Deloitte.

Risk Adjustment calculation under IFRS 17

Introduction

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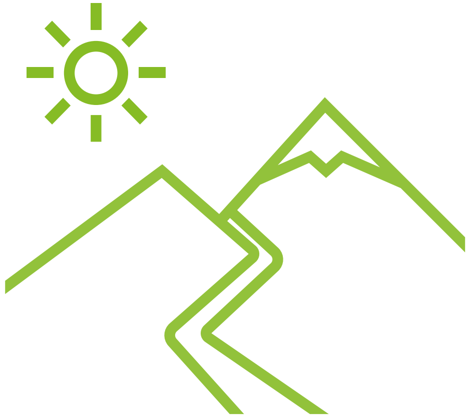
Projects in areas:

- Non-life
- IFRS 17

Motivation



- Calculate **risk adjustment** in a practicable way
- Fulfill **IFRS 17** requirements

Agenda

Theory:

- IFRS 17 standard
- Risk adjustment requirements
- Suitable calculation approaches

Practice:

- CoC approach calculation:
  - Required capital requirement and its projection
  - Risk adjustment allocation
  - Risk adjustment for reinsurance (held)
  - Confidence level determination

Liabilities in IFRS 17

Contractual service margin	A component of the carrying amount of the asset or liability for a group of insurance contracts representing the unearned profit the entity will recognise as it provides insurance contract services under the insurance contracts in the group.
Risk adjustment (for non-financial risk)	**An entity shall adjust the estimate of the present value of the future cash flows to reflect the compensation that the entity requires for bearing the uncertainty about the amount and timing of the cash flows that arises from non-financial risk.**
Time value of money	An entity shall adjust the estimates of future cash flows to reflect the time value of money and the financial risks related to those cash flows, to the extent that the financial risks are not included in the estimates of cash flows.
Estimates of future cash flows	An explicit, unbiased and probability-weighted estimate (i.e., expected value) of the present value of the future cash outflows minus the present value of the future cash inflows that will arise as the entity fulfils insurance contracts.

Risk Adjustment in IFRS 17 Standard

Need to be done:

- "An entity shall adjust the estimate of the present value of the future cash flows to reflect the compensation that the entity requires for **bearing the uncertainty** about the **amount and timing** of the cash flows that arises from **non-financial risk**" (Para 37)

Need to be disclosed

- "An entity shall **disclose** the **confidence level** used to determine the risk adjustment for non-financial risk. If the entity uses a technique other than the confidence level technique for determining the risk adjustment for non-financial risk, it shall **disclose** the **technique** used and the **confidence level** corresponding to the results of that technique." (Para 119)

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It means to model the whole world and its effect on the liabilities.

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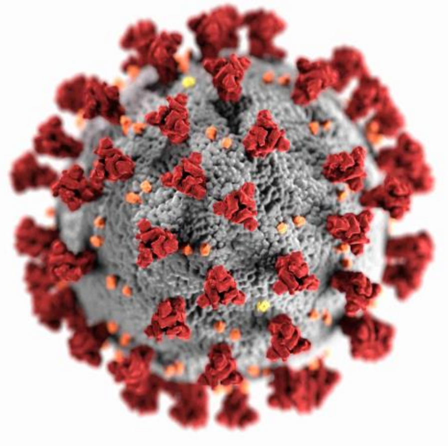
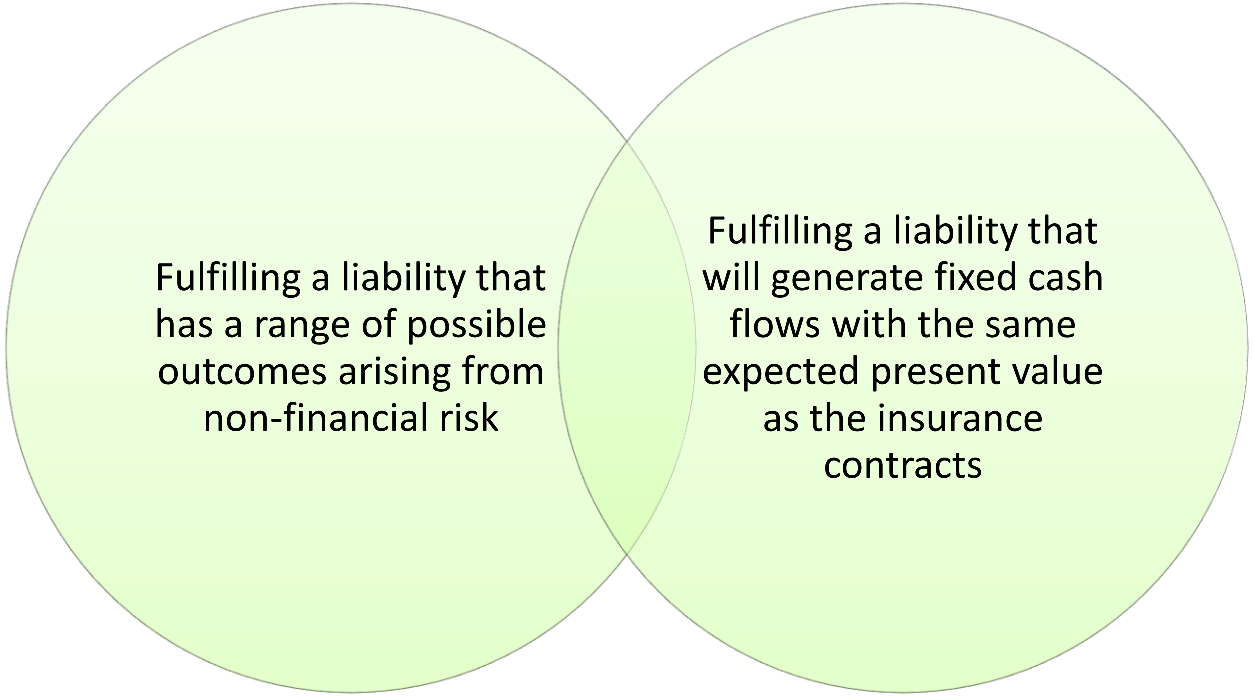
It means to model the whole world for the lifetime of insurance contracts and its effect on the liabilities.



Basic principles

The **risk adjustment** for non-financial risk for insurance contracts measures the compensation that the entity would require to make the entity indifferent between (B87):



Risk adjustment requirements

- IFRS 17 **does not** specify the estimation technique(s) used to determine the risk adjustment for non-financial risk.
- The **risk adjustment** for non-financial risk shall have the **following characteristics**:

1. Risks with **low frequency and high severity** will result in higher risk adjustments for non-financial risk than risks with high frequency and low severity
2. For similar risks, contracts with a **longer duration** will result in higher risk adjustments for non-financial risk than contracts with a shorter duration
3. Risks with a **wider probability distribution** will result in higher risk adjustments for non-financial risk than risks with a narrower distribution
4. The **less that is known** about the current estimate and its trend, the higher will be the risk adjustment for non-financial risk
5. To the extent that **emerging experience** reduces uncertainty about the amount and timing of cash flows, risk adjustments for non-financial risk will decrease and vice versa

Example:

Risks with low frequency and high severity will result in higher risk adjustments for non-financial risk than risks with high frequency and low severity

- **Consider loss** $\mathbf{L} = \sum_{i=1}^{N} X_i$ where X_i are iid random variables (with $E(X_i) = \mu$ and $Var(X_i) = \sigma^2$) and $N \sim Poisson(\lambda)$. N and X_i are independent.
  - $E(L) = E\big(E(L|N)\big) = E\left(E\big(\sum_{i=1}^{N} X_i \,|N\big)\right) = E\big(N \cdot E(X_i)\big) = E(N)E(X_i) = \lambda\mu$
  - $Var(L) = E\big(Var(L|N)\big) + Var\big(E(L|N)\big) = E(N)Var(X_i) + (EX_i)^2 Var(N) = \lambda(\sigma^2 + \mu^2)$

