Modeling of Automobile Insurance under Solvency II

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1  Automobile Insurance in Germany

The Market  
Pricing  
Reserving  
Reinsurance

2  Automobile Insurance under Solvency II

Solvency I & US Risk Based Capital  
Solvency II: Standard Model  
Solvency II: Internal Model  
Use Test of the Internal Model
Premium generated by the German insurance industry

Euro $18 \times 10^{10}$
… out of that:

1/2: LIFE

1/6: HEALTH

1/3: NON-LIFE*

€ 60 bn

* Property & Casualty
... and the Non-Life Market splits up in:

**Premium**

- Total
  - Automobile 33%
  - Liability 13%
  - Accident 11%
  - Property 43%

- € 20 bn

**Germany**

- About 55 million vehicles
- More than 45 million private passenger cars
- … which is 55 cars per 100 inhabitants

**Mexico**

- Around 30 million vehicles
- Approximately 30 cars per 100 inhabitants
- Only a quarter of the vehicles are insured

**Reserves**

- Total
  - Automobile 41%
  - Liability 27%
  - Accident 9%
  - Property 24%
Automobile Insurance in Germany

Lines of Business

- Motor Third Party Liability (MTPL): Mandatory since 1939
- Motor Own Damage (MOD):
  - Voluntary cover, split up in:
    - Partial coverage = fire, theft & nat cat
    - Full coverage = partial + accidental damage
- Accident cover for passengers and the driver
- Other additional covers, like
  - Assistance, Mobility
  - Extended Warranty, Gap
  - …
Automobile Insurance in Germany

Share of MTPL and MOD

3 out of 4 cars have an MOD cover

Premium (€ 8 bn + € 12 bn)

Reserves

Motor Own Damage 39%

MTPL 61%

Motor Own Damage 4%

MTPL 96%
Automobile Insurance in Germany

Legal requirements for MTPL

- Minimum coverage
  - Bodily injury (BI): €7.5 mn
  - Property damage: €1.0 mn
  - Other damages: €50,000

- Standard coverage
  - Used to be “unlimited”
  - Now: €50-100 mn, with BI limited to €8-15 mn per person

- Close co-operation between association of insurance companies, Vehicle registration offices, and the police
Automobile Insurance in Germany

Cumulative market shares of the 14 (out of about 100) largest players
Consequences of a strongly fragmented market

- Medium and small size insurers need support in their pricing by
  - German Insurance Association (GDV)
  - Pools
- Very competitive market (small margin – if any)
- Focus on distribution channels
- Innovations in tariff structures and pricing techniques
- Cyclical market
Automobile Insurance in Germany

The cycle: Claims(!)-ratios
Automobile Insurance in Germany

Market shares by distribution channels

- Agents 60%
- Direct 15%
- Broker 25%

Aggregators are gaining market share
- Across all distribution channels, yet ...
- ... mainly in Direct
  - 25% of new business and
  - >80% of this by one comparison website
Pricing of automobile insurance

Evolution of rating criteria

Prior to 1994: Type of vehicle, Type of occupation, Region, Bonus / Malus
Today: On average almost 20 factors, such as:
Pricing of automobile insurance

- Criteria to model: e.g. claims frequency
- Identification of risk criteria: e.g. nationality
- Selection of usable criteria: e.g. origin of driving license

Rating criteria 1
Rating criteria 2
Rating criteria 3
Rating criteria n

Grouping:
- Region
- Occupation
- Age*Gender

Cube-like structure
Pricing of automobile insurance

Cube-like structure of e.g. 3 dimensions

Tariff calculation uses factors:

Actuary: $x$
Munich: $y$
male & 35-40: $z$

... and derives the premium $P$ as:

$$P = \text{Base Rate} \times x \times y \times z$$
Pricing of automobile insurance

Multiplicative rating structure

Let I and K be rating criteria ...

