Empowering Chain Ladder: A Cass Business School Production

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Background

Our aim: a package implementing recent research developments.

2010 Including Count Data in Claims Reserving
2011 Cash flow simulation for a model of outstanding liabilities based on claim amounts and claim numbers
2012 Double Chain Ladder

2012 Statistical modelling and forecasting in Non-life insurance
2013 Double Chain Ladder and Bornhuetter-Ferguson
2013 Double Chain Ladder, Claims Development Inflation and Zero Claims
2014 RBNS preserving Double Chain Ladder (submitted)
The problem: the claims reserving exercise

The life of an individual claim in the general claims process:

- Accident happens
- Accident reported
- Final payment made
- Reporting delay
- Settlement delay

Three categories of claim:
- Incurred but not reported, IBNR
- Reported but not settled, RBNS
- Reported and paid, RBPS

The objectives:
- How large future claims payments are likely to be.
- The timing of future claim payments.
- The distribution of possible outcomes: future cash-flows.
Framework: Double Chain Ladder

What is Double Chain Ladder?
A firm statistical model which breaks down the chain ladder estimates into individual component.

Why?
- Connection with classical reserving (tacit knowledge)
- RBNS and IBNR claims
- The distribution: full cash flow

What is required?
It works on run-off triangles (adding expert knowledge if available).

The modelled data: two run-off triangles

We model annual/quarterly run-off triangles:
- Incremental aggregated payments (Paid triangle)
- Incremental aggregated counts data, which is assumed to be fully run off. (Counts triangle)
The Double Chain Ladder Model

Parameters involved in the model:

- Ultimate claim numbers: $\alpha_i$
- Reporting delay: $\beta_f$
- Settlement delay: $\gamma_i$
- Development delay: $\delta_i$
- Ultimate payment numbers: $\tilde{a}_i$
- Severity:
  - underwriting inflation: $\gamma_i$
  - delay mean dependencies: $\mu$

23 September 2014
The Double Chain Ladder Model

The payments triangle

<table>
<thead>
<tr>
<th>V1</th>
<th>V2</th>
<th>V3</th>
<th>V4</th>
<th>V5</th>
<th>V6</th>
<th>V7</th>
<th>V8</th>
<th>V9</th>
<th>V10</th>
<th>V11</th>
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<th>V13</th>
<th>V14</th>
<th>V15</th>
<th>V16</th>
<th>V17</th>
<th>V18</th>
<th>V19</th>
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The Double Chain Ladder Model

The reserve per underwriting year

<table>
<thead>
<tr>
<th>reserve</th>
<th>proportion of total reserve</th>
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</thead>
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<td>0.000000E+00</td>
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</tr>
<tr>
<td>8.304134E+02</td>
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<tr>
<td>1.873025E+02</td>
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<td>8.340906E+02</td>
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<td>9.807470E+07</td>
<td>0.52</td>
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</table>

= 86% of total reserve
The Double Chain Ladder Model

Summary of the major drawback of classical Chain Ladder (and thus the basic Double Chain Ladder method):

- The lack of sufficient data in the most recent underwriting years yields to a severity inflation estimation being too unstable and thus not trustworthy in those most recent years.
- Even worse, those most recent underwriting years account for the very major part of the reserve.

RBNS Preserving Double Chain Ladder

Solution: Incorporate Case estimates (expert knowledge):

Counts

Paid

Incurred
The incurred triangle:

- It is not data, but a mixture of data and expert knowledge
- It contains payments and case estimates of RBNS claims

From the incurred triangle, one can extract the RBNS part estimated by the case department.

The RBNS case estimates differ from the DCL RBNS estimates
RBNS Preserving Double Chain Ladder

The values of the severity inflation estimates in the most recent calendar years result in a big difference between DCL and case estimates based RBNS numbers.

What does RBNS preserving Double Chain Ladder (PDCL) do?

