Prediction Uncertainty in the Chain-Ladder Reserving Method

Mario V. Wüthrich
RiskLab, ETH Zurich

joint work with
Michael Merz (University of Hamburg)

Insights, May 8, 2015
Institute of Actuaries of Australia
Outline

• Introduction to claims reserving

• Chain-ladder method

• Claims development result

• Examples
# General insurance company's balance sheet

<table>
<thead>
<tr>
<th>assets as of 31/12/2013</th>
<th>mio. CHF</th>
</tr>
</thead>
<tbody>
<tr>
<td>debt securities</td>
<td>6’374</td>
</tr>
<tr>
<td>equity securities</td>
<td>1’280</td>
</tr>
<tr>
<td>loans &amp; mortgages</td>
<td>1’882</td>
</tr>
<tr>
<td>real estate</td>
<td>908</td>
</tr>
<tr>
<td>participations</td>
<td>2’101</td>
</tr>
<tr>
<td>short term investments</td>
<td>693</td>
</tr>
<tr>
<td>other assets</td>
<td>696</td>
</tr>
<tr>
<td>total assets</td>
<td>13’934</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>liabilities as of 31/12/2013</th>
<th>mio. CHF</th>
</tr>
</thead>
<tbody>
<tr>
<td>claims reserves</td>
<td>7’189</td>
</tr>
<tr>
<td>provisions for annuities</td>
<td>1’178</td>
</tr>
<tr>
<td>other liabilities and provisions</td>
<td>2’481</td>
</tr>
<tr>
<td>share capital</td>
<td>169</td>
</tr>
<tr>
<td>legal reserve</td>
<td>951</td>
</tr>
<tr>
<td>free reserve, forwarded gains</td>
<td>1’966</td>
</tr>
<tr>
<td>total liabilities &amp; equity</td>
<td>13’934</td>
</tr>
</tbody>
</table>

Claims reserves are the biggest position on the balance sheet of a general insurance company!

Source: Annual Report 2013 of AXA-Winterthur Versicherungen AG
Typically, insurance claims **cannot be settled immediately** (at occurrence):

1. reporting delay (days, weeks, months or even years);
2. settlement delay (months or years).

- Predict and value all future claims cash flows (of past exposure claims).
- Build *claims reserves* to settle these future claims cash flows.
### Claims development triangle

<table>
<thead>
<tr>
<th>Accident Year $i$</th>
<th>Development Year $j$</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
</tr>
</thead>
<tbody>
<tr>
<td>2004</td>
<td>1'216</td>
<td>1'347</td>
<td>1'786</td>
<td>2'281</td>
<td>2'656</td>
<td>2'909</td>
<td>3'283</td>
<td>3'587</td>
<td>3'754</td>
<td>3'921</td>
<td></td>
</tr>
<tr>
<td>2005</td>
<td>798</td>
<td>1'051</td>
<td>1'215</td>
<td>1'349</td>
<td>1'655</td>
<td>1'926</td>
<td>2'132</td>
<td>2'287</td>
<td>2'567</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2006</td>
<td>1'115</td>
<td>1'387</td>
<td>1'930</td>
<td>2'177</td>
<td>2'513</td>
<td>2'931</td>
<td>3'047</td>
<td>3'182</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2007</td>
<td>1'052</td>
<td>1'321</td>
<td>1'700</td>
<td>1'971</td>
<td>2'298</td>
<td>2'645</td>
<td>3'003</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2008</td>
<td>808</td>
<td>1'029</td>
<td>1'229</td>
<td>1'590</td>
<td>1'842</td>
<td>2'150</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2009</td>
<td>1'016</td>
<td>1'251</td>
<td>1'698</td>
<td>2'105</td>
<td>2'385</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2010</td>
<td>948</td>
<td>1'108</td>
<td>1'315</td>
<td>1'487</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2011</td>
<td>917</td>
<td>1'082</td>
<td>1'484</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2012</td>
<td>1'001</td>
<td>1'376</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2013</td>
<td>841</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

$\triangleright$ $C_{i,j}$ = cumulative (nominal) claims cash flows for accident year $i \in \{1, \ldots, I\}$ and development year $j \in \{0, \ldots, J\}$.

