Chances of Advanced Data Requirements under Solvency II -

In Context of Undertaking Specific Parameters (USP)

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About the speaker

Marius Reitz

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ROKOCO GmbH

- Provider of actuarial software and insurance consulting for all lines of business.
- Main business fields:
  - ✓ Asset Liability Management
  - ✓ Risk Management
  - ✓ Economic Scenario Generator (ESG)
  - ✓ Balance Sheet Analysis

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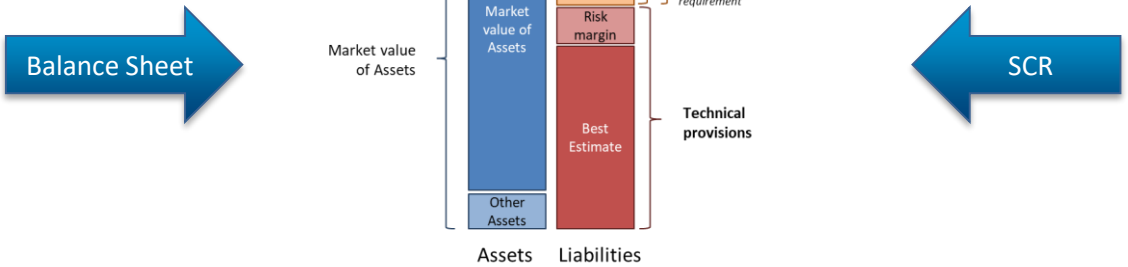
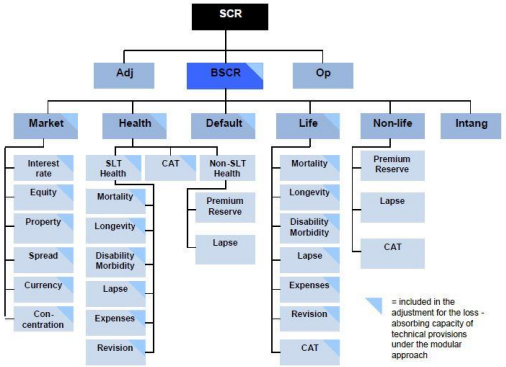
Introduction

Solvency II

- Legal framework for harmonising of insurance regulation and increase financial security (hold security capital SCR) in the European Union.
- Special Solvency II balance sheet:





Calculated with the standard model
Source: EIOPA-14/209

Introduction

Solvency II

- The SCR tree is composed of different types of risks
- Each risk is counted individually and uses various assumptions; for some sub-modules, market calibrated parameters are part of the standard model
  (e.g. non-life premium and reserve risk, NSLT health premium and reserve risk, health revision risk, life revision risk)
- A USP can replace these standard parameters with individual ones
- Today's focus: (Data requirements) of non-life premium and reserve risk

$$SCR_{pr/re} = 3 \cdot \sigma_{nl} \cdot V_{nl}$$

$$\sigma_{nl} = \frac{1}{V_{nl}} \sqrt{\sum_{s,t} \rho_{s,t} \cdot \sigma_s \cdot V_s \cdot \sigma_t \cdot V_t}$$

$$\sigma_s = \frac{\sqrt{\left(\sigma_{prem,s} V_{prem,s}\right)^2 + \sigma_{prem,s}\sigma_{res,s} V_{prem,s} V_{res,s} + (\dots)^2}}{V_{prem,s} + V_{res,s}}$$

Introduction

Use of USPs

- Better assessment of undertaking specific risk compared with the Solvency II standard model
- Viable option to reduce / increase the SCR
- Scenario settings for further examinations in ORSA

Case Study: LoB: Legal expense	Standard Model	RRM 1 (Standard Methods)	RRM 2 (Standard Methods)
σ_{res}	12 %	4.01%	1.59%
σ_{prem}	7 %	7.17%	-
σ_{nl}	5.4% (7.3% without USP)		
$SCR_{pr/re}$	119.228.521 (162.183.820)		

Actually granted USPs

- Whole EU: 83 insurers / reinsurers
- Germany: 6 insurers (only in P&C, LoB: legal expense) and 1 reinsurer

Source: EIOPA-CP-17/004, 4th July 2017

Introduction

Where is the USPs' legal framework defined?

