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THE RISKTECH FOR INSURANCE

4 NON-LIFE RESERVING METHODS TO HELP YOU IN YOUR ACTUARIAL CAREER

EXPERTS' INSIGHTS
NON-LIFE INSURANCE

RESERVING IS AN ART...

Reserving is **one of the three core functions of an actuary** in an insurance company, along with pricing and capital modelling. The reserving actuary's role is key, since his work will allow the company to anticipate the money it will need to reimburse its current and past policyholders for claims they have incurred or for claims they will incur for policies in force. In other words, it is also key in the bad scenario where it can lose investors' money by setting aside too much capital for claims than is needed; or worse, not enough money to settle claims that should have been foreseen resulting in a re-injection of capital or even insolvency. Therefore, it is one of the most scrutinized functions as well, with regular external audits and regulatory submissions to make sure that the numbers submitted reflect the available data.

This leads us to the million dollar question: just how do we get those numbers right?

Here, we focus on selecting the right reserving method, among four mains universally known and used methods around the actuarial world. Knowing them should help prepare young actuaries on their way to a successful career in P&C reserving, but this remains an introduction.

The focus here was on the most widely used deterministic techniques, but there exist numerous stochastic as well as many more deterministic methods not covered here that you will discover on your career path (Cape Cod, London Chain, ICR, Monte Carlo, just to name a few). Furthermore, the field is evolving still. New technologies such as machine learning may change how future generations calculate their reserves and redefine the role of the actuary. It is worth remembering that the field is still relatively young and many of the techniques in use today were invented by actuaries still in service.

The table below summarizes these four methods and when to use them. Of course, who can do more can do less : if you are able to get systematically the results from these four methods with your reserving tool on a quarterly basis, you are the happiest reserving actuary!

Method	When to use	When not to use	Judgment need
Chain-Ladder	Low volatility risks with stable data	High severity / volatility risks low development on recent years	Medium
Bornhuetter-Ferguson	High volatility risks with low development	Low volatility risks with stable data	High
Average Cost	High frequency low severity homogenous claims	Whenever there is variability in claim size or numbers	High
De Vylder	Incomplete or missing data	Complete and credible data	Low

Let's dive into each of those for methods.

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METHOD N°1

"CHAIN-LADDER: THE FIRST AND MOST IMPORTANT RESERVING METHOD FOR P&C INSURANCE"

The first and most important reserving method (far ahead all other methods in terms of use) for P&C insurance and one you have probably already heard of even in other actuarial disciplines is the chain ladder method.

It can be used on all kinds of data, whether claims, premiums, or commissions though it need not even be restricted to insurance data: it can be used almost anytime experience can be a useful indicator of future outcomes.

At its core, it involves cumulating data in a triangle by origin and by development and then calculating the multiplicative factors by which these data increase (or decrease) from one period to the next. If we take the simplest approach, it involves taking the sum of the m data points in development period $j+1$ and dividing them by the equal length vector of data points for the same m origin periods in period j to calculate these multiplicative factors but their estimation may take one of many variations: simple or weighted averages, over some or all periods, excluding outliers, etc.

These development factors are needed to obtain ultimate claim numbers. If analysing paid triangles, the result will be the ultimate claim payments and the difference between the ultimate paid and the paid to date is the total outstanding claims reserve. If using triangles of incurred claims, this ultimate result will be the total claims incurred and the difference between the ultimate and the incurred to date is the IBNR (Incurred but not reported) reserve. In both cases, the ultimate paid claims and ultimate incurred claims should be equal, at least theoretically.

To see how this would work, consider the following triangle of paid claims:

	1	2	3	4	5	6
2016	1,100	1,600	1,950	2,100	2,130	2,130
2017	1,000	1,530	1,900	2,000	2,040	
2018	1,200	1,660	2,010	2,200		
2019	1,090	1,600	2,000			
2020	1,150	1,700				
2021	1,120					

By taking the values in columns *j+1* and dividing them by the values in columns *j* we can obtain the following triangle of age-to-age factors:

	1-2	2-3	3-4	4-5	5-6
2016	1,455	1,219	1,077	1,014	1,000
2017	1,530	1,242	1,053	1,020	
2018	1,383	1,211	1,095		
2019	1,468	1,250			
2020	1,478				

Based on these data, we can select a representative factor for each development period by taking various averages or we can take a weighted average by taking the sums of columns *j+1* and dividing them by the sums of columns *j* obtaining the following vector of factors:

1-2	2-3	3-4	4-5	5-6
1,460	1,230	1,075	1,017	1,000

Knowing which factors to select and which to exclude often requires expert judgment and comes with experience. But in this example, if we take the above vector as our selection, we would then be able to calculate our ultimates, and therefore our reserves, as shown in the table below:

	Paid to Date	% Developed	Ultimate	Claims Reserve
2016	2,130	100%	2,130	0
2017	2,040	100%	2,040	0
2018	2,200	98%	2,238	38
2019	2,000	91%	2,187	187
2020	1,700	74%	2,286	586
2021	1,220	51%	2,396	1,176

The Chain-Ladder works best for triangles with little volatility between years and without very large claims distorting the data. It is most reliable on stable paid or incurred triangles of attritional claims. If that's not the case, another method may be more appropriate.

