Wie modelliert man Abhängigkeiten?

Bericht aus der Praxis - PrObEx

Eva Schläpfer de Montmollin
Daniel Dubischar

DVfVW Tagung 18.11.2015, Dresden

SCOR

Disclaimer

Any views and opinions expressed in this presentation or any material distributed in conjunction with it solely reflect the views of the author(s) and nothing herein is intended to, or should be deemed, to reflect the views or opinions of the employer of the presenter.

The information, statements, opinions, documents or any other material which is made available to you during this presentation are without any warranty, express or implied, including, but not limited to, warranties of correctness, of completeness, of fitness for any particular purpose.

Agenda

1	Introduction: Reinsurance and Risk modelling
2	Risk identification and dependencies
3	Calibration of dependencies: PrObEx – a Bayesian model
4	Justification & Documentation
5	Conclusion

What is an Internal Model - Definition and purpose

Definition [1)]

"Internal Model: *Risk management system of an insurer for the analysis of the overall risk situation of the insurance undertaking, to quantify risks and/or to determine the capital requirement on the basis of the company specific risk profile."*

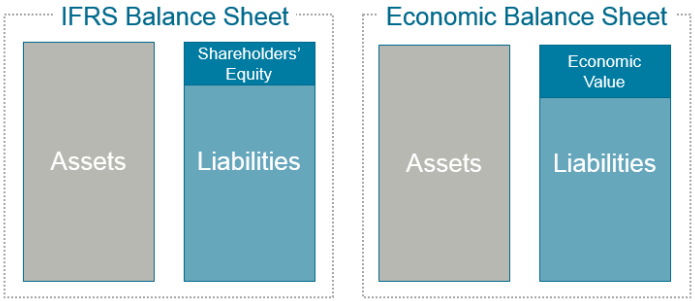
Purposes of an internal model	
Capital Requirement Assessment	❑ …a way to assess the need for capital to cover the risk assumed
Unified Risk Communication	❑ ... a unified way of communicating about risks within the company and with outside stakeholders (regulators, rating agencies, investors)
Strategic Decision Making	❑ ...a framework for taking strategic decisions, balancing risk and return: "Flight Simulator"
Portfolio Optimization	❑ …a tool for optimisation of both the asset and liability portfolios by modelling the diversification benefits
Understanding Economic Performance	❑ ...a possibility to measure the economic performance of the various lines of business

1) From CEA-Groupe Consultatif glossary (Annex C.08d))

Modelling the change in economic value

How does an internal model produce a risk profile and the Solvency Capital Requirement (SCR)

- The risk of an undertaking is the change in its value
- The valuation principles used in the internal model are economic. This means that the values of assets and the liabilities are determined by the same underlying principles
- As a consequence, for assessing the risk of the company we have to start by modeling the economic balance sheet



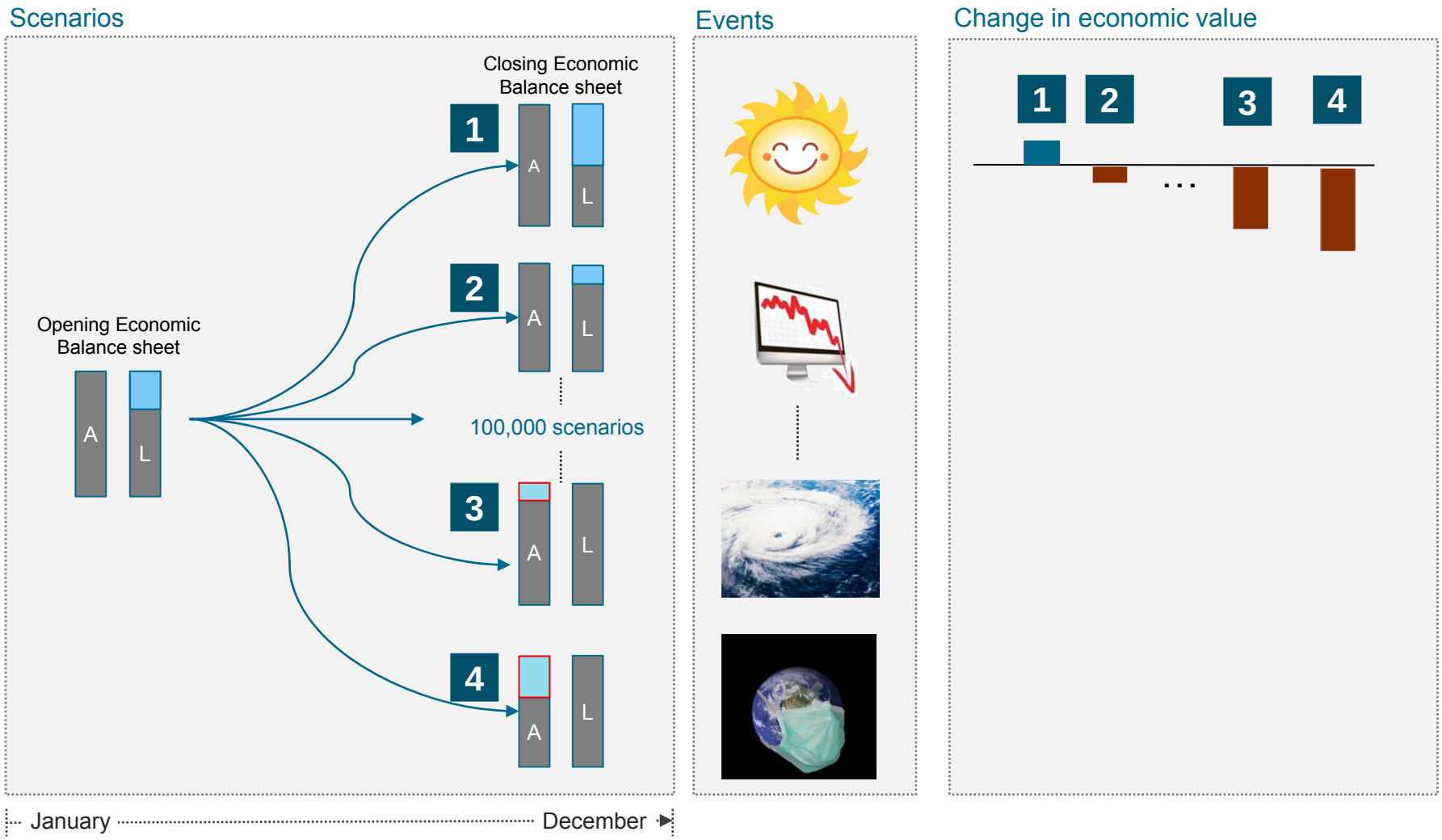
Scenario-based approach

- The value of the assets and liabilities change during the year due to both internal and external factors. The underlying drivers for these changes are called risk factors; for example movements in financial markets, occurrence of catastrophes and pandemics
- The internal model tries to simulate scenarios for these risk factors and does a forecast of the economic balance sheet at t=1 valuing the asset and liabilities under the influence of the risk factors
- We call the difference of the value of the company in a one-year time horizon the change in economic value. This is the basis for assessing the risk profile of the company as well as the Solvency Capital Requirement (SCR)

