THE TRANSITIONAL STATE CHAIN-LADDER METHOD WORKSHOP

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The Transitional State Chain-Ladder Method

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Summary

The purpose of this method is to offer the Reserving Actuary an alternative in cases where the Paid and the Incurred chain-ladder methods both fail to produce valid results.

Based on the Chain-ladder this method gives an alteration which allows the separation of claims which Settle, from those that remain Outstanding, at each development period.

Introduction

This method has been developed to tackle the problems of reserving for Bodily Injury Motor, and Employer's / Public Liability claims within my company. In Ireland these claims tend to take somewhat longer to settle than their equivalent in the UK, with delays of up to five years for Motor, and even 8 - 10 years for EL & PL.

The Paid chain-ladder method has the following problems :-

- Large claims have a significant effect on the outcome of each account year, the payments pattern and link ratios from the Paid chain-ladder are not sufficient to predict the liability for these claims.

- Our company changed computer systems four years ago, and hence the data extracted by our database is as yet incomplete. The Paid chain-ladder therefore needs to be adjusted with a tail factor.

- With a delay to settlement of five years, the mix of claims sizes may have changed during the period. In Ireland the quality of main roads have improved dramatically in the last two years, probably reducing the incidence of high speed accidents. Whereas the traffic density within the city centre has also increased, probably increasing the incidence of low speed accidents.

The Incurred chain-ladder method, advantages :-

- Large claims are identified by a case estimate from Claims Dept. hence if the estimate can be trusted the liability is more accurately identified.

- If the estimate can be trusted the tail factor after four years for the incurred data should be small.

- The Incurred method copes well with a change in the mix of claims sizes, since the case estimates made by Claims Dept. will reflect this.

The Incurred chain-ladder method, disadvantages :-

- The advantages above depend in large part on the reliability of the estimates provided by Claims Dept.

- With a long delay to settlement the bulk of the last four years incurred liability are still outstanding. Hence the reliability of case estimates provided by Claims Dept. is a significant question.

- The method is dependant on the consistency of case estimates, in particular if the level of case estimates changes in the conversion from one computer system to another, the tail factor from the new system could be difficult to estimate.

The Transitional State chain-ladder method, advantages :-

- The method incorporates case estimates provided by Claims Dept., and hence copes well with large claims, and changes in the mix of claim sizes.

- The method explicitly analyses the adequacy of case estimates, and hence can adjust for a bias in estimate levels.

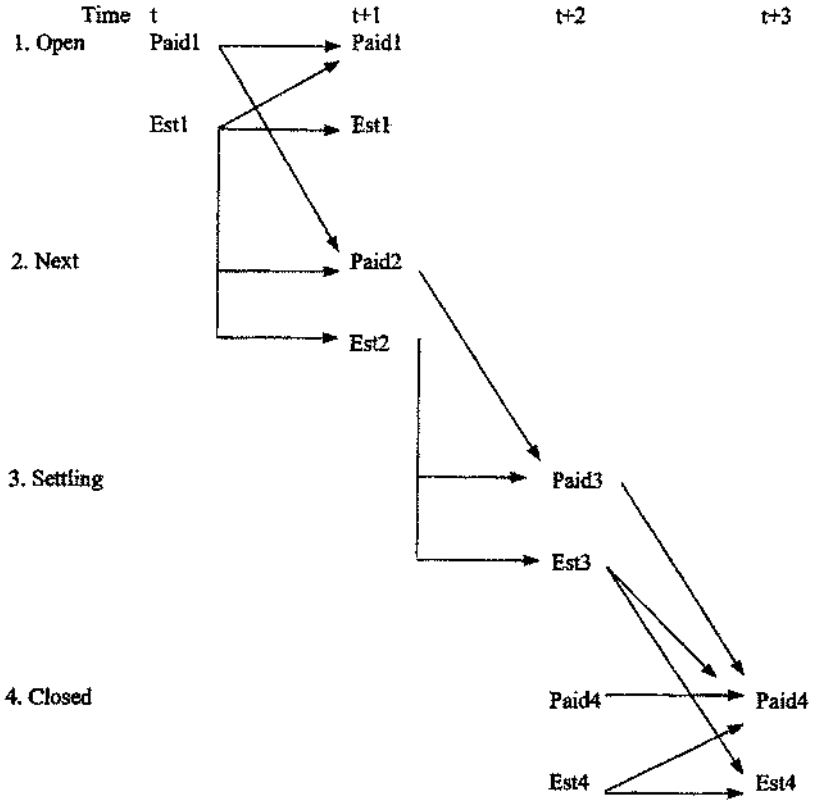
Transitional State Chain-Ladder Defined

The method analyses eight triangles of data simultaneously, that is a paid, and an estimate triangle for each of four transitional states :-

The aim of the split is to identify the estimate before settlement with the settlement value. These two cohorts of claims are identified by states two and three. State One and Four fill in the other possible states to include all claims.

