The 1 year view of reserving risk and risk margins with respect to simulation based capital models

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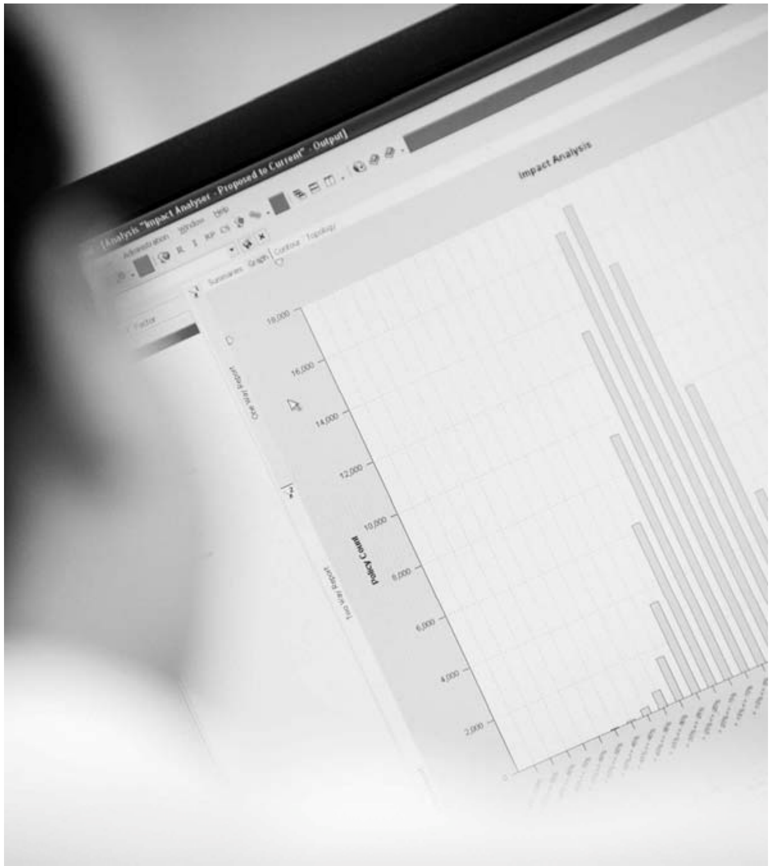
For a paper associated with this presentation, see:
http://www.emb.com/uk/corporate/SolvencyII_ERM.php

Agenda

- Background
- The “cost-of-capital” method for calculating risk margins
- Estimating capital requirements
- Reserve risk:
  - One yr view vs Ultimate view
- Implications for simulation based internal capital models
  - Line of business SCRs
  - The overall SCR
- Observations on QIS4
- A final word
- References



DIRECTIVE OF THE EUROPEAN PARLIAMENT

"The Solvency Capital Requirement corresponds to the economic capital a (re)insurance undertaking needs to hold in order to limit the probability of ruin to 0.5%, i.e. ruin would occur once every 200 years (see Article 101).

The Solvency Capital Requirement is calculated using Value-at-Risk techniques, either in accordance with the standard formula, or using an internal model: all potential losses, including adverse revaluation of assets and liabilities, over the next 12 months are to be assessed. The Solvency Capital Requirement reflects the true risk profile of the undertaking, taking account of all quantifiable risks, as well as the net impact of risk mitigation techniques."

DIRECTIVE OF THE EUROPEAN PARLIAMENT
Article 101

"The Solvency Capital Requirement shall be calibrated so as to ensure that all quantifiable risks to which an insurance or reinsurance undertaking is exposed are taken into account. With respect to existing business, it shall cover unexpected losses.

It shall *correspond* to the Value-at-Risk of the basic own funds of an insurance or reinsurance undertaking subject to a confidence level of 99.5% over a one-year period."

So it seems straightforward to estimate the SCR using a simulation-based model: simply create a simulated distribution of the basic own funds over 1 year, than calculate the VaR @ 99.5%.

"The devil is in the detail…"

DIRECTIVE OF THE EUROPEAN PARLIAMENT
Articles 88 and 75

Article 88

“Basic own funds shall consist of the following items:

(1) the excess of assets over liabilities, valued in accordance with Article 75 and Section 2 ;

(2) subordinated liabilities.”

Article 75

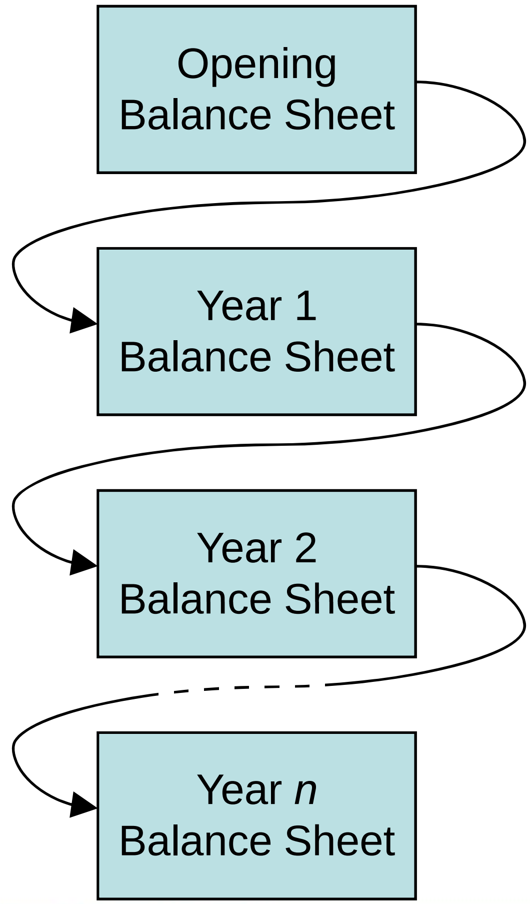
“Member States shall ensure that, unless otherwise stated, insurance and reinsurance undertakings value assets and liabilities as follows:

(a) assets shall be valued at the amount for which they could be exchanged between knowledgeable willing parties in an arm's length transaction;

(b) liabilities shall be valued at the amount for which they could be transferred, or settled, between knowledgeable willing parties in an arm's length transaction.”

A Projected Balance Sheet View

- When projecting Balance Sheets for solvency, we have an opening balance sheet with expected outstanding liabilities
- We then project one year forwards, simulating the payments that emerge in the year
- We then require a closing balance sheet, with (simulated) expected outstanding liabilities conditional on the payments in the year
- In a multi-year model, the closing balance sheet after one year becomes the opening balance sheet in the second year, and so on



Solvency II Requirements
A slight problem

- The Solvency II requirements are worded as an overall company requirement based on a 1 year ahead balance sheet, and in a simulation based internal capital model, the SCR can be found naturally from a simulated balance sheet after 1 year
- However, risk margins are required in the opening balance sheet and the 1 year ahead balance sheet
- To obtain risk margins by Solvency II line of business using the Cost-of-Capital approach, an 'SCR' by line of business is required, even though such a thing does not exist
- So we have to think in terms of overall capital requirements, AND notional (artificial) capital requirements by line of business
- We will try and consider both

The “Cost of Capital” Approach for Calculating Risk Margins

DIRECTIVE OF THE EUROPEAN PARLIAMENT
Article 77

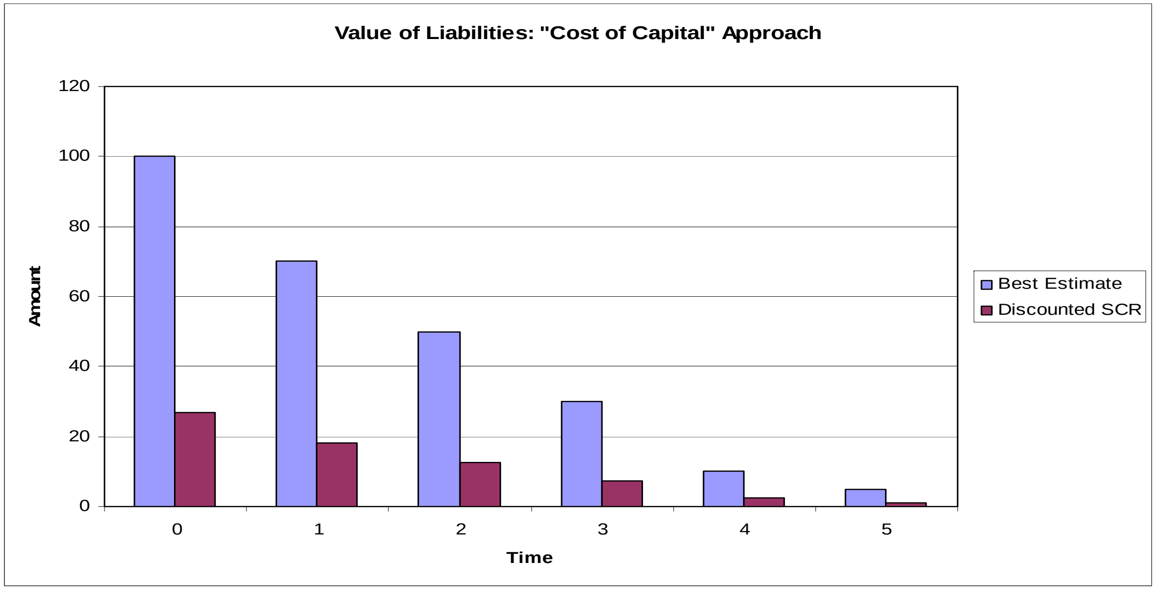
Article 77

"The risk margin shall be such as to ensure that the value of the technical provisions is equivalent to the amount insurance undertakings would be expected to require in order to take over and meet the insurance obligations…"

"… the risk margin shall be calculated by determining the cost of providing an amount of eligible own funds equal to the Solvency Capital Requirement necessary to support the insurance obligations over the lifetime thereof."

