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A REVIEW ON INDIVIDUAL RESERVING FOR NON-LIFE INSURANCE

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In recent decades, there has been great success with deterministic and stochastic unpaid claim reserving models based on triangles, such as those related to the chain ladder model (CLM). However, with the increased need for more accurate reserving models, taking advantage of the information embedded in individual claims data with appropriate claims development models are a promising alternative compared with the traditional aggregate loss development triangles. This research reviews on the development of using the individual claims data for reserving information.
***Keywords*:** individual claim reserve, loss reserving, run-off triangle, chain ladder model

1. Introduction

Reserving is a key foundation of an insurance company. Forecasting an outstanding amount and setting appropriate reserves is a crucial part for an insurance company to be able to perpetuate their business. An insurance company must always set aside sufficient amount of money to pay the claims made against themselves on the currently in-force policies. Setting an accurate and suitable amount of reserves is important for an insurance company as the accuracy of the reserves it sets will have direct impact on the company financial status. For an insurance company that have insufficient reserves for their claims may face bankruptcy or failure of the company. On the other hand, if an insurance company has kept exceptional number of reserves will cause it to have less competitive premium rates compare to the market.

As mentioned above, an insurance company is obliged to pay benefits to its insured in the event of claims filed against the insurance company. Thus, the calculation of the amount of claim reserves must be done carefully to avoid lost to the insurance company. Calculating claim reserves has always not been an easy task to accomplish. One of the easiest methods to calculate loss reserves is by using chain ladder method (CLM). CLM is recognized as an important actuarial loss reserving technique that is widely used in non-life insurance especially in Property and Casualty and Accident and Health Insurance.

Research done by Boumezoued and Courchene (2018) mentioned that traditional claim reserve has always been in used for loss reserving estimation in non-life insurance. This means it uses a single run-off triangle to represent the activity of several group of claims through their respective lifetimes. However, the usage of traditional reserving models has limitations in its own way and is more likely to generate error compared to Individual Claim Models (ICMs). The traditional reserving model is likely to generate material errors in estimation of reserves when the characteristics of portfolio in the run-off triangle alter unexpectedly over the period. This has caused the ICMs to arise in the research and practice of calculation of loss reserve to minimize the error of estimating reserves.

Prediction of future claims based on the data in which the fullness of the aspect of the data is available will be a better approach. The estimation of the final outcome of individual claims or a specific cohort of them by ICM provide a higher accuracy result. Thus, lead towards the estimation of the loss reserve liability and hence a loss reserve. While individual claim model is slowly gaining attention in loss reserving field, it initially started with Position Dependent Marked Poisson Process as proposed by Norberg (1993).

In this paper, we are aiming to review the literature on loss reserving in non-life insurance and to overview the comparison of loss reserving by using individual claim data compared with traditional models based on aggregate data. Section 2 reviews the traditional reserve methods and Section 3 shows the ICM's framework. Section 4 presents the comparisons of the traditional methods and ICMs. Section 5 conclude the research.

2. Traditional Reserve Methods

2.1 Claim Reserves

Background and influences of an insurance company must always be considered in the reserving process of a claim. When a so-called "risk" situation is exposed to a person and the situation is covered by the insurance company, this event will cause a loss to the insurance company and hence act as a claim to the insurance company. Normally, there will be a delay in term between the event occurrence time and reporting time to the insurance company and the final settlement from the insurance company. Figure 1 shows the non-life insurance claim development process.