- **Other loss** $\boldsymbol{Z} = \sum_{i=1}^{K} Y_i$ where $Y_i \sim \frac{1}{\boldsymbol{\alpha}} X_i$ (i.e., with $E(Y_i) = \frac{\mu}{\boldsymbol{\alpha}}$, $Var(Y_i) = \left(\frac{\sigma}{\boldsymbol{\alpha}}\right)^2$) and $\mathrm{K} \sim Poisson(\boldsymbol{\alpha}\lambda)$. K and Y_i are independent, $\alpha \epsilon (0,1)$. Coefficient of variance $\frac{\sigma}{\mu}$ remains the same.
  - $\boldsymbol{E}(\boldsymbol{Z}) = E(K)E(Y_i) = \alpha\lambda\frac{\mu}{\alpha} = \lambda\mu = \boldsymbol{E}(\boldsymbol{L})$
  - $\boldsymbol{Var}(\boldsymbol{Z}) = E(K)Var(Y_i) + (EY_i)^2 Var(K) = \alpha\lambda\left(\frac{\sigma^2+\mu^2}{\alpha^2}\right) = \frac{1}{\alpha}Var(L) > \boldsymbol{Var}(\boldsymbol{L})$

Example:

Risks with low frequency and high severity will result in higher risk adjustments for non-financial risk than risks with high frequency and low severity

- Change of **loss $\boldsymbol{Z}$** distribution: where Y_i with $E(Y_i) = \frac{\mu}{\alpha}$, $\boldsymbol{Var(Y_i) = \sigma^2}$), $\alpha \epsilon (0,1)$:
  - $\boldsymbol{E(Z)} = E(K)E(Y_i) = \alpha\lambda\frac{\mu}{\alpha} = \lambda\mu = \boldsymbol{E(L)}$
- Question is when the inequality holds:
  - $Var(Z) = \alpha\lambda\left(\frac{\mu^2}{\alpha^2} + \sigma^2\right) > Var(L) = \lambda(\sigma^2 + \mu^2)$
  - $\alpha\left(\frac{\mu^2}{\alpha^2} + \sigma^2\right) > (\sigma^2 + \mu^2)$
  - $\boldsymbol{\alpha^2} - \boldsymbol{\alpha}\left(1 + \frac{\mu^2}{\sigma^2}\right) + \frac{\mu^2}{\sigma^2} > 0$, it holds **only** for $\alpha \epsilon \left(0, \frac{\mu^2}{\sigma^2}\right) \cap (0,1)$

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- So, it **doesn't hold** in general.

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↓

- **Variance** is not a suitable measure for the risk adjustment.

Example:

Risks with a wider probability distribution will result in higher risk adjustments for non-financial risk than risks with a narrower distribution

- Let’s assume that “distribution widening” relates to the increase in the variance of the distribution, while considering the other moments to be fixed.
- By using the Cornish-Fisher approximation it can be illustrated how an increase in the skewness $S(X) = \frac{E(X-EX)^3}{\sqrt{Var(X)}^3}$ can compensate an increase in volatility:
  - $VaR_\alpha(X) - E(X) \approx \sqrt{Var(X)}\left(z_\alpha + \frac{1}{6}(z_\alpha^2 - 1)S(X)\right)$, where z_α is an α-percentile of the standard normal distribution $\mathrm{N}(0,1)$.

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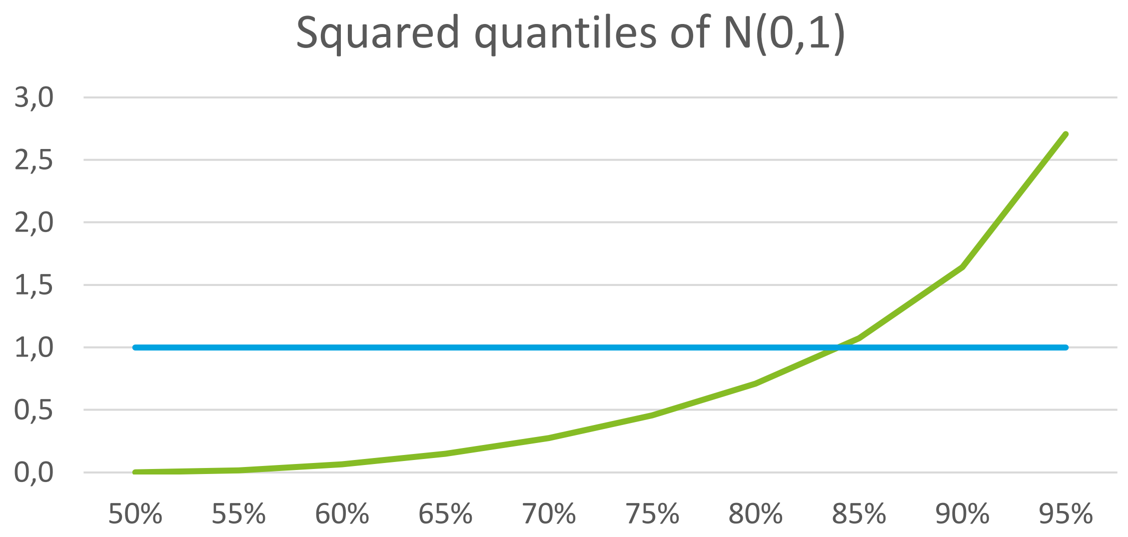

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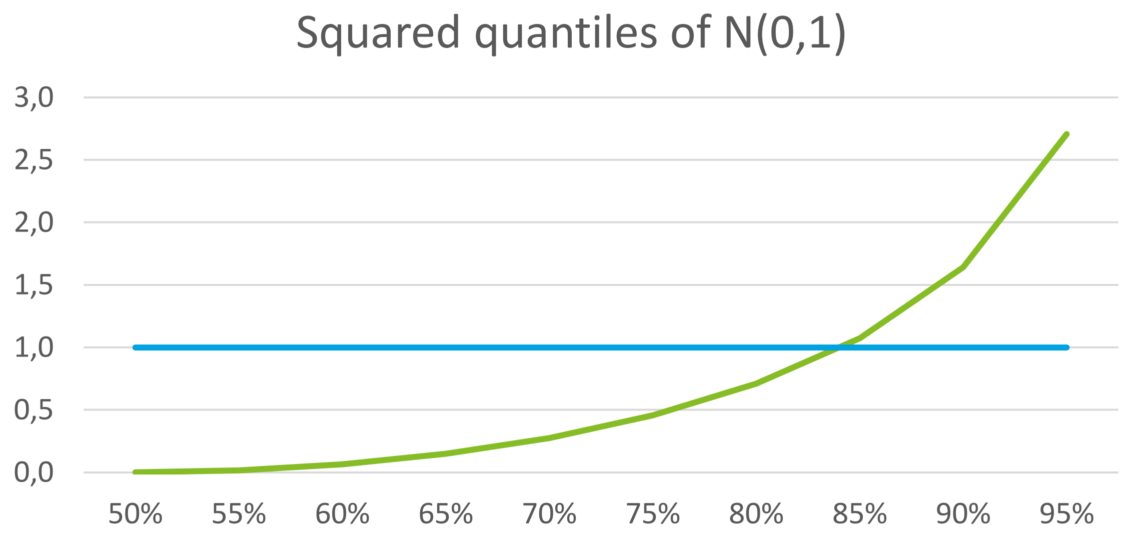
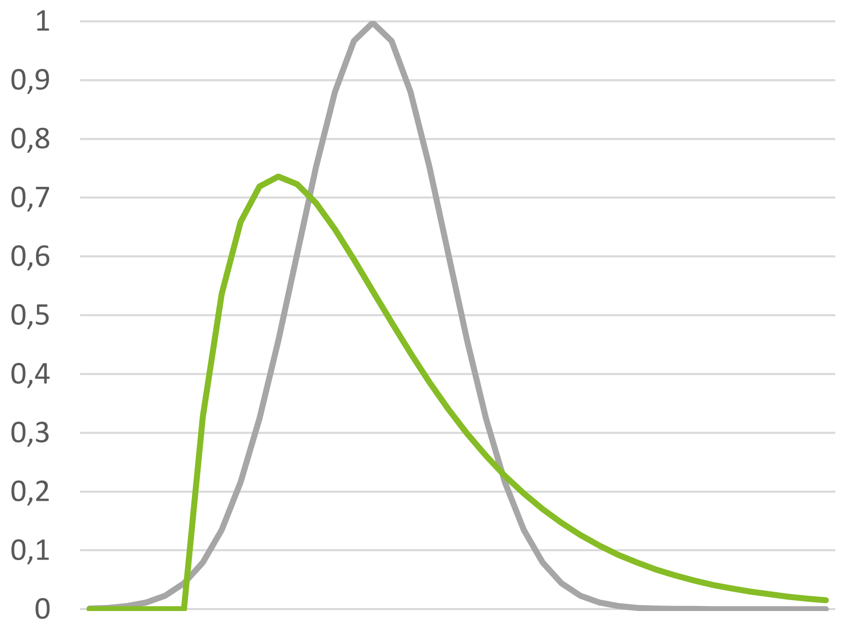