$\triangleright$ Observations at time $t$ are given by

$$D_t = \{C_{i,j}; \ i + j \leq t\}. $$
Outline

- Introduction to claims reserving
- Chain-ladder method
- Claims development result
- Examples
**Chain-ladder method**

<table>
<thead>
<tr>
<th>accident year $i$</th>
<th>development year $j$</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
</tr>
</thead>
<tbody>
<tr>
<td>2004</td>
<td>1'216</td>
<td>1'347</td>
<td>1'786</td>
<td>2'281</td>
<td>2'656</td>
<td>2'909</td>
<td>3'283</td>
<td>3'587</td>
<td>3'754</td>
<td>3'921</td>
<td></td>
</tr>
<tr>
<td>2005</td>
<td>798</td>
<td>1'051</td>
<td>1'215</td>
<td>1'349</td>
<td>1'655</td>
<td>1'926</td>
<td>2'132</td>
<td>2'287</td>
<td>2'567</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2006</td>
<td>1'115</td>
<td>1'387</td>
<td>1'930</td>
<td>2'177</td>
<td>2'513</td>
<td>2'931</td>
<td>3'047</td>
<td>3'182</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2007</td>
<td>1'052</td>
<td>1'321</td>
<td>1'700</td>
<td>1'971</td>
<td>2'298</td>
<td>2'645</td>
<td>3'003</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2008</td>
<td>808</td>
<td>1'029</td>
<td>1'229</td>
<td>1'590</td>
<td>1'842</td>
<td>2'150</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2009</td>
<td>1'016</td>
<td>1'251</td>
<td>1'698</td>
<td>2'105</td>
<td>2'385</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2010</td>
<td>948</td>
<td>1'108</td>
<td>1'315</td>
<td>1'487</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2011</td>
<td>917</td>
<td>1'082</td>
<td>1'484</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2012</td>
<td>1'001</td>
<td>1'376</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2013</td>
<td>841</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

$\Delta$

Chain-ladder (CL) algorithm is based on the observation that data often

$$C_{i,j+1} \approx f_j \ C_{i,j},$$

for CL factors $f_j$ not depending on accident year $i$.

$\Delta$

CL algorithm has been used for many decades in the insurance industry.
Mack’s stochastic CL model

Model assumptions (Mack 1993).
Assume there are fixed positive constants $f_0, \ldots, f_{J-1}$ and $\sigma_0^2, \ldots, \sigma_{J-1}^2$ given.

- $(C_{i,j})_{j=0,\ldots,J}$ are strictly positive, independent (in $i$) Markov processes (in $j$);
- for $i = 1, \ldots, I$ and $j = 0, \ldots, J - 1$

$$\mathbb{E} [C_{i,j+1} | C_{i,j}] = f_j C_{i,j},$$
$$\text{Var} (C_{i,j+1} | C_{i,j}) = \sigma_j^2 C_{i,j}.$$

Mack introduced this stochastic model for the study of the CL algorithm.

Mack’s CL model has the CL property: $C_{i,j+1} \approx f_j C_{i,j}$. 
CL predictor

▷ For known CL factors $f_j$ and given observations $\mathcal{D}_I$

$$
\mathbb{E} [ C_{i,J} | \mathcal{D}_I ] = C_{i,I-i} \prod_{j=I-i}^{J-1} f_j.
$$

▷ We define the CL predictor for unknown CL factors $f_j$ at time $I$ by

$$
\hat{C}_{i,J}^{(I)} = \mathbb{E} [ C_{i,J} | \mathcal{D}_I ] = C_{i,I-i} \prod_{j=I-i}^{J-1} \hat{f}_j^{(I)},
$$

with CL factor estimators at time $t \geq J$

$$
\hat{f}_j^{(t)} = \frac{\sum_{i=1}^{(t-j-1)^\wedge I} C_{i,j+1}}{\sum_{i=1}^{(t-j-1)^\wedge I} C_{i,j}}.
$$

▷ Note that $\hat{C}_{i,J}^{(I)}$ and $\hat{f}_j^{(I)}$ share many good properties (unbiased, uncorrelated).
## CL claims prediction