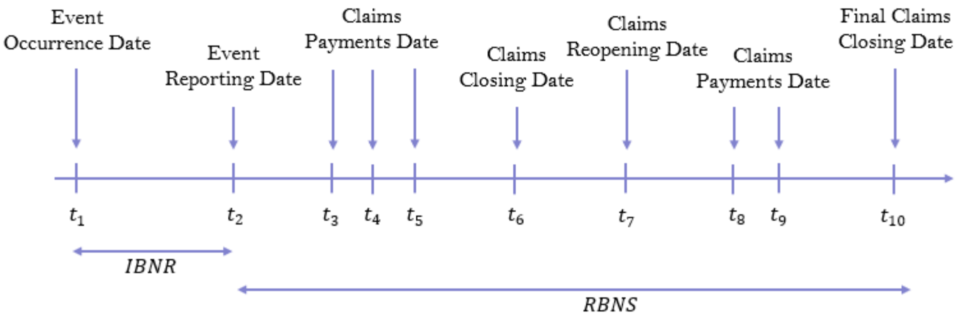

Figure 1: Non-Life insurance claim development process

The delay between the event occurrence date and the claim settlement dates urged the insurance company to prepare reserves beforehand in respect of those claims to be settled in the future. The reserves are required at any point of time to meet the cost of an insurance claim as they may arise anytime or to settle claims that have yet to be settled.

Incurred but Not Reported (IBNR) claims and Reported but Not Settled (RBNS) claims are the two types of outstanding claims that are normally used in the insurance industry. IBNR occurs when the event has happened but yet to be reported to the insurance company. Thus, reserves to pay future claims for the estimated loss have to be set up by the insurance company to prevent business failure or bankruptcy. On the other hand, RBNS occurs when occurrence of event has been reported to the insurance companies, but payment is yet to be settled. RBNS involves numerous types of claims due to the various features such as, claim involved may require several partial payments on different date over an extended period of time, reopened claims, etc.

2.2 Run-off Triangle

The main assumptions of CLM assume that claims happened previously is predicted to happen in the future. Thus, data accumulated from past loss experiences must be accurate to generate an accurate model for future prediction. By accumulating the claim data over a period of time, the run-off triangle which is a two-dimensional matrix can be generated. Information regarding the past experience claims of existing insurance policies are required to approximately calculate future claims losses in a run-off triangle.

Run-off triangle is normally the claims amount or the number of claims where both are usually depicting the aggregate claim data. The chain developments of the run-off triangle consist of accident periods and development periods. The run-off triangle is separated into observation at upper part and prediction at lower part.

Table 1: Cumulative Loss Data Run-Off Triangle

Accident Year, *i*	Development Years, *j*						
	1	2	3	4	…	*j-1*	*j*
1	$Q_{(1,1)}$	$Q_{(1,2)}$	$Q_{(1,3)}$	$Q_{(1,4)}$	…	$Q_{(1,j-1)}$	$Q_{(1,j)}$
2	$Q_{(2,1)}$	$Q_{(2,2)}$	$Q_{(2,3)}$	$Q_{(2,4)}$	…	$Q_{(2,j-1)}$	$\widehat{Q_{(2,j)}}$
3	$Q_{(3,1)}$	$Q_{(3,2)}$	$Q_{(3,3)}$	$Q_{(3,4)}$	…	$\widehat{Q_{(3,j-1)}}$	$\widehat{Q_{(3,j)}}$
4	$Q_{(4,1)}$	$Q_{(4,2)}$	$Q_{(4,3)}$	$Q_{(4,4)}$	…	$\widehat{Q_{(4,j-1)}}$	$\widehat{Q_{(4,j)}}$
…	…	…	…	…	…	…	…
i-1	$Q_{(i-1,1)}$	$Q_{(i-1,2)}$	$\widehat{Q_{(i-1,3)}}$	$\widehat{Q_{(i-1,4)}}$	…	$\widehat{Q_{(i-1,j-1)}}$	$\widehat{Q_{(i-1,j)}}$
i	$Q_{(i,1)}$	$\widehat{Q_{(i,2)}}$	$\widehat{Q_{(i,3)}}$	$\widehat{Q_{(i,4)}}$	…	$\widehat{Q_{(i,j-1)}}$	$\widehat{Q_{(i,j)}}$

CLM is one of the most classical method for estimating reserves for IBNR claims and are still generally used in the non-life insurance industry. The straightforward CLM utilizes cumulative data and thus develops development factors or link ratios (England and Verrall, 2002).

2.3 Transformation of Traditional Reserving Method to Individual Claim Method

The current reserving practice in most cases are using traditional loss reserving method for point estimate projections and capital requirement calculations. With the increasing needs within the reserving practice for a more accurate models, efficiency and accuracy of the estimation can be increased by taking benefits from the information embedded individual claims data. By using traditional loss reserving method, the reserve estimates can be easily calculated and interpreted as it is not complicated.

