Problems in Risk Modeling and Capital Allocation
A Practitioner's Experience

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Agenda

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1. Basics on Capital Allocation
2. Practical Experience
    1. Existence of Suitable Data
    2. Stability in Time
    3. Sensible Steering on the Level of Individual Contracts
    4. Acceptance within the Company
3. Conclusions

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Basics

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- Companies need risk capital, in order to survive also years with very bad results. Insurance companies live on diversification, such that the risk capital for the total portfolio is less than the sum of the risk capital for each individual risk.
- Necessary risk capital is typically defined as a multiple of a quantile or an expected shortfall of the total result distribution.

  ➔ Need total result distribution

  ➔ Need segmentation of total portfolio, result distribution of each segment and dependencies between them.

  Structure should optimally reflect dependencies and homogeneity of the portfolio
- We will consider and compare two risk measures:
  expected shortfall and standard deviation, and suitable dependency assumptions.
- What are typical problems when estimating the total risk capital, and allocating it back to individual risks for steering?

Basics
Example 1: Expected Shortfall

Consider the expected shortfall of a random variable X as risk measure:

$$K(X) = ES_\alpha(X) = -E[X \mid X \leq -VaR_\alpha(X)]$$

Resulting capital allocation (Euler capital allocation):
Conditional Shortfall

$$K(X_i \mid X) = ES_\alpha(X_i \mid X) = -E[X_i \mid X \leq -VaR_\alpha(X)]$$

Concept of Conditional Shortfall is intuitive and simple to explain

Basics
Example 1: Expected Shortfall

How can we model dependency structures, which reflect reality in a reasonable way, but also allow for a simple and robust way of calculation?

For the Conditional Shortfall, a “dependency tree” and representation with copulas is suitable.

Let X_i be a sub-portfolio of X with cumulative distribution . . Then we obtain:

$$K(X_i / X) = ES_\alpha(X_i / X) = - \int \; . \; (\;) h \; . \; , \; . \; (\;)$$

where h . , . ( ) = − . , . (,) and . , . denotes the Copula between X_i und X.

➔ Simple calculation if dependency structure is known. Integral over quantiles of distribution multiplied with a weight function h.

Basics
Example 2: Standard Deviation

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Consider the standard deviation as risk measure:

$$K(X) = c\,\sigma(X) = \sqrt{\quad(\,.\,)}$$

Resulting capital allocation (Euler capital allocation): **Covariance**

$$K(X_i / X) = c\,cov[X_i, X] / \sigma(X) = c\,\rho(X_i, X)\,\sigma(X_i)$$

where $\rho(X_i, X)$ denotes the correlation between X_i and X.

Concept of Covariance is less intuitive and more difficult to explain –
but non-mathematician tend to ask less questions since they believe they should already know it

Basics
Example 2: Standard Deviation

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For the covariance concept, we need to determine the correlations between a sub-portfolio and the total portfolio, or the pairwise correlation between any two sub-portfolios.

Main idea: split X into natcat-scenarios, which are independent of each other and the rest of the portfolio. Split the rest further into suitable segments.

For the natcat-scenarios we have:

$$K(X_i / X) = c\, cov[X_i, X] / \sigma(X) = c\, var[X_i] / \sigma(X)$$

➔ Reduction of the problem to determination of the correlations between the other segments.

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Existence of Suitable Data
Result Distributions

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Determination of the Result Distributions of a sub-portfolios X_i

- Covariance-Principle:
  - Estimate of $\sigma(X_i)$ is sufficient
  - Can be done with statistical methods on historical data
  - Implicit assumptions within the applied method
- Conditional Shortfall:
  - Need the whole distribution
  - Needs to be modelled in more detail
  - Explicit assumptions

Existence of Suitable Data
Result Distributions

Three possibilities to determine result distribution:

- Based on historical results
- Estimation by experts

  These two possibilities are typically used for non-natcat segments

- Based on exposure data

  This is typically used for natcat-scenarios

Existence of Suitable Data
Result Distributions

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- Estimation based on historical results
  - Need minimum of 10 – 15 years of historical data. For longtail business (Liability, Engineering-Projects) rather 20 – 30 years
    ➔ Relevance for current business is questionable
  - Very common are ruptures in the data: changes in the business, mergers and acquisitions, changes in the accounting methods, new processes, new IT-Systems, commutations, data errors, …
  - Models interpret changes and ruptures as volatility, even if they have no relevance for the risks assumed
  - Model on paid or incurred data?
    Paid data often develop very slowly to ultimates, incurred data reflect also reserve politics

Existence of Suitable Data
Result Distributions

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- Estimation by experts
  - Based on their experience and hence implicitly also on data
  - Can consider also current trends and changes
  - May appear arbitrary

- Practical Experience: Combination of the two methods successful
  - Modelling on historical data, but with profound knowledge of the portfolio and manual adjustments whenever adequate

Existence of Suitable Data
Result Distributions

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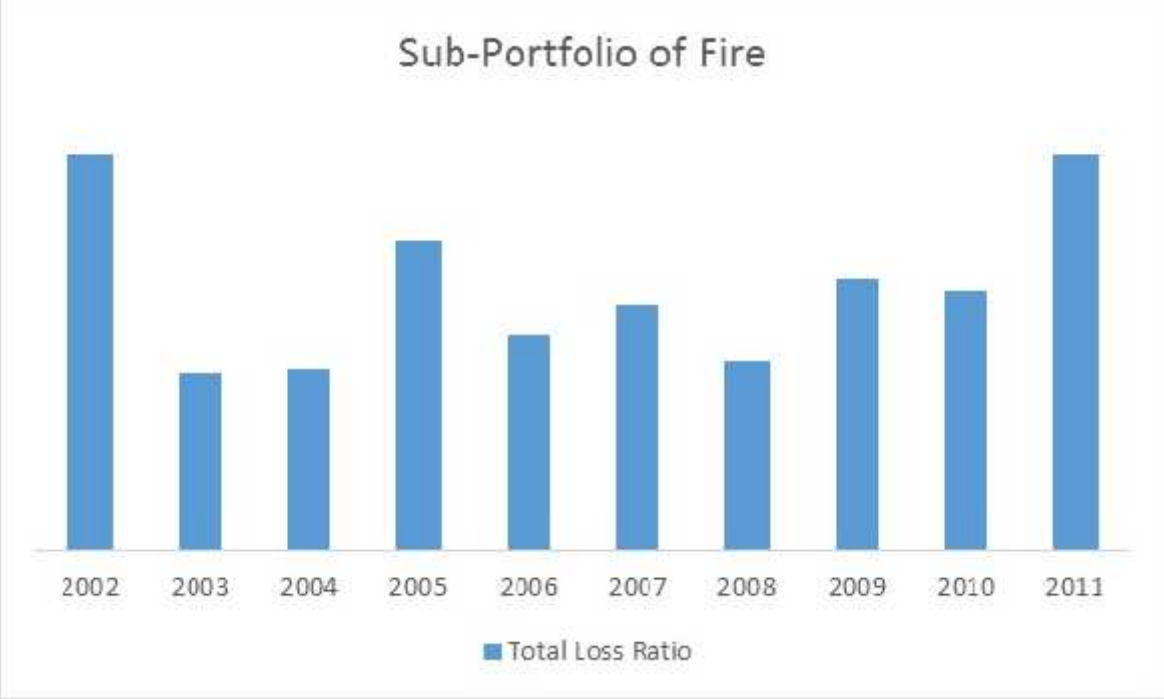
Example: Determine result distribution based on historical results