Main valuation principles of the modeled Economic Balance Sheet

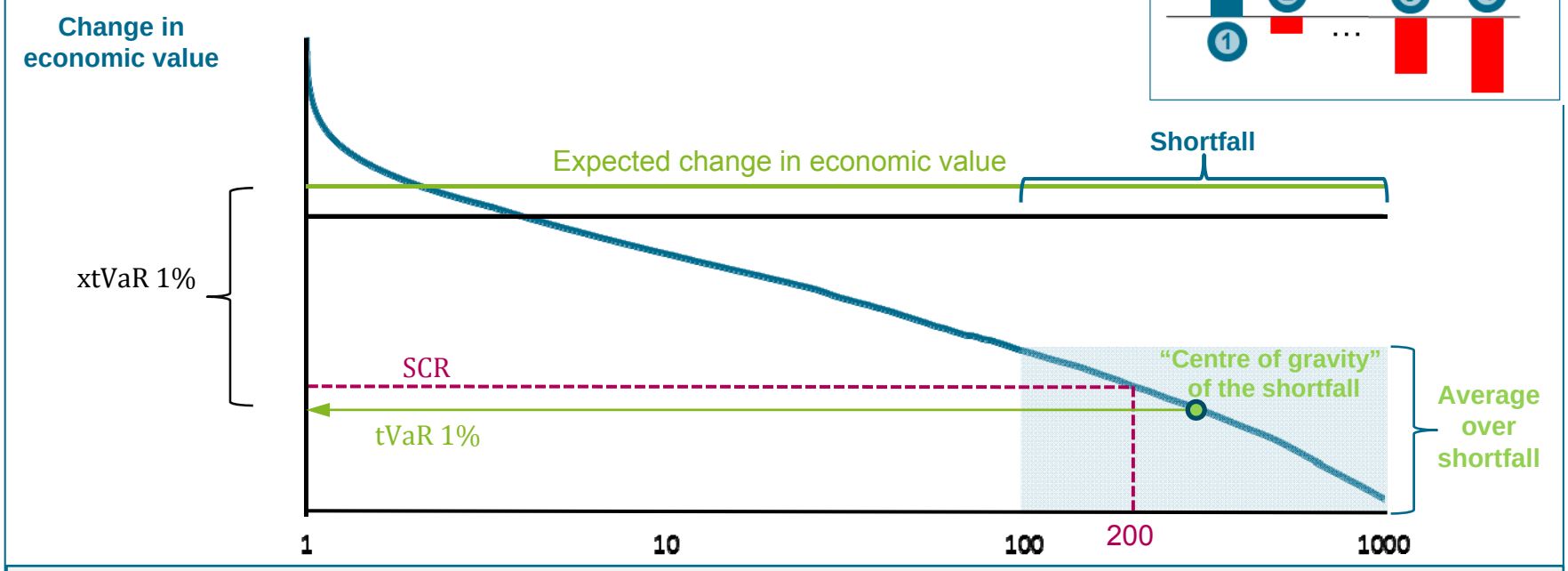
- Positions are valued as mark-to-market (if a liquid market exists), otherwise mark-to-model
- The main difference between the IFRS and economic balance are thus:
  - Discounting of future cash flows
  - Removal of goodwill
  - Removal of the future dividend foreseen at year-end
  - Tax on economic adjustments

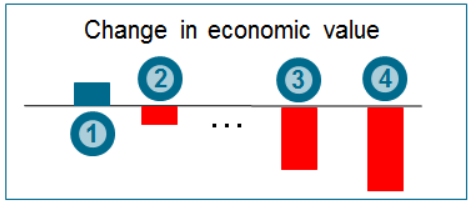
Modelling: time evolution in the internal model, scenarios



The distribution of the modeled annual change in economic value

Risk Profile





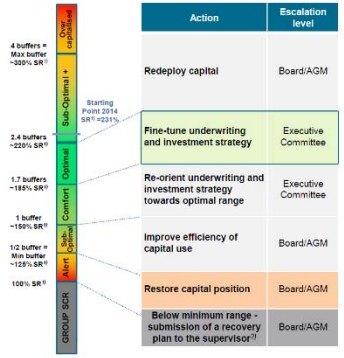
- The simulated scenarios are sorted (by change in economic value) and are plotted on the graph in relation to their likelihood - the horizontal axis shows the return periods in logarithmic scale, the vertical axis shows the respective change in economic value for the return period
- "SCR" is the worst 1-in-200-year (VaR 0.5%) event of the annual change in economic value
- tVaR 1% is the change in economic value averaged over the shortfall, which are the worst 1% results, and xtVaR 1% is the difference between tVaR 1% and the expected (average) change in economic value

Uses of the internal model

The analysis and understanding of risks, on a stand-alone and on a portfolio basis including their dependencies, and the use of the diversification effects form the basis of the (re)insurance business

Use of model: publicly available examples[1]

SCOR's solvency is actively monitored through a clear and flexible escalation framework



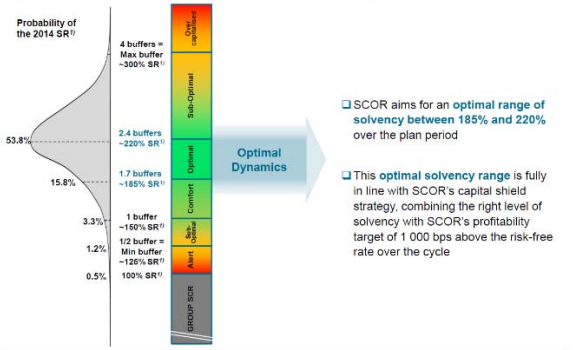
Action	Escalation level
Redeploy capital	Board/AGM
Fine-tune underwriting and investment strategy	Executive Committee
Re-orient underwriting and investment strategy towards optimal range	Executive Committee
Improve efficiency of capital use	Board/AGM
Restore capital position	Board/AGM
Below minimum range - submission of a recovery plan to the supervisor[2]	Board/AGM

- The optimal capital range enables the Group to achieve maximum profitability and satisfy the level of solvency which SCOR aims to offer its clients
- SCOR aims to make optimal use of the numerous options at its disposal to manage its capital position

1) As per Group Internal Model, ratio of Available Capital over SCR
2) When solvency II comes into force – Article 138 of the Solvency II directive

21

SCOR defines its optimal solvency and profitability level for Optimal Dynamics in the 185% - 220% solvency range



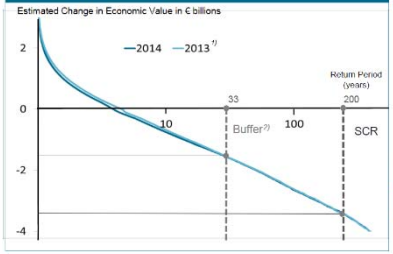
- SCOR aims for an **optimal range of solvency between 185% and 220%** over the plan period
- This **optimal solvency range** is fully in line with SCOR's capital shield strategy, combining the right level of solvency with SCOR's profitability target of 1 000 bps above the risk-free rate over the cycle

1) Solvency Ratio i.e. ratio of Available Capital over SCR

125

In 2014, SCOR confirms the strength of its capital position

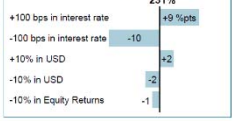
Risk profile stable from 2013 to 2014



SCOR reaffirms its solvency position

In € billions (rounded)	2013[1]	2014
Available capital (AC)[3]	7.2	7.5
SCOR Solvency Capital Requirement (SCR)	3.2	3.3
Solvency ratio (SR = AC/SCR)	221%	231%

Changes in interest and FX rates have a limited impact on SCOR's Solvency Ratio



Stable SCR after acquisition and business growth

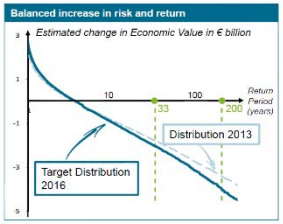
- Risk profile remains stable, as economic environment dampened the effect from the increase in business volume
- Risk profile of acquired Generali US business largely in line with due diligence estimates

1) 2013 figures correspond to the 2013 IR Day results including estimates of the impact of the acquisition of Generali US
2) The buffer capital is defined as the 97% VaR of the change in economic value distribution
3) Available capital as of 31/12 of the previous year

129

The new plan leverages an excellent starting position to further benefit from risk-taking, whilst seeking low results volatility

Balanced increase in risk and return



Risk split development

Capital position throughout the plan is in the optimal range

€ billions (rounded) Figures from Group Internal Model	2013E incl. Generali US[1]	2016E incl. Generali US[1]
Solvency Capital Requirement (SCR)	3.2	~4.0
Buffer Capital (BC)	1.6	~2.0
Threshold Capital (TC)	4.8	~6.0
Solvency ratio (AC/SCR)	221%	~200%

- Over the course of the plan, SCOR self finances its growth with **selected increases in risk taking, together with increased economic profitability**
- The increase is mainly driven by 2 factors:
  - a large part of the risk increase will be driven by natural growth, in-line with the underlying business volume
  - a smaller part will be driven by special initiatives to optimize returns over marginal increases in tail risk
- Divisional diversification remains stable at a high level

1) Subject to closing and regulatory approval. *2013 incl. Generali US* includes additional potential issuance of hybrid debt

121

[1] Examples from Investors' Day presentations e.g. 2013 Optimal Dynamics – available at www.scor.com

Modelling change in economic value…

We model a complex mix from natural catastrophes, biometric events, economic indicators where we have limited and incomplete information for many of these in low frequency events	…with a good risk mix we can live with the incomplete information
The combined occurrence of risks (especially in extremes) does have very limited to no statistical information and the rules are not clear	There may be a strange animal somewhere which decides what happens, and we only approximate the next step
How can we think that we know how things interact beyond a certain point?	…we shouldn't think that we know…
How do we know that we get it wrong?	…when we have more data…which is potentially a bit too late…

