Reserve Risk Dependencies
under Solvency II and IFRS 4 perspective

René Dahms
rene.dahms@ethz.ch

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1.2 Correlation of insurance risks

2 Modelling reserve risks
2.1 Classical triangle based reserving methods
2.2 Linear-Stochastic-Reserving-Methods (LSRM)

3 LSRMs and reserving risk
3.1 Derivation
3.2 Examples

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Types of insurance risks

SST and Solvency II

prior year risk (PY-risk) or reserving risk:
The risk of a huge negative claims development result in the next year-end closing. Or with other words, the risk of much too few claim reserves.
Types of insurance risks

SST and Solvency II

prior year risk (PY-risk) or reserving risk:
The risk of a huge negative claims development result in the next year-end closing. Or with other words, the risk of much too few claim reserves.

current year risk (CY-risk) or premium risk:
The risk of having much more current year incurred losses than premium.
Types of insurance risks

SST and Solvency II

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The risk of a huge negative claims development result in the next year-end closing. Or with other words, the risk of much too few claim reserves.
current year risk (CY-risk) or premium risk:
The risk of having much more current year incurred losses than premium.

IFRS 4

risk margin:
Should cover the uncertainty within the (discounted) future cash flows corresponding to insurance liabilities (includes already happened claims as well as future claims of already existing contracts).
Modelling insurance risk

A rough sketch of the classical way

1. Split up the total business into homogeneous portfolios.
Modelling insurance risk

A rough sketch of the classical way

1. Split up the total business into homogeneous portfolios.
2. Model each risk for each portfolio.
Modelling insurance risk

A rough sketch of the classical way

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2. Model each risk for each portfolio.
3. Aggregate the results via a correlation matrix.
Modelling insurance risk

A rough sketch of the classical way

1. Split up the total business into homogeneous portfolios.
2. Model each risk for each portfolio.
3. Aggregate the results via a correlation matrix.

Problem: How can we estimate such correlation matrix?
## 1.2 Correlation of insurance risks

### Correlation matrices in use

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#### EUR/Global

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### Reserve Risk Dependencies

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## 1 Introduction

### 1.2 Correlation of insurance risks

**Correlation matrices in use**

**SST**

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**Solvency II (QIS 5)**

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<td>Health (MALT)</td>
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4.2 Bibliography
Definition 2.1 ($\sigma$-algebras)

- $\mathcal{B}_{i,k}$ is the $\sigma$-algebra of all information of accident period $i$ up to development period $k$:
  \[ \mathcal{B}_{i,k} := \sigma \left( S_{i,j} : 0 \leq j \leq k \right) = \sigma \left( C_{i,j} : 0 \leq j \leq k \right) \]

- $\mathcal{D}^n$ is the $\sigma$-algebra of all information up to calendar period $n$:
  \[ \mathcal{D}^n := \sigma \left( S_{i,k} : 0 \leq i \leq I, 0 \leq k \leq J \land (n - i) \right) \]
  \[ = \sigma \left( C_{i,k} : 0 \leq i \leq I, 0 \leq k \leq J \land (n - i) \right) \]
  \[ = \sigma \left( \bigcup_{i=0}^{I} \bigcup_{k=0}^{J} \mathcal{B}_{i,k} \right) \]

- $\mathcal{D}_k$ is the $\sigma$-algebra of all information up to development period $k$:
  \[ \mathcal{D}_k := \sigma \left( S_{i,j} : 0 \leq i \leq I, 0 \leq j \leq k \right) \]
  \[ = \sigma \left( C_{i,j} : 0 \leq i \leq I, 0 \leq j \leq k \right) \]
  \[ = \sigma \left( \bigcup_{i=0}^{I} \mathcal{B}_{i,k} \right) \]

- $\mathcal{D}^n_k := \sigma \left( \mathcal{D}^n \cup \mathcal{D}_k \right)$
Chain-Ladder-Method (CLM)

Actuaries often use the Chain-Ladder-Method for reserving. That means they believe in

i) \( \text{CLM} \quad \mathbb{E} \left[ C_{i,k+1} | D_{k}^{i+k} \right] = f_k C_{i,k} \),

ii) \( \text{CLM} \quad \text{Var} \left[ C_{i,k+1} | D_{k}^{i+k} \right] = \sigma_k^2 C_{i,k} \) and

iii) \( \text{CLM} \quad \) accident periods are independent.
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ii) $\text{Var} \left[ C_{i,k+1} | D_k^{i+k} \right] = \sigma_k^2 C_{i,k}$ and

iii) accident periods are independent.