So we need an SCR for each future year as the reserves run-off

"Cost of Capital" Approach: Core Components



Sum Discounted (LoB) Capital Requirements (incl. time 0 capital) = 68
Cost of Capital = 6% (*above risk free rate*)
Risk Margin = 68 * 6% = 4.08

The "problem" reduces to estimating the capital requirements at each time point

Risk Margin calculations

Estimating the capital requirements:
A simple proxy

- Estimating the (LoB) capital required (in respect of reserves) at future time periods is not straightforward
- A proxy that has been suggested is to estimate the (LoB) capital required in the first year, then assume the capital required at further time periods is proportional to the outstanding liabilities at that time

- Let CR_0 be the opening capital required for reserving risk
  Let L_0 be the opening best estimate of outstanding liabilities
  Let L_t be the best estimate of outstanding liabilities at time t
- Then $CR_t = \frac{L_t}{L_0} CR_0$

- *So the problem reduces further to estimating the opening (LoB) capital required under this simplification*

Estimating Capital Requirements

Theoretical requirements for estimating capital

Risk Profile ← A distribution of profit/loss?

A distribution of (some definition of) net assets?

Risk Measure ← Standard Deviation?

Value-at-Risk?

Tail Value-at-Risk?

Etc…

Risk Tolerance ← 3 x SD

99.5% VaR

95% TVaR

Time Horizon ← One year?

Ultimate?

Solvency II: Overall SCR
Article 101

Risk Profile

Distribution of basic own funds

Risk Measure

Value-at-Risk

Risk Tolerance

99.5%

Time Horizon

One year

From Article 101

"Capital market consistent" value of liabilities

"Economic" balance sheet

Questions:

Using a formula based approach (eg QIS 4 SCR), with capital charges by risk type which are then aggregated, what is the risk profile? (What is the risk profile for each component?)

Can it be shown that it corresponds to a distribution of basic own funds?

If so, under what assumptions?

If not, does it satisfy Article 101?

Solvency II: Line of business SCRs

This is less clear, but a picture is beginning to emerge!

Risk Profile

Distribution of profit/loss on reserves?

Risk Measure

Value-at-Risk

Risk Tolerance

99.5%

Time Horizon

One year

Requires distribution of *expected* liabilities after 1 year

Profit on reserves after 1 year is called the "claims development result" or "run-off result"

This is different from the usual actuarial view of reserving risk, which looks over the lifetime of the liabilities (*eg* Mack, England & Verrall, Zehnwirth)

The “ultimo” vs the one-year view of reserving risk

The one-year run-off result (undiscounted)
Profit or loss on reserves after one year

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

Then

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

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

The one-year run-off result (undiscounted)
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 (say, VaR @ 99.5%)?
- We want a distribution of the CDR (not just a standard deviation)?

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 (see CP75 and CP71)

The one-year run-off result (undiscounted)
Profit or loss on reserves after one year

For a particular origin year, let:

The opening reserve estimate be R_0

The 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 estimate of the ultimate after one year are $U_0, U_1^{(i)}$

for each simulation *i*.

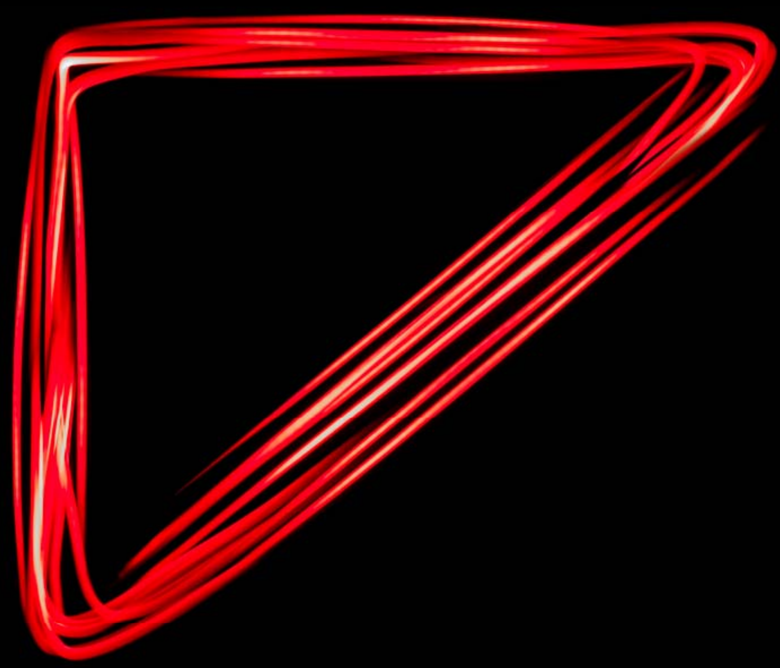
The one-year run-off result in a simulation model

Modus operandi

1. Given the opening reserve triangle, simulate all future claim payments to ultimate using a bootstrap or Bayesian MCMC technique.
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 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 a one-year model, this will underestimate the true volatility at the end of that year (even if the mean across all simulations is correct).

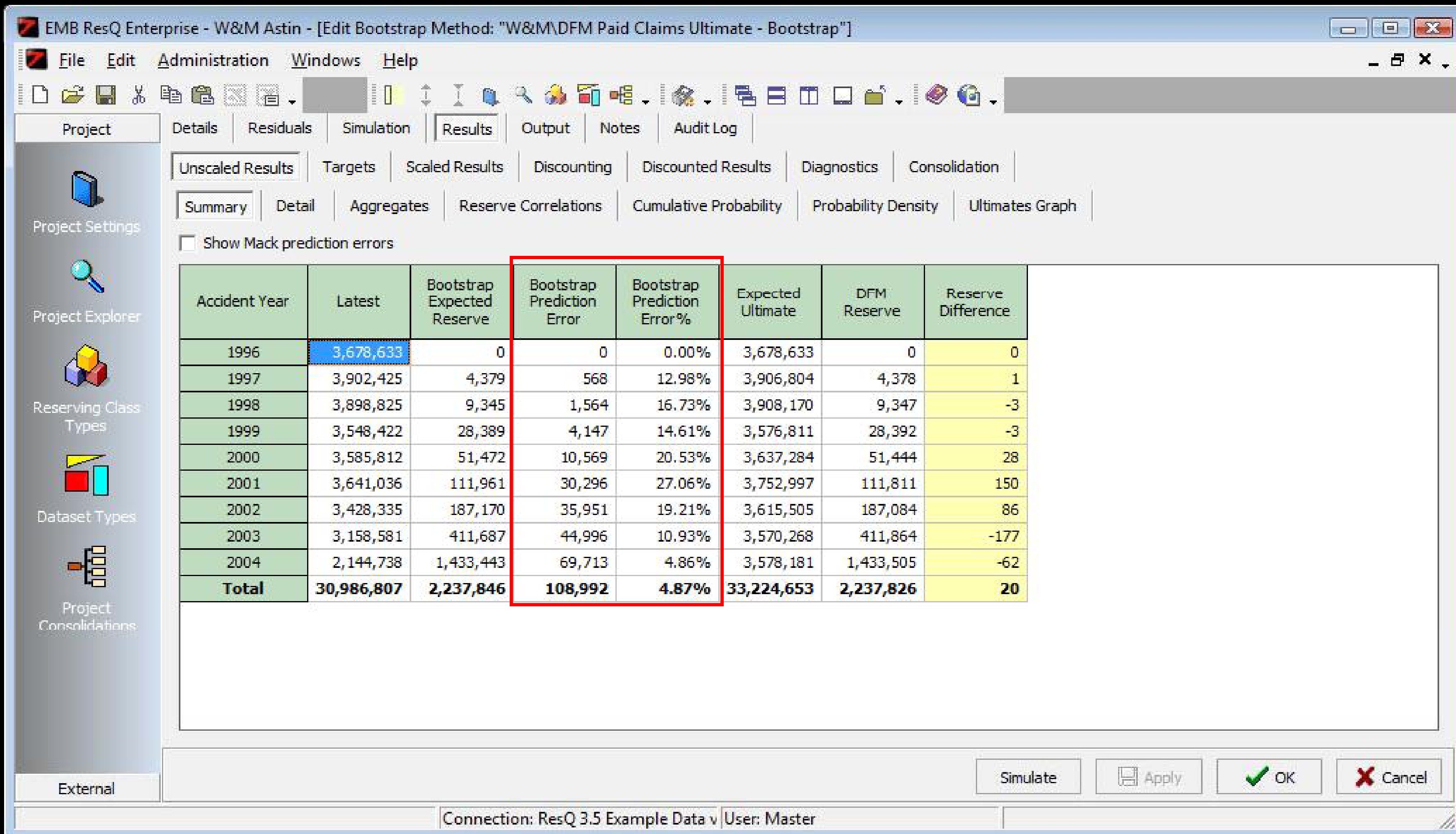
** The term "actuary-in-the-box" was coined by Esbjörn Ohlsson*