Example:

The less that is known about the current estimate and its trend, the higher will be the risk adjustments for non-financial risk

- **Model risk:**
  - Sometimes referred to as model specification risk, this refers to the possibility that a model may be selected that is **not a reliable representation** of the risk features / dynamics.
- **Parameter risk:**
  - Also known as estimation error, this is the source of **uncertainty in the parameters** of the model used to estimate the cash flows, in particular for low level of information contained in the data.
- Process risk
  - Sometimes referred to as variability risk, this refers to the stochastic nature of random variations that will inevitably occur in future cash flows even when the model and underlying parameters are accurate representations of the risks at stake.

IFRS 17 Risk Adjustment Techniques

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

Approach 1:

A risk measure applied to a distribution of the discounted fulfilment cash-flows over their lifetime:

- Value at risk (confidence level)

- Tail value at risk (conditional tail expectation)

- *Wang's proportional hazards transform*

Approach 2:

A Cost-of-Capital approach:

- Market view on the risk

Approach 1

Value at risk

Can be derived from a single simulation (high volatility, especially at higher percentile)

In the range from the minimum to the maximum simulated value

Low ability to depict skewness/extremes

Not a coherent risk measure (sub-additivity) – not useful for allocation to lower levels

Tail Value at risk

Uses equal weights above a given percentile level

Potentially better at catching skewness/extremes

In the range from the mean to the maximum simulated value

A coherent risk measure – potentially useful for allocation to lower levels

Proportional hazards transform

Uses increasing weights across all simulations

Potentially better at catching skewness/extremes

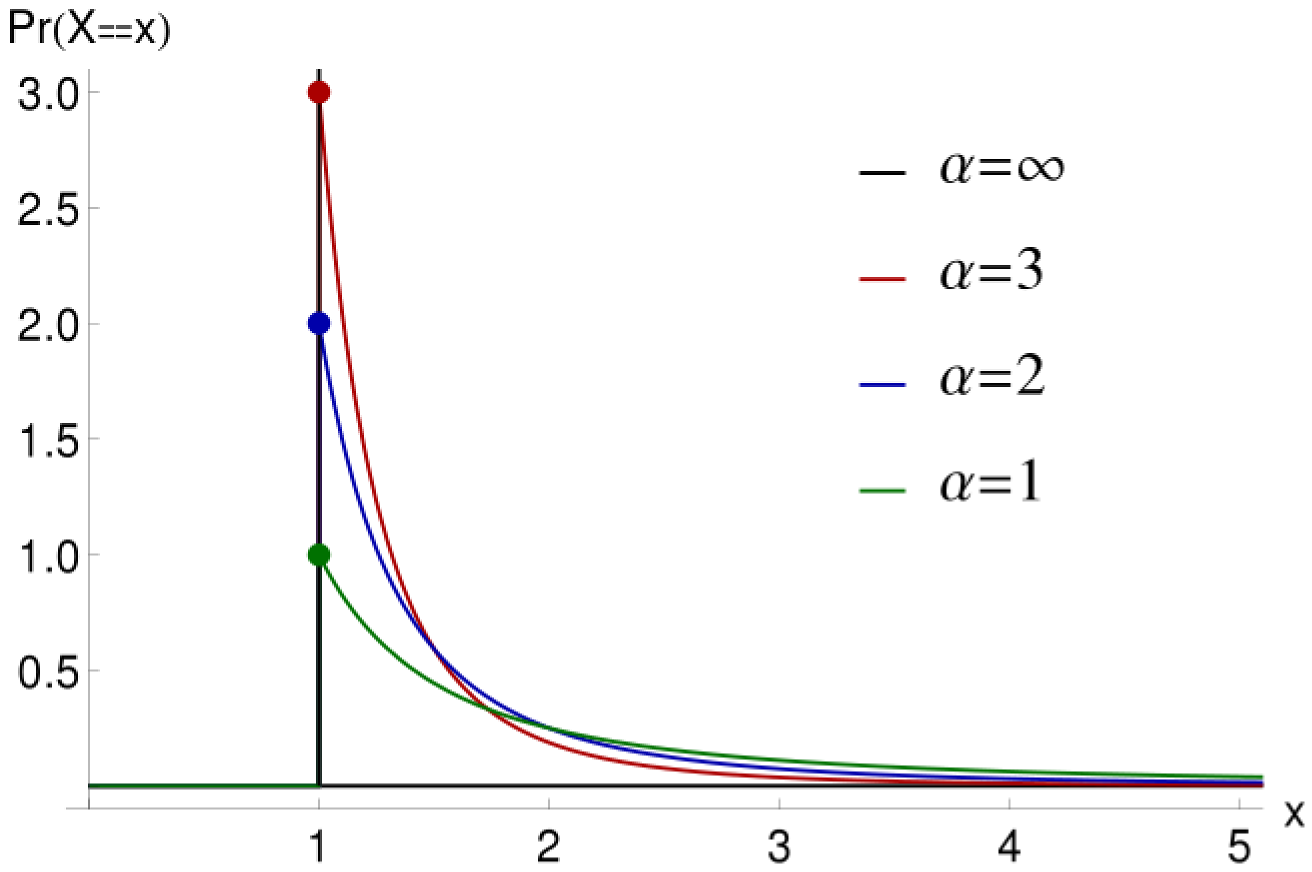
In the range from the mean to the maximum simulated value

A coherent risk measure – potentially useful for allocation to lower levels

Example:

Let's calculate these risk measure for some probability distribution

- **Pareto distribution of Loss X:**
  - Probability density function:
    - $f(x) = \frac{ab^a}{x^{a+1}} \cdot 1_{\langle b,+\infty)}$
  - Cumulative distribution function:
    - $F(x) = \left(1 - \left(\frac{b}{x}\right)^a\right) \cdot 1_{\langle b,+\infty)}$
  - Expected value:
    - $E(X) = \frac{ab}{a-1}, a > 1$
  - Variance:
    - $Var(X) = \frac{ab^2}{(a-1)^2(a-2)}, a > 2$



Example:

Value at risk at level α = 5 %

- **Value at risk:**
  - $VaR_{1-\alpha}(X) = inf\{x \in R: F(x) \geq 1-\alpha\}$
  - $P\left(X \leq VaR_{1-\alpha}(X)\right) = 1 - \mathrm{\alpha}$
  - $F\left(VaR_{1-\alpha}(X)\right) = 1 - \mathrm{\alpha}$
  - $1 - \left(\frac{b}{VaR_{1-\alpha}(X)}\right)^{a} = 1 - \mathrm{\alpha}$
  - $VaR_{1-\alpha}(X) = \frac{b}{\sqrt[a]{\alpha}}$

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	VaR	TVaR	PHT
	$\frac{b}{\sqrt[a]{\alpha}}$		
a = 2, b = 1	4.47		

Example:

Tail value at risk at level α = 5 %

- **Tail value at risk:**
  - $TVaR_{1-\alpha}(X) = E(X|X > VaR_{1-\alpha}(X))$
  - $TVaR_{1-\alpha}(X) = \frac{1}{1-F(VaR_{1-\alpha}(X))}\int_{VaR_{1-\alpha}(X)}^{+\infty} xf(x)dx$
  - $TVaR_{1-\alpha}(X) = \frac{1}{\alpha}\left[\frac{ab^{a}}{a-1}x^{1-a}\right]_{x=VaR_{1-\alpha}(X)}^{x=+\infty}$
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	VaR	TVaR	PHT
	$\frac{b}{\sqrt[a]{\alpha}}$	$\frac{a}{a-1}\frac{b}{\sqrt[a]{\alpha}}$	
a = 2, b = 1	4.47	8.94	