High volatility for a fire portfolio

Reason: Large and Cat losses included in data

Existence of Suitable Data
Result Distributions

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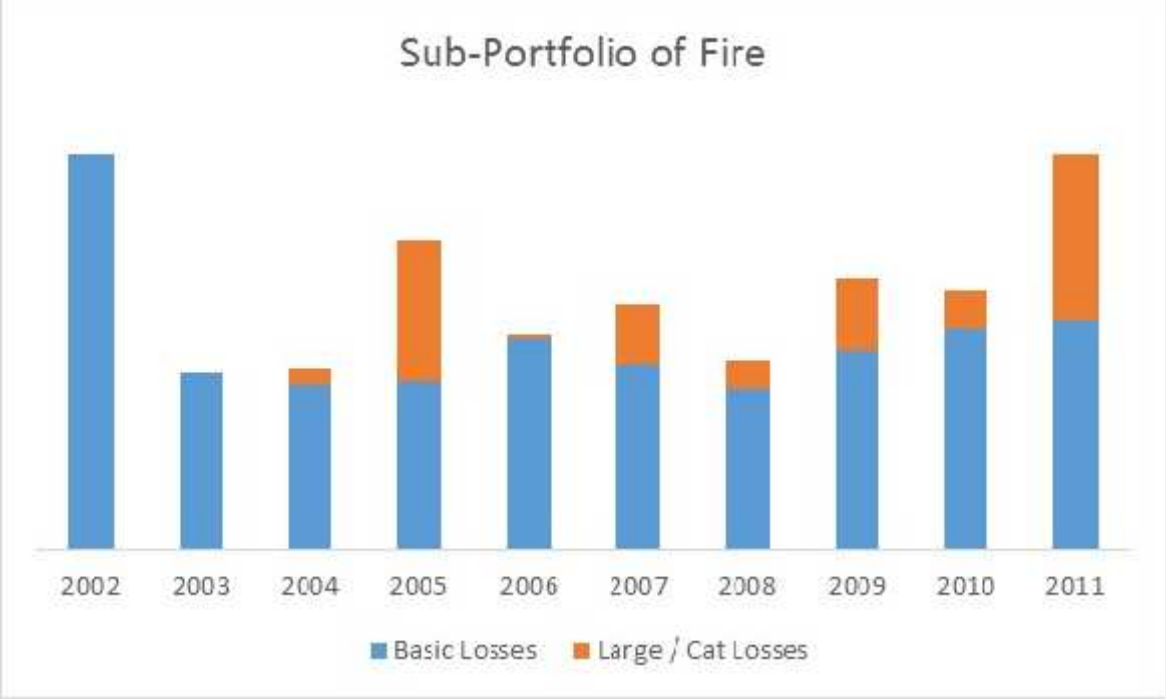
Example: Determine result distribution based on historical results



Identification of large losses prior to 2003 was incomplete

➔ Modelling of result distribution only sensible on data from 2003 on

Existence of Suitable Data
Result Distributions

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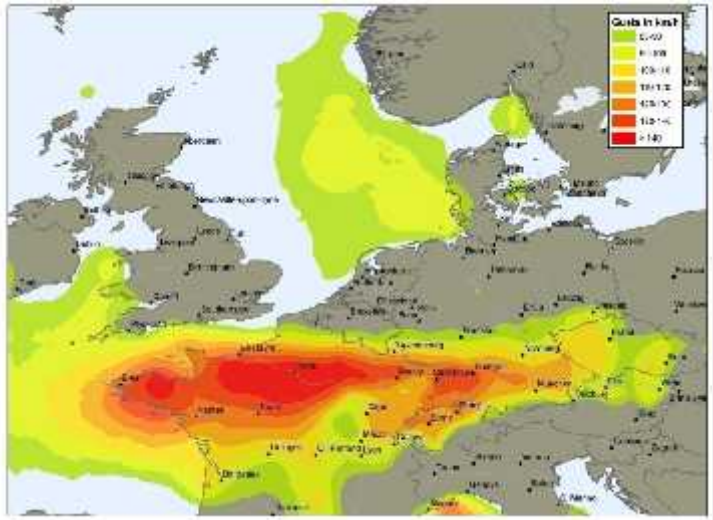
Determine Result distributions for natcat-scenarios