Moreover, in order to quantify the corresponding risk often

- the approach of Thomas Mack, see [4], is used for the ultimate risk.
- the approach of M. Merz and M. Wüthrich, see [5], is used for the solvency risk.
Chain-Ladder-Method (CLM)

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i)\(^{\text{CLM}}\) \( \mathbb{E} \left[ C_{i,k+1} | D_{k}^{i+k} \right] = f_{k} C_{i,k} \),

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Idea

Why not take several triangles \( C_{i,k}^{m}, 0 \leq m \leq M \) and couple them via

\[
\text{Cov} \left[ C_{i,k+1}^{m_1}, C_{i,k+1}^{m_2} | D_{k}^{i+k} \right] = \sigma_{k}^{m_1,m_2} \sqrt{C_{i,k}^{m_1} C_{i,k}^{m_2}}?
\]
Extended-Complementary-Loss-Ratio-Method (ECLRM)

We take incremental payments $S^0_{i,k}$, changes in reported amounts $S^1_{i,k}$, case reserves $R_{i,k}$ and assume that

\begin{align*}
\text{i) } &\mathbb{E}\left[S^m_{i,k} \mid \mathcal{D}^{i+k}_k\right] = f^m_k R_{i,k} \quad \text{and} \\
\text{ii) } &\text{Cov}\left[S^{m_1}_{i,k+1}, S^{m_2}_{i,k+1} \mid \mathcal{D}^{i+k}_k\right] = \sigma^{m_1,m_2}_k R_{i,k}.
\end{align*}
Extended-Complementary-Loss-Ratio-Method (ECLRM)

We take incremental payments $S_{i,k}^0$, changes in reported amounts $S_{i,k}^1$, case reserves $R_{i,k}$ and assume that

\begin{align*}
\text{i) } & \quad \text{CLM } \mathbb{E} \left[ S_{i,k}^m \middle| D_k^{i+k} \right] = f_k^m R_{i,k} \quad \text{and} \\
\text{ii) } & \quad \text{CLM } \text{Cov} \left[ S_{i,k+1}^{m_1}, S_{i,k+1}^{m_2} \middle| D_k^{i+k} \right] = \sigma_{k}^{m_1,m_2} R_{i,k}.
\end{align*}

Moreover, in order to quantify the corresponding risk we use

- the approach of R. D., see [1], for the ultimate risk.
- the approach of M. Wüthrich and R. D., see [3], for the solvency risk.
Extended-Complementary-Loss-Ratio-Method (ECLRM)

We take incremental payments $S_{0,i,k}^0$, changes in reported amounts $S_{1,i,k}^1$, case reserves $R_{i,k}$ and assume that

\[ i) \quad \mathbb{E}\left[ S_{i,k}^m \mid D_k^{i+k} \right] = f_k^m R_{i,k} \quad \text{and} \]
\[ ii) \quad \text{Cov}\left[ S_{i,k+1}^{m_1}, S_{i,k+1}^{m_2} \mid D_k^{i+k} \right] = \sigma_{k}^{m_1,m_2} R_{i,k}. \]

Moreover, in order to quantify the corresponding risk we use

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Idea

Why not take several portfolios and couple them via

\[ \text{Cov}\left[ S_{i,k+1}^{m_1}, S_{i,k+1}^{m_2} \mid D_k^{i+k} \right] = \sigma_{k}^{m_1,m_2} \sqrt{R_{i,k}^{m_1} R_{i,k}^{m_2}} \ ? \]
Other examples

Similar statements can be formulated for

- the Bornhuetter-Ferguson-Method,
- the Complementary-Loss-Ratio-Method,
- the Cape-Cod-Method,
- the Benktander-Hovinen-Method
- ...
Other examples
Similar statements can be formulated for
- the Bornhuetter-Ferguson-Method,
- the Complementary-Loss-Ratio-Method,
- the Cape-Cod-Method,
- the Benktander-Hovinen-Method
- ...