When applying for USPs …

- If an undertaking is able to use more than one stand. method … it has to use the method which better fulfills the data requirements.
- If an insurer is not able to demonstrate the superior accuracy of one method, the more conservative method is required.
  (Compare Article 220 Sec. 2; DR (EU) 2015/35)

→ Better negotiation position with extended (statistical) methods

	Article	Content
Directive	Article 104 (7)	Possibility to replace a standard parameter with an individual USP
Delegated Regulation (EU) 2015/35	DR Article 19	Data used in the calculation of technical provisions
	DR Article 218	Detailed list of parameters that can be replaced by an USP
	DR Article 219	Basic data requirements provided for USP calculations
	DR Article 220	Standardized methods for USP calculations
	DR Annex XVII	The calculation rules for all USP methods and the related **data requirements**
Additional:	Draft proposal (EIOPA-FinReq-11/023; 21 December 2011), Guidelines (EIOPA-BoS-14/178 EN), Guidelines of local supervisory authority, …	

Reserve Risk Method 1

Case Study

- For premium- and reserve risk method 1 the following data must be provided:
  - Loss triangle (paid) gross / net
  - Minimum size: X_t& Y_t (see following slide) must be available for at least 5 consecutive years
- Data was taken from 3 SFCR reports of German insurers
- The data is weighted and combined in one loss triangle:
  - LoB: Legal expense
  - Size: 10 Accident years (AY) → 10 Development years (DY)

Reserve Risk Method 1

Basic calculation workflow

Input

X_t and Y_t calculated from the triangle
(explanation on the following slide)

Minimi-sation

$$l(\gamma, \delta | data) = \frac{1}{2}\sum \pi_t (u_t - log\hat{\sigma})^2 + \frac{1}{2}\sum \ln(\omega_t)$$

Calculate sigma

$$\hat{\sigma}(\hat{\delta}, \hat{\gamma}) = exp\left(\hat{\gamma} + \frac{\frac{1}{2}T + \sum_{t=1}^{T} \pi_t(\hat{\delta}, \hat{\gamma}) \cdot ln\left(\frac{y_t}{x_t}\right)}{\sum_{t=1}^{T} \pi(\hat{\delta}, \hat{\gamma})}\right)$$

Plug into Credibility -Model

$$\sigma_{(res,s,USP)} = c \cdot \hat{\sigma}(\hat{\delta}, \hat{\gamma}) \cdot \sqrt{\frac{T+1}{T-1}} + (1-c) \cdot \sigma_{(res,s)}$$

Source: EIOPA-FinReq-11/023 (21 December 2011)
Delegated Regulation (EU) 2015/35 – Annex XVII

Reserve Risk Method 1

Deriving Data

Incremental Loss Triangle

AY	12M	24M	36M	48M	60M	72M	84M	96M	108M	120M
2007	21.164.769	26.161.024	10.439.789	5.870.277	4.140.641	2.781.345	2.453.334	2.189.753	1.913.987	1.488.959
2008	21.578.231	27.171.272	10.721.092	6.001.002	4.125.133	2.939.323	2.506.105	2.149.471	1.683.302	
2009	24.895.362	28.996.654	11.078.285	6.012.675	4.076.040	2.716.920	2.133.152	1.615.249		
2010	23.691.264	28.106.867	11.016.953	6.195.995	4.418.544	3.000.034	2.242.227			
2011	24.168.249	27.858.590	11.170.323	6.453.732	4.558.784	2.950.356				
2012	23.882.996	28.556.167	12.122.198	6.979.409	4.700.494					
2013	25.399.269	32.438.914	13.014.600	7.188.891						
2014	27.123.692	34.087.023	13.678.526							
2015	30.568.510	37.736.304								
2016	31.005.906									