METHOD N°2

"BORNHUETTER-FERGUSON: HOW TO PROVISION FOR THE RISKIER, MORE VOLATILE LINES OF BUSINESS "

Back before computers could make anyone an actuary, two Rons got together to solve the problem of how to provision for the riskier, more volatile lines of business such as financial lines or D&O (directors and officers) for which the standard chain ladder approach would often provide inconsistent results from one reporting period to the next, especially for the most recent origin periods.

What they came up with was a Bayesian credibility approach that relied on an a priori loss ratio assumption and a standard reserving approach (typically the chain ladder, but not necessarily) to derive an *a posteriori* loss ratio. The way it would work is, if you had a current year that was only 10% developed, you would only give 10% credibility to the year's projected result and 90% credibility to your *a priori* assumption. This equation can be formulated as:

LR (a posteriori) = c x LR (data) + (1-c) x LR (a priori)

This can also be expressed in terms of ultimate claims, which would equal **Paid to Date + (1-c) x Premium x LR (a priori)**

To illustrate this with an example, let's get back to our paid triangle from the Chain-ladder section. We need to add a vector of ultimate premiums per year, and development calculations from the chain-ladder section. These are summarized in the table below:

	Premium	Paid to Date	% Developed	A priori Loss Ratio	B-F Ultimate	A posteriori Loss Ratio
2016	2,500	2,130	100%	83%	2,130	85%
2017	2,550	2,040	100%	83%	2,040	80%
2018	2,600	2,200	98%	83%	2,236	86%
2019	2,650	2,000	91%	83%	2,188	83%
2020	2,700	1,700	74%	83%	2,275	84%
2021	2,750	1,220	51%	83%	2,340	85%

In this example, there is not much volatility in the data and, therefore, the differences between the ultimate claims and those calculated in the chain-ladder section are very small.

Indeed, the more developed a year the more the Bornhuetter-Ferguson method will converge with the chain-ladder approach. You would not typically use this method for such a stable triangle as there is no need for it, but for volatile risks with long development it is very useful. The drawback is that you do need a good a priori loss ratio estimates so typically more experienced actuarial judgment is required.

METHOD N°3

"AVERAGE COST:

ULTIMATE CLAIMS ARE THE PRODUCT OF THE COMPLETED ULTIMATE CLAIMS NUMBERS MATRIX AND THE ULTIMATE AVERAGE COSTS MATRIX "

While it can be said that the classic chain ladder technique does take into account claims inflation, it does so implicitly. If you wanted to do so explicitly, you could try a frequency x severity approach with a chain ladder triangle on claims numbers and a vector of average claims costs.

This technique could be useful for identifying trends in inflation on claims of a similar nature that occur with high frequency but increase in costs from one year to the next.

The most important requirement therefore is data for claims numbers. If these exist, then a triangle can be made and you can use one of the methods in this article that would be most appropriate (Chain ladder, B-F,...) to derive the ultimate claim numbers for each origin year. For the average claims cost, you can take the total claims cost for year i divided by the number of claims for year i) or an inflation-adjusted technique. Ultimate claims are then the product of the completed ultimate claims numbers matrix and the ultimate average costs matrix.

For a simple example, let's turn back to our triangle from earlier, but assume now that the triangle represents paid claims numbers. Assuming an average claim cost we obtain the following results:

	Numbers Date	% Developed	Ultimate Numbers	Average Claims Cost	Ultimate Claims
2016	2,130	100%	2,130	50	106,500
2017	2,040	100%	2,040	52	106,080
2018	2,200	98%	2,238	54	120,828
2019	2,000	91%	2,187	55	120,278
2020	1,700	74%	2,286	57	130,329
2021	1,220	51%	2,396	58	138,977

You might consider using this approach on triangles on claims of very similar nature and size where the only difference in claim size between one year and the next is inflation. While the chain ladder on amounts would also work in such instances, the average cost method would give you even more accurate results since you have a more accurate picture of claim size and claim numbers. However, this method is not useful where claims are of different natures and varying sizes.

METHOD N°4

"DE VYLDER: HOW TO PROVISION FOR RISKS WHERE THE ORIGIN PERIODS ARE UNKNOWN OR THE DATA ARE SPARSE AND UNRELIABLE"

A few years after the two Rons developed their now famous Bornhuetter-Ferguson method, a Dutch actuary, F.E. de Vylder, came up with an idea for how to provision for risks where the origin periods are unknown, or the data are sparse and unreliable.