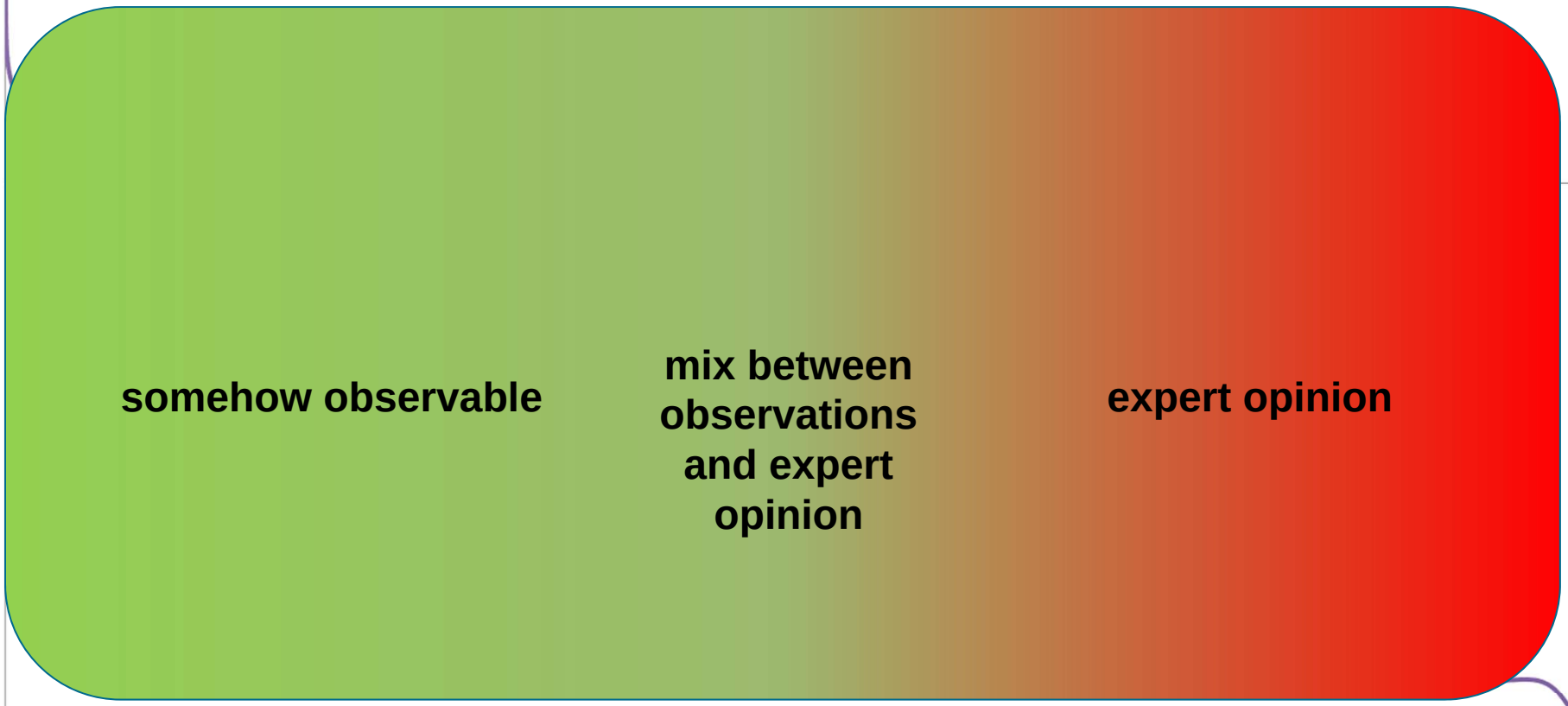
Pandemics

- We plausibilise today's ***impact*** of a severe pandemic e.g. with SIR models and assumptions
- Everybody seems to trust mitigation action and preparedness plans, governments and a stable society
- We cannot prove a more than short term dependence to economic indicators
- At some point this may turn uncontrollable, e.g. leading to riots, wars, fight for medication, food, and where we have follow-on effects on public health, GDP, complete change in behaviour?

Earthquake

- Well modeled in many ways, with lots of physics
- We think we know how large an earthquake will be, in which return period, and what it can destroy
- At some point this may turn uncontrollable, e.g. leading to riots, wars, fight for medication, food, and where we have follow-on effects on public health, GDP, complete change in behaviour?

What is the comfort zone?



- Who is an expert?
- We should never say “we survive a 1-in-x thousand year event” without specifying what this means
- What is the influence of “unmodeled” risks (known unknowns and unknown unknowns) in the far tail?

Agenda

1	Introduction: Reinsurance and Risk modelling
2	Risk identification and dependencies
5	Calibration of dependencies: PrObEx – a Bayesian model
6	Justification & Documentation
5	Conclusion

Identify risks

Risk identification and mapping in a nutshell

Objectives of a risk map

- The objective of a risk map is to complement the existing risk management tools with a tool providing a concise view of the undertaking's risks and an analysis to ensure whether an Internal Model covers all material quantifiable risks within its scope.
- It has to be maintained in line with other existing risk management processes

Key Definitions

Risk factor

- Variable associated with a change in the value of different EBS items. Impact of a risk factor can be both positive or negative
- One risk factor can include several underlying phenomena / events

Exposure

- Specific asset and/or liability which value may change due to a risk factor

Risk impact

- Combination of a risk factor and an exposure. Theoretical impact of a risk factor on a specific EBS item the company is exposed to

Identify risks

Construction process and governance

Phase 1: Describe your risk profile through a comprehensive list of risk factors and exposures

Step 1.1 – Top-down identification of risk factors based on existing risk management tools

Step 1.2 – Bottom-up review with internal experts and identification of impacts on economic balance sheet (EBS) items

Step 1.3 – Internal review

Typical sources
- Risk dashboards
- Risk analyses
- Public documents
- Internal model results
- External risk benchmarks

Involved
- Risk owners
- Model owners
- Risk management

Phase 2: Document whether these risks are modelled in the model

Step 2.1 – Top-down overall assessment of inclusion of risk factors

Step 2.2 – Bottom-up review at EBS item level

Step 2.3 – Internal review

Phase 3: Analyse risk factors not included in the model

Step 3.1 – Materiality assessment risk factors not included

Step 3.2 – Internal review

Communication to teams

Risk Map Design Example

		Investments	Reinsurance recoverables	Deposits, receivables, cash and cash equivalents	P&C lines of business	Life and Health lines of business	Deposits from reinsurers	Subordinated Liabilities
Nat Cat	Earthquake	✓	…	…	✓	…	…	…

Dependencies – Approaches for aggregation

We distinguish three approaches applied in the aggregation of risk factors, namely modelling dependence using

- Direct use of empirical data (e.g. sampling)
- Causation
- Copula

Adequately parameterizing the dependencies is a challenging task and resource intense, in the areas of research, processing and documentation

- Aggregation using empirical data
  - Generally, if there is sufficient historical data which we deem to be representative of the future, this is the preferred method for calibrating dependencies in the belly of the distribution as no further assumptions or expert input are required. In order to justify this method, evidence for the representativeness of the data for the future needs to be provided, for example by back testing.
  - Assessing the tail dependencies entirely by data is typically not sufficient, therefore e.g. this method can be complemented with a so-called tail correction

Dependencies – Approaches for aggregation

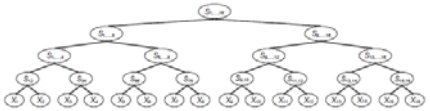
- Aggregation by causation
  - If there is strong evidence for a causal relationship between various risk factors, then the modelling choice is called causation. Having such strong evidence, for example, as derived from laws of nature, facilitates the justification of using such a dependence model
  - For example, the occurrence of severe NatCat losses may trigger downgrading or even default of retrocessionaires

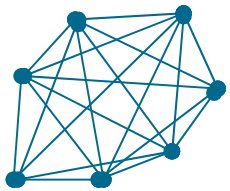
- Aggregation by Copulas
  - Copulas are tools for modelling dependence between several random variables. From a practical point of view, the advantage of the copula-based approach to modelling is that appropriate marginal distributions for the components of a multivariate system can be selected and then linked through a suitable copula. That is, copula functions allow us to model the dependence structure independently of the marginal distributions.
  - Generally, we investigate more than one type of copula and then decide on which the best fit is – the main types of copulas used are the Gaussian copula and the flipped Clayton copula
  - We use different methods to parameterise the copulas used in the aggregation of risks depending on the nature of the risks, though all are inspired by PrObEx, which we will outline in the following

Dependency structures

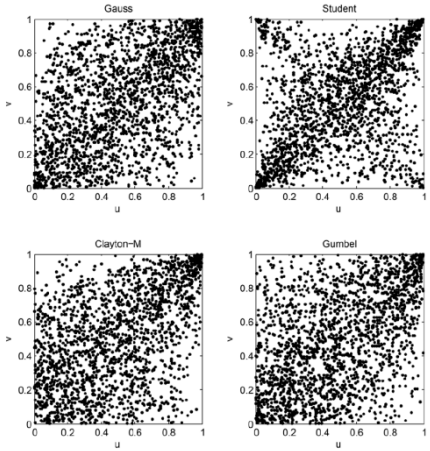
Modelling of tail dependencies is a key component for appropriate calculation of capital requirements.

