Risk Management under Solvency II - Spotlight on Internal Models -

Dr. Thomas Knispel (Talanx AG)

DGVFM-Workshop für junge MathematikerInnen
October 23, 2015
Agenda

1. Talanx Group – Facts and Figures
2. What is Solvency II?
3. Internal Models – Key Aspects & Mathematical Challenges
4. Remarks on Model Validation
Talanx Group: Five business areas

- **Industrial Lines**
  - HDI
  - HDI GERLING
  - TARGO • VERSICHERUNG
  - PB Versicherungen
  - neue leben Versicherungen

- **Retail Germany**
  - HDI
  - Warta
  - Europa
  - Posta Biztosito
  - CiV Life

- **Retail International**
  - Hannover re
  - e:s rück

- **Reinsurance (P/C and Life/Health)**
  - Talanx Asset Management
  - Ampega
  - Talanx Immobilien Management
  - Talanx Reinsurance
  - Talanx Reinsurance Broker

- **Financial Services**
  - Talanx
Our ranking in Germany: Unchanged on rank 3

<table>
<thead>
<tr>
<th>Rank</th>
<th>Company/Group</th>
<th>Gross premiums (EUR billion)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>2014</td>
</tr>
<tr>
<td>1</td>
<td>Allianz</td>
<td>115.7</td>
</tr>
<tr>
<td>2</td>
<td>Munich Re</td>
<td>48.8</td>
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<tr>
<td>3</td>
<td>Talanx-Konzern</td>
<td>29.0</td>
</tr>
<tr>
<td>4</td>
<td>R+V^{2)}</td>
<td>14.0</td>
</tr>
<tr>
<td>5</td>
<td>Debeka^{1)}</td>
<td>9.3</td>
</tr>
<tr>
<td>6</td>
<td>VKB Versicherungskammer Bayern^{2)}</td>
<td>7.3</td>
</tr>
<tr>
<td>7</td>
<td>HUK^{1)}</td>
<td>5.6</td>
</tr>
<tr>
<td>8</td>
<td>Signal Iduna^{1)}</td>
<td>5.5</td>
</tr>
<tr>
<td>9</td>
<td>Gothaer^{2)}</td>
<td>4.5</td>
</tr>
<tr>
<td>10</td>
<td>W&amp;W^{1)}</td>
<td>3.9</td>
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Source: Own presentation based on annual reports
1) Figures 2014
2) Preliminary figures 2014
Europe: Talanx among the 9 largest insurance providers by premium income

<table>
<thead>
<tr>
<th>Rank</th>
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<th>2013</th>
<th>Gross premiums (EUR billion)</th>
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<tr>
<td>1</td>
<td>Allianz</td>
<td>115.7</td>
<td></td>
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<tr>
<td>2</td>
<td>AXA¹</td>
<td>86.3</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Generali</td>
<td>70.4</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Munich Re</td>
<td>48.8</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Prudential¹,²</td>
<td>42.0</td>
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<tr>
<td>6</td>
<td>Zurich</td>
<td>39.3</td>
<td></td>
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<tr>
<td>7</td>
<td>CNP¹</td>
<td>30.6</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Crédit Agricole¹</td>
<td>29.7</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Talanx</td>
<td>29.0</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Aviva</td>
<td>27.7</td>
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¹ Preliminary figures 2014, as at 20.03.2015
² gross premium earned
Talanx worldwide – subsidiaries and branches

5 continents
about 150 countries

21,400 employees worldwide
(As at December 2014)

10,200 employees outside Germany
(As at December 2014)

America
AR Argentina
BM Bermuda
BR Brazil
CA Canada
CL Chile
CO Colombia
MX Mexico
PE Peru
US USA
UY Uruguay

Europe
AT Austria
BE Belgium
CH Switzerland
CZ Czech Republic
DE Germany
DK Denmark
ES Spain
FR France

GR Greece
HU Hungary
IE Ireland
IT Italy
LU Luxembourg
NL Netherlands
NO Norway
PL Poland
SE Sweden

SK Slovakia
TR Turkey
UA Ukraine
UK

Africa
ZA South Africa

Australia
AU Australia

Asia/Pacific
BH Bahrain
CN China
IN India
JP Japan
KR Korea
MY Malaysia
SG Singapore
RU Russia
TW Taiwan
My way into the insurance industry …

**Education & Employment:**

- **1999-2004:** Studies of mathematics at Humboldt-Universität zu Berlin
  - Specialisation in probability theory as well as in insurance and financial mathematics
  - Minor subject: Economics with focus on insurance business management and risk management; in this context: internship at Allianz Versicherung AG

- **2004-2009:** PhD studies in financial mathematics at HU Berlin („Optimal long term investment under model ambiguity“)

- **2009-2013:** PostDoc at the Chair of Insurance and Financial Mathematics, Leibniz University Hanover

- **Since March 2013:** **Talanx AG, Group Risk Management**
  - Current focus: **Validation of Internal Models** for the calculation of the Solvency Capital Requirement
## Agenda

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What is Solvency II?

