The Actuary and IBNR Techniques

Section 1 – Introduction

Since Bornhuetter and Ferguson (1973) encouraged actuaries to pay attention to the topic of IBNR reserves, a vast literature on loss reserving techniques has emerged; see for example Schmidt (2015) and Wüthrich and Merz (2008). Several main strands of this literature can be identified. Firstly, many new IBNR reserving techniques have been developed since the introduction of the Bornhuetter-Ferguson (BF) technique, with a notable example of methods used in common practice being the Cape Cod (CC) (Bühlmann & Straub, 1983) and the Generalized Cape Cod (GCC) methods (Gluck, 1997). Secondly, a deeper statistical understanding of IBNR reserving has been achieved through contributions such as Mack (1993), Renshaw and Verrall (1998) and Wüthrich et al. (2008), allowing for the estimation of the uncertainty contained in an IBNR analysis.

Ironically, the proliferation of techniques that can be applied when reserving can confuse the choice of IBNR reserving technique, since the literature has not provided clear guidance on the choice between the various techniques. Instead, actuaries in practice often rely on heuristics to guide the choice of reserving model, for example using the Bornhuetter-Ferguson technique to reserve for less developed accident years and the Chain Ladder technique for more developed accident years. Since choosing between techniques is not done systematically, it can be difficult to justify the choices made to auditors and regulators.

Another disconnect between the literature and practise is that claims experience contained in loss triangles often departs from the model examples found in the literature. For example, loss development factors may display trends relating to changing claims settlement delays or shifting loss recognition practices and outliers relating to large claims may be present in the triangles. Also in this case, heuristics are used to deal with these problems – for example, only the most recent diagonals in a triangle may be used to calculate loss development factors and outliers may be excluded – but a systematic method for performing the analysis required to derive IBNR reserves on realistic triangles has not emerged.

Furthermore, the context in which many IBNR techniques are presented in the literature is often restricted to a reserving analysis performed at a point in time to arrive at loss reserves. Actuaries in practise, though, must re-estimate loss reserves on a frequent basis (often quarterly), applying techniques to loss triangles that are augmented with new data and then reporting continually on the results. The accuracy of the actuary's previous reserving exercise is often evaluated using an Actual versus Expected analysis (Bruce et al., 2015), which helps to guide the setting of reserves on the basis of emerging experience, but changes in loss reserves must be justified to the Board and senior management of the insurance operation in which the actuary is employed. The literature does not address the process of setting reserves with the goal of accurate forecasts which result in the smallest quarterly changes, which can be framed as aiming to minimize the differences between Actual and Expected claim experience.

The development of Solvency II has complicated the issue of IBNR reserving further; Solvency II requires that reserves are set at the "best estimate" of the loss distribution. Without a systematic method of identifying the techniques that produce a best estimate reserve, actuaries are not only forced to rely on their professional judgement that a particular technique produces the best estimate, but must convince regulators of this as well.

The goal of this paper is to present a framework in which the actuary can analyse the properties of the reserving methods which are may be applied when setting reserves. Since large reserving triangles are available to many actuaries working in companies with an extensive loss history, it is proposed that the actuary re-reserves consecutive prior accident years and investigates the outcome of each reserving exercise based on the actual experience contained in the triangle. In order to re-reserve these prior years, a goal for the reserving exercise and the set of techniques to be applied must be articulated. The optimal set of techniques is then found in relation to the goal of the reserving exercise.

The rest of the paper is organised as follows. Section 2 provides a notation for the framework proposed in Section 3. Section 4 provides two case studies and Section 5 concludes.

Section 2 – Notation and Methods

Notation

Without loss of generality, suppose that in calendar period K a loss triangle with accident periods $1..I$ and development periods $1..J$ is available, represented as $\Delta^K_{I,J}$. In this study, quarterly accident and development periods will be considered. $C_{i,j}$ represents the cell of the cumulative triangle relating to accident period i and development period j, and could be cumulative incurred or paid claims, or claim counts and $I_{i,j} = C_{i,j} - C_{i,j-1}$ represents the cells of the incremental triangle.

The most recent diagonal of claims experience occurs in calendar period $K = I + J - 1$.