Example:
Proportional hazards transform

- **Survival function:**
  - $S(x) = P(X > x) = 1 - P(X \leq x) = 1 - \mathrm{F}(x)$
  - Used in biostatistics (e.g., useful for remaining lifetime)
- **PH-mean:**
  - PH-mean refers to the expected value under the **proportional hazards (PH) transform** $\left(\boldsymbol{S}(\boldsymbol{x})\right)^{\boldsymbol{r}}$
  - $H_r(X) = \int_0^{+\infty} \left(S(x)\right)^r dx \, , 0 < r \leq 1$
- **What is the connection between the confidence level $\boldsymbol{\alpha}$ and the index $\boldsymbol{r}$?**

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- **What is the connection between the confidence level α and the index r?**
  - Let's check limit values:
    - $r = 0$: $H_0(X) = \int_0^{+\infty} 1_{\{P(X>x)>0\}} dx = \boldsymbol{max(X)}$
    - $r = 1$: $H_1(X) = \int_0^{+\infty} S(x)dx = \boldsymbol{E(X)}$ *… A proof can be found in an appendix.*
    - Same limits as for $TVaR \rightarrow \boldsymbol{\alpha \approx r}$

Example:

Proportional hazards transform for Pareto distribution

- **Survival function:**
  - $S(x) = 1 - \mathrm{F}(x) = 1_{\langle 0,b)} + \left(\frac{b}{x}\right)^{a} \cdot 1_{\langle b,+\infty)}$

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  - A quick check:
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	VaR	TVaR	PHT
	$\frac{b}{\sqrt[a]{\alpha}}$	$\frac{a}{a-1} \frac{b}{\sqrt[a]{\alpha}}$	$\frac{abr}{ar-1}$
a = 2, b = 1, α = r = 0.05	4.47	8.94	+∞

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a = 2, b = 1, α = r = 0.05	4.47	8.94	$+\infty$
a = 201, b = 1, α = r = 0.05	1.015	1.020	1.110

Quantile methods in practice

Simulation

- **Inputs from insurer**
  - Model point
  - Assumptions (e.g., mortality table, lapse rates, …)
  - The risk horizon

Inputs

Quantile methods in practice

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Quantile methods in practice

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Inputs

Cash flow projection

- Best estimate calculation
- Risk exposure calculation

Quantile methods in practice

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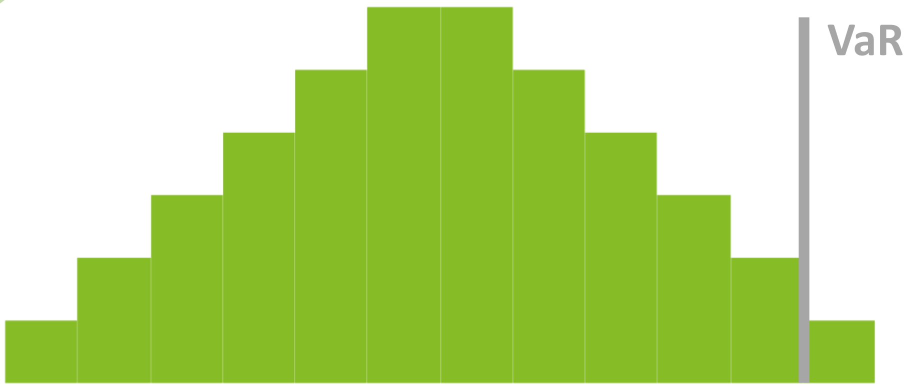
Quantile estimation

- Directly



Quantile methods in practice

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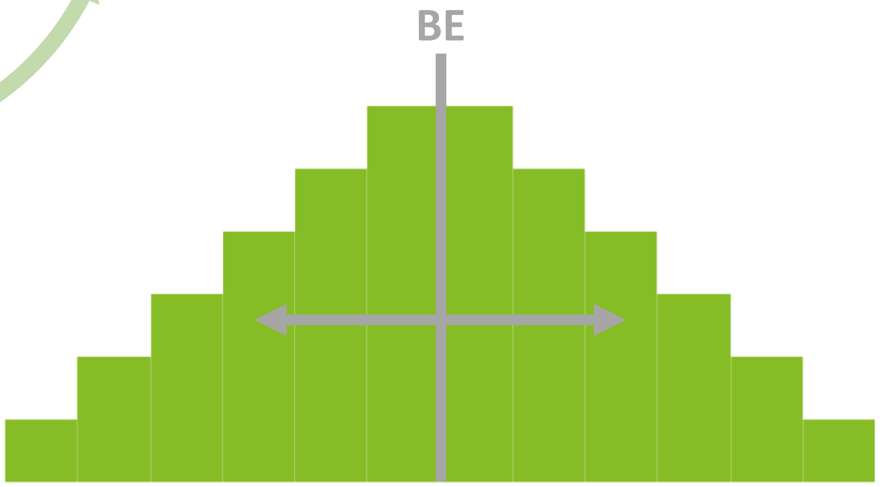
- Directly, or
- By using some approx. (Cornish-Fisher method)

Quantile estimation



Approach 2

Cost of capital

$$RA = CoC \sum_{t \geq 0} \frac{RC_t}{(1 + i_t)^t}$$

- CoC: a cost of capital rate
- RC_t: a required capital for the risk in the scope (resulting from non-financial risks) to be held at date t
- i_t: a discount rate at date t

Cost of Capital approach

Risk adjustment requirements

$$RA = CoC \sum_{t \geq 0} \frac{RC_t}{(1+i_t)^t}$$

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- Risks with a **wider probability distribution** will result in higher risk adjustments for non-financial risk than risks with a narrower distribution
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- To the extent that **emerging experience** reduces uncertainty about the amount and timing of cash flows, risk adjustments for non-financial risk will decrease and vice versa

It's not clear at the first sight.

It depends how the required capital is constructed.

What is used in practice?

… as I know CoC approach wins.

Risk adjustment calculation based on CoC approach

Step 1: Required capital calculation

How to calculate the required capital in the beginning (t=0)?

- **CoC approach formula is very similar to Solvency II Risk Margin formula:**
  - $RM = CoC_S \sum_{t\geq 0} \frac{\boldsymbol{SCR_t}}{(1+r_t)^t}$
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Or not?

Differences
between **Solvency II** and **IFRS 17** view

- **Contract boundaries** interpretation (also for reinsurance held)

Contract boundary

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Contract boundary

- **IFRS 17:**
  - Cash flows are within the boundary of an insurance contract if they arise from substantive rights and obligations that exist during the reporting period in which the entity can compel the policyholder to pay the premiums or in which the entity has a substantive obligation to provide the policyholder with insurance contract services. A substantive obligation to provide insurance contract services ends when:

1. **the entity has the practical ability** to reassess the risks of the particular policyholder and, as a result, can set a price or level of benefits that fully reflects those risks; or

2. both of the following criteria are satisfied:
   - **the entity has the practical ability** to reassess the risks of the portfolio of insurance contracts that contains the contract and, as a result, can set a price or level of benefits that fully reflects the risk of that portfolio; and
   - the pricing of the premiums up to the date when the risks are reassessed does not take into account the risks that relate to periods after the reassessment date.