- **Solvency II** = EU-wide insurance regulatory regime, particular focus on capital requirements and rules relating to own funds


- “The main purposes of the Solvency II Directive are to increase the protection of policyholders, create a level playing field for the insurance industry in the European single market and ensure substantially uniform supervisory practices throughout Europe (Directive 2009/138/EC, Recital (3) and Article 27).”

- Solvency II follows a principle-based approach:

  - Level 1: Directive 2009/138/EC
  - Level 2: Commission Delegated Regulation (EU) 2015/35
  - Level 3: Guidelines
  - Communiques of BaFin

- Implemented in German law, see “Gesetz zur Modernisierung der Finanzaufsicht über Versicherungen” for the revision of the “Versicherungsaufsichtsgesetz” (VAG) (valid from January 1, 2016 onwards)

Solvency II comes into effect on **January 1, 2016**.
Three pillar system

<table>
<thead>
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<th>Pillar 1: Quantitative Requirements</th>
<th>Pillar 2: Supervisory Review</th>
<th>Pillar 3: Disclosure</th>
</tr>
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<tr>
<td>Technical provisions</td>
<td>Risk Management and Governance</td>
<td>Annual published Solvency and Financial Conditions Report</td>
</tr>
<tr>
<td>Solvency Capital Requirement (SCR)</td>
<td>Own Risk and Solvency Assessment (ORSA)</td>
<td>Market Discipline</td>
</tr>
<tr>
<td>Minimum Capital Requirement</td>
<td>Supervisory Review</td>
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Solvency Capital Requirement (SCR)

**Directive 2009/138/EC of the European parliament and of the council, Recital (64):**

„In order to promote good risk management [...], the Solvency Capital Requirement should be determined as the economic capital to be held by insurance and reinsurance undertakings in order to ensure that ruin occurs no more often than once in every 200 cases or, alternatively, that those undertakings will still be in a position, with a probability of at least 99.5 %, to meet their obligations to policy holders and beneficiaries over the following 12 months. That economic capital should be calculated on the basis of the true risk profile of those undertakings, taking account of the impact of possible risk-mitigation techniques, as well as diversification effects.”

**Key aspects:**
- Capital requirement: Quantile at level 0.5% or 200 years event
- Risk measurement at a one-year horizon
- Measurement of the true risk profile
- Diversification

**Directive 2009/138/EC of the European parliament and of the council, Article 101 (3):**

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

See also § 96, VAG (valid from January 1, 2016 onwards)
Capital Adequacy Ratio (CAR)

**Goal:**
- Preparation of the Economic Balance Sheet and assessment of the capital endowment

### Assets
- Market Value of Assets: EUR mn 1,800

### Liabilities
- Excess Capital: EUR mn 400
- Risk-Based Capital: EUR mn 500
- Market Value of Liabilities: EUR mn 900

**Available Risk-Based Capital**

**SCR**

\[
\text{CAR} = \frac{\text{Available Solvency Capital}}{\text{Solvency Capital Requirement}} = \frac{900 \text{ mn}}{500 \text{ mn}} = 180\%
\]
Criticism:
- Since it is intended to be a "standard", it cannot reflect the specific risk profile of an insurance undertaking.
- The square root formula implicitly assumes a multivariate Gaussian setting.
- ...
A better approach: The Internal Model

**Directive 2009/138/EC of the European parliament and of the council, Recital (68):**

„In accordance with the risk-oriented approach to the Solvency Capital Requirement, it should be possible, in specific circumstances, to use partial or full internal models for the calculation of that requirement rather than the standard formula. In order to provide policy holders and beneficiaries with an equivalent level of protection, such internal models should be subject to prior supervisory approval on the basis of harmonised processes and standards.”