- with classes $i \in (1, \ldots, n)$ and $k \in (1, \ldots, l)$ respectively
- producing a cube $Q$ of tariff clusters $(i,k) \in ((1, \ldots, n) \times (1, \ldots, l)) =: Q$

Let $v_{i,k}$ be the volume and $S_{i,k}$ the amount of losses in $(i,k)$, then:

The pure premium in cluster $(i,k)$ should equal $E(S_{i,k} / v_{i,k}) =: P_{i,k}$

In a multiplicative structure there are parameters $\mu, \alpha_i, \beta_k$ such that

$$P_{i,k} = \mu \alpha_i \beta_k \quad \text{for all } (i,k) \in Q$$

$\mu$ being a base rate and $\alpha_i, \beta_k$ (normalized) rating factors
Reserving in automobile insurance

Reserving under local German GAAP requested to be prudent!

Usually we see patterns like this …

Thus run-off losses do occur on portfolio level,
but are exceptional with regard to single known claims
Reserving in automobile insurance

Development Factor Methods

(e.g. Chain-Ladder, Bornhuetter/Ferguson)

- Historical claims development is used to predict future development
- Apply "Tail Factor" – if need be … which most often is the case
- … subject to: data are homogeneous, no systematic changes, etc.
Reserving in automobile insurance

DF-Methods are applied to both Incurred and Paid

In theory we would expect the two projections to converge at one “Best Estimate”

In reality this seldomly works out

**Munich Chain Ladder** (by Th. Mack & G. Quarg, 2004)

- Analyzing correlations between paid and incurred, we often observe
  - after a low “paid to incurred ratio” higher than average paid factors
  - after a high “paid to incurred ratio” lower than average paid factors
- Making use of this can reduce the gap between paid and incurred projections
Reserving of automobile insurance

Some of the challenges we face

- The claims frequency in MTPL is declining over time (safety standards)
- ... while the average cost of claims is increasing (increasing values, cost of medical treatment)
- Duration of BI-claims increases in MTPL (less people die after an accident)
- ... but in MOD claims are settled much faster (better claims management)
- Court decisions change, mostly in favor of the insured or the claimant (annuity vs lump sum payment)
- ... many more
Reinsurance in automobile insurance

Typical programs would be

**MTPL**

<table>
<thead>
<tr>
<th>Quota Share</th>
<th>Risk-based Excess of Loss, e.g.:</th>
</tr>
</thead>
<tbody>
<tr>
<td>€ 4 mn xs € 1 mn</td>
<td></td>
</tr>
<tr>
<td>€ 15 mn xs € 5 mn</td>
<td></td>
</tr>
<tr>
<td>€ 80 mn xs € 20 mn</td>
<td></td>
</tr>
</tbody>
</table>

**MOD**

<table>
<thead>
<tr>
<th>Quota Share</th>
<th>Event-based Excess of Loss, e.g.</th>
</tr>
</thead>
<tbody>
<tr>
<td>€ 25 mn xs € 25 mn</td>
<td></td>
</tr>
<tr>
<td>€ 50 mn xs € 50 mn</td>
<td></td>
</tr>
</tbody>
</table>

Stop Loss for nat-cat perils
Facultative Reinsurance
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Solvency I – The old world

Local German Regulation for Solvency I in Non-Life

**Solvency Margin** = \( \max (\text{Premium index}; \text{Claims index}) \)

**Premium index** =

\[
18\% \times \text{Premium of up to } €50\text{ mn } \times \text{Self Retention} \\
+ 16\% \times \text{Premium above } €50\text{ mn } \times \text{Self Retention}
\]

**Claims index** =

\[
26\% \times \text{Incurred Claims of up to } €35\text{ mn } \times \text{Self Retention} \\
+ 23\% \times \text{Incurred Claims above } €35\text{ mn } \times \text{Self Retention}
\]
US Risk Based Capital for P/C (NAIC)