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  - Some **investment or financing component** under IFRS 17 may be identified as **insurance cash flows** under Solvency II.
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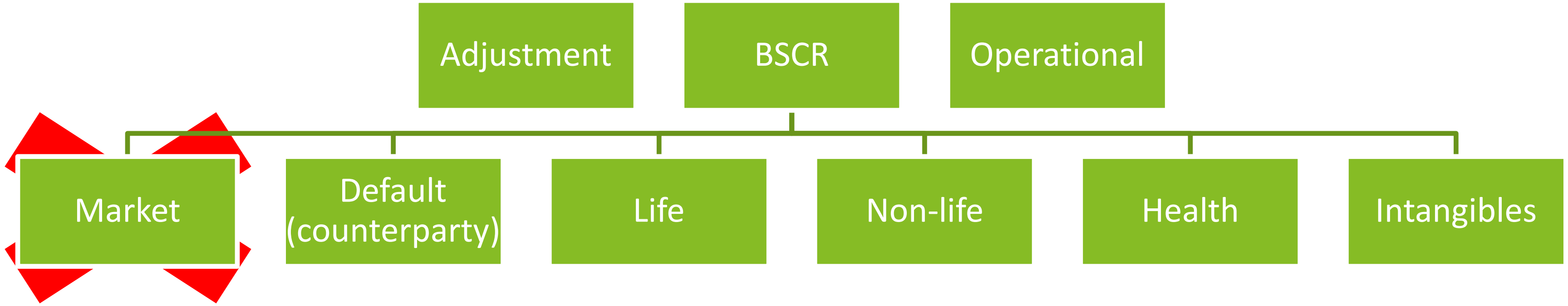
  - e.g., risk of default for receivables (other than reinsurer default)
  - This may be relevant to unit-linked business with guarantees from external counterparties.

Solvency II

Solvency capital requirement

- The **SCR** incorporates these **risk modules**:



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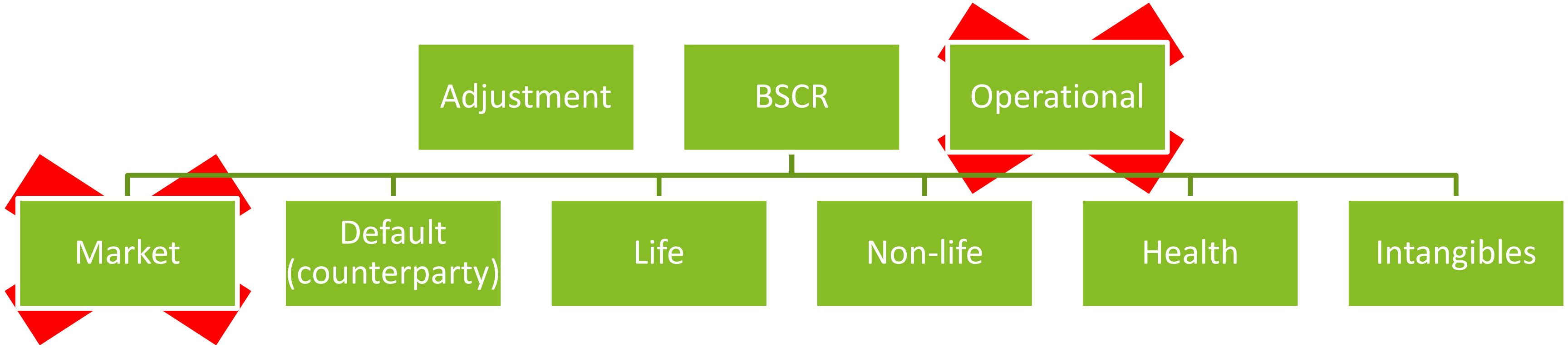

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- **Discount rate**

Discount rate

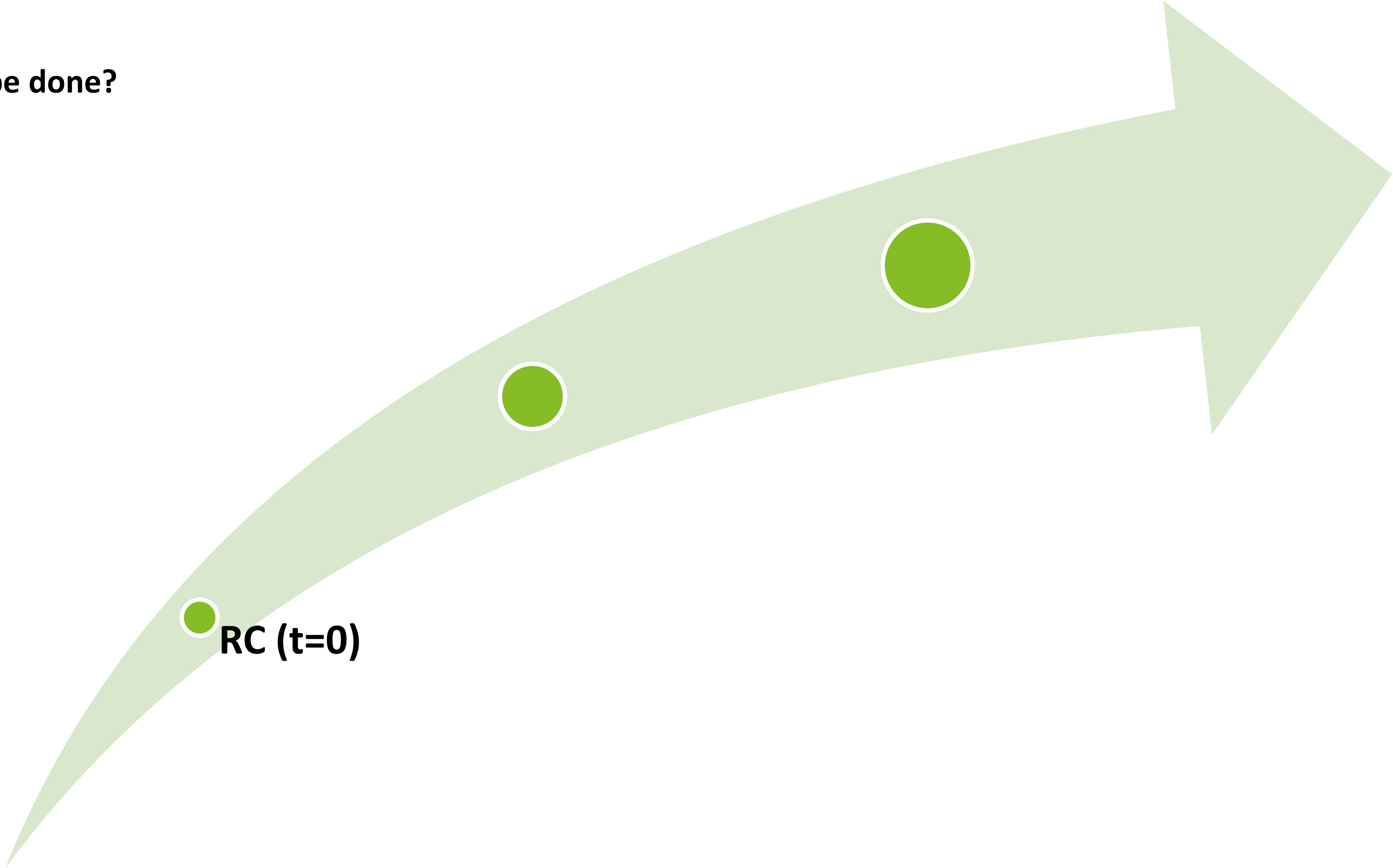
- **Solvency II:**
  - Prescribed EIOPA discount curve
- **IFRS 17:**
  - The discount rates applied to the estimates of the future cash flows shall:
    - reflect the time value of money, the characteristics of the cash flows and the liquidity characteristics of the insurance contracts;
    - be consistent with observable current market prices (if any) for financial instruments with cash flows whose characteristics are consistent with those of the insurance contracts, in terms of, for example, timing, currency and liquidity; and
    - exclude the effect of factors that influence such observable market prices but do not affect the future cash flows of the insurance contracts.