The IBNR reserve for accident period i in calendar period k is the difference between the ultimate claims that will be incurred in accident period i, $Ult_i = C_{i,J}$,and the claims incurred up to development period j. $C_{i,j}$ is known, but Ult_i is not, so reserving methods seek to forecast Ult_i to produce the estimated IBNR reserves. This forecast is made at different times, so we extend the usual notation of the ultimate claims to $Ult^k_{i,j}$, which represents the forecast made of the ultimate claims for accident period i in development period j at time k. The estimated IBNR reserve for accident period i at development period j in calendar period k is then $R^k_{i,j} = Ult^k_{i,j} - C_{i,j}$. Since

$Ult_i = C_{i,J} = I_{i,J} + C_{i,J-1}$, this expression can be rearranged in terms of the forecast incremental claims such that $R^k_{i,j} = \sum_{n=1}^{J-j} I^k_{i,j+n}$.

If a perfect forecast (in other words, incorporating all of the future claims experience) of Ult_i (and the future incremental claims experience, $\sum_{n=1}^{J-j} I^k_{i,j+n}$) could be made by the actuary in period j, then $Ult^k_{i,j}$ = $Ult^{k*}_{i,j}$ for all forecasts made in future periods. Since perfect forecasts cannot be made, then the actuary's forecasts of the ultimate claims may change in consecutive calendar periods.

Claims Development Result

Differences between forecasts of the ultimate claims in consecutive periods give rise to the Claims Development Result ('CDR') of Wüthrich et al. (2008).

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\begin{aligned}
& CDR(j+1, j) = Ult^{k+1}_{i,j+1} - Ult^k_{i,j} \\
& = R^{k+1}_{i,j+1} + C_{i,j+1} - (R^k_{i,j} + C_{i,j}) \\
& = \sum_{n=1}^{J-j-1} I^{k+1}_{i,j+1+n} + C_{i,j+1} - (\sum_{n=1}^{J-j} I^k_{i,j+n} + C_{i,j}) \\
& = R^{k+1}_{i,j+1} - R^k_{i,j+1} + (I_{i,j+1} - I^k_{i,j+1}) \\
& = R^{k+1}_{i,j+1} - R^k_{i,j+1} + FE_k(I_{i,j+1})
\end{aligned}
$$

As shown above, the CDR can be expressed as the sum of the difference between the forecasts of the IBNR reserves for development period $j+1$ and the difference between the actual incremental claims experience in development period $j+1$ and the expected claims experience.

The latter part of the CDR is expressed in the notation as $FE_k(I_{i,j+1})$, which is the error of the forecast of the incremental claims made at time k. $FE_k(I_{i,j+1})$ is often inspected by actuaries in the form of an actual versus expected analysis. On the basis of this analysis, changes can then be made to the IBNR reserves for the next accident and development periods. Changes made to the reserves on the basis of the CDR will reflect in the profit and loss statement of the insurance entity.

Bootstrap errors

$FE_k(I_{i,j+1})$ forms the basis of the bootstrap methods proposed by England and Verrall (1999).

At time k, the CDR is not yet known. However, with a suitably long claims history, the CDR that would have arisen in previous time periods (< k) had a particular IBNR reserving philosophy been followed can be calculated. The CDR in previous time periods can provide an indication to the actuary how suitable his reserving method is. In this paper we propose to find the optimal reserving method that minimizes the CDR is previous time periods.

Methods

This section briefly reviews three of the most well-known IBNR reserving methods.

Chain Ladder

The chain ladder method forecasts $C_{i,J}$ on the assumption that future claims development will be in line with past claims development. The forecasts are made using loss development factors, f_j such that $C_{i,j+1} = f_j C_{i,j}$ and $C_{i,J}$ is forecast by $C_{i,J} = f_J C_{i,J-1} = \prod_{k=j}^{J} f_k C_{i,j} = F_j C_{i,j}$.

Mack (1993) provides unbiased estimates of f_j as $f_j = \frac{\sum_{i=1}^{n-j} C_{i,j+1}}{\sum_{i=1}^{n-j} C_{i,j}} = \frac{\sum_{i=1}^{n-j} C_{i,j}.f_{i,j}}{\sum_{i=1}^{n-j} C_{i,j}}$, which is a weighted average of the individual development factors $f_{i,j} = \frac{C_{i,j+1}}{C_{i,j}}$.