How to structure the business?





Which dependencies to apply?



And how to calibrate the model?

Sources: EIOPA: Technical Specifications for the Solvency II valuation and Solvency Capital Requirements calculations, 2012
M.-P. Côté and Chr. Genest: A copula based risk aggregation model, Canadian Journal of Statistics vol 43, No 1,

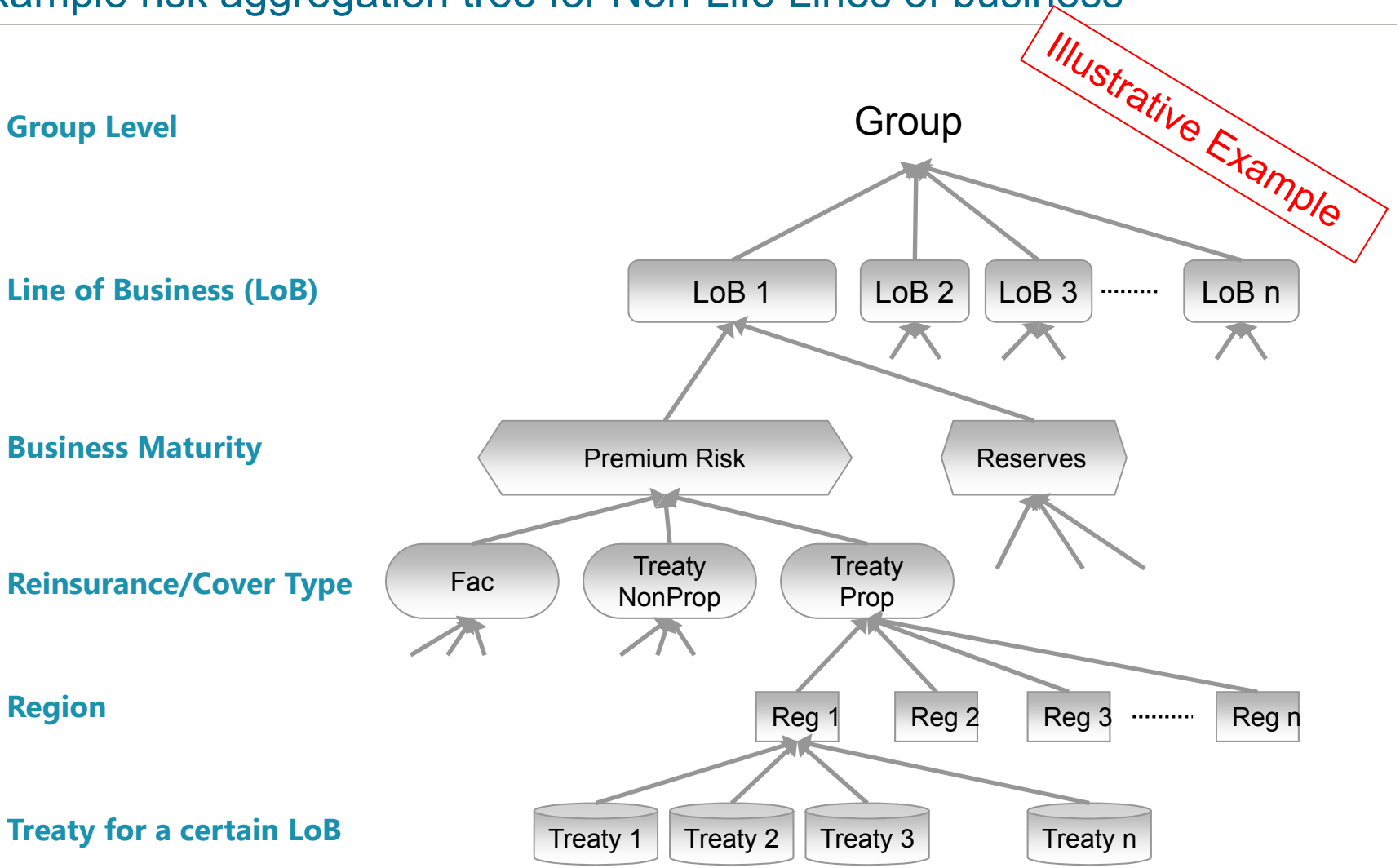
Dependencies & Hierarchical Tree

Example	Dimensions
10 Lines of business	10
New business and reserves	2 * 10
Direct and reinsurance	2 * 20
Proportional and non-proportional	2 * 40
10 regions	10 * 80

If correlations or in general dependencies have to be defined between all risk baskets this would lead to the following issues:

- Around 800 * (800 – 1) / 2 dependency parameters to calibrate
- Risk factors to determine some dependencies are difficult to explore

Example risk aggregation tree for Non-Life Lines of business



The aggregation tree for Non-Life

Illustrative Example

GIM new LE (Assembly Tree Collection) - 2011Q1 Operational Run (Scor Global P&C) (new LE structure) - NORMA

File Tools Window Help

Overview | Edit Tree | Assign Collections | Assign Models | Planning Data | Edit Dependency/Correlation | Reports | Diversification Functions | Users

Name	Modelling Unit	ReinsuranceType	Cover Type	Business Maturity	Legal Entity
All; All; All; All; All; None;	All	All	All	All	All
CASUALTY RELATED	All	All	All	All	All
Auto_All incl Lloyds Syndicates	Auto_All	All	All	All	All
Auto SCOR ASIA PACIF.	Auto	All	All	All	SCOR ASIA PACIF.
Auto SCOR ASIA PACIF. (Beijing branch of Scor SE)	Auto	All	All	All	SCOR ASIA PACIF. (Beijing branch of Scor SE)
Auto SCOR CANADA	Auto	All	All	All	SCOR CANADA
Auto SCOR GERMANY	Auto	All	All	All	SCOR GERMANY
Auto SCOR ITALIA	Auto	All	All	All	SCOR ITALIA
NewBusiness	Auto	All	All	NewBusiness	SCOR ITALIA
Treaty NonProportional	Auto	Treaty	NonProportional	NewBusiness	SCOR ITALIA
Treaty Proportional	Auto	Treaty	Proportional	NewBusiness	SCOR ITALIA
PriorYearBusiness	Auto	All	All	PriorYearBusiness	SCOR ITALIA
Reserves	Auto	All	All	Reserves	SCOR ITALIA
Auto SCOR RE US	Auto	All	All	All	SCOR RE US

Once the tree is defined, the dependencies have to be calibrated. In the following slides we outline the PrObEx approach using prior information, observations and expert judgment.

Agenda

1	Introduction: Reinsurance and Risk modelling
2	Risk identification and dependencies
5	Calibration of dependencies: PrObEx – a Bayesian model
6	Justification & Documentation
5	Conclusion

The model copula family and dependence measure

Let $\mathscr{C}_0 = \{C_\gamma : \gamma \in \Gamma\}$ denote a family of bivariate copulas, with parameter set Γ and density $c(\cdot|\gamma)$
We assume that

$$C = C_{\gamma_0} \in \mathscr{C}_0$$

where γ_0 is an unknown but fixed parameter. **Our aim is to estimate** γ_0

This is done indirectly through ***using a dependence measure*** *(*which is familiar to the business experts and can be linked to the copula parameter)

Let $\rho(\cdot,\cdot)$ denote a fixed dependence measure. The set of attainable values of ρ for copulas in $\mathscr{C}_0$
Is defined by

$$\Theta = \{\rho(U^*, V^*) : (U^*, V^*) \sim C^* \in \mathscr{C}_0\}$$

We assume that Θ is an interval, i.e. $\Theta = [a, b] \subset \mathbb{R}$
We focus on $\rho(\cdot,\cdot)$ which satisfy $\rho(U, V) = \rho(X, Y)$

We assume there exists $g : [a, b] \to \Gamma$ a bijective link function such that $g(\rho(U^*, V^*)) = \gamma^*$
for all $(U^*, V^*) \sim C_{\gamma^*}$

Calculating an estimate $\widehat{\theta_0}$ of θ_0 leads to an estimate $\widehat{\gamma_0} = g(\widehat{\theta_0})$ of γ_0.