<table>
<thead>
<tr>
<th>Accident year $i$</th>
<th>Development year $j$</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
</tr>
</thead>
<tbody>
<tr>
<td>2004</td>
<td>1'216</td>
<td>1'347</td>
<td>1'786</td>
<td>2'281</td>
<td>2'656</td>
<td>2'909</td>
<td>3'283</td>
<td>3'587</td>
<td>3'754</td>
<td>3'921</td>
<td></td>
</tr>
<tr>
<td>2005</td>
<td>798</td>
<td>1'051</td>
<td>1'215</td>
<td>1'349</td>
<td>1'655</td>
<td>1'926</td>
<td>2'132</td>
<td>2'287</td>
<td>2'567</td>
<td>2'681</td>
<td></td>
</tr>
<tr>
<td>2006</td>
<td>1'115</td>
<td>1'387</td>
<td>1'930</td>
<td>2'177</td>
<td>2'513</td>
<td>2'931</td>
<td>3'047</td>
<td>3'182</td>
<td>3'424</td>
<td>3'577</td>
<td></td>
</tr>
<tr>
<td>2007</td>
<td>1'052</td>
<td>1'321</td>
<td>1'700</td>
<td>1'971</td>
<td>2'298</td>
<td>2'645</td>
<td>3'003</td>
<td>3'214</td>
<td>3'458</td>
<td>3'612</td>
<td></td>
</tr>
<tr>
<td>2008</td>
<td>808</td>
<td>1'029</td>
<td>1'229</td>
<td>1'590</td>
<td>1'842</td>
<td>2'150</td>
<td>2'368</td>
<td>2'534</td>
<td>2'727</td>
<td>2'848</td>
<td></td>
</tr>
<tr>
<td>2009</td>
<td>1'016</td>
<td>1'251</td>
<td>1'698</td>
<td>2'105</td>
<td>2'385</td>
<td>2'733</td>
<td>3'010</td>
<td>3'221</td>
<td>3'465</td>
<td>3'619</td>
<td></td>
</tr>
<tr>
<td>2010</td>
<td>948</td>
<td>1'108</td>
<td>1'315</td>
<td>1'487</td>
<td>1'731</td>
<td>1'983</td>
<td>2'184</td>
<td>2'337</td>
<td>2'514</td>
<td>2'626</td>
<td></td>
</tr>
<tr>
<td>2011</td>
<td>917</td>
<td>1'082</td>
<td>1'484</td>
<td>1'769</td>
<td>2'058</td>
<td>2'358</td>
<td>2'597</td>
<td>2'779</td>
<td>2'990</td>
<td>3'123</td>
<td></td>
</tr>
<tr>
<td>2012</td>
<td>1'001</td>
<td>1'376</td>
<td>1'776</td>
<td>2'116</td>
<td>2'462</td>
<td>2'821</td>
<td>3'106</td>
<td>3'324</td>
<td>3'577</td>
<td>3'736</td>
<td></td>
</tr>
<tr>
<td>2013</td>
<td>841</td>
<td>1'039</td>
<td>1'341</td>
<td>1'598</td>
<td>1'859</td>
<td>2'130</td>
<td>2'346</td>
<td>2'510</td>
<td>2'701</td>
<td>2'821</td>
<td></td>
</tr>
</tbody>
</table>

|$\hat{f}_j^{(I)}$ | 1.2343 | 1.2904 | 1.1918 | 1.1635 | 1.1457 | 1.1013 | 1.0702 | 1.0760 | 1.0444 |

### What about prediction uncertainty?

### Consider the conditional mean square error of prediction (MSEP)

$$\text{mse}_{C_i,j|D_I} \left( \hat{C}_{i,j}^{(I)} \right) = \mathbb{E} \left[ \left( C_{i,j} - \hat{C}_{i,j}^{(I)} \right)^2 \middle| D_I \right].$$
Mack’s conditional MSEP formula

Mack (1993) gives the following MSEP estimate for single accident years $i$:

$$
\text{mse}_{C_{i,j} \mid D_I}^{\text{Mack}} \left( \hat{C}_{i,j}^{(I)} \right) = \left( \hat{C}_{i,j}^{(I)} \right)^2 \sum_{j=I-i}^{J-1} \left[ \frac{\sigma_j^2}{\hat{f}_j(I)^2} \frac{\hat{C}_{i,j}^{(I)}}{\hat{C}_{i,j}} + \frac{\sigma_j^2}{\sum_{\ell=1}^{I-j-1} C_{\ell,j}} \right].
$$

- ▶ Note that this is an estimate because of
  - unknown parameters $f_j$ (and $\sigma_j$) need to be estimated, and
  - estimation error cannot be calculated explicitly.

- ▶ Aggregation over accident years $i$ is slightly more involved, but can be done.
Consider the **CL reserves** at time $I$ defined by

\[
\widehat{R}_i^{(I)} = \widehat{C}_{i,J}^{(I)} - C_{i,I-i},
\]

and the corresponding prediction uncertainty.
Outline

• Introduction to claims reserving
• Chain-ladder method
• Claims development result
• Examples
Mack’s formula considers the total prediction uncertainty over the entire run-off.