EMB ResQ Example



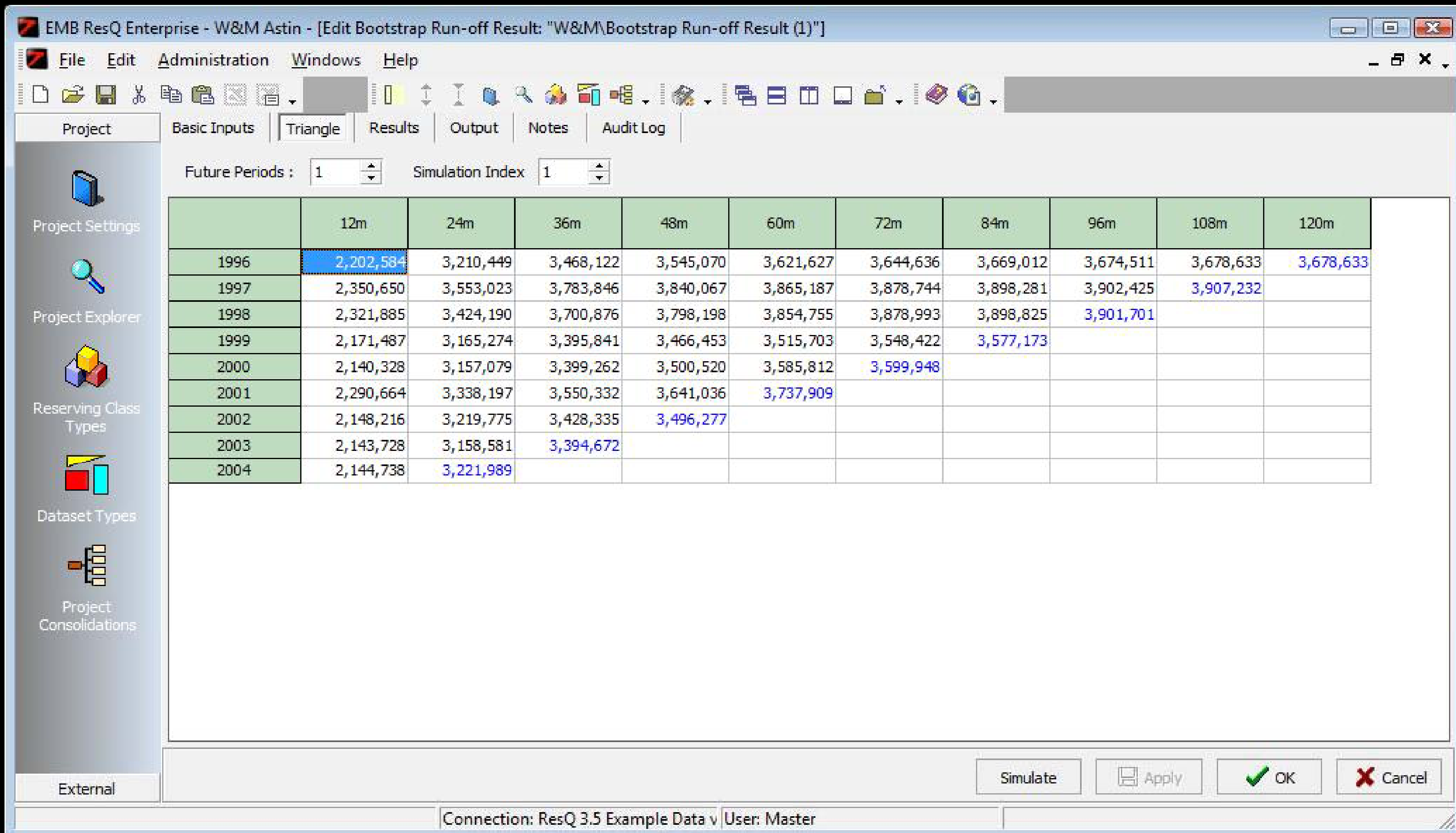
ResQ Example

Bootstrap Results Summary – “Ultimo” perspective



Accident Year	Latest	Bootstrap Expected Reserve	Bootstrap Prediction Error	Bootstrap 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	4,379	568	12.98%	3,906,804	4,378	1
1998	3,898,825	9,345	1,564	16.73%	3,908,170	9,347	-3
1999	3,548,422	28,389	4,147	14.61%	3,576,811	28,392	-3
2000	3,585,812	51,472	10,569	20.53%	3,637,284	51,444	28
2001	3,641,036	111,961	30,296	27.06%	3,752,997	111,811	150
2002	3,428,335	187,170	35,951	19.21%	3,615,505	187,084	86
2003	3,158,581	411,687	44,996	10.93%	3,570,268	411,864	-177
2004	2,144,738	1,433,443	69,713	4.86%	3,578,181	1,433,505	-62
Total	**30,986,807**	**2,237,846**	**108,992**	**4.87%**	**33,224,653**	**2,237,826**	**20**

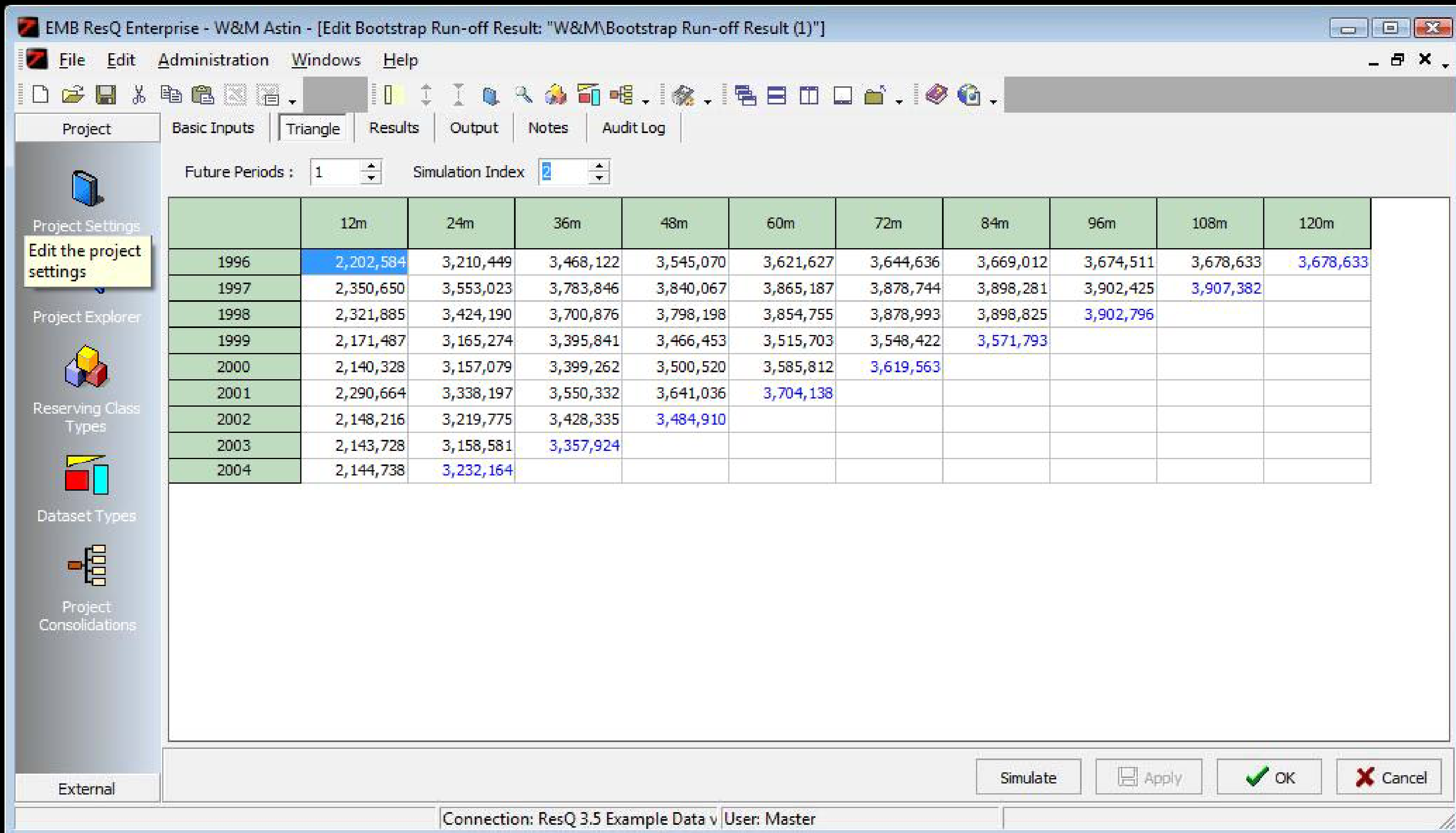
ResQ Example
1 Year ahead – Simulation 1



	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	3,907,232	
1998	2,321,885	3,424,190	3,700,876	3,798,198	3,854,755	3,878,993	3,898,825	3,901,701		
1999	2,171,487	3,165,274	3,395,841	3,466,453	3,515,703	3,548,422	3,577,173			
2000	2,140,328	3,157,079	3,399,262	3,500,520	3,585,812	3,599,948				
2001	2,290,664	3,338,197	3,550,332	3,641,036	3,737,909					
2002	2,148,216	3,219,775	3,428,335	3,496,277						
2003	2,143,728	3,158,581	3,394,672							
2004	2,144,738	3,221,989								