What do have those methods in common?
- the expectation of next years development is proportional to some exposure, which is a linear combination of the past developments,
- covariances are proportional to some exposure, which depends only on the past developments.
Linear-Stochastic-Reserving-Methods (LSRMs)

We have several claim properties (triangles) $S_{i,k}^m$ and assume that:

i) $^{\text{LSRM}}$ There exist exposures $R_{i,k}^m \in D_{i+k} \cap D_k$, which depend linearly on claim properties $S$, such that

$$E \left[ S_{i,k+1}^m \mid D_{k}^{i+k} \right] = f_k^m R_{i,k}^m := f_k^m \Gamma_{i,k}^m S.$$ 

ii) $^{\text{LSRM}}$ There exist exposures $R_{i,k}^{m_1,m_2} \in D_{i+k} \cap D_k$ such that

$$\text{Cov} \left[ S_{i,k+1}^{m_1} , S_{i,k+1}^{m_2} \mid D_{k}^{i+k} \right] = \sigma_{k}^{m_1,m_2} R_{i,k}^{m_1,m_2}.$$  

An updated version of the original paper, see [2], can be obtained from the author.
LSRM step by step

$S^0$  $S^1$  $S^M$
LSRM step by step

\[ S^0 \quad S^1 \quad \ldots \quad S^M \]
LSRM step by step

\[ S^0 \]

\[ k \]

\[ S^1 \]

\[ \ldots \]

\[ S^M \]

\[ S_{i,k+1}^0 \]

\[ R^0 \]

\[ k \]

\[ R_{i,k}^0 \]
LSRM step by step

\[ S^0 \quad S^1 \quad \ldots \quad S^M \]

\[ R^0 \]

\[ \Gamma_{i,k}^0 \]

\[ S_{i,k+1}^0 \]

\[ R_{i,k}^0 \]
LSRM step by step

\[ S^0 \quad \rightarrow \quad k \quad \rightarrow \quad S^1 \quad \rightarrow \quad \ldots \quad \rightarrow \quad S^M \]

\[ \Gamma_{i,k}^0 \cdot f_k^0 \]

\[ R^0 \quad \rightarrow \quad k \quad \rightarrow \quad R^0_{i,k} \]
LSRM step by step

\[ S^0 \to S^1 \to \ldots \to S^M \]

\[ S^0 \]

\[ S^1 \]

\[ S^M \]
LSRM step by step

$S^0$ \hspace{2cm} $S^1$ \hspace{2cm} $S^M$

$R^1$

$S^1_{i,k+1}$
2 Modelling reserve risks

2.2 Linear-Stochastic-Reserving-Methods (LSRMs)

LSRM step by step
LSRM step by step

$S^0$  $S^1$  $S^M$

$R^1$

$k$

$i$

$S^1_{i,k+1}$

$\Gamma^1_{i,k}$

$R^1_{i,k}$

$f^1_k$

$c$
LSRM step by step

$S^0$  $S^1$  $\ldots$  $S^M$

$k$

$i$

$S_{i,k+1}^M$
2 Modelling reserve risks

2.2 Linear-Stochastic-Reserving-Methods (LSRMs)

LSRM step by step

\[ S^0 \rightarrow S^1 \rightarrow \cdots \rightarrow S^M \]

\[ R^0 \rightarrow R^1 \rightarrow \cdots \rightarrow R^M \]
LSRM step by step

\[ S^0 \rightarrow S^1 \rightarrow \cdots \rightarrow S^M \]

\[ \Gamma_{i,k}^M \rightarrow R_{i,k}^M \]

\[ i \rightarrow k \]

\[ \bullet \]

\[ S_{i,k+1}^M \]
LSRM step by step
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Modelling all portfolios at once

We can look at the total ultimate

\[
\sum_{m=0}^{M} \sum_{i=0}^{I} \sum_{k=0}^{J} \alpha_{m}^{i} \alpha_{m}^{i} S_{i,k},
\]

where \( \alpha_{m}^{i} \) are arbitrary real numbers (mixing weights).

Then the variance of the reserving risk can be estimated by the mean squared error of prediction (mse), which is of the form

\[
\hat{\text{mse}} = \sum_{m_{1}, m_{2}=0}^{M} \sum_{i_{1}, i_{2}=0}^{I} \alpha_{m_{1}}^{i_{1}} \alpha_{m_{2}}^{i_{2}} \beta_{m_{1}, m_{2}}^{i_{1}, i_{2}}.
\]

That is true for the ultimate reserving risk as well as for the solvency reserving risk (with different \( \beta \)'s of course).
Reverse engineering of a correlation matrix