- Cut suited triangles
- Develop them to a rectangle (e.g. with tail)
- Discount and extrapolate CF

	12M	24M	36M	48M	60M	Future Cashflows
2007	21.164.769	26.161.024	10.439.789	5.870.277	4.140.641	-
2008	21.578.231	27.171.272	10.721.092	6.001.002	4.260.089	4.260.089

	12M	24M	36M	48M	60M	72M	Future Cashflows
2007	21.164.769	26.161.024	10.439.789	5.870.277	4.140.641	2.781.345	-
2008	21.578.231	27.171.272	10.721.092	6.001.002	4.125.133	2.856.042	2.856.042
2009	24.895.362	28.996.654	11.078.285	6.012.675	4.544.503	3.099.422	7.643.925
2010	23.691.264	28.106.867	11.016.953	6.165.435	4.416.301	3.011.986	13.593.722
2011	24.168.249	27.858.590	11.153.938	6.201.328	4.442.011	3.029.521	24.826.798
2012	23.882.996	28.596.931	11.251.075	6.255.334	4.480.696	3.055.905	53.639.940
Diagonal Payments		51.794.696					102.560.427

Reserve Risk Method 1

Best Estimate of claim provision

	Begin of year t		End of year t for prior years		Payments in t for prior claims
	without tail	with tail	without tail	with tail	
2011			37.511.970	59.771.098	49.326.796
2012	89.431.413	117.580.899	48.920.487	66.852.382	51.794.696
2013	102.560.427	124.200.333	62.157.853	87.884.774	55.391.181
2014	122.387.157	152.349.743	79.821.767	113.132.695	62.846.166
2015	147.325.191	185.863.837	98.432.245	136.634.523	67.836.460
2016	177.279.211	221.566.758	116.655.048	152.148.064	73.284.309

Reserve Risk Method 1

	x(t) without tail	y(t) without Tail	Ratio	x(t) with tail	y(t) with tail	Ratio
2011	-	-	-	-	-	-
2012	89.431.413	100.715.183	112,62%	117.580.899	118.647.078	100,91%
2013	102.560.427	117.866.284	114,92%	124.200.333	143.275.956	115,36%
2014	122.387.157	142.923.371	116,78%	152.349.743	175.978.861	115,51%
2015	147.325.191	166.268.705	112,86%	185.863.837	204.470.983	110,01%
2016	177.279.211	189.939.357	107,14%	221.566.758	225.432.373	101,74%

$$^{*}x_t = \sum_{i=1}^{t-1} R_{i,t-1-i} \qquad ^{**}y_t = \sum_{i=1}^{t-1} Z_{i,t-i} + R_{i,t-i}$$

The amount referred to paragraph 1b* / 1a** Delegated Regulation (EU) 2015/35 Annex XVII)

Reserve Risk Method 1

Statistical data requirement i)

"the amount referred to paragraph 1(a) in that particular segment and financial year is linear proportional in the best estimate of the provision for claims outstanding in that particular segment and financial year; "
(DR, Annex XVII (C) Sect. 2 (e) i)

Interpretation:

- Check that Y_t is directly proportional to X_t
- *Options provided:*
  - *Scatterplot with regression line*
  - *F-Test / t-Test*

What we expect to see:
- Points along the line
- $R^2 > 0.8$

F-Test / t-Test:
- Slope <> 0
- Intercept ≈ 0

Reserve Risk Method 1

Statistical data requirement ii)

" … the variance of the amount referred to paragraph 1(a) in a particular segment and financial year is quadratic in the provision for claims outstanding in a particular segment and financial year;"
(DR, Annex XVII C Sect. 2 (e) ii)

Interpretation:

- *Check for quadratic conjunction between the variance of Y_t and X_t*
- *Quadratic proportionality is specified in the draft proposal* (EIOPA-FinReq-11/023)

$$Var(y_t) = \sigma^2 \cdot \left((1-\delta)\bar{x}x_t + \delta x_t^2\right)$$

with $\bar{x} = \frac{1}{T}\sum_{t=1}^{T} x_t$

and $\delta \,\&\, \sigma^2$ *from minimisation*

Reserve Risk Method 1

Statistical data requirement ii)