Paid and Estimate figures are included at each state to allow for the reality of expense & partial payments before settlement date, and expense reserves lingering after the settlement date.

- State One Open Claims not settling for at least two months
- State Two Claims Settling Next month
- State Three Claims Settling this month
- State Four Settled Claims



Data Extraction, a touch of SQL

The following scripts (somewhat simplified) have been used to extract data from our database. They show how to divide up the Paid and Estimate data into the four different states which we require for our method. The beauty of an SQL database is that with a little training any actuary would be able to define his (her) own data, something that would not have been contemplated in the old days of mainframes and Cobol programs.

Two tables are used in this query, Val_Monthly_Date is a simple table with one row for each month of processing, containing the month end date. Claim_History is a large complex table providing the paid and estimate position of each individual claim at every month end from the date the claim was reported through to the current month for open claims, and the final payment for closed claims. The claim status Ch.Status = 'C' means that the direct loss is closed, regardless of any expense reserve.

```
Rem Version 1
rem This file is for Bodily Injury Classes
rem To Generate amounts Paid and Case Estimates at delay t
rem where the direct loss was not settled on or before delay t + 1
rem
rem Ch1 is the claim_row at delay t     Claim Open
rem Ch2 is the claim_row at delay t + 1 Claim Open
rem
Insert Into TempvalBI1
  Select
    Last_Day ( Ch1.Date_Reported ) Notify_Month,
    Months_Between ( Last_Day ( Md.Monthly_Date ),
                     Last_Day (  Ch1.Date_Reported )) Delay_Month,
    Sum ( Ch1.Paid_To_Date ) Cumulative_Claim_Paid,
    Sum ( Ch1.Claim_Reserve ) Claim_Estimate
  From Claim_History    Ch1,
       Claim_History    Ch2,
       Val_Monthly_Date Md
  where Ch1.Fk_Claim_Number       = Ch2.Fk_Claim_Number
/* This section is for version 1, replace it with the alternatives for verions 2, 3, and 4.*/
     and (( Md.Monthly_Date = Ch1.Monthly_Date
            and Months_Between ( Ch2.Monthly_Date, Ch1.Monthly_Date ) = 1 )
          or ( Ch1.Monthly_Date = Ch1.Latest_Monthly_Date
            and Ch2.Monthly_Date = Ch1.Latest_Monthly_Date
            and Ch1.Monthly_Date = Md.Monthly_Date ))
       and not ( Ch2.Status = 'C' )
       and not ( Ch1.Status = 'C' )
/* This section is for version 1, replace it with the alternatives for versions 2, 3, and 4.*/
group by
    Last_Day ( Ch1.Date_Reported ),
    Months_Between ( Last_Day ( Md.Monthly_Date ),
                     Last_Day (  Ch1.Date_Reported ));
Commit;
```

```
Rem Version 2
rem
rem Ch1 is the claim_row at delay t    Claim Open
rem Ch2 is the claim_row at delay t + 1 Claim Closed
rem
    and ( Md.Monthly_Date = Ch1.Monthly_Date
          and Months_Between ( Ch2.Monthly_Date, Ch1.Monthly_Date ) = 1 )
    and ( Ch2.Status = 'C' )
    and not ( Ch1.Status = 'C' )

Rem Version 3
rem
rem Ch1 is the claim_row at delay t    Claim Closed
rem Ch2 is the claim_row at delay t - 1 Claim Open
rem
    and ( Md.Monthly_Date = Ch1.Monthly_Date
          and Months_Between ( Ch1.Monthly_Date, Ch2.Monthly_Date ) = 1 )
    and not ( Ch2.Status = 'C' )
    and ( Ch1.Status = 'C' )

Rem Version 4
rem
rem Ch1 is the claim_row at delay t    Claim Closed
rem Ch2 is the claim_row at delay t - 1 Claim Closed
rem
    and (( Md.Monthly_Date = Ch1.Monthly_Date
          and Months_Between ( Ch1.Monthly_Date, Ch2.Monthly_Date ) = 1 )
         or ( Ch1.Monthly_Date = Ch1.Latest_Monthly_Date
           and Ch1.Monthly_Date = Ch2.Monthly_Date
           and Ch1.Monthly_Date < Md.Monthly_Date ))
      and ( Ch2.Status = 'C' )
      and ( Ch1.Status = 'C' )
```

Inflation Adjustment

Having obtained the Payment and Estimate triangle using the SQL code above, we then apply an inflation adjustment to get present values for all the data.

The process for Estimates is quite simple since any estimate at a point in time can be converted to a present value – Est (t) -> Est (t) * NPV (t)

For Paid data each payment should be converted to a present value again at the point in time at which the payment is made. This is difficult for the Paid triangle of a single state, since payment data transfers from one state down through settlement into a different state, and this transfer of cumulative payments must not be treated as an actual payment.

A practical solution is to sum the paid data for all four triangles, decumulate the data, apply NPV factors, recumulate, and then proportion the total across the four triangles in the same ratio as the original data.