Risk adjustment calculation based on CoC approach

Step 2: Projection of required capital

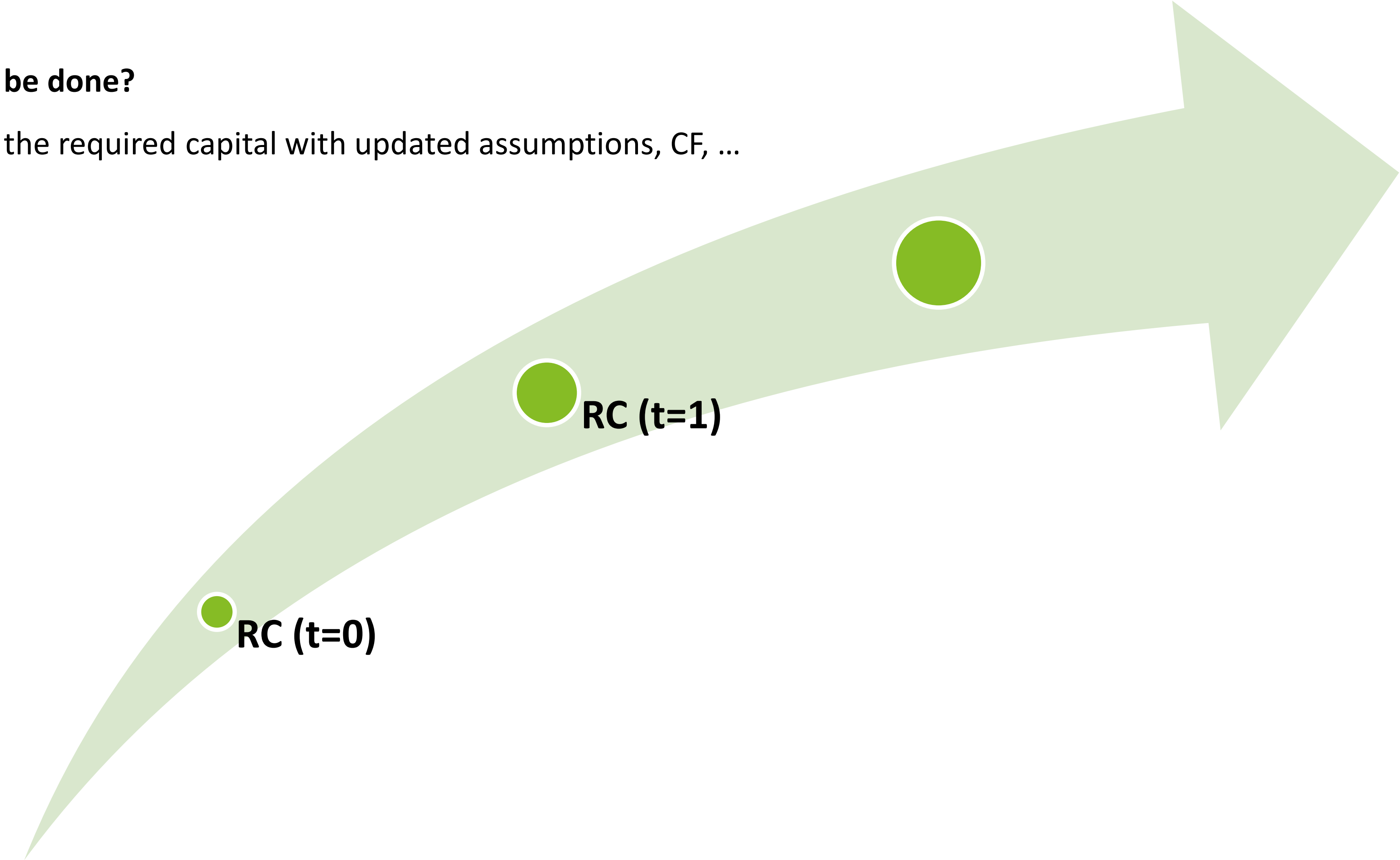
Required capital projection

- **What should be done?**



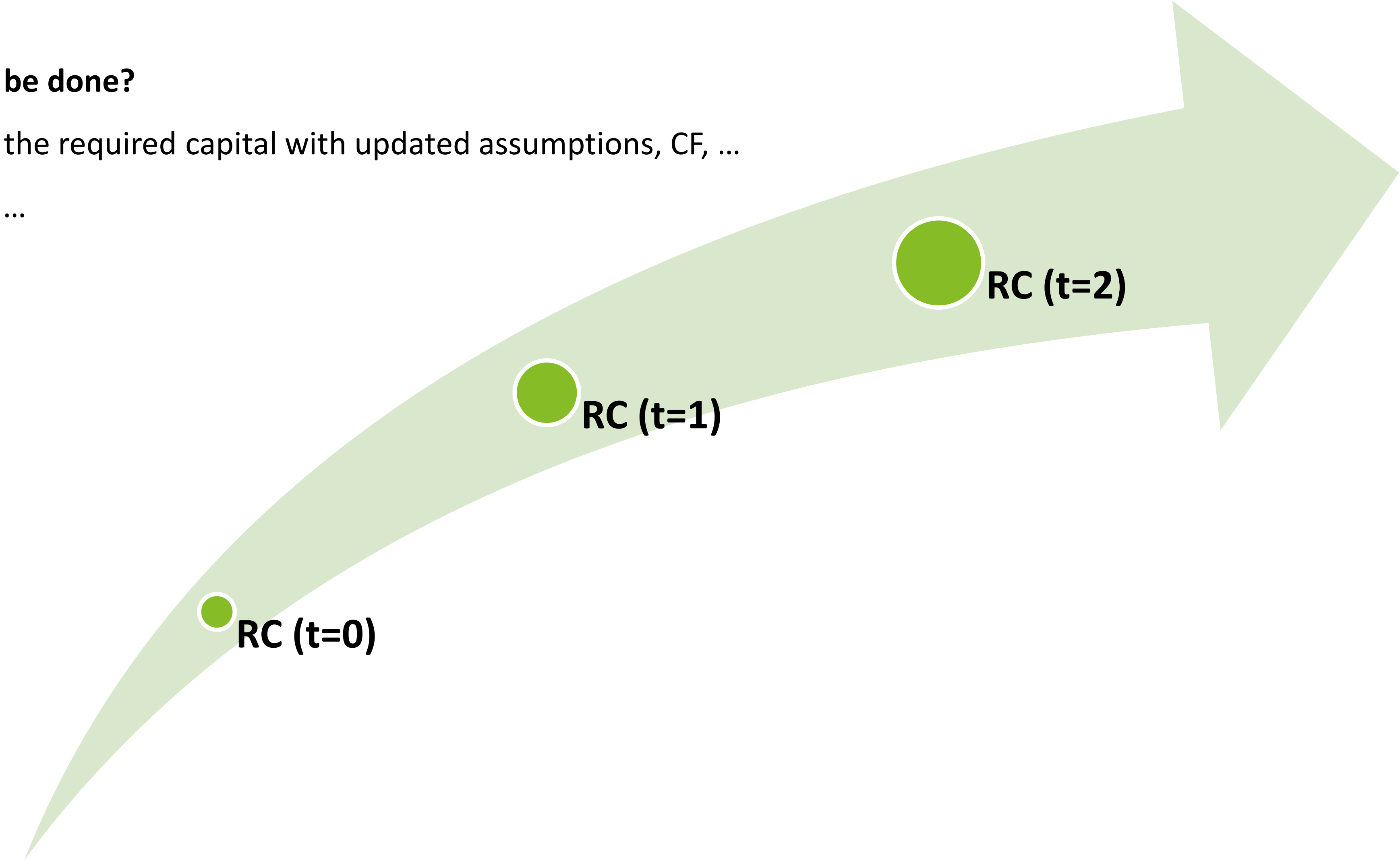
Required capital projection

- **What should be done?**
  - Recalculate the required capital with updated assumptions, CF, …
  - For t = 1



Required capital projection

- **What should be done?**
  - Recalculate the required capital with updated assumptions, CF, …
  - For t = 1, 2, …



Required capital projection

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    - e.g., mathematical reserve, present value of future cash flows:
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      - $RD_t = \frac{PV\ of\ future\ CFs\ at\ t}{PV\ of\ future\ CFs\ at\ 0}$
    - **It should be still calculated under IFRS 17 conditions !**