- The variance of one expression is difficult to measure
- A short proof verifies that if the ratio of Y_t/X_t follows a lognormal distribution, there is a quadratic relationship between the variance of Y_t and X_t.
- Provided tests: Shapiro-Wilk, Anderson-Darling or Kolmogorov-Smirnov

Hypothesis:

$$Z_t = \frac{Y_t}{X_t}; \quad H_0: Z_t \sim LN_{\mu,\sigma}$$

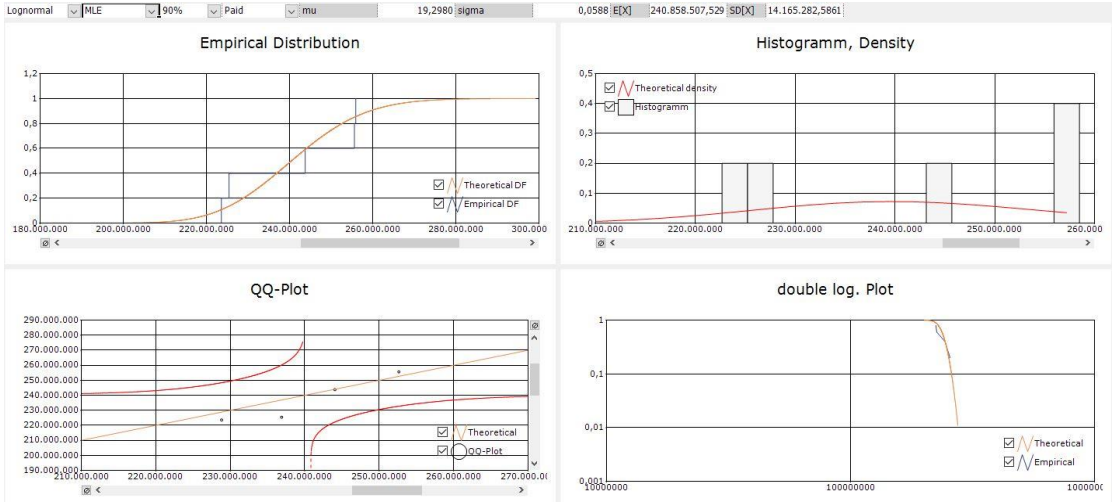
	Shapiro-Wilk	Kolmogorov-Smirnov	Anderson-Darling
Test statistic	W = 0.9192	D = 0.2756	AD = 0.3437
p-Value	0.5245	0.7574	0.8987

- Further examinations of the following plots are possible:
  Residuals vs. squared X_t or Weighted residuals vs. X_t

Reserve Risk Method 1

Statistical data requirement iii)

" … the amount referred to paragraph 1(a) follows a lognormal distribution" *(DR Annex XVII C Sect. (2) (e) iii)*



Lognorm.	**Teststat.**	**p-Value**
Shapiro Wilk	W=0.975	0.9086 ✓
Kolmogorov Smirnov	D=0.175	0.9908 ✓
Anderson Darling	AD=0.20	0.9918 ✓

Gamma	**Teststat.**	**p-Value**
Kolmogorov Smirnov	D=0.153	0.9984 ✓

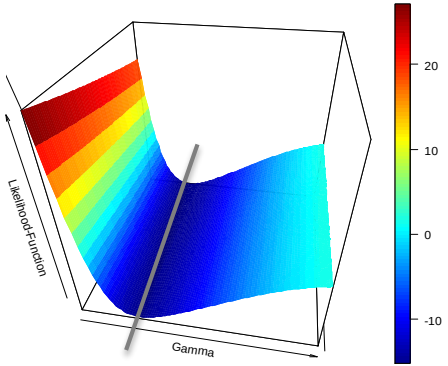
Reserve Risk Method 1

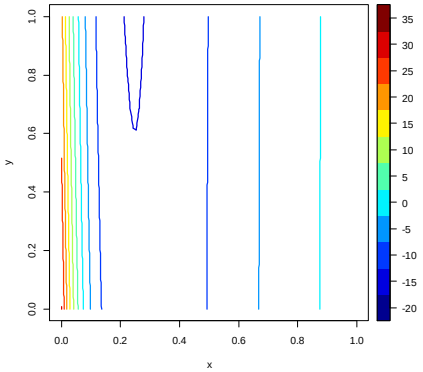
Statistical data requirement iv)