However, the prediction errors obtained by using traditional loss reserving method can be significant (England and Verall, 2002) due to lesser data sets available in the run-off triangle. There are multiples of limitations to a better estimation by using this method (Boumezoued and Courchene, 2018) such as loss of partial information when aggregating data details of original claims, small number of observations available for recent accident year, etc.

The limitations of computation for insurance company have prohibited their use and improvement in their reserve estimation. With the advancement in technology in 21st century, actuaries and researchers have started implementing reserving models with ICM more meticulously. With ICM, the use of information which are not been used by CLM are able to increase the reliability of estimated loss reserves and thus establishing a more stable linkage between pricing and reserving process.

3. Individual Claim Methods

In terms of distributions for each reporting delay and claim payment, claim processes is not modelled in the traditional claim reserving approach which has caused the arising of low accuracy in calculating reserve. The ICM enables the insurance company to monitor each and every aspect separately in the claim process. Thus, allowing the highest granularity in the evaluation of the accuracy of the claim reserve estimates. Characteristics of the ICM increase the preciseness of the claim reserve. Therefore, ICM provides a better insight into the structure of the claims to the insurance company.

To increase the accuracy of the loss reserve estimation, claims data of each individual customers are used by some authors to carry out their estimation. The individual data that those authors used are:

(i) Delay in time reporting to the insurance company.
(ii) Delay in the payments from the insurance company to its policyholder.
(iii) Differences in severity of each claim.

The improved process of reserving enables users to understand the underlying reasons that leads to the change in aggregate payments. Moreover, ICM enhances value to insurance company's reserving process and enables reserving actuaries to contribute more accurately on conversations regarding portfolio performance at granular level (Antonio and Plat, 2014).

There has been a small stream of literature dealing with individual claims reserve models in discrete time, usually modelled on the aggregate level. Verrall and Nielsen (2010) has done the most notable job to set up a model.

Taylor et al. (2008) had applied Generalized Linear Model (GLM) on individual claims data where the stochastic model of the sum of amount paid finalized claim was fitted using GLM. Although the process was complicated compared to traditional loss reserving method, each model is manageable and parameters of the models can be more accurately estimated (Larsen, 2007). Norberg (1999) defines Marked Poisson Process (MPP) as below:

Pair up a claim as $A=(T,Y)$, where *T* represents the claim occurrence time and *Y* describes the development from occurrence time to final claim payment time. The claim process is represented by a random group of claims $\{(T_t,Y_t)\}$ for $t=1,2,\cdots,N$. Where the index t indicates sequential order so that $0<T_1<T_2<T\cdots<T_N$.

Let *Y* denote the associated mark. The distribution of the mark *Y* is assumed to be only dependent on t through T_t where $Y_t=Y_T$. Where $\{Y_t\}_{t>0}$ is considered as a mutually independent random elements of one another and it is independent of the Poisson process. Thus, $Y_t \sim P_{Y:t}$. It is assumed that the occurrence of claims is a Poisson process with inhomogeneous intensity measure $\omega(t)$. With the definition of R_i representing reporting delay and X_i representing the development process after notification, $Y_i=(R_i,X_i)$, Y follows a position-dependent distribution $P_{Y|T}$.

$$P_{Y|T}=P_{R|T}\times P_{X|T,R} \tag{1}$$

The time-varying risk exposure $\rho(t)$ is considered as a non-homogeneous intensity Poisson process in the Norberg (1993, 1999) initial framework. The extension of the intensity function by Antonio and Plat (2014) has allowed a time-varying claim occurrence rate of $\alpha(t)$. Thus, the intensity function of $\rho(t)\,\alpha(t)$ is presented with known $\rho(t)$ and to be estimate $\alpha(t)$. However, following the intensity function specified by Antonio and Plat (2014), the exposure of $\rho(t)$ has yet to be available for our data. Hence, we let $\omega(t)=\rho(t)\,\alpha(t)$ and use $\omega(t)$ as a parameter estimation.

