital: 6.00%

☑ Projected Reserves On Discounted Basis

Time	Projected Reserve	Projected Capital Requirement	Capital Profile	Proj. Capital Req'm't Percentage	Projected Cost of Capital	Discounted Cost of Capital
0	17,381,602	**4,868,731**	100.0%	28.0%	292,124	283,615
1	12,598,695	**3,226,604**	66.3%	25.6%	193,596	182,483
2	8,735,034	**2,427,678**	49.9%	27.8%	145,661	133,300
3	5,818,790	**1,666,389**	34.2%	28.6%	99,983	88,834
4	3,834,408	**1,176,485**	24.2%	30.7%	70,589	60,891
5	2,364,307	**734,447**	15.1%	31.1%	44,067	36,905
6	1,239,956	**352,811**	7.2%	28.5%	21,169	17,212
7	521,786	**265,624**	5.5%	50.9%	15,937	12,581
8	85,285	**134,725**	2.8%	158.0%	8,083	6,195
9	0	0	0.0%	28.0%	0	0
10	0	0	0.0%	28.0%	0	0
Total	n/a	n/a	n/a	n/a	891,210	822,017

Apply | OK | Cancel

Cost-of-Capital Risk Margin
Variance Basis

Edit Risk Margin Calculation: "Taylor and Ashe\Risk Margin Calculation - Variance Basis"

Basic Inputs | Projected Cost of Capital | Summary | Notes | Audit Log

Discounting | Data | Cost of Capital Graph | Capital Profile Graph

Opening Capital Requirement: 4,868,731

Exponent: 1.000

Cost of Capital: 6.00%

☑ Projected Reserves On Discounted Basis

Time	Projected Reserve	Projected Capital Requirement	Capital Profile	Proj. Capital Req'm't Percentage	Projected Cost of Capital	Discounted Cost of Capital
0	17,381,602	**4,868,731**	100.0%	28.0%	292,124	283,615
1	12,598,695	**2,138,334**	43.9%	17.0%	128,300	120,935
2	8,735,034	**1,210,505**	24.9%	13.9%	72,630	66,467
3	5,818,790	**570,344**	11.7%	9.8%	34,221	30,405
4	3,834,408	**284,287**	5.8%	7.4%	17,057	14,714
5	2,364,307	**110,791**	2.3%	4.7%	6,647	5,567
6	1,239,956	**25,566**	0.5%	2.1%	1,534	1,247
7	521,786	**14,492**	0.3%	2.8%	870	686
8	85,285	**3,728**	0.1%	4.4%	224	171
9	0	0	0.0%	28.0%	0	0
10	0	0	0.0%	28.0%	0	0
Total	n/a	n/a	n/a	n/a	553,607	523,808

Apply | OK | Cancel

Cost-of-Capital Risk Margin

Value-at-Risk @ 99.5% Basis

Edit Risk Margin Calculation: "Taylor and Ashe\Risk Margin Calculation - VaR @ 99.5% Basis"

Basic Inputs | Projected Cost of Capital | Summary | Notes | Audit Log

Discounting | Data | Cost of Capital Graph | Capital Profile Graph

Opening Capital Requirement: 4,868,731

Exponent: 1.000

Cost of Capital: 6.00%

☑ Projected Reserves On Discounted Basis

Time	Projected Reserve	Projected Capital Requirement	Capital Profile	Proj. Capital Req'm't Percentage	Projected Cost of Capital	Discounted Cost of Capital
0	17,381,602	4,868,731	100.0%	28.0%	292,124	283,615
1	12,598,695	**3,161,151**	64.9%	25.1%	189,669	178,781
2	8,735,034	**2,376,627**	48.8%	27.2%	142,598	130,497
3	5,818,790	**1,626,023**	33.4%	27.9%	97,561	86,682
4	3,834,408	**1,144,731**	23.5%	29.9%	68,684	59,247
5	2,364,307	**717,806**	14.7%	30.4%	43,068	36,069
6	1,239,956	**338,957**	7.0%	27.3%	20,337	16,536
7	521,786	**257,370**	5.3%	49.3%	15,442	12,190
8	85,285	**132,721**	2.7%	155.6%	7,963	6,103
9	0	0	0.0%	28.0%	0	0
10	0	0	0.0%	28.0%	0	0
Total	n/a	n/a	n/a	n/a	877,447	809,722

Apply | OK | Cancel

Application to Cost-of-Capital Risk Margins

1. For Solvency II at least, VaR @ 99.5% applied to a sequence of distributions of the 1 yr-ahead CDRs is an appropriate risk measure for reserve risk capital requirements
2. A recursive "actuary-in-the-box" approach is suitable for obtaining the distributions
3. However, VaR @ 99.5% is an extreme percentile, and requires a large number of simulations for stability
4. Interestingly, "capital profiles" given by standard deviation and VaR measures are almost indistinguishable
5. A standard deviation measure requires far fewer simulations for stability
6. So use a standard deviation measure as a proxy, instead of VaR @ 99.5%
7. In some cases, an analytic formula giving the SD of the CDRs may be sufficient without simulation at all (eg Merz-Wüthrich: the full picture)
8. Any initial capital amount can be "plugged-in" (eg using a capital model)
9. Then use a "capital profile" obtained using risk measures applied to a sequence of distributions of the CDR to estimate future capital requirements
10. This will be more justifiable than a profile obtained using "best estimates", or could justify using a "best estimate" profile as a proxy

Obtaining Equivalence Between Cost-of-Capital, VaR, TVaR, and PHT approaches

	Cost-of-Capital (Best estimate basis)	Value at Risk	Tail Value at Risk	Proportional Hazards Transform
Risk Tolerance *		65.4%	21.7%	1.85
Best Estimate (Disc)	17,381,682	17,382,445	17,382,445	17,382,445
Risk Adjustment	818,269	818,591	818,344	816,826
Total	18,199,871	18,201,036	18,200,789	18,199,271
Risk Adjustment %	4.71%	4.71%	4.71%	4.70%

* *Risk tolerances selected to give approximately similar results only*

The “confidence level” corresponding to the cost-of-capital technique is 65.4%

With this example, the Cost-of-Capital risk adjustment looks quite low (or the distribution used for the cash-flow risk profile is too wide)

Conclusions

- Approaches to estimating the risk adjustment under IFRS 17 using a risk measure applied to the distribution of fulfilment cash flows are straightforward to apply
  - Given a distribution of the fulfilment cash flows, select a risk measure and risk tolerance level
- The cost-of-capital method is more complex and requires additional variables, assumptions, and sensitivities
  - Opening capital requirement
  - Future capital requirements
  - Cost of capital rate
  - Discount rate
- Note that under IFRS 17, the time horizon for capital is the lifetime of the fulfilment cash flows.
  - This is different from Solvency II, so Solvency II risk margins cannot be used for IFRS 17
  - It could be argued that this affects the estimation of the opening capital requirement only, and an appropriate "capital profile" could then be used to estimate future capital requirements
- Under IFRS 17, the equivalent "confidence level" has to be disclosed anyway, so why bother with the "Cost-of-Capital" approach at all?

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Questions

Comments

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