"maximum likelihood estimation is appropriate" *(DR Annex XVII C Sect. (2) (e) iv)*

Interpretation:

- Check if the minimisation is successful
- Analyse different numerical methods
- Methods provided:
  - "Excel Solver"
  - Multidimensional Newton Method
  - Downhill Simplex Method
  - Mutation-Selection-Method





Reserve Risk Method 1

Statistical data requirement iv)

Analysis of significant parameters:

Numerical Method	Iterations	Minimum of $l(\gamma, \delta \mid data)$	USP
Downhill-Simplex	100	-15.20420	4.008%
Excel-Solver	100	-15.20420	4.008%
Multidimensional Newton	100	-15.20420	4.008%
Mutation-Selection-Method	10.000	-11.71892	4.725%

Used years	Delta & USP	Delta & USP (Tail)
5	1.00 (4.008%)	0.197 (7.602%)

Start value Gamma	Start value Delta	USP (without CM)
-15	0 0.5 1	0.000% 4.008% 0.000%

What other methods could be applied if Maximum-Likelihood-Estimation is not appropriate?

- Empirical Standard Deviation of ratios $\frac{Y_t}{X_t}$ → USP: 3.62% (without tail); 7.10% (with tail)
- OLS

Reserve Risk Method 2

Model of Merz & Wüthrich (Source: "Modelling the Claims Development Result For Solvency Purposes")

Input

- Net triangle for at least 5 AY & DY that includes claims management expenses
- Representative for the next 12 month (DR Annex XVII D Sec. 2 (a)-(g))

Calculate Sigma and BE

$$\widehat{msep} = \sum_{i=1}^{I} \left(\hat{C}_{i,J}^{I}\right)^2 \left(\frac{\hat{\sigma}_{I-i}^2 \Big/ \left(\hat{f}_{I-i}^{I}\right)^2}{C_{i,I-i}} + \frac{\hat{\sigma}_{I-i}^2 \Big/ \left(\hat{f}_{I-i}^{I}\right)^2}{\sum_{k=1}^{i} C_{i,j}} + \sum_{j=I-i+1}^{J-1} \frac{C_{I-j,j}}{\sum_{k=1}^{I-j+1} C_{i,j}} \cdot \frac{\hat{\sigma}_j^2 \Big/ \left(\hat{f}_j^{I}\right)^2}{\sum_{k=1}^{I-j} C_{i,j}} \right) + 2 \sum_{k>i>1} \dots$$

Plug into Credibility-Model

$$\sigma_{(res,s,USP)} = c \cdot \frac{\sqrt{\widehat{msep}}}{\sum_{i=0}^{J} \left(\hat{C}_{(i,J)} - \hat{C}_{(i,I-i)}\right)} + (1-c) \cdot \sigma_{(res,s)}$$