- PDCL preserves the RBNS case estimates.
- Hereby, the RBNS reserve part is not just replaced by the case estimates.
- The DCL parameters estimates are also adjusted accordingly.
- Therefore, PDCL estimates the exact RBNS case estimates but also corrects the IBNR estimates.
The Double Chain Ladder package

The kernel: calibrating the model

Data

Expert knowledge

Full cash-flow (RBNS/IBNR)

Best estimate (RBNS/IBNR)

Visualizing the data: the histogram

Payment data

Counts data

DEVELOPMENT

REPORTING

23 September 2014
The kernel: parameter estimation using DCL

- The function `Plot.dcl.par()` to visualize the break down of the classical chain ladder parameters.

```r
Plot.dcl.par(DCL) R Documentation

Plotting the estimated parameters in the DCL model

Description
Show a two by two plot with the estimated parameters in the Double Chain Ladder model

Usage
`Plot.dcl.par(dcl.par, type.inflat = 'DCL')`

Arguments
- `dcl.par` A list object with the estimated parameters. The value returned by the functions `dcl.estimation`, `bdcl.estimation` and `idcl.estimation`.
- `type.inflat` Method used to estimate the inflation. Possible values are: 'DCL' (default) if it was used `dcl.estimation`, 'BDCL' if `bdcl.estimation`, and 'IDCL' if `idcl.estimation`.
```

The kernel: parameter estimation using DCL

- dcl.estimation(), bdcl.estimation(),
idcl.estimation(), pdcl.prediction()

Parameter estimation - Double Chain Ladder model

Description
Compute the estimated parameters in the model (delay parameters, severity underlying inflation, severity mean and variance) using the Double Chain Ladder method

Usage
`dcl.estimation(Xtriangle, method = 1, Tables = TRUE, num.dec = 4)`

Arguments
- `Xtriangle` The paid run-off triangle. Incremental aggregated payments. It should be a matrix with incremental aggregated payments located in the upper triangle and the lower triangle consisting in missing or zero values.
- `method` The method used to estimate the inflation in the `Xtriangle`. Possible values are: 'DCL' (default) if it was used `dcl.estimation`, 'BDCL' if `bdcl.estimation`, and 'IDCL' if `idcl.estimation`
- `Tables` Logical. If `TRUE` (default) it is showed a table with the estimated parameters.
- `num.dec` Number of decimal places used to report numbers in the tables (if `Tables=TRUE`).
### The functions in action: an example

Parameter estimates in two cases: the basic DCL model (only mean specifications) and the distributional model.

### The best estimate: RBNS/IBNR split using DCL

- The function `dcl.predict()`
The full cash-flow: Bootstrapping using DCL

- The function `dcl.boot()`

![Bootstrap distribution: the full cashflow](image)

- The function `Plot.cashflow()`

The functions in action: an example

- A table showing a summary of the distribution: mean, std. deviation, quantiles.
- Arrays and matrices with the full simulated distributions
The functions in action: an example

Validation

- The function `validating.incurred()`

Testing results against experience:
1. Cut c=1,2,…. diagonals (periods) from the observed triangle.
2. Apply the estimation methods.
3. Compare forecasts and actual values.
Validation

![Validation Diagram]

Summary: the content of the package

- **Data**: dcl.estimation, bdcl.estimation, idcl.estimation, Plot.dcl.par, clm, Plot.clm.par
- **Expert knowledge**: extract, prior
- **The kernel: calibrating the model**: dcl.predict, pdcl.predict, dcl.predict.prior, validating.incurred
- **Full cash-flow (RBNS/IBNR)**: dcl.boot, dcl.boot.prior, Plot.cashflow
- **Best estimate (RBNS/IBNR)**: clm, Plot.cashflow
- **3 run-off triangles**: Plot.triangle
- **Aggregate, get.incremental, get.cumulative**
Questions

Comments

Expressions of individual views by members of the Institute and Faculty of Actuaries and its staff are encouraged.

The views expressed in this presentation are those of the presenter.