The first “Factor-Model” in insurance

Define:

\[ R_0 := \text{Asset Risk} - \text{subsidiary insurance companies} \]
\[ R_1 := \text{Asset Risk} - \text{fixed income investment} \]
\[ R_2 := \text{Asset Risk} - \text{Equity} \]
\[ R_3 := \text{Asset/Credit risk} - \text{Recoverables, Reinsurance} \]
\[ R_4 := \text{Reserve Risk} \]
\[ R_5 := \text{Premium Risk} \]

and put:

Total Risk Based Capital := \[ R_0 + \sqrt{R_1^2 + R_2^2 + R_3^2 + R_4^2 + R_5^2} \]
Europe wants „A new drug ...“

To achieve ...

- consumer protection
- focus on risk-management & risk-steering
- higher transparency on underlying risks

... in 2009 the Directive stipulated

- Principle based approach to supervision
- Market consistent approach for valuing assets and liabilities
- Capital requirements linked to the company’s risk profile

... to come into force in 2013!? 
Solvency II Directive

A three-pillar structure

Originally focused on adequate risk management systems
Solvency II Directive

Pillar 1: Quantitative requirements

Limit worst case (financial ruin) within one year to a 0.5% probability

- Availability of free own funds to cover losses of current business (premium risk) and run-off losses (reserve risk)

- Market Value Balance Sheet (“Fair Value”)
  - Minimum Capital Required (MCR) similar to Solvency I
  - Use of approved internal models to evaluate the Solvency Capital Required (SCR)
    - Reduction in required capital is estimated to be 20%, yet …
    - …only a minority of insurers will apply for the usage of an internal model
  - Individual evaluation of risks with standard formula, allowing for diversification
  - Stepwise intervention of the regulator in case MCR < Own Funds < SCR
Solvency II Capital Requirement

Based on Monte-Carlo simulations

One year Value at Risk (VaR) approach

Level of Confidence
AAA  AA  A

Frequency

Worst case  Risk capital

Expected Value

Change in economic value
Solvency II Directive

Pillar 2: Governance & Risk management

Adequate and transparent assessment of all risks

- Risk oriented approach: All material risks need to be included
- Principle based approach to allow for individual implementations at company level
- Principle of “Proportionality”: Medium and small sized insurers should not be overburdened
- Extensive audits and evaluations by the supervisor, e.g. of strategies, processes, governance systems etc.
- Far-reaching authorization of the supervisor, e.g. in case of outsourcing
- Germany: Introduction of “MaRisk” in 2009 already anticipates much of that
Solvency II Directive

Pillar 3: Disclosure & transparency

Disclosure of information regarding the risk situation –
both public and to the supervisor only

- Uniform supervisory reporting within the EEC
- Public disclosure of the solvency situation following the „Solvency and Financial Condition Report“ including e.g.
  - Business policy, corporate structure, market environment, strategies, …
  - Governance structure and compliance statement
  - Principles of evaluation of assets and liabilities
  - Internal governance
  - Required MCR / SCR
  - Disclosure and justification in case the capital requirements are not meet
The Standard Model

Solvency Capital Required (SCR)

- Intangibles
- Non-Life
- Life
- Health
- Credit Risk
- Market
The Standard Model – Non-Life Risk

Non-Life

Premium Risk

Reserve Risk

Nat Cat Risk
The Standard Model

Correlation:
How likely is it to have a major hurricane and to increase reserves for prior years at the same time?