Reserve Risk Method 2

Case Study

- Data basis analogue to Reserve Risk Method 1

AY	12M	24M	36M	48M	60M	72M	84M	96M	108M	120M	Future Cashflows	Predictive Error
2007	21.164.769	47.325.794	57.765.583	63.635.860	67.776.502	70.557.847	73.011.180	75.200.933	77.114.920	78.603.879	-	-
2008	21.578.231	48.749.503	59.470.595	65.471.598	69.596.730	72.536.053	75.042.158	77.191.629	78.874.931	80.397.873	1.522.942	136.898
2009	24.895.362	53.892.016	64.970.301	70.982.976	75.059.016	77.775.937	79.909.089	81.524.338	83.448.754	85.060.009	3.535.671	266.753
2010	23.691.264	51.798.131	62.815.084	69.011.079	73.429.623	76.429.657	78.671.884	80.726.826	82.632.417	84.227.910	5.556.025	514.045
2011	24.168.249	52.026.839	63.197.162	69.650.894	74.209.678	77.160.034	79.582.759	81.661.493	83.589.146	85.203.112	8.043.078	380.091
2012	23.882.996	52.439.163	64.561.361	71.540.770	76.241.264	79.287.763	81.777.296	83.913.352	85.894.162	87.552.634	11.311.370	284.872
2013	25.399.269	57.838.183	70.852.783	78.041.673	82.990.856	86.307.060	89.016.989	91.342.150	93.498.319	95.303.614	17.261.941	359.788
2014	27.123.692	61.210.715	74.889.241	82.435.340	87.663.157	91.166.059	94.028.555	96.484.620	98.762.179	100.669.111	25.779.869	484.605
2015	30.568.510	68.304.814	83.280.492	91.672.122	97.485.710	101.381.108	104.564.343	107.295.607	109.828.364	111.948.965	43.644.151	748.972
2016	31.005.906	68.790.820	83.873.054	92.324.393	98.179.346	102.102.461	105.308.346	108.059.043	110.609.822	112.745.511	81.739.605	2.171.260
	CLF	2,219	1,219	1,101	1,063	1,040	1,031	1,026	1,024	1,019	**198.394.653**	**3.170.465**

$$\sigma_{(res,s,USP)} = c \cdot \frac{\sqrt{\widehat{msep}}}{\sum_{i=0}^{J}\left(\hat{C}_{(i,J)} - \hat{C}_{(i,I-i)}\right)} + (1-c) \cdot \sigma_{(res,s)} = 1 \cdot \frac{3.170.465}{198.394.653} + (1-1) \cdot 0.12 \approx 1.598\,\%$$

Reserve Risk Method 2

Statistical data requirement i) & requirement ii)

Requirement i)

"cumulative claims amounts for different accident years are mutually stochastically independent" *(DR, Annex XVII Sect. D (2) (h) i)*

Requirement ii)

"for all accident years the implied incremental claim amounts are stochastically independent" *(DR, Annex XVII Sect. D (2) (h) ii)*

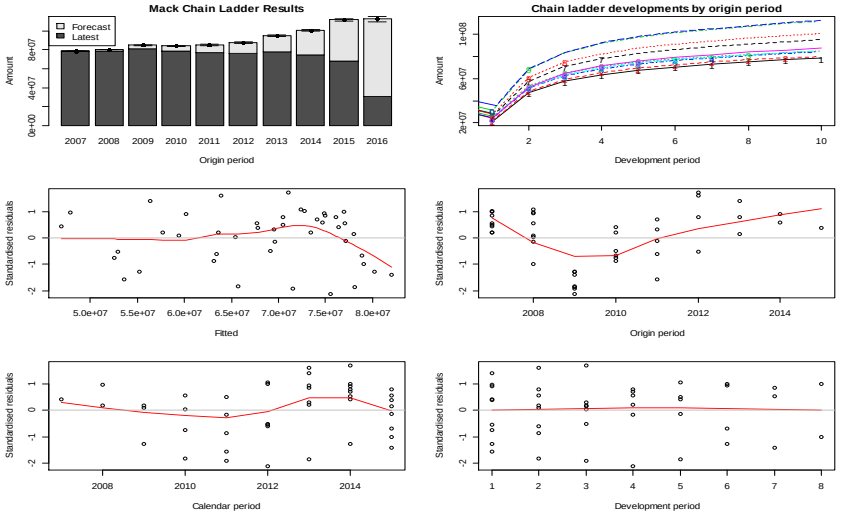
→ Requirement i) and Requirement ii) can be examined together