Risk adjustment calculation

Total value

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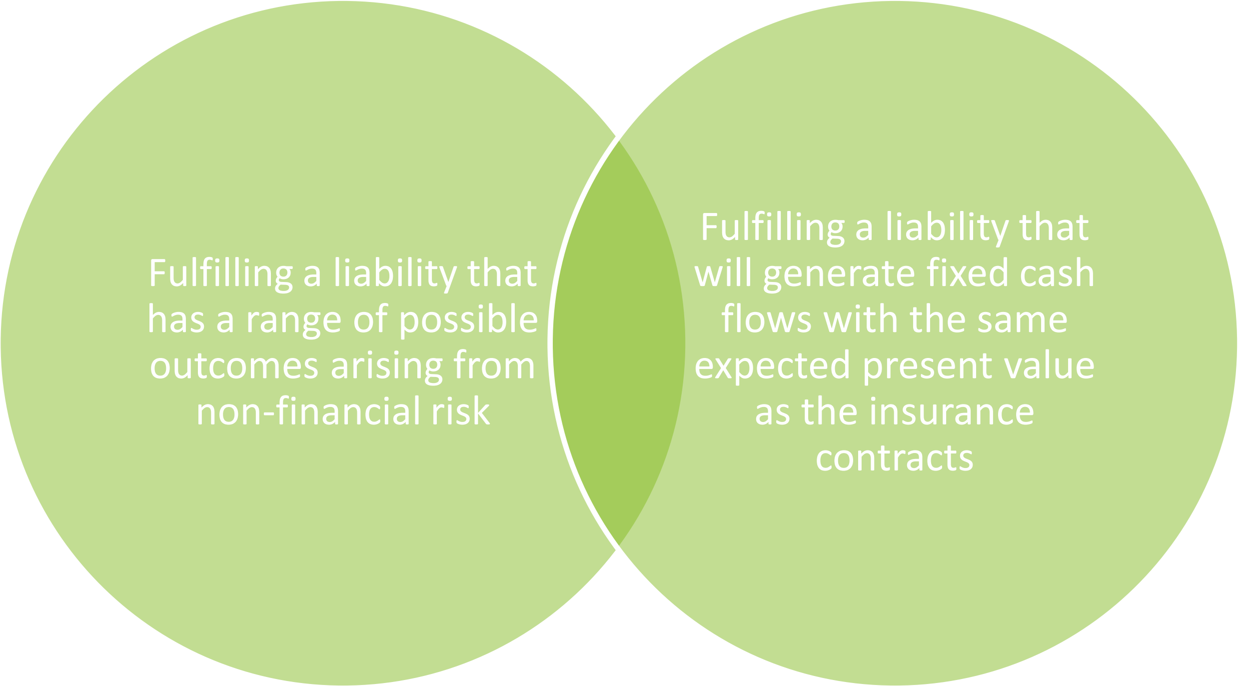
- IFRS 17 discount rate is used.
- CoC rate should be determined based on the base IFRS 17 risk adjustment rule:



Risk adjustment calculation

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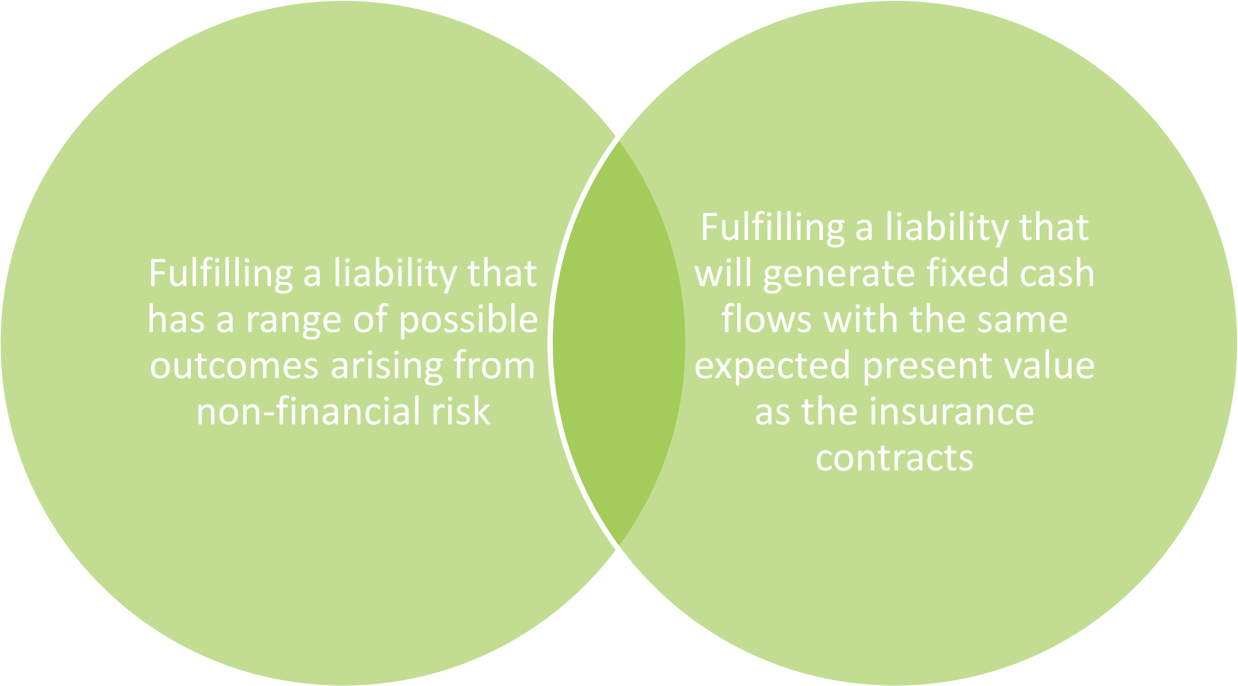

…and based on the risk appetite of insurer.

Risk adjustment calculation based on CoC approach

Step 3: Allocation to the group of insurance contracts

Risk adjustment allocation

- It’s necessary to have some **allocation key**.
- The key **has to fulfil** IFRS 17 **restrictions** defined for RA.
- **Possible choices:**
  - PV of future CFs

Allocation key

PV of future CFs

Expected CFs	Year 1	Year 2
GIC 1	50	50
GIC 2	100	

- Let's assume a positive discount rate i.

$$PV_1 = \frac{50}{(1+i)} + \frac{50}{(1+i)^2} < \frac{100}{(1+i)} = PV_2$$

Allocation key

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- It **doesn't** fulfil the following requirement:
  - For similar risks, contracts with a **longer duration** will result in higher risk adjustments for non-financial risk than contracts with a shorter duration

Risk adjustment allocation

Other (direct) approach

- It's necessary to have some **allocation key**.
- The key **has to fulfil** IFRS 17 **restrictions** defined for RA.
- **Possible choices:**
  - PV of future CFs
  - PV of future premium (or nominal value)

Allocation key
PV of future premium

- **Premium** is calculated to cover expected claims (best estimate value), expenses and also **includes** some **risk margin**.
- It doesn’t mean that **a premium** for a risk with **wider probability distribution** (and lower best estimate) has to be higher.

Allocation key

PV of future premium

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- It doesn’t mean that **a premium** for a risk with **wider probability distribution** (and lower best estimate) has to be higher.

- It **doesn’t** fulfil the following requirement:
  - Risks with a **wider probability distribution** will result in **higher risk adjustments** for non-financial risk than risks with a narrower distribution

Risk adjustment allocation

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- The key **has to fulfil** IFRS 17 **restrictions** defined for RA.
- **Possible choices:**
  - PV of future CFs
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  - **More complex allocation key is needed:**
    - Risk intensities which are determined individually for each type of risk (premium, reserve risk)
    - e.g., some combination of previous ones (a ratio of unearned premium reserve and PV of future outflows)

Risk adjustment calculation based on CoC approach

Step 3: Allocation to gross and ceded part

Risk adjustment allocation into gross and ceded GICs

- Risk adjustment should be allocated into individual GICs (also **reinsurance** ones).
- It’s **not enough** to have only **net values** (as in case of Solvency II).
- It can be easy in case that there is one QS reinsurance treaty which covers one primary insurance GIC:
  - $RA_{Gross} = \frac{RA_{Net}}{(1-QS)}$
  - $RA_{Ceded} = QS\frac{RA_{Net}}{(1-QS)}$