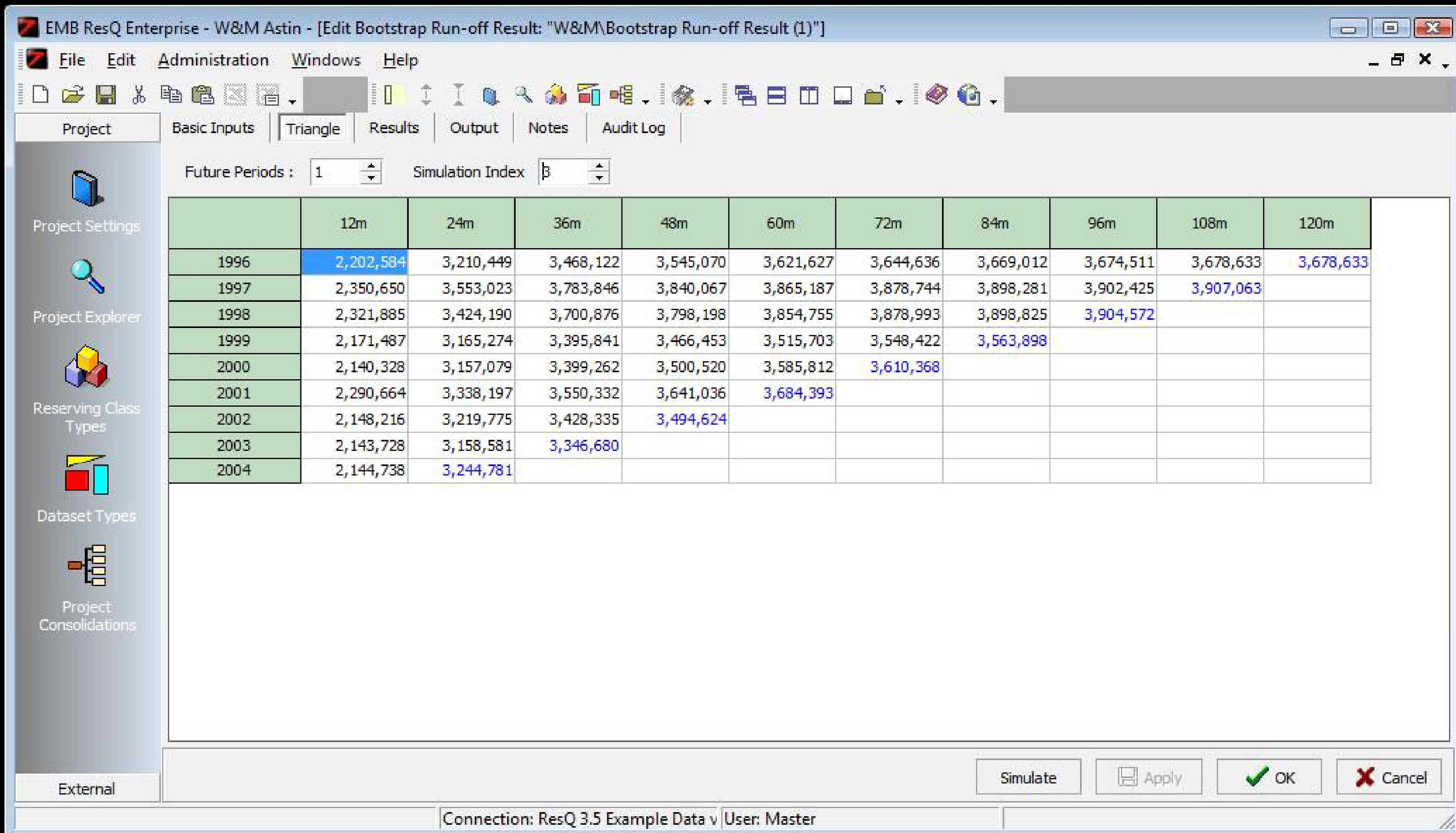
ResQ Example

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	3,907,382	
1998	2,321,885	3,424,190	3,700,876	3,798,198	3,854,755	3,878,993	3,898,825	3,902,796		
1999	2,171,487	3,165,274	3,395,841	3,466,453	3,515,703	3,548,422	3,571,793			
2000	2,140,328	3,157,079	3,399,262	3,500,520	3,585,812	3,619,563				
2001	2,290,664	3,338,197	3,550,332	3,641,036	3,704,138					
2002	2,148,216	3,219,775	3,428,335	3,484,910						
2003	2,143,728	3,158,581	3,357,924							
2004	2,144,738	3,232,164								

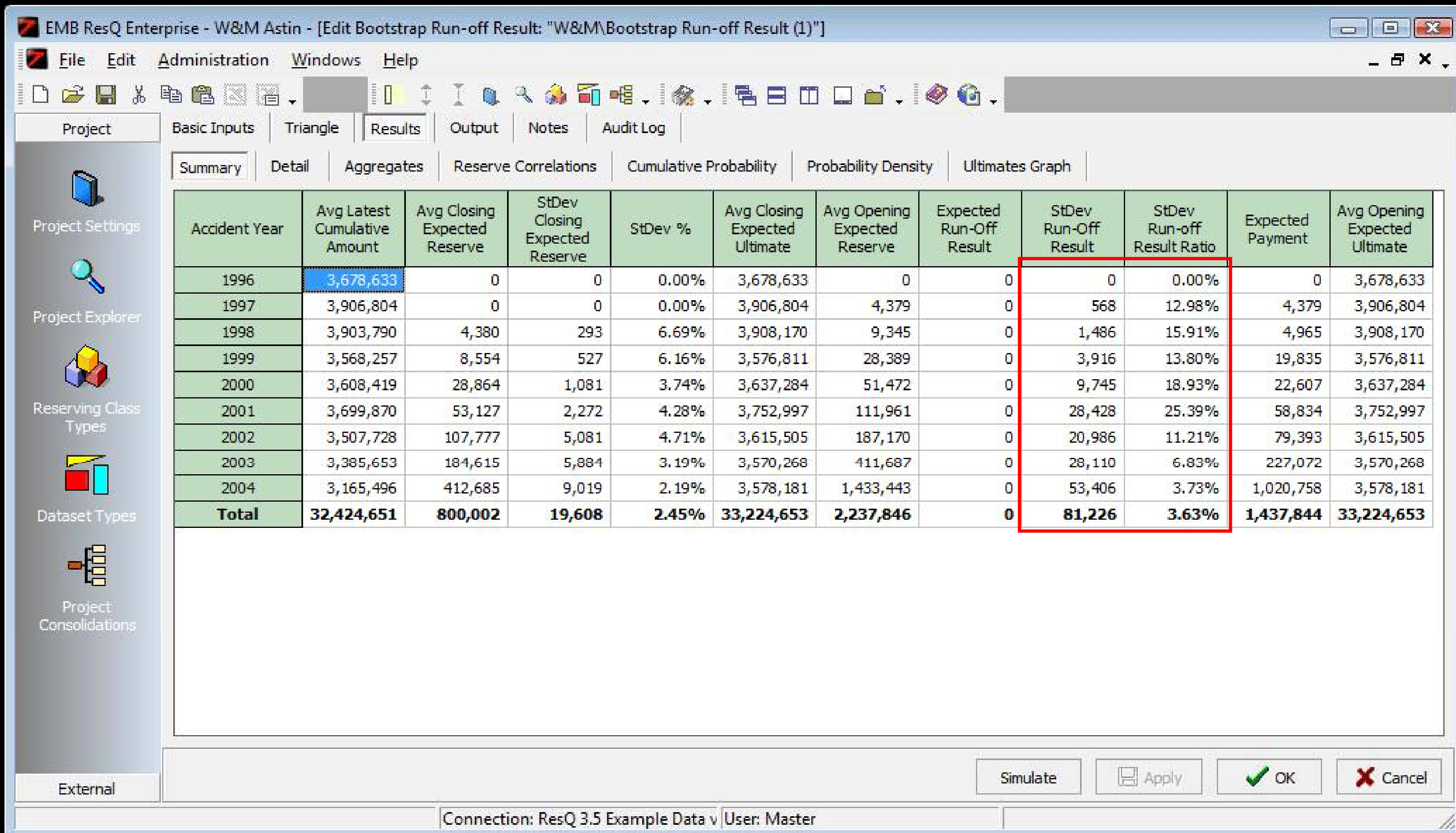
ResQ Example
1 Year ahead – Simulation 3



	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	3,907,063	
1998	2,321,885	3,424,190	3,700,876	3,798,198	3,854,755	3,878,993	3,898,825	3,904,572		
1999	2,171,487	3,165,274	3,395,841	3,466,453	3,515,703	3,548,422	3,563,898			
2000	2,140,328	3,157,079	3,399,262	3,500,520	3,585,812	3,610,368				
2001	2,290,664	3,338,197	3,550,332	3,641,036	3,684,393					
2002	2,148,216	3,219,775	3,428,335	3,494,624						
2003	2,143,728	3,158,581	3,346,680							
2004	2,144,738	3,244,781								

ResQ Example

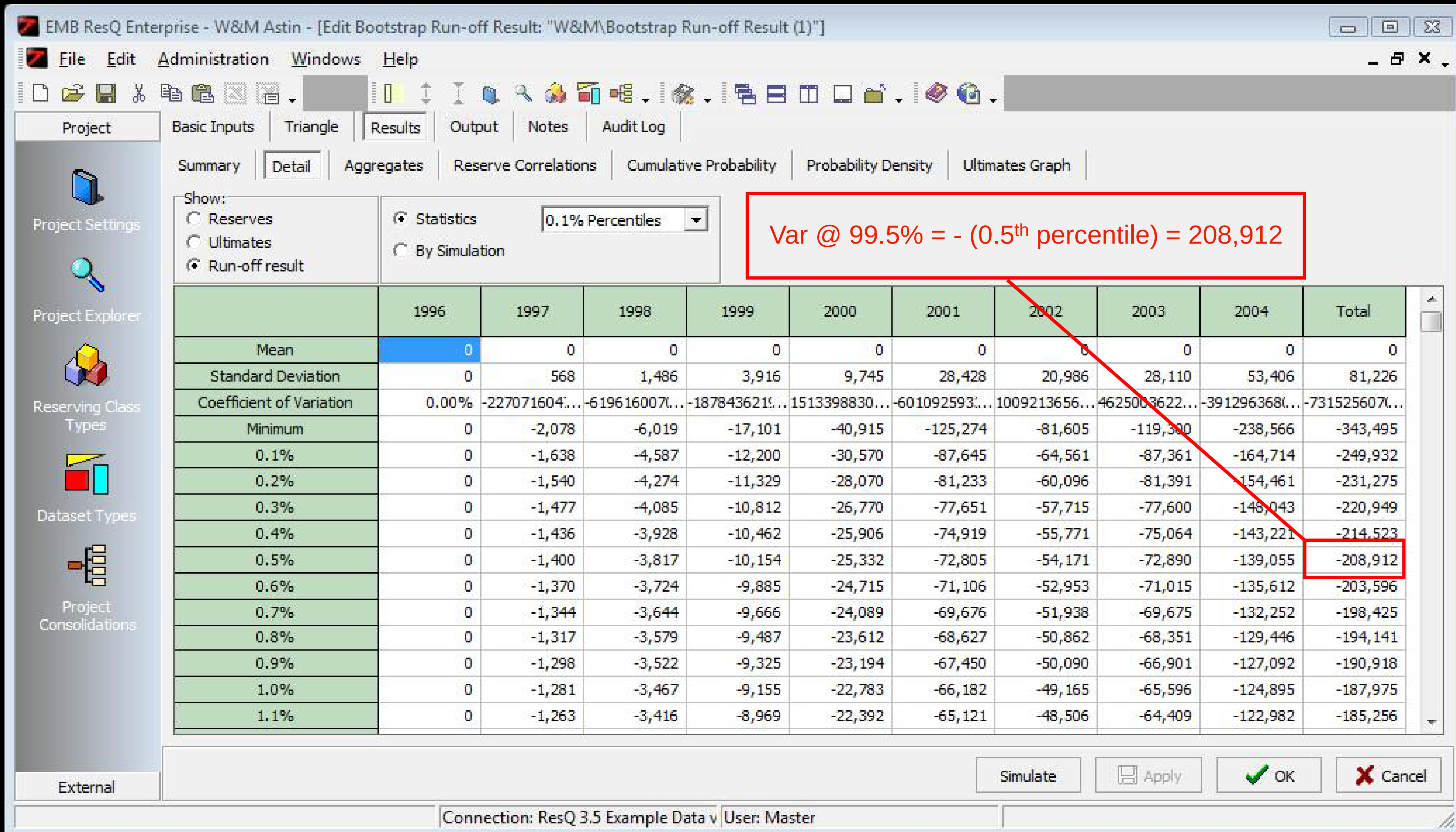
Bootstrap Run-off Results Summary – 1 year perspective