If we are required to use a correlation approach we could use the components of overall $\hat{\text{mse}}$ in order to define the correlation matrix, i.e. we could take

$$
\begin{pmatrix}
\sum_{i_1, i_2=0}^{I} \alpha_{i_1}^{m_1} \alpha_{i_2}^{m_2} \hat{\beta}_{i_1, i_2}^{m_1,m_2} \\
\sqrt{\sum_{i=0}^{I} \alpha_i^{m_1} \alpha_i^{m_1} \hat{\beta}_i^{m_1,m_1} \sum_{i=0}^{I} \alpha_i^{m_2} \alpha_i^{m_2} \hat{\beta}_i^{m_2,m_2}}
\end{pmatrix}
\begin{pmatrix}
0 \\
0 \leq m_1, m_2 \leq M
\end{pmatrix}
$$

as correlation matrix.
Reverse engineering of a correlation matrix

If we are required to use a correlation approach we could use the components of overall $\hat{\text{mse}}$ in order to define the correlation matrix, i.e. we could take

$$
\left( \begin{array}{c}
\sum_{i=0}^{I} \alpha_{m_1}^{m_1} \alpha_{m_2}^{m_2} \hat{\beta}_{m_1,m_2} \\
\sqrt{\sum_{i=0}^{I} \alpha_{i}^{m_1} \alpha_{i}^{m_1} \hat{\beta}_{i,i} \sum_{i=0}^{I} \alpha_{i}^{m_2} \alpha_{i}^{m_2} \hat{\beta}_{i,i}}
\end{array} \right)_{0 \leq m_1, m_2 \leq M}
$$

as correlation matrix.

Model error

Since the real world does not entirely follow the assumption on LSRMs, our estimations of the reserve risk should be increased by an model error.
3.2 Examples

Fire non commercial vs. motor own damage

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<td>mixed CLM</td>
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<tr>
<td>CLM on paid</td>
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<tr>
<td>CLM on incurred</td>
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</tr>
<tr>
<td>ECLRM</td>
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<td>-5 %</td>
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### 3.2 Examples

#### Fire non commercial vs. motor own damage

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<td>mixed CLM</td>
<td>20 %</td>
<td>25 %</td>
</tr>
<tr>
<td>CLM on paid</td>
<td>25 %</td>
<td>35 %</td>
</tr>
<tr>
<td>CLM on incurred</td>
<td>20 %</td>
<td>30 %</td>
</tr>
<tr>
<td>ECLRM</td>
<td>-5 %</td>
<td>-5 %</td>
</tr>
</tbody>
</table>

#### Motor TPL vs. motor own damage

<table>
<thead>
<tr>
<th>correlation</th>
<th>ultimate</th>
<th>solvency</th>
</tr>
</thead>
<tbody>
<tr>
<td>SST</td>
<td></td>
<td>15 %</td>
</tr>
<tr>
<td>QIS 5</td>
<td></td>
<td>50 %</td>
</tr>
<tr>
<td>mixed CLM</td>
<td>5 %</td>
<td>5 %</td>
</tr>
<tr>
<td>CLM on paid</td>
<td>0 %</td>
<td>0 %</td>
</tr>
<tr>
<td>CLM on incurred</td>
<td>10 %</td>
<td>15 %</td>
</tr>
<tr>
<td>ECLRM</td>
<td>10 %</td>
<td>20 %</td>
</tr>
</tbody>
</table>
1 Introduction
1.1 Insurance risk (in Non-Life insurance)
1.2 Correlation of insurance risks

2 Modelling reserve risks
2.1 Classical triangle based reserving methods
2.2 Linear-Stochastic-Reserving-Methods (LSRM)

3 LSRMs and reserving risk
3.1 Derivation
3.2 Examples

4 Outlook, tools and bibliography
4.1 Outlook and tools
4.2 Bibliography
Including CY-risk

This month a master student will start to investigate the possibilities to include the CY-risk. The basic idea is:

- add a column at the left side of each triangle that corresponds to the estimated ultimate of the next period (CY ultimate).
- explore different exposures with respect to stability and comparability.
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LSRM-Tools

There is a runtime library that implements LSRMs under the public licence GPL 3. Moreover, it includes an Excel-Add-In that allows easy access to these futures. The examples of this presentation have been generated by using these tools. All can be obtained from the author.
Bibliography

[1] R. D.
A Loss Reserving Method for Incomplete Claim Data.

Linear stochastic reserving methods.

Claims development result for combined claims incurred and claims paid data.

Distribution-free calculation of the standard error of chain ladder reserving estimates.

Prediction Error of the Expected Claims Development Result in the Chain Ladder Method.