- With exposure based models
  - Whole distribution is known
  - We also know those scenarios, which contribute to the shortfall of the total portfolio
  - Very high volume of data in case of detailed models



Wind field "Lothar" December 1999

Existence of Suitable Data
Result Distributions

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Determine Result distributions for natcat-scenarios

- Covariance principle:
  - Variance is simple to calculate
  - Natcat-scenarios are essentially independent of each other and of other sub-portfolios ➔ Risk capital is proportional to the variance of the scenario
  - Uniform growth in the exposure leads in first approximation to the same relative increase in the capital intensity (= risk capital per exposure)
- Conditional Shortfall:
  - Conditional shortfall for a natcat-scenario of a sub-portfolio or an individual contract or risk is simple to calculate
  - Uniform growth in the exposure leads to non-linear effects, which can be hard to predict

Existence of Suitable Data Dependencies

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Estimation of dependencies

- Covariance principle:
  - Need pairwise correlations $\rho(X_i, X_j)$
  - Possible with statistical methods applied to historical data
  - Implicit assumptions in these methods
- Conditional shortfall:
  - Need detailed information on dependencies: Copulas
  - Explicit Assumptions, estimations by experts e.g. for tail dependency

Tail dependencies for copulas are difficult to determine. With the covariance principle this is not necessary. However, this does also not allow for a more sophisticated approach!

Existence of Suitable Data Dependencies

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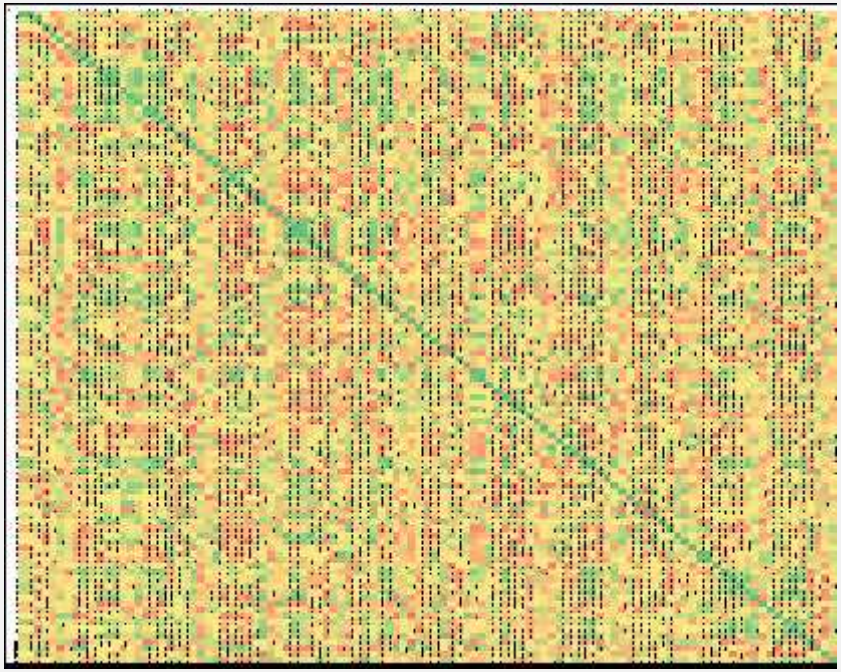
Estimation of pairwise correlations $\rho(X_i, X_j)$ for about 100 segments:



Green: Correlation = 1

Red: Correlation = -1

Problem: considerably more result parameters than input parameters

➔ Results are essentially arbitrary

Existence of Suitable Data Dependencies

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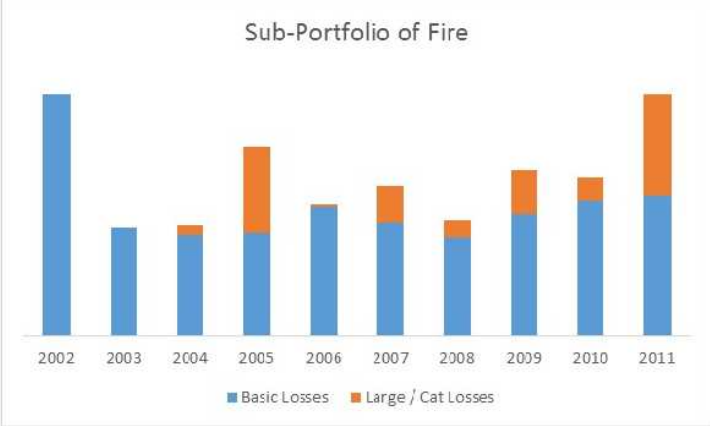
Estimation of pairwise correlations $\rho(X_i, X_j)$ for about 100 segments :

Potential solution: Determine average correlation and apply the same parameters for all segments, which are not clearly independent from the other segments.

Attention: In case of data problems like the incomplete identification of large losses, we will measure the correlation between adjusted and unadjusted data. This may lead to substantially increased values!



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Stability in Time

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Common situation: Results of the risk model are significantly different than in the previous year

- Reasons difficult to identify and to explain – complex interaction of several causes and effects:
  - If the data of the affected segments are significantly different: are the new data more correct, or just different?
  - What are the effects of changes in the total risk model?
- Comprehensible communication of reasons on management level is often very difficult
- Credibility of model result and its applicability for steering may get questioned

Stability in Time

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Recommendations:

- Keep model simple. What you gain in „correctness“ with very sophisticated models is often small, the loss in traceability and transparency however is high.
- Prior to the introduction of new models or parts of models, calculate results on real data of several (previous) years – including data problems as they existed
- Introduce new (parts of) models only if their behaviour is sufficiently understood and seems mature and reasonable
- Analyse overall change stepwise, as sequence of individual changes; show effects graphically
- Have the courage to do nothing:
  If movements look arbitrary, do not translate them into steering, but wait another year. Often, there will then be some movements in the opposite direction, or the reasons for the trend become clearer.

Stability in Time

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Recommendations :

- Anticipate changes in your planning:
  - Which changes in the data or the model are conceivable?
  - Which effects will they have? Will they partially compensate or rather amplify each other?
- Gradual implementation, especially if the change may lead to an opposing reaction
  - Example: growth in exposure in a natcat scenario will generate a higher capital intensity, and the resulting increase in prices may lead to a decrease in next years exposure

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Sensible Steering on the Level of Individual Contracts