PrObEx – Combining three sources of information

- (Up to) three sources of information can be combined:

Prior — A prior density $\pi(\theta):[a,b]\rightarrow[0,\infty)$ e.g. from previous years or from regulators

Observation — N independent observations (U_n ,V_n), n=1,…,N of independent observations of $(U,V) \sim C_{\gamma_0}$ .The set of observation is denoted by $\mathcal{O}$

Experts — K experts, each providing one point estimate φ_k , k=1,…, K of the dependence measure $\rho(U,V)$. The set of expert assessments is denoted by $\mathcal{E}$

- Using Bayes' Theorem, we replace the prior density by a posterior density given both the observations and the expert opinions

$$\pi(\theta|\mathcal{O},\mathcal{E})h(\mathcal{O},\mathcal{E}) = h(\mathcal{O},\mathcal{E}|\theta)\pi(\theta),$$

- Assuming independence between expert assessment and observation leads to

$$h(\mathcal{O},\mathcal{E}|\theta) = h_O(\mathcal{O}|\theta)h_E(\mathcal{E}|\theta)$$

PrObEx continued

- We make the following assumptions:
  - The expert assessments and the observations are independent
  - The observations are independent
  - The experts form their opinion independently of each other

- Under these assumptions, the posterior distribution of the value of the dependence measure reads as:

$$\pi(\theta|\mathcal{O},\mathcal{E}) \propto \underbrace{\pi(\theta)}_{\text{Prior}} \underbrace{\prod_{n=1}^{N} c(U_n, V_n|g(\theta))}_{h_O(\mathcal{O}|\theta)\ \text{Observation}} \underbrace{\prod_{k=1}^{K} e_k(\varphi_k|\theta)}_{h_E(\mathcal{E}|\theta)\ \text{Experts}}$$

Where $c(u,v|\gamma) = \frac{\partial}{\partial u}\frac{\partial}{\partial v} C_\gamma(u,v)$ and $e_k(\cdot|\theta)$ is the conditional density, given θ of *k*-th expert assessment

- Through this posterior distribution we can:
  - Estimate the value of the dependence measure
  - Assess the uncertainty of our estimate

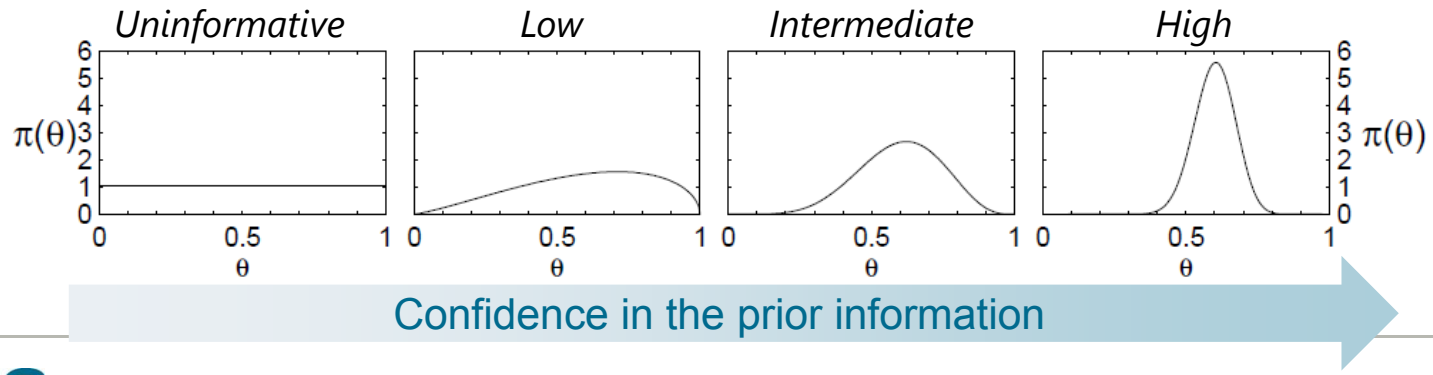
Prior information

- Suppose we can infer a point estimate $\widehat{\theta}_p$ of θ_0 from the prior source of information.
- We then model $\pi(\theta)$ with a shifted Beta distribution with mean $\mathbb{E}[\theta] = \widehat{\theta}_p$.

- If the source of information leading to $\widehat{\theta}_p$ does not specify a measure of uncertainty, we determine $\mathrm{var}(\theta)$ through a qualitative approach:

$$\mathrm{var}(\theta) = \begin{cases} 0.005(b-a)^2 & \text{for high confidence,} \\ 0.02(b-a)^2 & \text{for intermediate confidence,} \\ 0.05(b-a)^2 & \text{for low confidence.} \end{cases}$$

- If no prior belief is available then $\pi(\theta)$ can be set uninformative.
- The four mentioned qualitative approaches:



The elicitation of expert opinions

- An expert elicitation procedure needs to satisfy five principles in order to reach rational consensus, namely:
  - Reproducibility
  - Accountability
  - Empirical control
  - Neutrality
  - Fairness
- Psychological effects are involved and have to be considered carefully
- The literature distinguishes between behavioral vs. mathematical approaches

The modeling of expert opinions

- The conditional density of the k-th expert is modeled via a shifted Beta distribution.

- We model the expert estimates to be conditionally unbiased, i.e. $\mathbb{E}[\varphi_k|\theta] = \theta$.

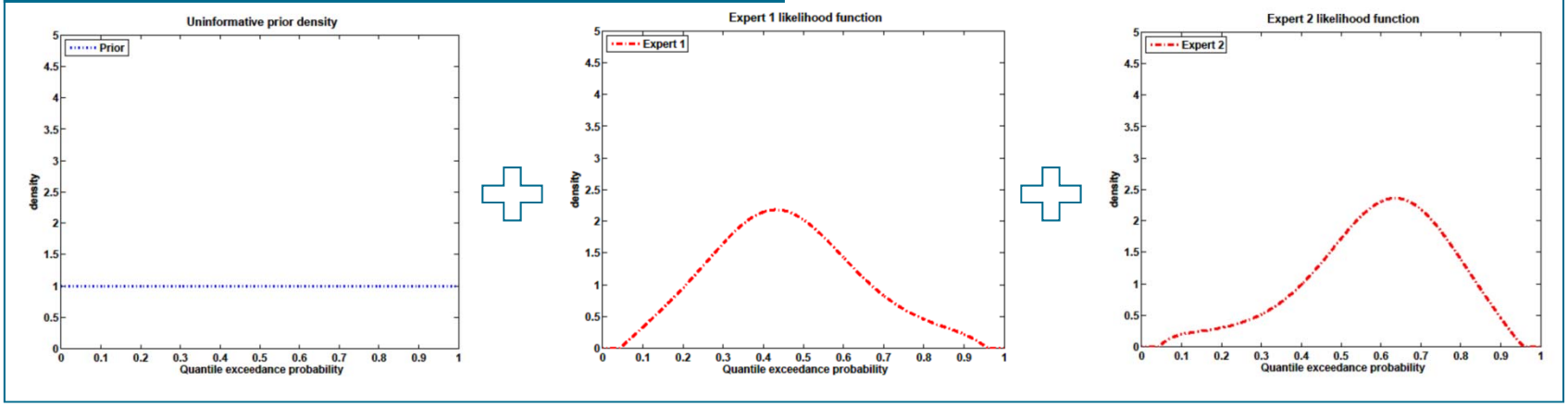
- To reflect the expert uncertainty we assign each expert a variance σ_k^2 , which is assumed to be independent of θ, i.e. $\mathrm{var}(\varphi_k|\theta) = \sigma_k^2$

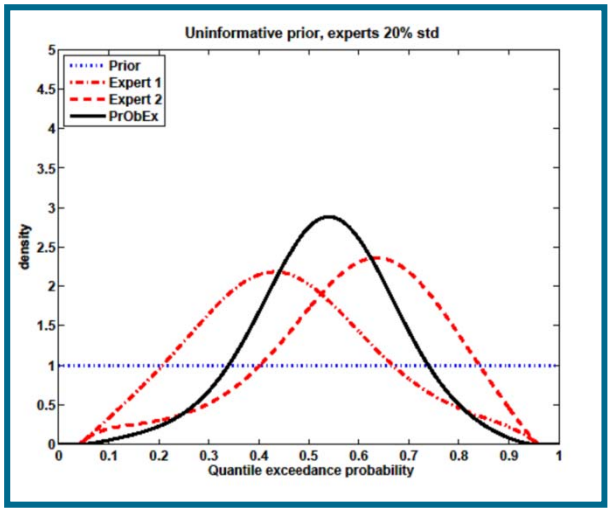
- Three possible approaches to calculate estimates $\widehat{\sigma_k^2}$ of σ_k^2 are considered:

  - Subjective variances
  - Homogeneous experts
  - Seed variables

PrObEx Example (1/3)
With two experts equally certain and no prior information

Combining different sources of information

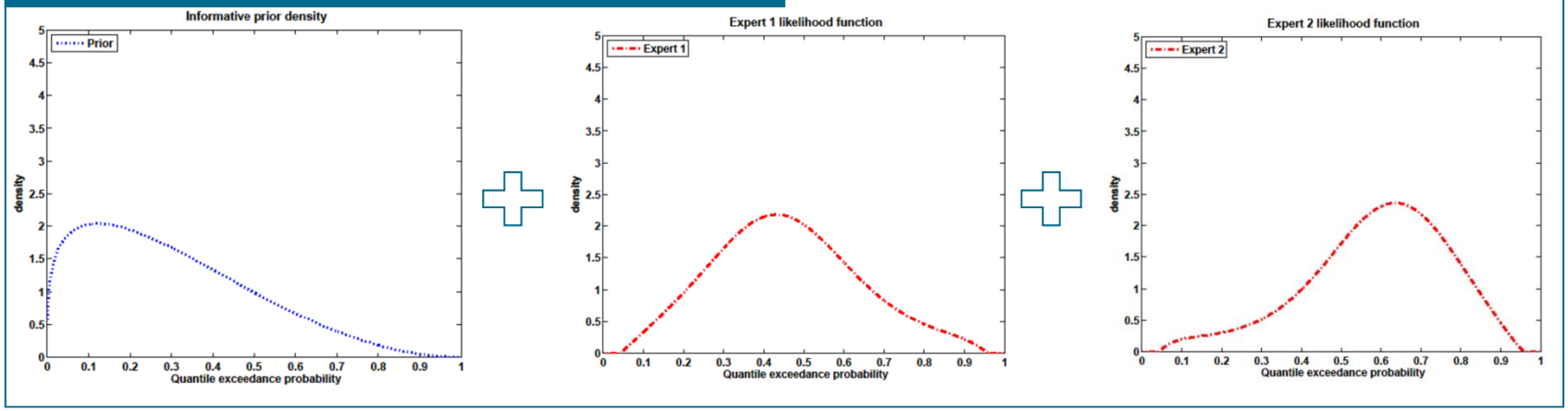


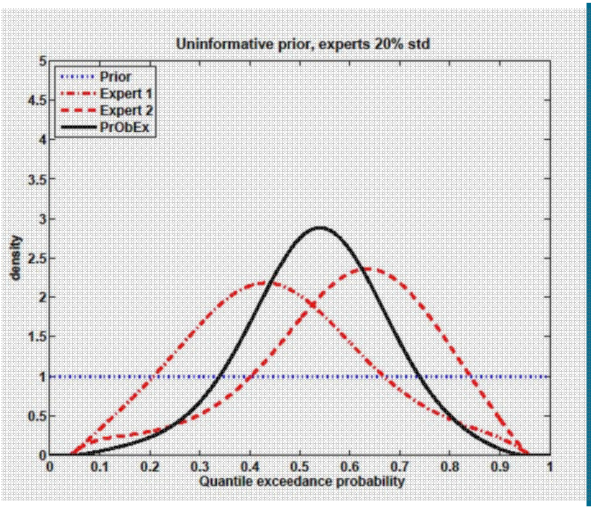


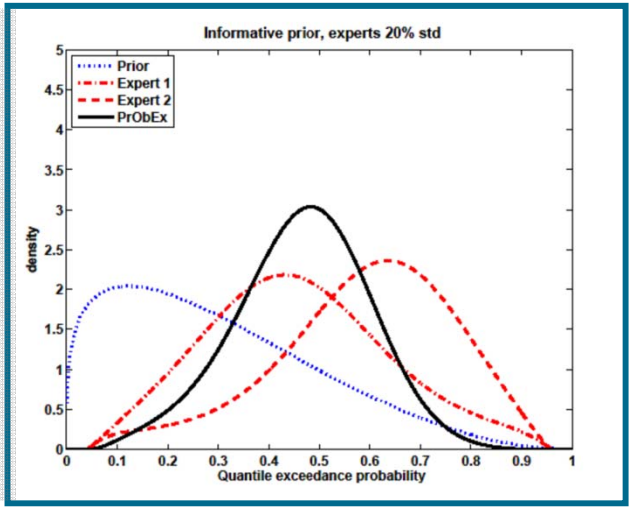
Combining two experts' opinions reduces the uncertainty around the estimator

PrObEx Example (2/3)
With an informative prior

Combining different sources of information



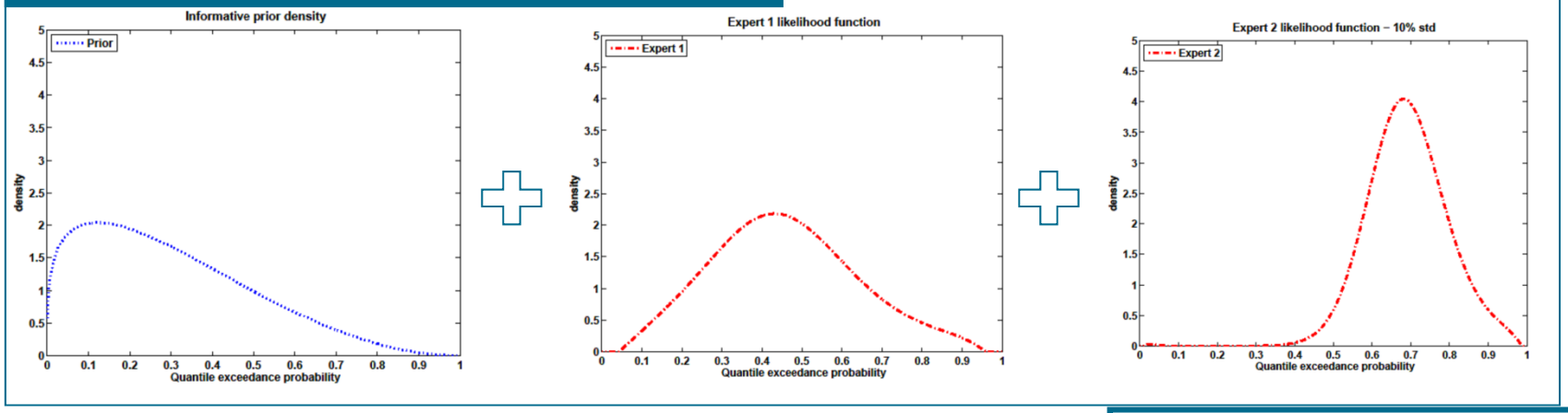


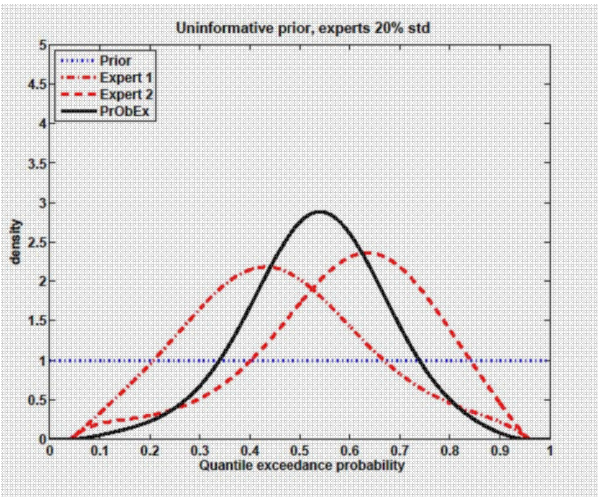


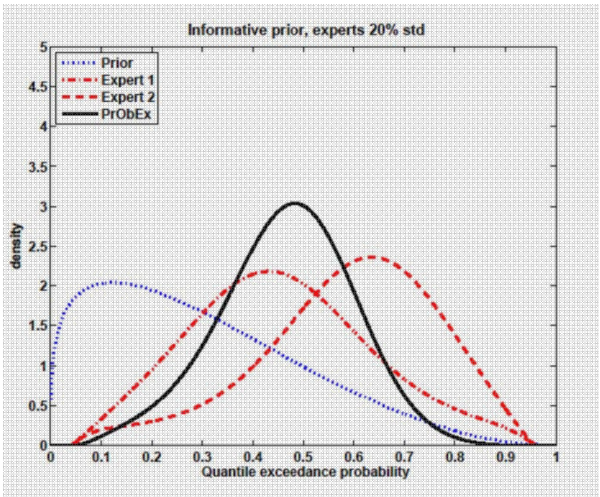
Adding prior information further reduces the uncertainty around the estimator

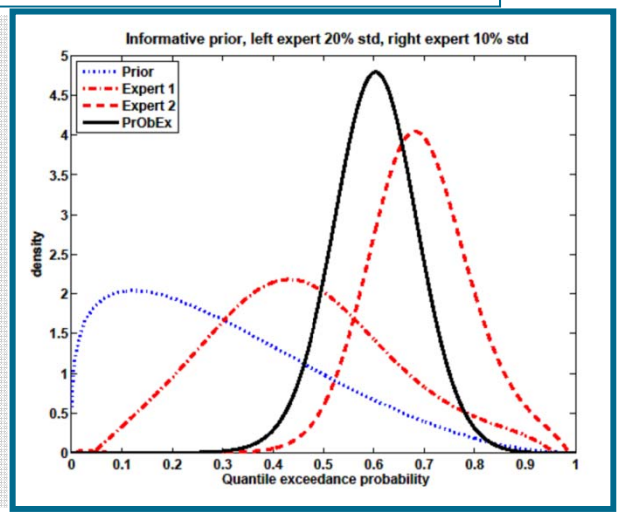
PrObEx Example (3/3)
With confident experts - increasing further the precision

Combining different sources of information









The uncertainty around the estimator reduces further using reliable experts.