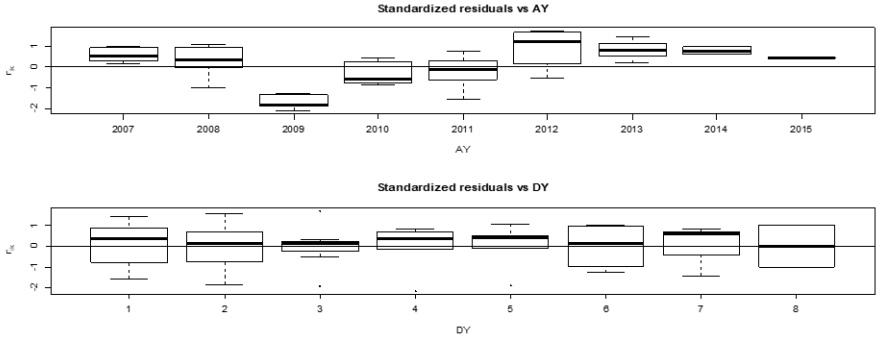
The assumption incl. the proofing method is extensively discussed in literature.

(E.g. Thomas Mack 2nd Edition "Schadenversicherungsmathematik" (Page 257 - Assumption (CL2))

Reserve Risk Method 2

Statistical data requirement i) & requirement ii)





Analysing residuals:

What we expect to see: Fluctuation / "White noise"

Further test possibilities:

- Iteration tests
- Examine further residuals of underlying LM

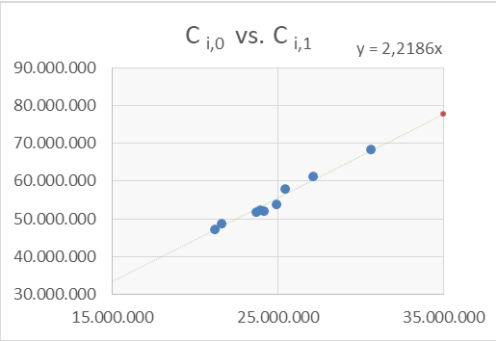
Reserve Risk Method 2

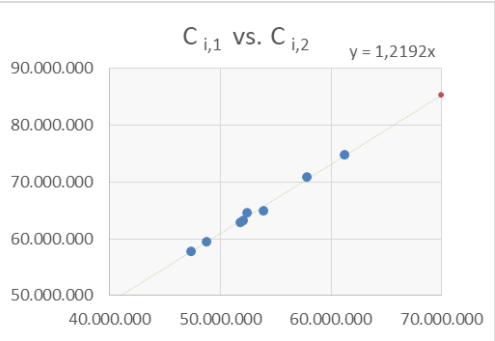
Statistical data requirement iii)

"for all accident years the expected value of the cumulative claims amount for a development year is proportional to the cumulative claims amount for the preceding development year;"
(DR, Annex XVII, D Sect. (2) (h) iii)

Interpretation:

- Proof proportionality of the CL Model
  $E\left(C_{i,k+1}|C_{i,1},\dots,C_{i,k}\right) = f_k C_{i,k}$ (CL 1)
- Check the scatterplots (e.g. along Mack's suggestion)
  (Thomas Mack 2nd Edition "Schadenversicherungsmathematik", p. 257)
- Proportionality should be proved for several years





Reserve Risk Method 2

Statistical data requirement iv)

"for all accident years the variance of the cumulative claims amount for a development year is proportional to the cumulative claims amount for the preceding development year."
(DR, Annex XVII, D Sect. (2) (h) iv)

Variance assumption:

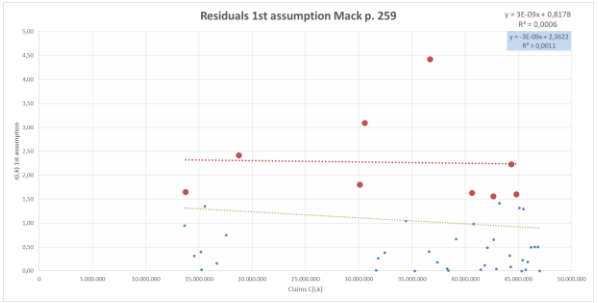
$$Var\left(C_{i,k+1}\middle|C_{i,1},\dots,C_{i,k}\right)=C_{i,k}^{p}\hat{\sigma}_k^2$$