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  - $RA_{Gross} = \frac{RA_{Net}}{(1-QS)}$
  - $RA_{Ceded} = QS\,\frac{RA_{Net}}{(1-QS)}$
- **But reality is more complex:**
  - Closing scale reinsurance provision
  - One reinsurance treaty can cover more primary GICs (and vice versa).
  - Reinsurance treaty can cover only a part of risks.
  - Coverage periods can be different
  - Non-performance risk (counterparty default risk)

Risk adjustment calculation based on CoC approach

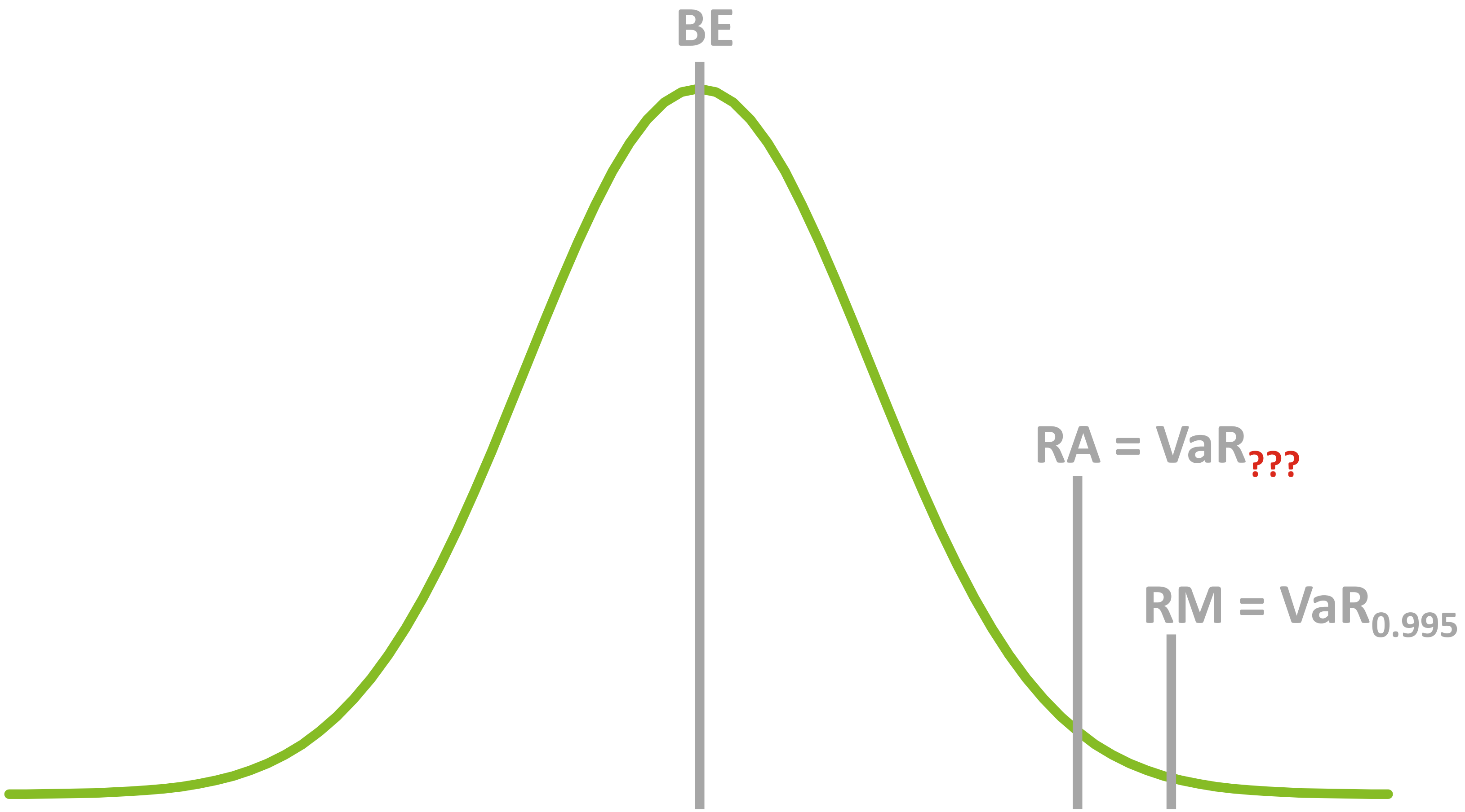
Step 3: Confidence level disclosure

Confidence level disclosure

- **Confidence level** (without modeling of all possible scenarios) **can be estimated only with** some **simplifications** and **assumptions:**

1. Liabilities are normally distributed
2. Solvency II risk margin is a 99.5% quantile

Confidence level disclosure



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- Then we can calculate (with best estimate of mean) variance by Cornish-Fisher approximation:
  - $Var(X) = \left(\frac{RM - E(X)}{z_{0.995}}\right)^2$
  - $\alpha = \Phi\left(\frac{RA - E(X)}{RM - E(X)} z_{0.995}\right)$

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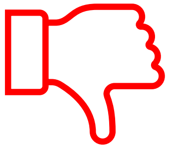
  - …but RM is the quantile of **a one-year horizon**.



Confidence level disclosure

The second option

- All possible scenarios have to be modelled for the whole lifetime of contracts in the portfolio.

Confidence level disclosure

The second option

- All possible scenarios have to be modelled for the whole lifetime of contracts in the portfolio.

- **Where to get the data?**

Risk adjustment calculation

Take home message

Take home message

- Risk adjustment calculation (and disclosure) is a very ambitious task.
- It's a compromise between finding the most appropriate and practicable approach and making simplifications.

Thank you for your attention

Sources

1. IFRS 17 standard
2. EAA presentation: “IFRS 17 –Challenges in the Derivation of the Risk Adjustment and Its Confidence Level”
3. EMC Actuarial & Analytics presentation: IFRS 17 Risk Adjustments: Reserving or Capital Modelling? (link: Microsoft PowerPoint - Peter England - IFoA TIGI 2019.pptx (actuaries.org.uk))
4. Shaun Wang: IMPLEMENTATION OF PROPORTIONAL HAZARDS TRANSFORMS IN RATEMAKING, 1997

Appendix

Proof

- Let $X \geq 0$ and $E(X) < +\infty$. Then $\int_0^{+\infty} S(x)dx = E(X)$.
  - Integration by parts for Lebeque-Stieltjes integral:
    - $F(s) \cdot \mathrm{s} - 0 = \int_0^s F(x -)\,\mathrm{dx} + \int_0^s x\mathrm{dF(x)}$
    - $\int_0^s x\mathrm{dF(x)} = F(s) \cdot \mathrm{s} - \int_0^s F(x -)dx$
  - Subtraction s from the right-hand side and add it back in form of $\int_0^s 1dx$:
    - $\int_0^s \boldsymbol{x}\mathbf{dF(x)} = (F(s) - 1)\mathrm{s} + \int_0^s \big(1 - F(x -)\big)dx = (F(s) - 1)\mathrm{s} + \int_0^s \boldsymbol{S(x)dx}$
  - Taking the limit as $s \to +\infty$ on both sides. The left-hand side converges to $E(X)$ and right-hand side to $\int_0^{+\infty} S(x)dx$
  - What about the term $(F(s) - 1)\mathrm{s}$?
    - $E(X) = \int_0^{+\infty} xdF(x) = \int_0^s xdF(x) + \int_s^{+\infty} xdF(x) \geq \int_0^s xdF(x) + s\int_s^{+\infty} dF(x) = \int_0^s xdF(x) + s\big(1 - F(s)\big)$
    - $0 \leq s\big(1 - F(s)\big) \leq E(X) - \int_0^s xdF(x) \to 0\ as\ s \to +\infty$

Appendix

Coherent measure

The coherent risk measure satisfies:

1) Translation equivariance: $\rho(X + a) = \rho(X) + a, for\ all\ X\ and\ constants\ a$
2) Positive homogeneity: $\rho(0) = 0, and\ \rho(aX) = a\rho(X), for\ all\ X\ and\ all\ a > 0$
3) Subaditivity: $\rho(X) + \rho(Y) \leq \rho(X + Y), for\ all\ X\ and\ Y$
4) Monotonicity: $\rho(X) \leq \rho(Y),\ when\ X\ \leq\ Y$