Although the calculations in Mack (1993) use all of the accident years in the triangle, in practice, actuaries often use data from only the most recent accident years to calculate f_j, or exclude some of the factors, effectively reweighting the calculation of $f_j = \frac{\sum_{i=1}^{n-j} C_{i,j}.f_{i,j}.w_{i,j}}{\sum_{i=1}^{n-j} C_{i,j}.w_{i,j}}$ with weights $w_{i,j}$, which are chosen subjectively. Another option is to calculate the weights based on an exponential decay factor, $\gamma^{abs(i-n)}$ xxxx.

Bornhuetter-Ferguson

The BF method seeks to reduce the reliance on the current claims amount $C_{i,j}$ when projecting the ultimate claims, by assuming that future claims development will be proportional to the actuary's expectation of the ultimate loss, $C_{i,J} = C_{i,j} + (1-\beta_j)E(Ult_{i,j}^k)$, often expressed using an expected ultimate loss ratio $E(Ult_{i,j}^k) = \pi_i.E(ULR_i^k)$, where π_i is the earned premium in accident period i. The expected ultimate losses may be set using input from pricing actuaries or underwriters, or on the basis of past experience. Setting expected loss ratios is often xxxxx

Cape Cod and Generalized Cape Cod

The Cape-Cod method of Bühlmann and Straub (1983) provides a way of inferring the ultimate losses from the loss data in a statistically principled manner. On the assumption that all accident years have the same ultimate loss ratio, the Cape Cod loss ratio is calculated as

$$CCLR_i^k = \frac{\sum_{n=1}^{I} C_{n,I-n+1}}{\sum_{n=1}^{I} \pi_n \beta_{I-n+1}}$$

. Relaxing this assumption leads to the Generalized Cape Cod method of Gluck (1997) who specified that the loss ratio be calculated as

$$GCCLR_i^k = \frac{\sum_{n=1}^{I} C_{n,I-n+1} . \gamma^{abs(i-n)}}{\sum_{n=1}^{I} \pi_n \beta_{I-n+1} \gamma^{abs(i-n)}}$$

,

where the decay factor γ weights the observed claims experience by time. A decay factor of zero produces the chain-ladder forecast and a decay factor of one produces the Cape-Cod loss ratio, and therefore the GCC method generalizes between these methods. In practice, the decay factor is often set equal to 75%, but this requires judgement on the part of the actuary.

Section 3 - Framework

In this section, we adopt the algorithmic view of claims reserving described in Björkwall, Hössjer, and Ohlsson (2009). From this perspective, to derive the claims reserve for the triangle $\Delta^K_{I,J}$, the actuary adopts an algorithm h , such that $R^k_{i,j} = h(\Delta^K_{I,J})$. The algorithm may consist of several steps, for example:

- Derive a payment pattern for each accident period using a weighted average estimator of the development factors, $$f_j = \frac{\sum_{i=1}^{n-j} C_{i,j} . f_{i,j} . w_{i,j}}{\sum_{i=1}^{n-j} C_{i,j} . w_{i,j}}$$, where the weights are set according to an exponential decay function. Any individual development factors greater than a certain threshold are excluded from the calculation by setting the weight to zero. Both the value of the decay function and the threshold are set by subjective judgement.
- If working with an incurred triangle, decide on how much negative development to allow for.
- Using the development pattern, apply the Generalized Cape Cod method using a decay function set by judgement.
- In some circumstances, modify the reserves using a different loss ratio assumption.

Since there are many choices $h \in H$ that can be made, the next part of the framework is to introduce the concept of a score, which is a quantitative measure of how well the algorithm $h \in H$ has performed on triangle $\Delta^K_{I,J}$. The score should reflect the goals of the reserving analysis. For example, an algorithm that fits the triangle well will be easier to justify than an algorithm that fits the triangle poorly. If the analysis is to be updated on a quarterly basis, then the algorithm that minimises the forecast errors $FE_k(I_{i,j+1})$ is a sensible choice of scoring. To calculate $FE_k(I_{i,j+1})$, it is necessary to compare the actual claims experience to the expected and therefore we proceed as follows:

- For the first calendar period K, $R_{i,j}^{k} = h(\Delta_{I,J}^{K})$.
- Calculate $FE_k(I_{i,j+1})$
- Increment K.
- Repeat until the most recent calendar period K is reached.

The score can then be summarized using the average.

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