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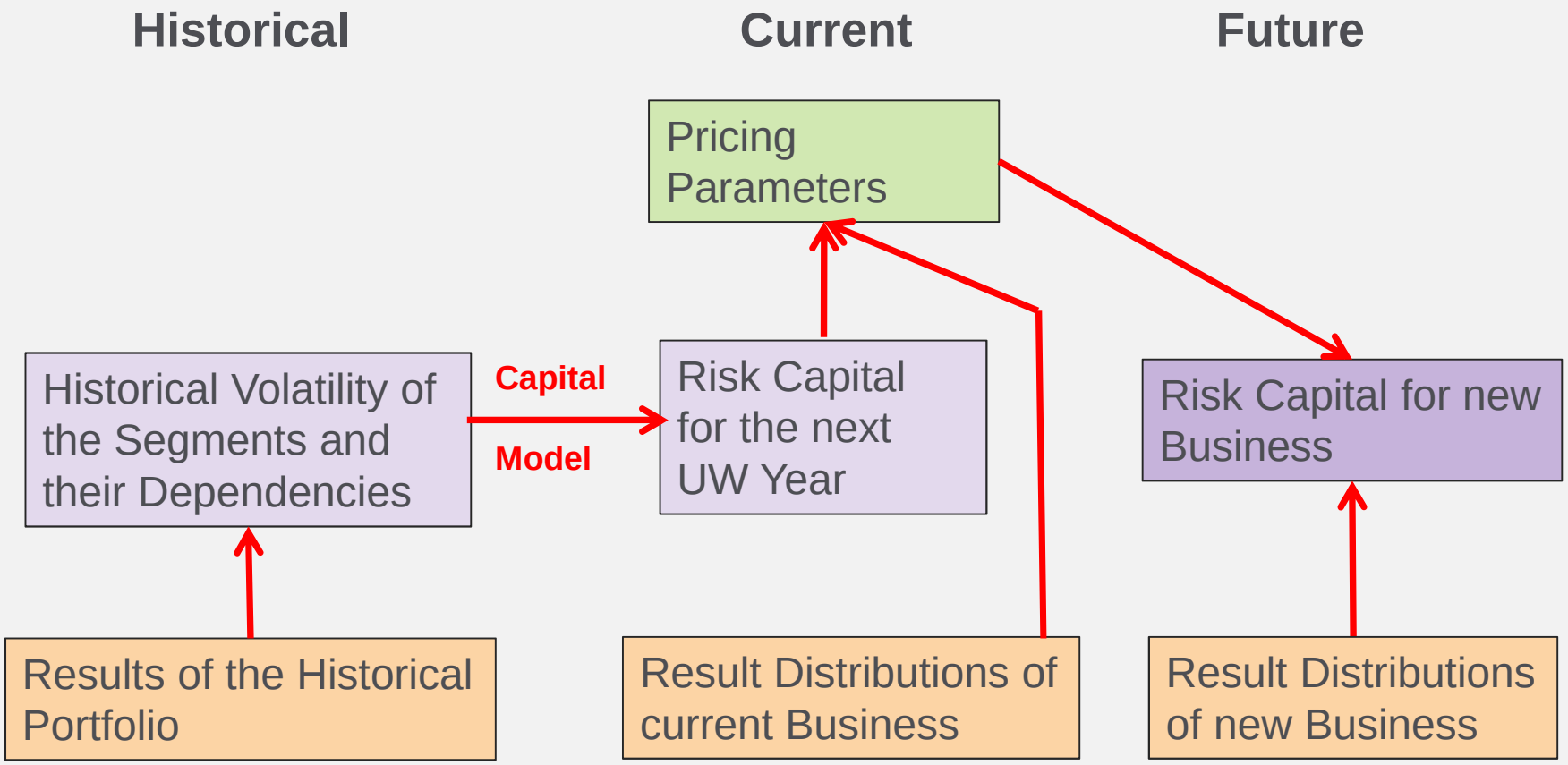
Difficulties if the business changes in time:



Sensible Steering on the Level of Individual Contracts

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Dealing with changes in the business:

- Consistency in the business is a fundamental precondition in capital models
  ➔ no mechanical standard solution possible if business changes
- Main idea 1: when determining the risk capital for the next underwriting year, take the expected portfolio structure (volume, dependencies) into account
- Main idea 2: determine the pricing parameters on a (sub-) portfolio which is comparable to the historical portfolio
- Assumption: the resulting parameters will also be reasonable for the new business
- Attention: the resulting risk capital allocated in steering may deviate significantly from the requirement from the capital model!