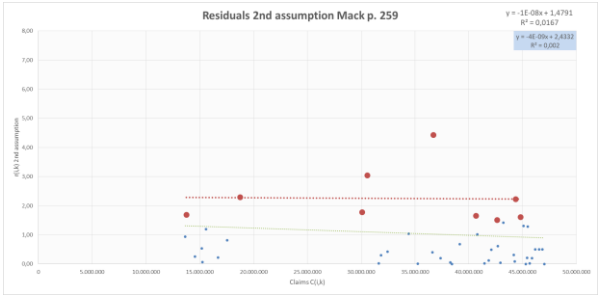
With $\hat{f}_k=\frac{\sum_{i=1}^{I-k}C_{i,k}^{1-p}C_{i,k+1}}{\sum_{i=1}^{I-k}C_{i,k}^{2-p}}$ and $\hat{\sigma}_k^2=\frac{1}{I-k-1}\sum_{i=1}^{I-k}C_{i,k}^{2-p}\left(\frac{C_{i,k+1}}{C_{i,k}}-\hat{f}_k\right)^2$

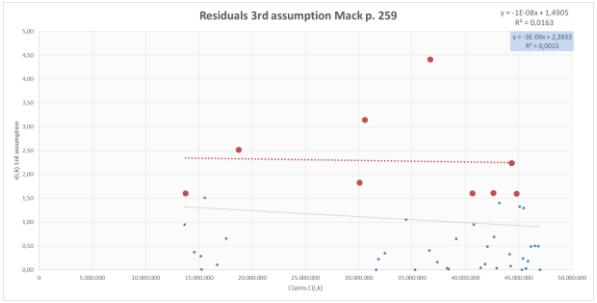
(E.g. Thomas Mack "Schadenversicherungsmathematik" 2nd Edition (Page 251 ff - Assumption (CL3))

Reserve Risk Method 2

Statistical data requirement iv)







1st Assumption

$$Var\left(C_{i,k+1}|C_{i,1},\dots,C_{i,k}\right) = C_{i,k}^{p}\cdot\hat{\sigma}_k^2$$

For p=1 the classic CL-Modell applies:

$$\hat{\sigma}_k^2 = \frac{1}{I-k-1}\sum_{j=1}^{I-k} C_{j,k}\left(\frac{C_{j,k+1}}{C_{j,k}} - \hat{f}_k\right)^2$$

2nd Assumption

$$Var\left(C_{i,k+1}|C_{i,1},\dots,C_{i,k}\right) = C_{i,k}^{p}\cdot\hat{\alpha}_k^p$$

For p=2 the following formula applies:

$$\hat{\alpha}_k^2 = \frac{1}{I-k-1}\sum_{j=1}^{I-k}\left(\frac{C_{j,k+1}}{C_{j,k}} - \hat{f}_{k0}\right)^2$$

3rd Assumption

$$Var\left(C_{i,k+1}|C_{i,1},\dots,C_{i,k}\right) = \hat{\beta}_k^2$$

For p=0 the following formula applies:

$$\hat{\beta}_k^2 = \frac{1}{I-k-1}\sum_{j=1}^{I-k} C_{j,k}^2\left(\frac{C_{j,k+1}}{C_{j,k}} - \hat{f}_{k2}\right)^2$$

Summary

- USPs (and their underlying data requirements) can:
  - improve the assessment of the own risk compared with the Solvency II standard model;
  - often reduce the SCR;
  - be used as scenarios for ORSA calculations (resp. the actuarial function).
- Admittedly, the requirements should not be underestimated:
  - Need for supervisory approval and strict internal processes;
  - guidelines and a sufficient database, which also must fulfill presented data requirements.
- However, application of USPs is much easier than certification of an (partial) internal model.

Thank you very much for your attention!

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