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	3,906,804	0	0	0.00%	3,906,804	4,379	0	568	12.98%	4,379	3,906,804
1998	3,903,790	4,380	293	6.69%	3,908,170	9,345	0	1,486	15.91%	4,965	3,908,170
1999	3,568,257	8,554	527	6.16%	3,576,811	28,389	0	3,916	13.80%	19,835	3,576,811
2000	3,608,419	28,864	1,081	3.74%	3,637,284	51,472	0	9,745	18.93%	22,607	3,637,284
2001	3,699,870	53,127	2,272	4.28%	3,752,997	111,961	0	28,428	25.39%	58,834	3,752,997
2002	3,507,728	107,777	5,081	4.71%	3,615,505	187,170	0	20,986	11.21%	79,393	3,615,505
2003	3,385,653	184,615	5,884	3.19%	3,570,268	411,687	0	28,110	6.83%	227,072	3,570,268
2004	3,165,496	412,685	9,019	2.19%	3,578,181	1,433,443	0	53,406	3.73%	1,020,758	3,578,181
Total	**32,424,651**	**800,002**	**19,608**	**2.45%**	**33,224,653**	**2,237,846**	**0**	**81,226**	**3.63%**	**1,437,844**	**33,224,653**

ResQ Example

99.5th percentile of the Bootstrap Run-off Result



	1996	1997	1998	1999	2000	2001	2002	2003	2004	Total
Mean	0	0	0	0	0	0	0	0	0	0
Standard Deviation	0	568	1,486	3,916	9,745	28,428	20,986	28,110	53,406	81,226
Coefficient of Variation	0.00%	-227071604...	-619616007(...	-187843621...	1513398830...	-601092593...	1009213656...	4625003622...	-391296368(...	-731525607(...
Minimum	0	-2,078	-6,019	-17,101	-40,915	-125,274	-81,605	-119,300	-238,566	-343,495
0.1%	0	-1,638	-4,587	-12,200	-30,570	-87,645	-64,561	-87,361	-164,714	-249,932
0.2%	0	-1,540	-4,274	-11,329	-28,070	-81,233	-60,096	-81,391	-154,461	-231,275
0.3%	0	-1,477	-4,085	-10,812	-26,770	-77,651	-57,715	-77,600	-148,043	-220,949
0.4%	0	-1,436	-3,928	-10,462	-25,906	-74,919	-55,771	-75,064	-143,221	-214,523
0.5%	0	-1,400	-3,817	-10,154	-25,332	-72,805	-54,171	-72,890	-139,055	-208,912
0.6%	0	-1,370	-3,724	-9,885	-24,715	-71,106	-52,953	-71,015	-135,612	-203,596
0.7%	0	-1,344	-3,644	-9,666	-24,089	-69,676	-51,938	-69,675	-132,252	-198,425
0.8%	0	-1,317	-3,579	-9,487	-23,612	-68,627	-50,862	-68,351	-129,446	-194,141
0.9%	0	-1,298	-3,522	-9,325	-23,194	-67,450	-50,090	-66,901	-127,092	-190,918
1.0%	0	-1,281	-3,467	-9,155	-22,783	-66,182	-49,165	-65,596	-124,895	-187,975
1.1%	0	-1,263	-3,416	-8,969	-22,392	-65,121	-48,506	-64,409	-122,982	-185,256

Merz & Wuthrich (2008)

Analytic vs Simulated: Summary

	Analytic Prediction Errors		Simulated Prediction Errors	
Accident Year	1 Year Ahead CDR	Mack Ultimate	1 Year Ahead CDR	Mack Ultimate
0	0	0	0	0
1	567	567	568	568
2	1,488	1,566	1,486	1,564
3	3,923	4,157	3,916	4,147
4	9,723	10,536	9,745	10,569
5	28,443	30,319	28,428	30,296
6	20,954	35,967	20,986	35,951
7	28,119	45,090	28,110	44,996
8	53,320	69,552	53,406	69,713
Total	81,080	108,401	81,226	108,992

Re-reserving in Simulation-based Capital Models

The advantage of investigating the claims development result (using re-reserving) in a simulation environment is that the procedure can be generalised:

- Not just the chain ladder model
- Not just Mack's assumptions
- Can include curve fitting and extrapolation for tail estimation
- Can incorporate a Bornhuetter-Ferguson step
- Can be extended beyond the 1 year horizon to look at multi-year forecasts
- Provides a *distribution* of the CDR, not just a standard deviation
- Can be used to help calibrate Solvency II internal models

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

So on an undiscounted basis we have:

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

If we use discounted reserves, then it gets harder, since we should also take account of allocated investment income (I) on the reserves held during the year:

$$CDR_t^{(i)} = R_{t-1}^{d(i)} + I_t^{(i)} - C_t^{(i)} - R_{t,d}^{d(i)}$$

If we use discounted reserves plus risk margins, then it gets harder still, since we need a risk margin (M) for each simulation conditional on that simulation and time period.

$$CDR_t^{(i)} = \left(R_{t-1}^{d(i)} + M_{t-1}^{(i)}\right) + I_t^{(i)} - C_t^{(i)} - \left(R_{t,d}^{d(i)} + M_t^{(i)}\right)$$

What is appropriate under Solvency II, and how do we use the results?

Line of business capital requirements for risk margin calculations

Line of business SCR

Simulated claims development result (CDR) options

- We need to decide what items are included in the CDR (and which basis), and under what assumptions we can make simplifications

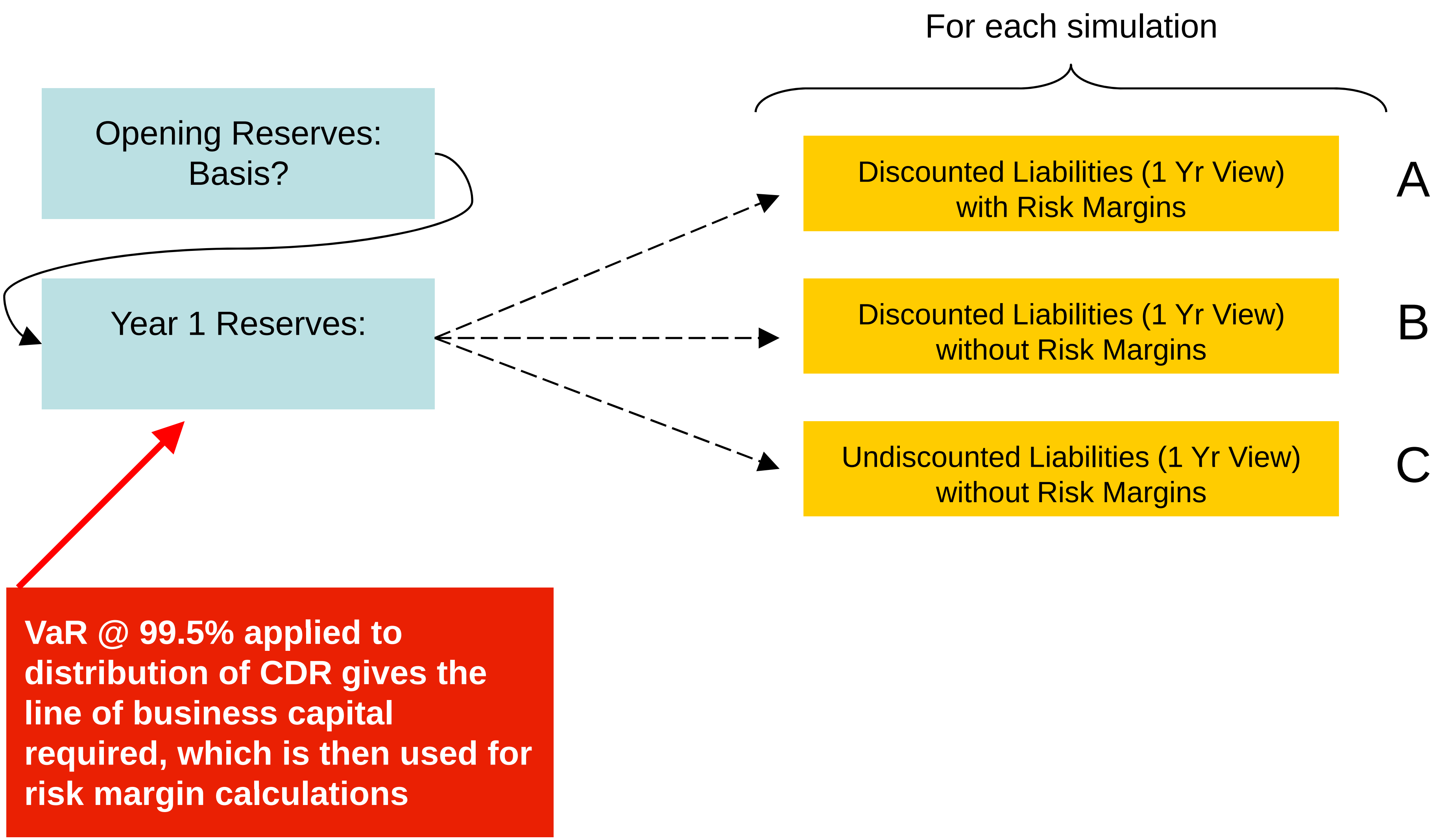
$$CDR_t^{(i)} = \left(R_{t-1}^{d(i)} + M_{t-1}^{(i)}\right) + I_t^{(i)} - C_t^{(i)} - \left(R_{t,d}^{d(i)} + M_t^{(i)}\right)$$