Sensible Steering on the Level of Individual Contracts

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Properties of the covariance principle in steering:

- Allocation of risk capital to individual contracts by their standard deviation and variance
  - Contracts independent from each other ➔ allocation through variance only
  - Contracts 100% correlated ➔ allocation through standard deviation only
  - ➔ For natcat-scenarios allocation through standard deviation, in the other segments through standard deviation and variance
- Little requirements on data: estimating the standard deviation of the result distribution sufficient
- Changes in pricing parameters due to changes in the portfolio relatively simple to understand

Sensible Steering on the Level of Individual Contracts

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Properties of the covariance principle in steering :

- Reacts in a symmetric way on volatility due to excellent or very bad results
- Terms and conditions which reduce the volatility in the result distribution, lead to a decrease in the capital requirements
- Change in capital requirement of a contract due to a change in the estimated result distribution rather simple to understand
- Natcat: no distinction between exposures in areas with very high accumulations and other areas, if dependencies within the scenario are not analysed for each contract individually
  ➔ Other components than only the standard deviation should be used for capital allocation per contract

Sensible Steering on the Level of Individual Contracts

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Properties of the covariance principle in steering :

- Allocation through variance leads to an increased capital intensity (= capital per premium), if the share of a contract is increased. To some extent this is desired, but may be too strong in extreme cases
- No automatic benefit for bad data quality: in multiline contracts without separate data per line of business, the variance term will counteract the diversification effects within the contract
- It is possible that a contract obtains more risk capital than its maximal liability. But this happens only in rare cases.

Sensible Steering on the Level of Individual Contracts

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Properties of the conditional shortfall in steering:

- Allocation of risk capital to an individual contract depends on its total result distribution
- Higher requirements on the data of individual contracts
- If the estimated result distribution of a contract changes, it is difficult to foresee the effects on its allocated capital
- It is difficult to predict changes in pricing parameters and their effects on individual contracts due to changes in the portfolio

Sensible Steering on the Level of Individual Contracts

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Properties of the conditional shortfall in steering :

- The bad outcomes of the result distribution drive the risk capital of a contract
- A contract can obtain negative risk capital
- Terms and conditions leading to a reduction of bad outcomes in the result distribution of a contract lead to a decrease in the capital requirements
- Natcat: the method differentiates between exposures in areas with high accumulations and other areas
- Difficult to handle multiline contracts appropriately if there are no separate data per line of business
- Capital intensity (= capital per premium) remains unchanged if the share of a contract is increased, if the model does not explicitly consider the change in dependencies due to volume effects

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Acceptance within the Company

Application for the steering of a company only possible if the method is sufficiently accepted in top management

- Communication is key for any larger changes
- Reasons of changes must be made transparent on a high level of abstraction
- Managers want to know how they can actively impact the results with their decisions (for example, that higher accumulations in a natcat scenario leads to higher capital intensities)

Acceptance within the Company

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Recommendations:

- Actively involve affected units as early as possible, e.g. by collaboration of their actuaries when determining new pricing parameters
- Put effects into their context:
  - Communication of costs of capital, not of the risk capital itself
  - Use graphs, e.g. showing which volume of business is affected by which changes
- Costs of capital are highly uncertain for an individual contract
  ➔ RoRaC only makes sense on an aggregated level, not for individual contracts
  ➔ Do not show the RoRaC for individual contracts
- Find a good balance: keep models simple, but still address the relevant risks!
- Do not mechanically implement results from the risk model, but only clear trends and sufficiently understood effects (unproblematic also with use-test)

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Conclusions

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- Both allocation methods – the conditional shortfall and the covariance principle – lead to sensible steering impulses for a large part of the business
- Conditional shortfall is mathematically nicer, but the requirements on the data are higher
- For communication: Conditional shortfall is more intuitive, but the impact of changes is more difficult to understand and to communicate
- It is key to know the limits of the model. Beyond them, it is often more efficient to do manual adjustments then to seek further sophistication of the model
- Sound data quality and good knowledge on the portfolio are key to a sensible capital allocation

Conclusions

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- Uncertainty in the allocated risk capital remains high, especially on a granular level
- Communication is key
- For most business, the cost of capital is small compared to e.g. the expected loss
  ➔ Efforts and resources for steering should remain in a sensible relation to its effects

Thank you for your attention!

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