The calibration process at SCOR

33 workshops

7 locations around the world

Workshop

1'300+ dependence assessments

100+ experts

Overview → **Training** → **Brainstorming** → **Questionnaire**

Prior information + **Observation** + **Experts opinion**

PrObEx

↓

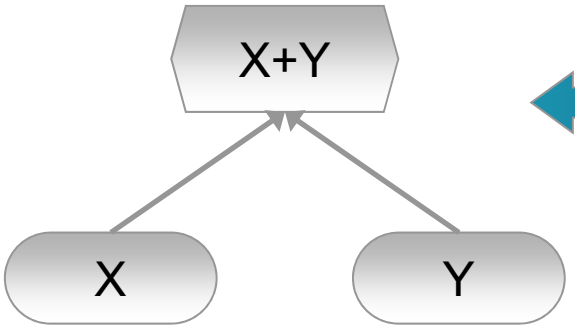
Dependence parameters

Risk aggregation

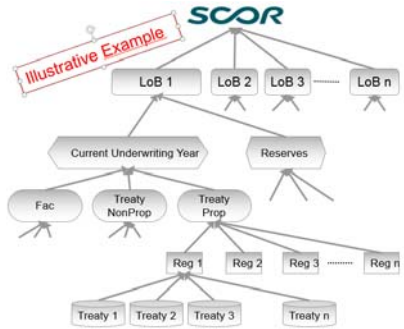
↓

e.g. Solvency Capital Requirement (SCR)

Dependence measure – what we asked the SCOR experts



How to measure dependence?



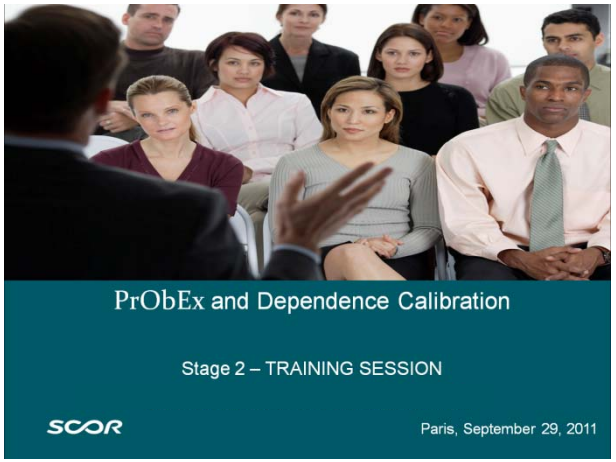
- The experts were asked to answer a question like:

"Suppose Y exceeds the 1-in-100 year threshold.
What is the probability that also X exceeds its 1-in-100 year threshold?"

- This is equivalent to quantify the so called Quantile Exceedance Probability:

$$P\left[X > VaR_{0.99}(X) \mid Y > VaR_{0.99}(Y)\right]$$

Workshop agenda



Expert judgment and heuristics[1] (1/4)

- Representativeness (1)

Linda is 31 years old, single, outspoken and very bright. She majored in philosopy. As a student, she was deeply concerned with issues of discrimination and social justice, and also participated in antinuclear demostrations.

Is it more likely that:

(A) Linda is a bank teller?

(B) Linda is a bank teller and active in the feminist movement?

[1] Examples in this section following D. Kahneman & A. Tversky, full references can be found in the first reference at the end of the presentation

Expert judgment and heuristics (2/4)

- Representativeness (2)

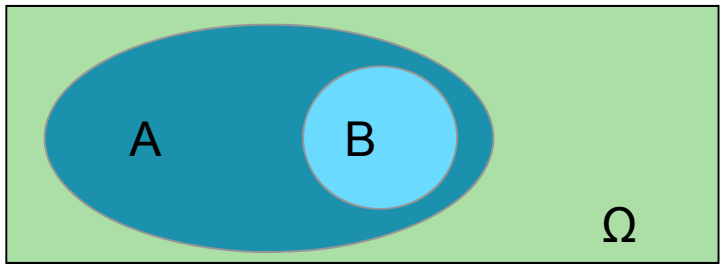
Linda is 31 years old, single, outspoken and very bright. She majored in philosopy. As a student, she was deeply concerned with issues of discrimination and social justice, and also participated in antinuclear demostrations.

There are 100 people who fit the description above. How many of them are:

(A) bank tellers?

(B) bank tellers and active in the feminist movement?

Answer:



Expert judgment and heuristics (3/4)

- Availability

Are there more words in the English language that begin with R or have R as their third letter?

Which hazard claims more lives in the United States: lightning or tornadoes?

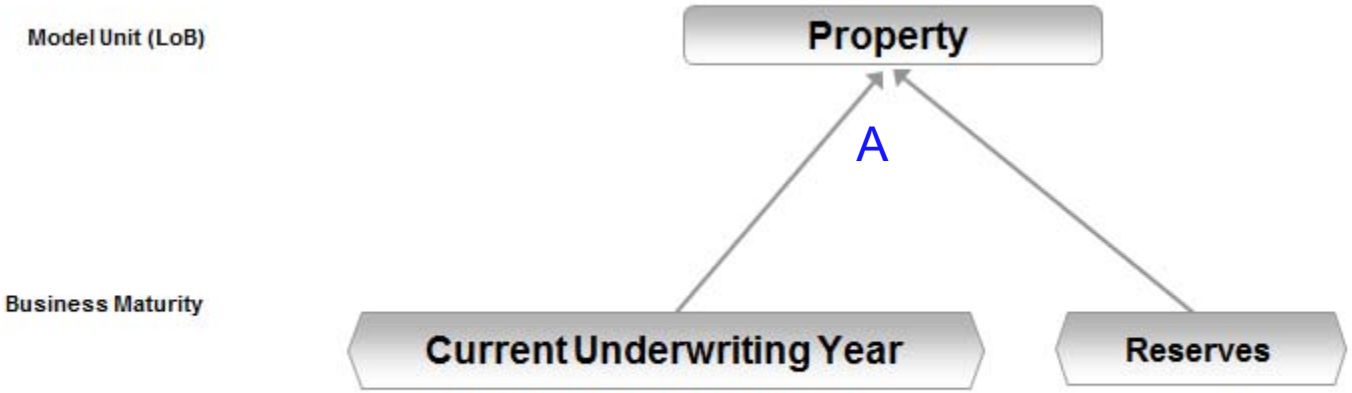
Expert judgment and heuristics (4/4)

- Anchoring

Is the population of Chicago more or less than 200,000?
Estimate the population.

Is the population of Chicago more or less than 5 million?
Estimate the population.

Questionnaire (example) (1/2)



Given that an extremely bad outcome is observed in the Current Underwriting Year (CUY), what is your estimate of the probability that also Reserve will need to be strengthened in an extreme manner?