The proof that this method is only an approximation to the real situation where the present values of each payment are taken, before summarisation into the triangles, is left as an exercise for the more resilient reader.

Example

	t	t+1	t+2	t+3	t+4	t+5
Cum Paid1	100	200	100	0	0	0
Cum Paid2	0	0	110	100	0	0
Cum Paid3	0	0	0	1010	1000	0
Cum Paid4	0	0	0	0	1010	2210
Cum Total	100	200	210	1110	2010	2210
Decum Total	100	100	10	900	900	0
NPV Factor	1.5	1.4	1.3	1.2	1.1	1
NPV Decum Total	150	140	13	1080	990	0
NPV Cum Total	150	290	303	1383	2373	2573
NPV Cum Paid1	150	290	144	0	0	0
NPV Cum Paid2	0	0	159	125	0	0
NPV Cum Paid3	0	0	0	1258	1181	0
NPV Cum Paid4	0	0	0	0	1192	2573

Derivation of Link Ratio triangles

For an ordinary chainladder method the link ratio stage is a simple case of taking appropriate ratios from the base triangle and then overriding these as required.

For the Transitional State Chainladder there are several triangles of data, which are inextricably linked. The ratios we use must therefore recognise this link to produce meaningful values ready for the human touch.

Define Liab1 (t) = Paid1 (t) + Est1 (t)
Note Paid1 (t) is taken to be the Net Present Value of cumulative payments to time t.

The drift during the open period.

$$\textbf{OpenLiab drift} = \frac{\text{Liab1 (t+1)} + \text{Liab2 (t+1)} - \text{Paid1 (t)}}{\text{Est1 (t)}}$$

The proportion paid next month.

$$\textbf{OpenPaid drift} = \frac{\text{Paid1 (t+1)} - \text{Paid1 (t)} + \text{Paid2 (t+1)}}{\text{Est1 (t)}}$$

The proportion paid settling next month.
This ratio is constructed so that a value of 0 leaves the claims all in state1,
and a value of 1 transfers all claims to state 2.

$$\textbf{NextPaid drift} = \frac{\text{Paid2 (t+1)}}{\text{Paid1 (t+1)} + \text{Paid2 (t+1)}}$$

The proportion estimates settling next month.

$$\textbf{NextEst drift} = \frac{\text{Est2 (t+1)}}{\text{Est1 (t)}}$$

The ratio at settlement.

$$\textbf{SettleRatio drift} = \frac{\text{Liab3 (t+1)} - \text{Paid2 (t)}}{\text{Est2 (t)}}$$

The proportion of estimates at settlement.

$$\textbf{SettleEst drift} = \frac{\text{Est3 (t+1)}}{\text{Est2 (t)}}$$

The drift of paid + estimates during the while settled.

ClosedLiab drift = $\dfrac{\text{Liab4 (t+1) - Paid3 (t) - Paid4 (t)}}{\text{Est3 (t) + Est4 (t)}}$

The drift of estimates during the while settled.

ClosedEst drift = $\dfrac{\text{Est4 (t+1)}}{\text{Est3 (t) + Est4 (t)}}$

In practice several of the ratios developed above tend not to be very significant, these can either be left unaltered, or subjected to a rigorous smoothing process.

The ratio **SettleRatio** however is of paramount importance for our analysis. A complete triangle of ratios can be calculated from the data, (as well as the usual ratio at the bottom of each column), and this shows the Ratio of Case Estimate the month before settlement with the actual value of the claim payment, by date reported and settlement delay.

Recalculation of Paid and Estimate triangles

Having chosen values for the Ratios above the Paid and Estimate triangles can then be projected using the reverse of the ratio formulae.

paid2(t+1) = (**OpenPaid** * Est1(t) + Paid1(t)) * **NextPaid**
paid1(t+1) = Paid2(t+1) * (1 - **NextPaid**) / **NextPaid**
est2(t+1) = **NextEst** * Est1(t)
est3(t+1) = **SettleEst** * Est2(t)
est4(t+1) = **ClosedEst** * (Est3(t) + Est4(t))
est1(t+1) = **OpenLiab** * Est1(t) + Paid1(t) - Paid1(t+1) - Paid2(t+1) - Est2(t+1)
paid3(t+1) = **SettleRatio** * Est2(t) + Paid2(t) - Est3(t+1)
paid4(t+1) = **ClosedLiab** * (Est3(t) + Est4(t)) - Est4(t+1) + Paid3(t) + Paid4(t)

Analysis of Ratios

The pattern of **SettleRatio** by date reported helps determine changes to case estimate levels over time. The latest diagonal of ratios gives the current values for the adequacy of case estimates by age of claim.

OpenLiab is an interesting ratio since it reveals the trend for claims that remain open. If estimates are suddenly, or gradually, marked up, this ratio will reveal the pattern.

ClosedLiab reveals the adequacy of expense reserves, which in my company tend to be settled a month or two after the direct loss.