See also § 111, VAG (valid from January 1, 2016 onwards)

**Key aspects:**

- Use of Internal Models possible for calculating the Solvency Capital Requirement
- Parameterisation and Monte-Carlo simulation of all relevant risks and of economic balance sheets on a one year horizon (prognosis distribution); Calculation of the SCR from the simulated prognosis distribution
- Approval by supervising authority required
  - High effort/expenses for insurance undertakings
  - But: better measurement of the „true risk profile“
- Internal Models are more than just a tool to compute the SCR („Use Test“)
  - Integration of the Internal Model into the risk-management system
  - Value Based Management

Talanx Group expects supervisory approval of its Internal Model soon.
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TERM – Key ideas in a nutshell

**Talanx Enterprise Risk Model:** Internal risk models throughout Talanx Group at entity level and consolidated group model

**Key idea:**
- Economic Balance Sheets on market value basis for entities at \( t=0 \)
- Determine a forecast distribution on a one year horizon (\( t=1 \)) based on a so-called path-identical approach using 10,000 real-world paths
- Different methods for Life entities (e.g. Replicating Portfolio) and Non-Life entities

**Shareholders Net Assets (SNA):**
- The projection of economic balance sheets yields the forecast distribution of \( \text{SNA}_1 \) at \( t=1 \).
- The Solvency Capital Requirement (SCR) is computed by
  \[
  \text{SCR} := \mathbb{E}[\text{SNA}_1] - \text{VaR}[\text{SNA}_1, 99.5%],
  \]
  where \( \mathbb{E} \) denotes the expectation with respect to the real-world measure, \( \text{VaR} \) the Value-at-Risk (quantile at level 0.5%) and the index 1 the end of the one year time horizon.
- All variables are estimated from the simulated distribution.

**SCR derived from a forecast distribution of SNA on a one-year horizon.**
Risk categorisation of Talanx Group

**Regulatory Requirements according to SIID 2009/138/EC, Article 101 (4):**
The Solvency Capital Requirement shall cover at least the following risks:
(a) non-life underwriting risk;
(b) life underwriting risk;
(c) health underwriting risk;
(d) market risk;
(e) credit risk;
(f) operational risk.

Projection of the balance sheet accounts for various risks and risk factors.
The Talanx Group Model
Example: Internal Model Non-Life

**Underwriting Risk**
- **Premium risk**
  - Attritional Losses
  - Large Losses
  - NatCat
  - Gross/Net

**Reserving Risk**
- Gross/Net

**Non-Underwriting Risk**
- **Market Risk**
  - Interest Rate
  - Credit
  - Equity
  - Inflation
  - Currency
  - Property
- Market risk affects both assets and liabilities. Modelling includes dependencies between risk factors, asset classes, economies, …

**Operational Risk**
- **Reinsurance Default**
- Modelling of diversification effects
  - Dependencies between LoBs within premium and reserving risk have to be modelled.
  - Reinsurance Default scenarios and Operational Risk have to be related to other risk categories.

**Questions:**
- SCR and risk capital per risk category, LoB?
- Is the capital endowment sufficient?
- Diversification effects between risks and LoB?
- How large is the probability of a Combined Ratio<100%?
- Optimisation of the investment strategy/reinsurance structure
- …

**Modelling is based on sophisticated mathematical methods – as we all love it!**

Modelling of diversification effects within the Internal Model and hence the capital requirement.

Modelling via Copula C:

\[ F_{X,Y}(x, y) = C(F_X(x), F_Y(y)) \]
Requirements on Internal Models

- Key requirements on Internal Models can be found in the Directive 2009/138/EC, Articles 120-126:
  - Article 120: Use Test
  - Article 121: Statistical quality standards
  - Article 122: Calibration standards
  - Article 123: Profit and loss attribution
  - Article 124: Validation standards
  - Article 125: Documentation standards
  - Article 126: External models and data
  - Article 115: Policy for changing the full and partial internal models

- Implemented in German law, see “Gesetz zur Modernisierung der Finanzaufsicht über Versicherungen” for the revision of the “Versicherungsaufsichtsgesetz” (VAG) (valid from January 1, 2016 onwards)

An Internal Model is more than the computational core.
SCR 2014: Results of Talanx Group (Economic View)

RISK CATEGORISATION FOR THE TALANX GROUP (EXCLUDING NON-CONTROLLING INTERESTS)

TALANX GROUP — ECONOMIC VIEW

Values in EUR mn

Model Risk

Model Risk (from a practitioners perspective):
- Model risk reflects uncertainty about the model output. As a consequence, the figure for modelled risk and actual risk may deviate.
- Model risk is separated into:
  - Monte-Carlo uncertainty
  - Stochastic uncertainty
  - Model quality

Spotlight on academic papers:

Model risk is more than an academic problem – it’s a challenge for practitioners.
How does Talanx cope with model risk?

Quantification of Model Risk:
- Sensitivity analyses regarding key model parameters and assumptions, particularly expert judgements
- Quantification of statistical errors (confidence intervals)
- Quantification of Monte-Carlo errors
- Aggregation of all uncertainties in a conservative manner

TERM 2014 update – Additional and voluntary capital buffer to cover uncertainties.

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Regulatory Requirements – Level 1

**Solvency II Directive 2009/138/EC, Article 124:**

Insurance and reinsurance undertakings shall have a regular cycle of model validation which includes monitoring the performance of the internal model, reviewing the ongoing appropriateness of its specification, and testing its results against experience.