Premium Risk

Reserve Risk

Nat Cat Risk

Measurement of the Risk Exposure:

- Volume * Factor
- Based on volatility & 99.5% percentile
- For reserves and future business
- Allow for diversification by line of business and country
The Standard Model

Concept for Nat Cat

- Scenario based
- Geographical exposure and insured volume
- Add manual Cat if needed
- Allow for diversification
### Solvency II – Internal model for P/C business

#### Ultimate premium risk (non-cat)

<table>
<thead>
<tr>
<th>Gross Model (Sub-LoB Level)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1 Data Input</strong></td>
</tr>
<tr>
<td>Raw Data</td>
</tr>
<tr>
<td>- Planning data</td>
</tr>
<tr>
<td>(Premium/Expenses/Exposure/Losses)</td>
</tr>
<tr>
<td>- Historical data</td>
</tr>
<tr>
<td>(Premium/Exposure/Losses)</td>
</tr>
<tr>
<td>- Individual Large Losses</td>
</tr>
<tr>
<td>- Best Estimate Ultimate by AY</td>
</tr>
<tr>
<td>- Inflation Indices</td>
</tr>
<tr>
<td><strong>2 Data Adjustment</strong></td>
</tr>
<tr>
<td>Adjusted Data</td>
</tr>
<tr>
<td>- Exposure adjustment</td>
</tr>
<tr>
<td>- Inflation Adjustment</td>
</tr>
<tr>
<td>- IBNR/IBNER adjustment</td>
</tr>
<tr>
<td><strong>3 Distribution fitting</strong></td>
</tr>
<tr>
<td>Large Losses</td>
</tr>
<tr>
<td>Attritional Losses</td>
</tr>
<tr>
<td>Premium Cycle</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Net Model (LoB Level)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>4 Dependencies</strong></td>
</tr>
<tr>
<td>- Sub-LoB aggregation</td>
</tr>
<tr>
<td>- Frequency &amp; Severity</td>
</tr>
<tr>
<td><strong>5 Reinsurance</strong></td>
</tr>
<tr>
<td>- 6 Levels of reinsurance</td>
</tr>
<tr>
<td>1 - QS &amp; Surplus</td>
</tr>
<tr>
<td>2 – Risk XoL</td>
</tr>
<tr>
<td>3 – Event XoL</td>
</tr>
<tr>
<td>4 – Multi-Line XoL</td>
</tr>
<tr>
<td>5 – Stop Loss</td>
</tr>
<tr>
<td>6 – Net QS</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>UW Result (LoB &amp; LE Level)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>6 Dependencies</strong></td>
</tr>
<tr>
<td>- LoB aggregation</td>
</tr>
<tr>
<td>- Low/Medium/High</td>
</tr>
<tr>
<td><strong>7 UW result gross/net</strong></td>
</tr>
</tbody>
</table>

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Assessing the reserve risk by bootstrapping techniques

A Parameterisation

1. Data triangle
2. Fit a CL model to your data
3. Fitted triangle
4. Calculate residuals
5. Generate pseudo triangles
6. Refit the same CL model
7. Distribution of reserves

- Pearson residuals
- for incremental losses (ODP)
- for individual development factors (Mack)
- deviation from fitted to original triangle
- need to be standardised

What would have been the historical data given the latest loss information and under the assumption the CL model is the true model?

- Residuals can be used for sampling with replacement
- Fitted triangle plus different sets of residuals result in pseudo triangles

B Simulation

- Process error is included when forecasting
- Also provides stochastic cash flow
Solvency II – Use Test

In order to prove the quality of the internal model, Solvency II requires it to be used for daily business decisions!
Example

The large loss model & hence the purchase of reinsurance

- Large losses very much depend on the individual insurer
- No standard model is able to reflect this appropriately
- The internal model is simulating empirical large losses
- The reinsurance program should provide appropriate protection against them

Hence:

The large loss model should match the reinsurance program
Linking Risk Models and Business Management

Business Management

- Strategic Planning
- NatCat Limit Controlling
- Reinsurance Optimization
- ALM
- Underwriting
- Reserving
- Plan Year’s Exposure A.
- Loss Ratio A.
- MVM Calculation
- Claims Analysis
- Reporting
- Technical Pricing
- Capital Assessment
- RC Calculation

PRISM

The P&C Insurance Risk Model

Result Assessment

Exposure Assessment
Thank you for your attention!

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