His idea? Instead of using the chain ladder on cumulated triangles to calculate the loss development factors (LDFs), because some of the values may not be complete, use a least-squares approach on incremental triangles to select the factors that minimize the mean square error (MSE) of the triangle. This works because each incremental value can be considered as a fraction of the ultimate which we are trying to estimate.

To give an example, let's go back to our paid claims' triangle from earlier, but assume now that some of the earlier data are missing:

	1	2	3	4	5	6
2016				2,100	2,130	2,130
2017			1,900	2,000	2,040	
2018		1,660	2,010	2,200		
2019	1,090	1,600	2,000			
2020	1,150	1,700				
2021	1,120					

The chain-ladder method could still be used here, but it would be less reliable since only two data points per development period are available.

The first step in the de Vylder method is to create the incremental triangle but excluding the points in 2016-4, 2017-3, and 2018-2 since these are not incremental values. The resulting incremental triangle looks like this:

	1	2	3	4	5	6
2016					30	0
2017				100	40	
2018			350	190		
2019	1,090	510	400			
2020	1,150	550				
2021	1,220					

Each of these incremental amounts represents a percentage of the ultimate claims for that year. So from this triangle, 30 = p(5) x Ultimate(2016) and 1220 = p(1) x Ultimate(2021).

The least squares calculation to be solved, therefore, is **Σi,j (Ultimate(i) x p(j) – C(i,j))² for all** origin years *i* and development periods *j* in the triangle. Minimizing this formula will give us our de Vylder incremental development percentages and also our ultimates.

For this example, the results are summarised in the following table:

	Paid to Date	% Developed	Ultimate Paid	Claims Reserve
2016	2,130	100%	2,130	0
2017	2,040	100%	2,045	5
2018	2,200	98%	2,245	45
2019	2,000	93%	2,144	144
2020	1,700	76%	2,239	539
2021	1,220	51%	2,372	1,152

Despite the missing data, the results are still very close to those from the chain-ladder on the full triangle, which is indeed the point. The main drawback of this method is that it does not deal well with tail factors, so if you do have one, make sure to add it after the fact.

On complete and reliable data, this method would be unnecessary at best and less reliable than the other options at worst but on data with missing or incomplete elements, it may be the most useful.

OTHER THINGS TO CONSIDER:

In each of those four methods except for De Vylder's, you will sometimes need to exclude some data from your selections. Knowing which factors to exclude requires expert judgment and comes with experience. Generally, you can exclude (or smooth) factors that are abnormally high or low and represent one-off events. An example of this are large losses or natural catastrophes, which are often excluded from triangles for a more reliable estimate of the development factors. This does not mean that these outliers are excluded from the ultimate, however. You still need to hold appropriate reserves, which includes provisions for large losses and natural catastrophes, but these can be calculated by other means (for example, they could be more parametric or focused on individual claims).

Another thing to consider is that in some lines of business you will have salvages and subrogations. These occur in property insurance when some of the goods written off are recovered and in casualty insurance when the damages are subrogated from the victim's policy to the insurance policy of the liable party. These events will show up as negative values in your data and you will need to decide whether to include these items in your triangles or not. Some factors to weigh in your decision are regulatory requirements (some regulators require S&S to be reported separately) and data quality (do you have enough S&S to construct a separate triangle? Or do your development factors become more reliable if they are removed?).

Finally, you may need to decide whether to use paid or incurred data. Theoretically, your ultimate derived from both approaches should converge to the same values, but in practice, this is rarely the case. Generally, if case reserves are held long enough before payment, it may be better to use incurred data, as you would miss out on some case reserves from your estimates. Conversely, if your business pays rapidly and rarely holds reserves (such as may be the case with medical expenses insurance), it may be more sensible to use only paid data. It may also depend on whether you need a cash flow or development result since paid triangles will give you payment patterns whereas incurred triangles will give you claim development patterns.

The different methods you now have in hand will lead you to very different results from each other, and sensitive to the underlying assumptions. The choice and justification will thus have to be based on qualitative elements as described in this document, but also on quantitative elements, which must be integrated into your analyses, in particular the comparison of the results obtained from one method to another. This comparison will also allow you to propose a confidence interval for your final estimates. Thus, you will have the keys to ensure the robustness of your studies and will perfectly play your role of actuary reserving.

GLOSSERY OF TERMS:

Origin Period: an origin period is the time unit during which the triangle data emerged. For claims, this is typically either the date of the accident (normally used for traditional insurance contracts for a fixed coverage period such as one year) or the date of the underwriting of the contract (generally used for more open-ended policies such as shipment insurance (marine), trade credit, and many types of reinsurance). There can, of course, be other origin types such as for engineering, the date of the beginning of the project is typically used.

Loss Ratio: the most essential non-life insurance KPI (key performance indicator) used to measure a risk's performance for a given year (accident, accounting, underwriting...). It is calculated as the ultimate losses divided by the ultimate premiums.