- If we can't make simplifications, we need an appropriate methodology
- The problem is that we need a notional line of business SCR *for each future year, for each simulation*

The notional LoB SCR for each future year

- It looks like the SCR depends on the risk margin, and the risk margin depends on the SCR
  - This paradox is resolved by starting at the end and working backwards
  - At the end of the run-off, the expected reserves are zero and the risk margin is zero
  - Moving one step back, the 99.5% VaR of the CDR is required for each simulation (conditional on information available up to that time), giving a distribution of the SCR
  - The risk margin can be obtained for each simulation (as the cost of capital)
  - The expected risk margin can also be calculated, which is required for the CDR at the previous step
- The problem is obtaining the 99.5% VaR of the CDR for each simulation, without performing simulation on simulation
- So, what are the options?

Line of Business SCRs
Year 1 Claims Development Result



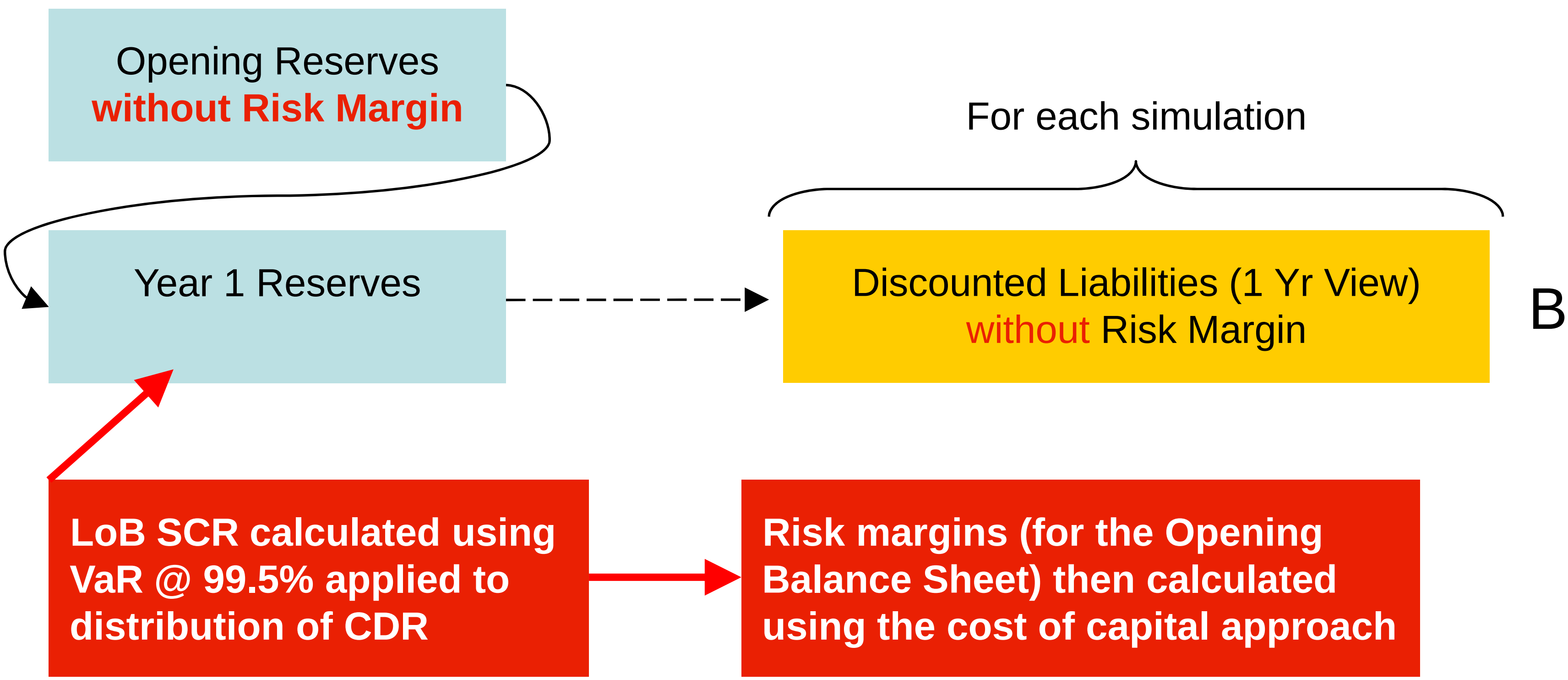
Line of business SCR
Simulated claims development result (CDR) options

- **Option A**
  - Seems technically correct
  - But very difficult to calculate in a simulation environment, without simplifying assumptions
- **Option B**
  - Relatively easy to calculate in a simulation environment
  - But requires a re-reserving process for each simulation, and allocated investment income on the reserves.
- **Option C**
  - Easy to calculate in a simulation environment.
  - Requires a re-reserving process for each simulation, but does not require allocated investment income on the reserves.

Risk margin calculations: An interesting result

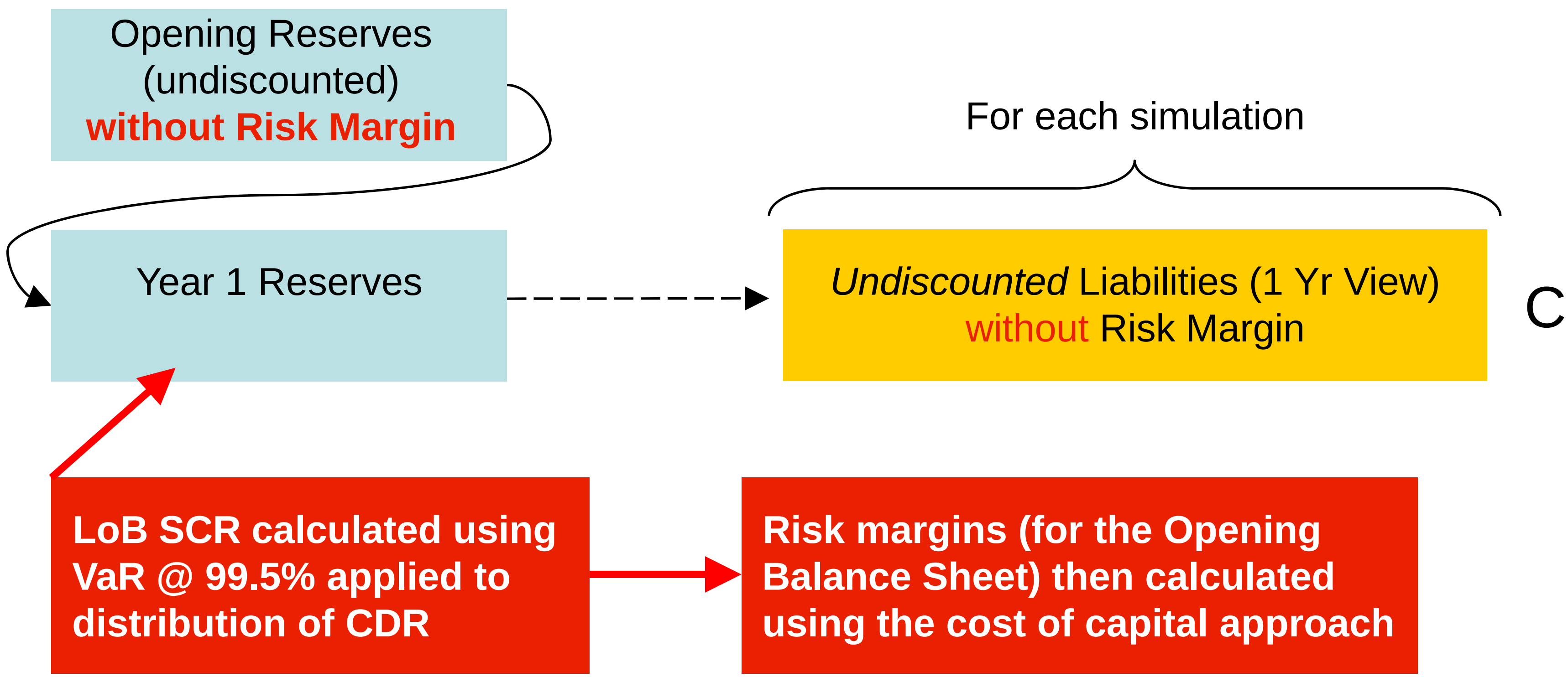
Using the “proportional proxy” for the CoC approach

Ohlsson & Lauzeningks (2008/9) suggest that when using the “proportional proxy” for line of business capital requirements in the cost of capital approach, the risk margin itself drops out, so the (LoB) SCR can be calculated ignoring risk margins.



CP71 and CP75
Methods for calculating the reserve risk standard deviations

The reserve risk standard deviation calculations (including M&W) in CP71 and CP75 only make sense if "PCO" is *undiscounted*, even though PCO is defined as the "best estimate", which is defined as the expected *present value* of future cash flows. So CP71 and CP75 implicitly seem to favour Option C



This would make life a lot easier – we revert to the basic CDR!