Questionnaire (example) (2/2)

		Risk Driver Categories				
		Risk Driver Category 1	Risk Driver Category 2	Risk Driver Category 3	Risk Driver Category 4	Risk Driver Category 5
Step 1	Is this RD capable of producing a 1-in-100 or worse outcome in the CUY?	Yes	No	No	Yes	No
Step 2	Out of 100 scenarios where a 1-in-100 or worse outcome is observed in the CUY, how many are due to this RD?	70			30	
	Check	OK				
Step 3	If a 1-in-100 or worse outcome is observed in the CUY due to this RD, would you deem possible that also Reserves would need to be strenghtened in an extreme manner due to this RD?	No			Yes	
Step 4	Given that a 1-in-100 or worse outcome is observed in the CUY due to this RD, how likely it is that also Reserves will need to be strengthened in an extreme manner due to this RD?				20%	

Answer	Given that a 1-in-100 or worse outcome is observed in the CUY, your estimate of the probability that also Reserves will need to be strengthened in an extreme manner is:				
	7%				
Confidence	Not so confident				Very confident
	☐ 1	☐ 2	☑ 3	☐ 4	☐ 5

Dependence parameters – illustrative results

Illustrative Example

Overview | Edit Tree | Assign Collections | Assign Models | Planning Data | Edit Dependency/Correlation | Reports | Diversification Functions | Users

	Name	Modelling Unit	Legal Entity	Cover Type	Reinsurance Type	Business Maturity	Region	Copula Type	Theta Parameter	Exceedance Probability
1262	Auto Scor Switzerland AG	Auto	Scor Switzerland AG	All	All	All	None	Clayton	0.76	0.41
1263	Reserves	Auto	Scor Switzerland AG	All	All	Reserves	None	Clayton	0.596	0.33
1265	Treaty NonProportional	Auto	Scor Switzerland AG	NonProportional	Treaty	Reserves	None			
1266	Facultative NonProportional	Auto	Scor Switzerland AG	NonProportional	Facultative	Reserves	None			
1267	PriorYearBusiness	Auto	Scor Switzerland AG	All	All	PriorYearBusiness	None			
1268	Treaty Proportional	Auto	Scor Switzerland AG	Proportional	Treaty	PriorYearBusiness	None			
1269	Treaty NonProportional	Auto	Scor Switzerland AG	NonProportional	Treaty	PriorYearBusiness	None			
1270	Auto SCOR GERMANY	Auto	SCOR GERMANY	All	All	All	None			
1271	NewBusiness	Auto	SCOR GERMANY	All	All	NewBusiness	None			
1272	Treaty Proportional	Auto	SCOR GERMANY	Proportional	Treaty	NewBusiness	None			
1273	Treaty NonProportional	Auto	SCOR GERMANY	NonProportional	Treaty	NewBusiness	None			
1274	Reserves	Auto	SCOR GERMANY	All	All	Reserves	None			
1275	Treaty Proportional	Auto	SCOR GERMANY	Proportional	Treaty	Reserves	None			
1286	Treaty NonProportional	Auto	SCOR ITALIA	NonProportional	Treaty	Reserves	None			
1287	Facultative NonProportional	Auto	SCOR ITALIA	NonProportional	Facultative	Reserves	None			
1288	PriorYearBusiness	Auto	SCOR ITALIA	All	All	PriorYearBusiness	None			
1289	Treaty Proportional	Auto	SCOR ITALIA	Proportional	Treaty	PriorYearBusiness	None			
1290	Auto SCOR RE US	Auto	SCOR RE US	All	All	All	None			
1291	NewBusiness Standard lines template	Auto	SCOR RE US	All	All	NewBusiness	None			
1292	Treaty Proportional	Auto	SCOR RE US	Proportional	Treaty	NewBusiness	None			
1293	Treaty NonProportional	Auto	SCOR RE US	NonProportional	Treaty	NewBusiness	None			
1294	Reserves Standard lines template	Auto	SCOR RE US	All	All	Reserves	None			
1295	Treaty Proportional	Auto	SCOR RE US	Proportional	Treaty	Reserves	None			
1296	Treaty NonProportional	Auto	SCOR RE US	NonProportional	Treaty	Reserves	None			
1297	Facultative NonProportional	Auto	SCOR RE US	NonProportional	Facultative	Reserves	None			
1298	PriorYearBusiness Standard lines template	Auto	SCOR RE US	All	All	PriorYearBusiness	None			
1299	Treaty Proportional	Auto	SCOR RE US	Proportional	Treaty	PriorYearBusiness	None			
1300	Treaty NonProportional	Auto	SCOR RE US	NonProportional	Treaty	PriorYearBusiness	None			
1301	Auto SCOR REASS. excl. UK, Italy, Germany an	Auto	SCOR REASS. excl. UI	All	All	All	None			
1302	NewBusiness Standard lines template	Auto	SCOR REASS. excl. UI	All	All	NewBusiness	None			
1303	Treaty Proportional	Auto	SCOR REASS. excl. UI	Proportional	Treaty	NewBusiness	None			
1304	Treaty NonProportional	Auto	SCOR REASS. excl. UI	NonProportional	Treaty	NewBusiness	None			
1305	Reserves Standard lines template	Auto	SCOR REASS. excl. UI	All	All	Reserves	None			
1306	Treaty Proportional	Auto	SCOR REASS. excl. UI	Proportional	Treaty	Reserves	None			
1307	Treaty NonProportional	Auto	SCOR REASS. excl. UI	NonProportional	Treaty	Reserves	None			
1308	PriorYearBusiness Standard lines template	Auto	SCOR REASS. excl. UI	All	All	PriorYearBusiness	None			
1309	Treaty Proportional	Auto	SCOR REASS. excl. UI	Proportional	Treaty	PriorYearBusiness	None			

Export... Import...

Agenda

1	Introduction: Reinsurance and Risk modelling
2	Risk identification and dependencies
5	Calibration of dependencies: PrObEx – a Bayesian model
6	Justification & Documentation
5	Conclusion

Documentation and justification

Important aspects for the documentation and justification:

- Appropriate list of risk drivers enables the identification of dependencies
- Even though the experts' opinions have to be treated with a certain confidentiality, who the experts are is relevant for judging the quality of the exercise. In particular, no bias should be introduced through overlapping roles of experts and members of the management validation
- The right balance has to be found for update of such a calibration exercise. Some aspects may be relevance of the risk factors for changing portfolio, uncertainty around experts' opinions

Expert Judgement under Solvency II

The more **material** the impact **the higher the requirements** on **expertise of the expert** as well as on process, **documentation and governance.**

From EIOPA Guidelines on Pre-Application of Internal Models (EIOPA-CP-13/011) - Chapter 4: Assumption setting and expert judgement:

Through the pre-application process national competent authorities should for a view on:

Guideline 18 – **Assumptions setting**

- How assumptions are set and expert judgement is used
- How materiality is assessed, taking into account both quantitative and qualitative indicators

Guideline 19 – **Governance**

- How it is ensured that the use of expert judgement follows a validated and documented process
- That assumptions are derived and used consistently over time an fit for intended use
- How assumptions are signed off at levels of sufficient seniority according to their materiality, for most material assumptions up to and including their administrative, management or supervisory body

Guideline 20 – **Communication and uncertainty**

- How it is ensured that processes mitigate the risk of misunderstanding or miscommunication
- How a formal and documented feedback process between providers and users of material expert judgement is ensured
- How the uncertainty is made transparent around the assumptions as well as associated variations in final results

Guideline 21 – **Documentation**

- How process is documented in a transparent way including materiality, experts involved, intended use and period of validity

Guideline 22 – **Validation**

- How process for choosing assumptions and using expert judgement is being validated, including where appropriate stress testing and sensitivity testing, relying on independent internal and external expertise
- How changes in material assumptions in response to new information is tracked
- How occurrence of circumstances under which assumptions would be considered as false are detected,

Justification & Validation

The calibrated hierarchical tree needs to be validated with the following techniques:

- Sensitivity Analysis: Define different scenarios to confirm robustness of results
  - Use different definitions of variance by expert
  - Exclude prior information
  - Use simple average of expert's views
- Aggregation:
  - Analyses of combined effects for partially aggregated risk elements
- Back-testing:
  - Historical performance of risk elements combined and checked against the modelled loss curve
- Benchmarking:
  - Comparison against published benchmarks as well as analysis and explanation of differences.
- Tail dependency test
  - Review of output quantile exceedance probabilities

Agenda

1	Introduction: Reinsurance and Risk modelling
2	Risk identification and dependencies
5	Calibration of dependencies: PrObEx – a Bayesian model
6	Justification & Documentation
5	Conclusion

Conclusion

- An internal model can be at the center of or supporting a variety of business and risk management decisions. Modelling dependencies is an essential component of an internal model.
- Three methods applied in the hierarchical aggregation of risk factors, namely modelling dependence using: Empirical data, Causation, Copula. Adequately parameterizing the dependencies is a challenging task and resource intense, in the areas of research, processing and documentation
- PrObEx provides a sound mathematical framework for estimating copula parameters and allows to reduce the parameter uncertainty when estimating copula parameters
- PrObEx can be used to calibrate dependencies also in other contexts (e.g. Life, Economy, etc.)
- A scientific paper on PrObEx has been published in the ASTIN Bulletin

Thank you!

…for your attention

References

- Arbenz, P. and Canestraro, D. (2010): PrObEx - *A new method for the calibration of copula parameters from prior information, observations and expert opinions*. SCOR Paper n. 10

- Arbenz, P. and Canestraro, D. (2012): *Estimating copula for insurance from scarce observations, expert opinion and prior information: a Bayesian approach*. ASTIN Bulletin, 42 (1): 271-290

- Dacorogna, M.D. and Canestraro, D. (2010): *The Influence of Risk Measures and Tail Dependencies on Capital Allocation*. SCOR Paper n. 7