Solvency considerations require a dynamic view: possible changes in predictions over the next accounting year (short term view).

Define the claims development result of accounting year \( t + 1 > I \) by

\[
\text{CDR}_i(t + 1) = \hat{C}_{i,J}^{(t+1)} - \hat{C}_{i,J}^{(t)}.
\]

Martingale property of \( (\hat{C}_{i,J}^{(t)})_{t \geq I} \) implies

\[
\mathbb{E} \left[ \text{CDR}_i(t + 1) \mid \mathcal{D}_t \right] = \mathbb{E} \left[ \hat{C}_{i,J}^{(t+1)} - \hat{C}_{i,J}^{(t)} \mid \mathcal{D}_t \right] = 0.
\]
### Claims development result (2/2)

<table>
<thead>
<tr>
<th>accident year</th>
<th>development year $j$</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
</tr>
</thead>
<tbody>
<tr>
<td>2004</td>
<td></td>
<td>1'216</td>
<td>1'347</td>
<td>1'786</td>
<td>2'281</td>
<td>2'656</td>
<td>2'909</td>
<td>3'283</td>
<td>3'587</td>
<td>3'754</td>
<td>3'921</td>
</tr>
<tr>
<td>2005</td>
<td></td>
<td>798</td>
<td>1'051</td>
<td>1'215</td>
<td>1'349</td>
<td>1'655</td>
<td>1'926</td>
<td>2'132</td>
<td>2'287</td>
<td>2'567</td>
<td></td>
</tr>
<tr>
<td>2006</td>
<td></td>
<td>1'115</td>
<td>1'387</td>
<td>1'930</td>
<td>2'177</td>
<td>2'513</td>
<td>2'931</td>
<td>3'047</td>
<td>3'182</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2007</td>
<td></td>
<td>1'052</td>
<td>1'321</td>
<td>1'700</td>
<td>1'971</td>
<td>2'298</td>
<td>2'645</td>
<td>3'003</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2008</td>
<td></td>
<td>808</td>
<td>1'029</td>
<td>1'229</td>
<td>1'590</td>
<td>1'842</td>
<td>2'150</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2009</td>
<td></td>
<td>1'016</td>
<td>1'251</td>
<td>1'698</td>
<td>2'105</td>
<td>2'385</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2010</td>
<td></td>
<td>948</td>
<td>1'108</td>
<td>1'315</td>
<td>1'487</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2011</td>
<td></td>
<td>917</td>
<td>1'082</td>
<td>1'484</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2012</td>
<td></td>
<td>1'001</td>
<td>1'376</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2013</td>
<td></td>
<td>841</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

> Martingale property of $(\hat{C}_{i,J}^{(t)})_{t \geq I}$ implies

$$
\mathbb{E} \left[ \text{CDR}_{i}(I + 1) | \mathcal{D}_I \right] = \mathbb{E} \left[ \hat{C}_{i,J}^{(I+1)} - \hat{C}_{i,J}^{(I)} | \mathcal{D}_I \right] = 0.
$$

> Solvency: study the **one-year uncertainty** of next accounting year $t = I + 1$

$$
msep_{\text{CDR}_{i}(I+1)|\mathcal{D}_I}(0) = \mathbb{E} \left[ (\text{CDR}_{i}(I + 1) - 0)^2 | \mathcal{D}_I \right].
$$
Merz-W. (2008) give the following MSEP estimate for single accident years $i$:

$$msep_{CDR_i(I+1)|D_I}(0) = \left( \hat{C}_{i,J}(I) \right)^2$$

$$\times \left[ \frac{\sigma^2_{I-i}/\left( \hat{f}_{I-i}^{(I)} \right)^2}{C_{i,I-i}} + \frac{\sigma^2_{I-i}/\left( \hat{f}_{I-i}^{(I)} \right)^2}{\sum_{\ell=1}^{i-1} C_{\ell,I-i}} + \sum_{j=I-i+1}^{J-1} \alpha_j^{(I)} \frac{\sigma^2_{j}/\left( \hat{f}_{j}^{(I)} \right)^2}{\sum_{\ell=1}^{I-j-1} C_{\ell,j}} \right],$$

with (credibility) weight

$$\alpha_j^{(I)} = \frac{C_{I-j,j}}{\sum_{\ell=1}^{I-j} C_{\ell,j}} \in (0, 1).$$

Eric Dal Moro (SCOR) and Joseph Lo (Aspen UK) basically write:

*the problem is solved for the CL method,*

see industrial discussion paper, ASTIN Bulletin 44/3, September 2014.
Total uncertainty vs. one-year uncertainty

Mack’s formula for total uncertainty:

\[
msep_{C_{i,J}|\mathcal{D}_I}^{\text{Mack}} \left( \hat{C}_{i,J}^{(I)} \right) = \left( \hat{C}_{i,J}^{(I)} \right)^2 \sum_{j=I-i}^{J-1} \left[ \frac{\sigma_j^2 / \left( \hat{f}_j^{(I)} \right)^2}{\hat{C}_{i,j}^{(I)}} + \frac{\sigma_j^2 / \left( \hat{f}_j^{(I)} \right)^2}{\sum_{\ell=1}^{I-j-1} C_{\ell,j}} \right].
\]

MW formula for one-year uncertainty:

\[
msep_{\mathcal{C}_{DR, (I+1)}|\mathcal{D}_I}^{\text{MW}} (0) = \left( \hat{C}_{i,J}^{(I)} \right)^2 \times \left[ \frac{\sigma_{I-i}^2 / \left( \hat{f}_{I-i}^{(I)} \right)^2}{\hat{C}_{i,I-i}^{(I)}} + \frac{\sigma_{I-i}^2 / \left( \hat{f}_{I-i}^{(I)} \right)^2}{\sum_{\ell=1}^{i-1} C_{\ell,I-i}} + \sum_{j=I-i+1}^{J-1} \alpha_j^{(I)} \frac{\sigma_j^2 / \left( \hat{f}_j^{(I)} \right)^2}{\sum_{\ell=1}^{I-j-1} C_{\ell,j}} \right].
\]

Process uncertainty, parameter estimation uncertainty and its reduction in time.
Residual uncertainty for \( t \geq I + 2 \)

This suggests for accounting year \( t = I + 2 \):

\[
\mathbb{E} \left[ \text{mse}_{\text{CDR}(I+2)}^{\text{MW}} \big| D_{I+1} \right] (0) \big| D_I \] 

\[
\approx \left( \hat{C}_{i,J}^{(I)} \right)^2 \left[ \frac{\sigma^2_{I-i+1} / \left( \hat{f}_{I-i+1}^{(I)} \right)^2}{\hat{C}_{i,I-i+1}^{\text{CL}(I)}} + \left( 1 - \alpha_{I-i+1}^{(I)} \right) \frac{\sigma^2_{I-i+1} / \left( \hat{f}_{I-i+1}^{(I)} \right)^2}{\sum_{\ell=1}^{i-2} C_{\ell,I-i+1}} \right] 
\]

\[
+ \left( \hat{C}_{i,J}^{(I)} \right)^2 \sum_{j=I-i+2}^{J-1} \left[ \alpha_{j-1}^{(I)} \left( 1 - \alpha_{j}^{(I)} \right) \frac{\sigma^2_{j} / \left( \hat{f}_{j}^{(I)} \right)^2}{\sum_{\ell=1}^{I-j-1} C_{\ell,j}} \right].
\]

- This can be derived analytically and iterated for \( t > I + 2 \! \\

- This allocates Mack’s MSEP formula across different accounting periods, i.e., this provides a run-off pattern of the total prediction uncertainty.
Outline

• Introduction to claims reserving
• Chain-ladder method
• Claims development result
• Examples
Expected run-off of claims reserves is faster than the one of underlying risks.

Legal environment is important for run-off.
Different lines of business behave differently (short- and long-tailed business).
Subrogation and recoveries need special care.
Conclusions

- The Merz-W. formula was generalized to arbitrary accounting years.
- This allocates Mack’s *total* uncertainty formula across accounting years.
- This provides a run-off pattern for “risk”.
- This improves and interprets risk margin calculations (Solvency II versus APRA).
- Standard approximation techniques typically under-estimate run-off risk.
- Portfolio characteristics and legal environment are important for risk margins.
References


Workshop at UNSW

Upcoming conferences & events

Recent Advances in Stochastic Loss Reserving Workshop

- **Date:** Monday 25 May 2015
- **Time:** 9:00am – 4:00pm (registration from 8:30am)
- **Venue:** Theatre 4, UNSW CBD Campus, 1 O'Connell Street Sydney NSW 2000

Looking for a course coordinator or someone to help?

- **Phone:** +61 2 9385 3391
- **Email:** rasadmin@unsw.edu.au

Register now