A simple risk margin method

1. Apply bootstrapping in the usual way
2. Generate a distribution of the one-year CDR (using re-reserving)
3. Estimate opening capital required by applying a risk measure to the one-year CDR distribution (eg VaR @ 99.5%)*
4. Apply the proportional proxy for future capital requirements
5. Multiply by the cost-of capital loading
6. Discount and sum

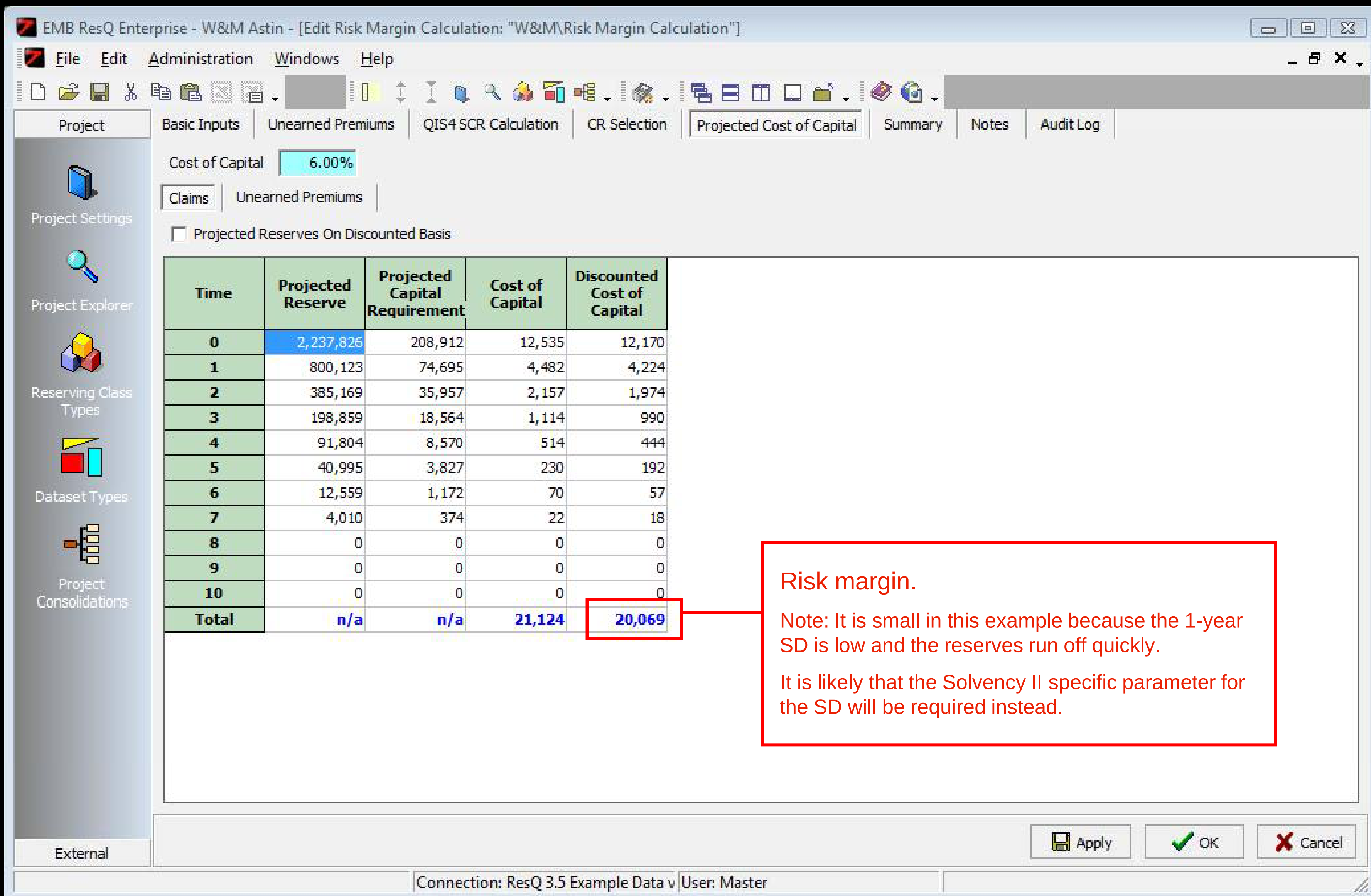
Issues:

UPR, dependencies, aggregation, paid vs incurred, gross vs net, non-bootstrapped lines, discounting/investment income, non-annual analysis dates, accident vs underwriting year issues, attritional/large claims split, scaling…

* *making adjustments for reinsurance credit default and operational risk, and the UPR component*

ResQ Example

“Cost of Capital” Risk Margin Method



Time	Projected Reserve	Projected Capital Requirement	Cost of Capital	Discounted Cost of Capital
0	2,237,826	208,912	12,535	12,170
1	800,123	74,695	4,482	4,224
2	385,169	35,957	2,157	1,974
3	198,859	18,564	1,114	990
4	91,804	8,570	514	444
5	40,995	3,827	230	192
6	12,559	1,172	70	57
7	4,010	374	22	18
8	0	0	0	0
9	0	0	0	0
10	0	0	0	0
Total	n/a	n/a	21,124	20,069

Risk margin.

Note: It is small in this example because the 1-year SD is low and the reserves run off quickly.

It is likely that the Solvency II specific parameter for the SD will be required instead.

A final word

Solvency II Requirements

- The best estimate is equal to the expected present value of all future potential cash-flows (probability weighted average of distributional outcomes)…
  - Cash-flows are required
- Risk margins: A cost-of-capital methodology should be used
  - Cash-flows are required
- The risk modules that need to be taken into account in the cost-of-capital calculations are operational risk, underwriting risk with respect to existing business and counterparty default risk with respect to ceded reinsurance.
- So actually, the calculation of risk margins (for each simulation) within simulation based internal capital models has further complications

Solvency II Risk Margin Issues

- Requires SCR (non-life) proxy at LoB level, excluding market risk
- PCO: discounted or undiscounted?
- “UPR”: implicitly discounted?
- “UPR”: exclude profit?
- “UPR”: gross of commission (Lloyd’s)?
- Calculated at S2 LoB level, or at sub-LoB level and aggregated?
- RI default calculations by LoB?

- “Best estimate liability” (BEL) estimate under QIS4: discounted or undiscounted?
- BEL: If discounted, think about yield curve at each point in time
- UPR risk margin: 1st year estimate vs 2nd year onwards
- Calibration of “Reserve standard deviations” in an internal model?

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Extra Slides for Discussion

Observations on QIS 4

Solvency 2 - QIS 4 Spreadsheets

- The QIS 4 formula based calculation of the overall "SCR Non-life" does not require risk margins as an input
  - The "Provisions for Claims Outstanding" (PCO) are required
  - These are the discounted expected values of outstanding claims, by line of business (and country)
  - A "standard deviation" is required for each line of business
    - It is not the standard deviation on an ultimate basis
    - CP71 and CP75 imply that a calculation based on the 1 year CDR is appropriate
- The SCR is compared to available capital from a balance sheet WITH risk margins in the liabilities
  - The risk margins are calculated separately, by Solvency II line of business
  - A 'line of business' SCR is required, which must be approximated
  - In the 'helper' spreadsheets, the 'proportional proxy' is used in the cost-of-capital risk margin calculations

Solvency II Questions
Simulation based internal capital models

Risk margins do not appear in the QIS 4 formula based SCR. So can we:

- Use a balance sheet excluding risk margins in the liabilities for the opening position and at Year 1*;*
  - Then calculate the excess capital required (using VaR @ 99.5% applied to the Yr 1 balance sheet) for the overall SCR calculation
- Then perform a "Cost-of-Capital" risk margin calculation, using an appropriate notional 'SCR' methodology by line of business;
- Then compare the overall SCR with a restated opening balance sheet with risk margins in the liabilities, for assessing capital adequacy?
- Or do we need an opening balance sheet with risk margins in the liabilities, and calculate risk margins for each simulation for the Yr 1 balance sheet?
- Are there other options that simplify the modelling?

Internal Capital Model Implications:

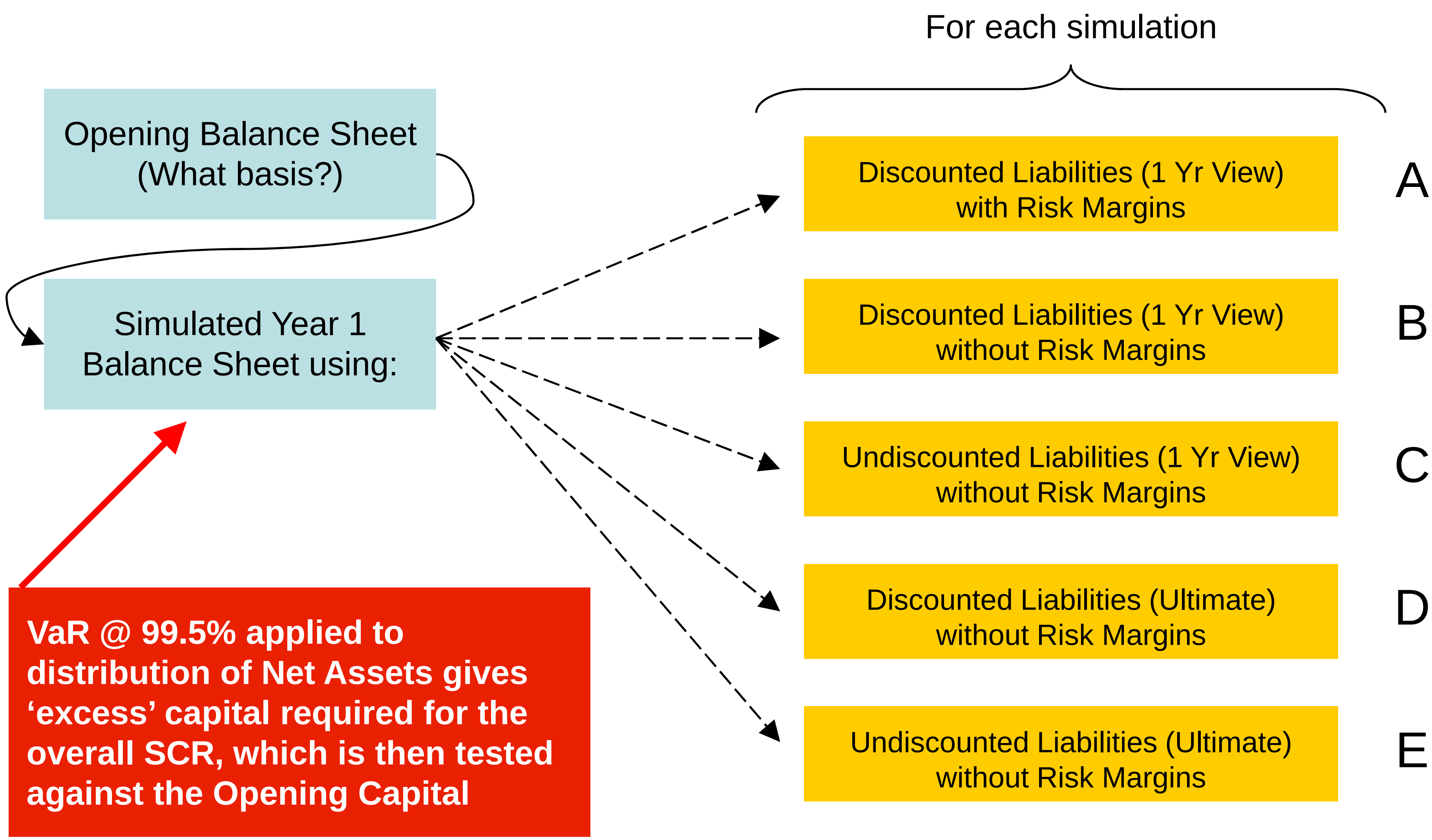
The Overall SCR

The Overall SCR

- **We still have the problem of a suitable definition of liabilities for estimating net assets for the overall SCR calculation**
  - Do we need risk margins for each simulation in the liabilities at the Year 1 position, or can we use similar simplifications?
  - If we do need risk margins for each simulation in the liabilities at the Year 1 position, how should they be calculated?

Overall SCR

Simulated Year 1 balance sheet options



Simulated balance sheet definitions after 1 year

Option A – Discounted liabilities (1 yr view) with risk margins

Advantages

- Appears to obey the rules

Limitations

- Shareholder perspective: ensures profit is available for shareholders
- Does not adequately protect policyholders
- Extremely difficult to calculate risk margins on a simulation by simulation basis without simplifying assumptions
- Of limited practical use, since the business is not managed on that basis
- “One year” view of reserving risk calculated in a robotic way

Simulated balance sheet definitions after 1 year

Option B – Discounted liabilities (1 yr view) without risk margins

Advantages

- Relatively straightforward to calculate in a simulation environment, using the "actuary-in-the-box" methodology
- Protects policyholders better, since the "total resources" are considered, which do not change if the risk margin method changes

Limitations

- At first sight, does not appear to match the Solvency II criteria
- "One year" view of reserving risk calculated in a robotic way
- Requires consideration of allocated investment income on the reserves

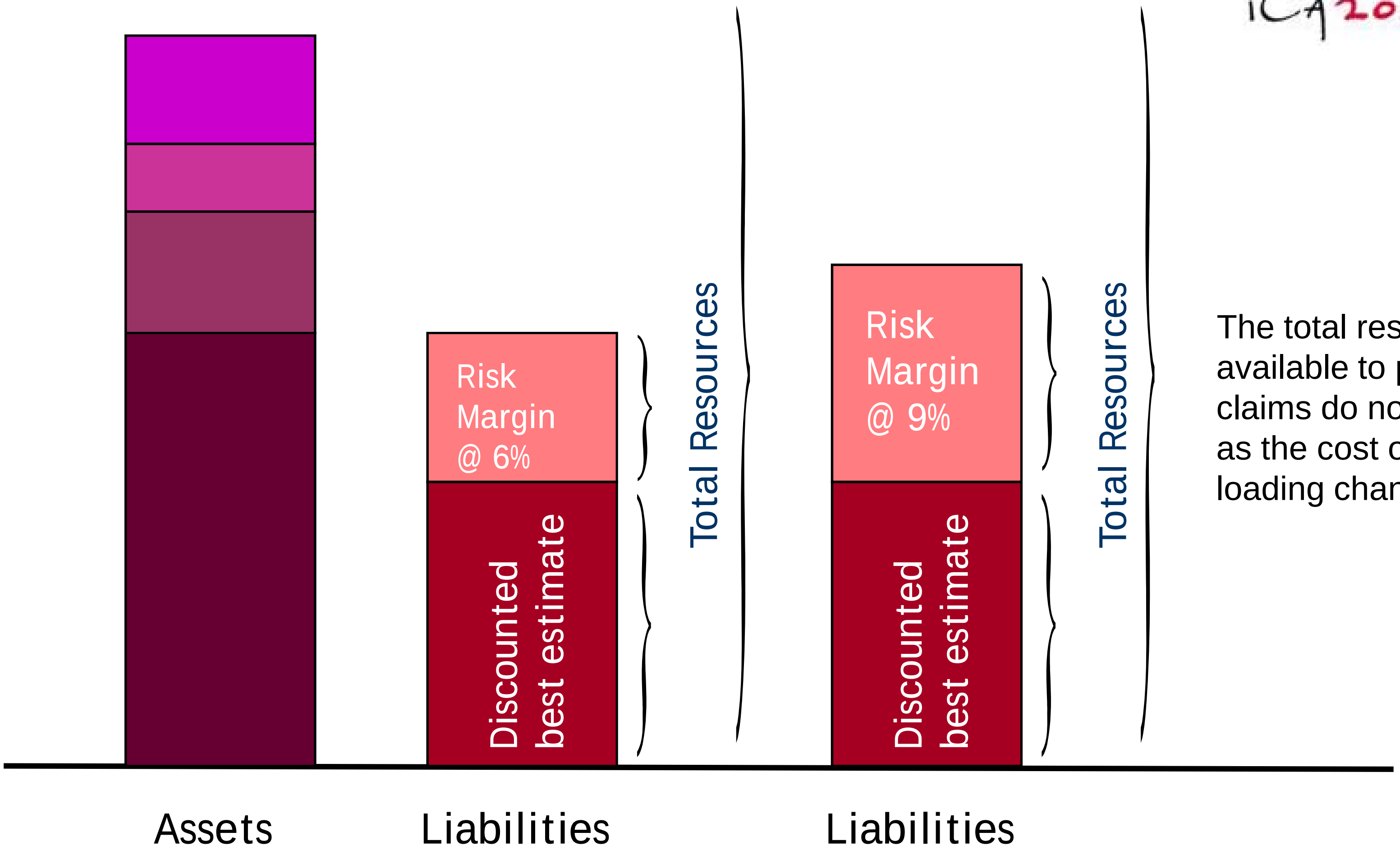
"Economic" Balance Sheet?

Suppose all other capital has been exhausted, except the Risk Margin, and another claim comes in. Does that claim get paid? That is, when does default occur?

It is the Total Resources that are important for protecting policyholders

- Avoids counter-intuitive results if the basis for the margin is strengthened
- Any argument about margins is then (almost) irrelevant, since it is just a partition of the Total Resources (which are fixed)

“Economic” Balance Sheet?



The total resources available to pay claims do not change as the cost of capital loading changes

Simulated balance sheet definitions after 1 year

Option C – Undiscounted liabilities (1 yr view) without risk margins

Advantages

- Straightforward to calculate in a simulation environment, using the “actuary-in-the-box” methodology
- Protects policyholders better, since the “total resources” are considered, which do not change if the risk margin method changes

Limitations

- At first sight, does not appear to match the Solvency II criteria
- “One year” view of reserving risk calculated in a robotic way

Simulated balance sheet definitions after 1 year

Option D – Discounted liabilities on an ultimate basis without risk margins

Advantages

- Easy to calculate in a simulation environment, using standard reserving risk methods
- No need for a robotic "re-reserving" methodology and the additional assumptions required
  - We assume perfect foresight
- Protects policyholders, since the ultimate claims paying ability is considered

Limitations

- Does it satisfy the Solvency II rules?
  - May satisfy the Solvency II criteria if it can be shown that this approach is at least as strong
  - This will depend on the "Cost of Capital" percentage

Simulated balance sheet definitions after 1 year

Option E – Undiscounted liabilities on an ultimate basis without risk margins

Advantages

- Even easier to calculate in a simulation environment, using standard reserving risk methods
- No need for a robotic "re-reserving" methodology and the additional assumptions required
  - We assume perfect foresight
- Protects policyholders, since the ultimate claims paying ability is considered

Limitations

- Does it satisfy the Solvency II rules?
  - May satisfy the Solvency II criteria if it can be shown that this approach is at least as strong
  - This will depend on the "Cost of Capital" percentage

Simulated balance sheet definitions after 1 year?

A convenient procedure

Opening Balance Sheet
without Risk Margins in the Liabilities

For each simulation

Simulated Year 1 Balance Sheet

Discounted Liabilities (1 Yr View) without Risk Margin

B

'Excess' capital calculated using VaR @ 99.5% applied to distribution of Net Assets

This is used to calculate the overall SCR which is then tested against the opening capital using a Balance Sheet WITH Risk Margins in the Liabilities

Under what assumptions can we use a balance sheet definition without risk margins in simulation based internal capital models for calculating the overall SCR?

(This would avoid unnecessary complications, and is analogous to the way QIS 4 seems to operate)

Biography

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Peter joined EMB in November 1999, after working as “Manager, Capital Modelling” in the Market Risk Unit at Lloyd's. He is a Chartered Statistician with a PhD in Actuarial Science, and has over 20 years’ experience in statistical and financial modelling.

He is also a Senior Visiting Fellow at the Cass Business School, London, and is the author (or co-author) of numerous papers, including the prize-winning Institute of Actuaries paper "Stochastic Claims Reserving in General Insurance".

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