The model validation process shall include an **effective statistical process** for validating the internal model which enables the insurance and reinsurance undertakings to demonstrate to their supervisory authorities that the resulting capital requirements are appropriate.

The statistical methods applied shall test the appropriateness of the probability distribution forecast compared not only to loss experience but also to all material new data and information relating thereto. The model validation process shall include an analysis of the stability of the internal model and in particular the testing of the sensitivity of the results of the internal model to changes in key underlying assumptions. It shall also include an assessment of the accuracy, completeness and appropriateness of the data used by the internal model.

**Key Aspects:**

- Regular cycle of model validation
- Review of the appropriateness of the model specification
- Verification of the appropriateness of the resulting capital requirements
- Statistical methods to test the appropriateness of the forecast distribution
- Analysis of the stability of the Internal Model and testing the sensitivity of results to key assumptions
- Assessment of the three dimensions of data quality: Accuracy, Completeness and Appropriateness

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No supervisory approval of an Internal Model without appropriate validation!
Why do we conduct in-depth validations …

Three perspectives of validation:

- Firstly, from the company’s point of view, validation can give impulses for model improvements and thereby increase the own confidence in the Internal Model and its output.

- Secondly, an appropriate validation can have a signalling effect for rating agencies and thus might have positive monetary effects.

- Thirdly, regulatory specifications must be implemented (particularly Article 124 of the Solvency II Directive 2009/138/EC).
Three-level approach to validation

Three-level approach in Talanx Group, due to the Group structure and the model landscape:

- Validation of input models such as economic scenarios, scenarios for natural catastrophes, biometric risk stress levels
- Validation of Internal Models of solo entities for the calculation of solvency capital
- Validation of the aggregation at the Group level

Validation follows a **holistic approach** and applies to **all parts** of an Internal Model.
Starting point - Statistical analysis and validation

Output analysis to ensure the quality of Internal Model results and as part of the regular validation:

- **Statistical Analysis** of the prognosis distribution and risk categories; in particular comparison to last years SCR run and the Model Change Run as well as benchmarking with other entities within Talanx Group
- **Topics:** summary statistics, violin plots, model fitting, analysis of outliers, tail behaviour, analysis of correlations and diversification effects, sensitivity analyses with respect to potentially misstated parameters, …
- Analysis on Group level, divisions, Solo entities with Internal Model

![Violin Plot](image1.png)

- **Violin Plot:** Statistical analysis is useful to detect conspicuous features or changes to previous year.

![Contour Plots & Diversification](image2.png)

- **Contour Plots & Diversification:**

![Analysis of worst paths](image3.png)

- **Analysis of worst paths:**
Detailed validation of an Internal Model – Key tasks

A) Inspection of qualitative aspects
- Documentation of the Internal Model, Expert Judgements, Data Quality Management, Use Test, etc.

B) Inspection of the components of the Internal Model:
- Focus on the appropriateness of methods and statistical quality standards
- The analysis follows the structure of the Internal Model.
  - Life: MCEV, Replicating Portfolio, Non-Financial Risks
  - Non-Life: Premium Risk, Reserve Risk, NatCat, Market Risk (including sub-categories), Operational Risk, Counterparty Default Risk
- As required in Article 124 of the Solvency II Directive 2009/138/EC, the “analysis of the stability of the internal model and in particular the testing of the sensitivity of the results of the internal model to changes in key underlying assumptions” forms a focal point.
- Dependencies between LoBs and model components
- Consistency of the risk model to the economic balance sheet

C) Output analysis
- Statistical analysis of the prognosis distribution and risk categories including a rationale for changes; in particular summary statistics, violin plots, analysis of correlations and diversification effects, sensitivity analyses with respect to potentially misstated parameters, …
- Comparison to Standard Formula results
- Analysis of the Monte-Carlo error

D) Back testing
- Back testing at different levels, e.g. prognosis distribution, risk categories, loss ratios
- Profit & Loss Attribution

Example: Back testing

Results of the validation recorded in validation reports for BaFin and rating agencies.
Summary:

- Solvency II is an EU-wide insurance regulatory regime coming into effect on January 1st, 2016.
- It is based on a three pillar system which consists of quantitative requirements, requirements for the governance and risk management of insurers, as well as of disclosure requirements.
- One key aspect is the calculation of the Solvency Capital Requirement (Pillar I). The calculation can be done either by the “Standard Formula” or based on an “Internal Model”.
- The Internal Model is based on sophisticated mathematical techniques (probability theory, statistics, insurance and financial mathematics, numerics, …).
- Solvency II thus provides challenging tasks for high-tech mathematicians with inclination for economic questions.

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Thank you for your attention!

Questions?