4. Discussion

4.1 Advantages of Claims Reserving Models Based on Individual Data over Traditional Models on Aggregated Data

Insurance company always need to set up sufficient amount of loss reserves to be able to pay for future claim liabilities filed against them. Thus, having an accurate estimation in reserving for the outstanding claim liabilities is very critical for insurance company.

ICM always provide a better estimation compared to traditional reserve method. This is because the successful capture of each individual claims' lifetime development process, from event occurrence time to event reporting time to the claim settlement time by the insurance company. By using all the dates recorded in each individual claim to estimate the claim reserve for the insurance company, the estimated reserves needed by the insurance company can be approximated more accurately.

Thus, strengthening the linkage between pricing and reserving process. ICMs are expected to produce a more reliable estimation of reserves. Next, ICM is able to integrate information of each individual claim and hence has a higher ability to manage the heterogeneities of each claim data. Problems of over parameterization and lack of sturdiness can be avoided with the higher accuracy of reserve estimation of ICM.

4.2 Comparison Based on Root Mean Square Error Prediction

Jin and Frees (2013) compared CLM with ICM using root mean square error prediction (RMSEP) under six scenarios. Jin and Frees (2013) used equation (2) for the calculation of mean square error (MSE), Where N represents the number of claim samples, $\hat{E}$ represents reserve estimates on any given valuation date and E represents outstanding liability.

$$MSE = \frac{\sum_{n=1}^{N}\left(\hat{E}^{(n)} - E^{(n)}\right)^2}{N} \tag{2}$$

CLM able to provides an accurate for reserve estimation when the change in environment is stable. While individual claim reserves are assured to provide a better estimation of reserves despite the changes in environment as it estimates reserves based on the actual original claim process.

4.3 Comparison Based on Number and Amount of IBNR and RBNS Claims

Based on medical malpractice case study and motor third party case study (Boumezoued and Courchene, 2018), the number and amount of IBNR and RBNS claims are used to compare the accuracy of CLM and ICM on loss reserving.

The IBNR simulation for ICM and comparing it with traditional reserve model, it is shown that both case studies' individual claim reserve using IBNR simulation provides a higher accuracy than the CLM while the CLM tends to overestimate the number of IBNR claims and results in a larger uncertainty estimate. The estimation error is reduced significantly in ICM comparing to CLM. The ICM takes the advantages of the detailed claims information in order to calibrate the data more reliably. Lastly, the process error has also been reduced.

4.4 Comparison Based on Asymptotic Variances

Based on research done on an ICM with independent reporting and claim settlement (Huang et al., 2015), the estimation of reserves is estimated using three methods, CLM, Bornhuetter-Ferguson method and ICM. All three reserves are asymptotically unbiased predictors of the most precise reserve to estimate outstanding losses. Thus, in terms of the asymptotic variances, smaller variance indicates closer closeness of the reserving to the individual reserve.

The simulation of these three scenarios show that the asymptotic variances of ICM is the smallest and CLM is the largest. The statistical independence between reporting and settlement process enables researchers to demonstrate a clearer picture on the advantages one can gain by using individual data compared to aggregated data in run-off triangle.

5. Conclusion

Based on research done by previous researchers Jin and Frees (2013), Boumezoued and Courchene (2018) and Huang et al. (2015), on the comparison of traditional claim reserving and individual claim reserving, the estimation of claim reserve using ICM has proven to increase the accuracy of the reserves estimated. At the same time, it provides stronger modelling on the process of claims. Individual claim reserve provides a higher predictive power and lower uncertainty in estimation of claim reserves while CLM has a higher tendency to overestimate claim reserve.

In ICM, occurrence time of the event, reporting delay (IBNR), settlement delay (RBNS) and the process of development of the claim are fitted into a data set with individual claims development, instead of aggregating them using CLM. Thus, the assumption of using CLM to estimate claim reserve are not restricted in the scenarios where insurance claims activity that has happened in the past will continue to happen in the future.

Results show that individual claim reserve provides a strong foundation for insurance company to explore the most suitable and appropriate method on their claim reserving. Insurance company will be able to enhance the individual model based on their actuaries' perspectives to develop the most suitable distribution on claim reserving. A more cautious approach is to be considered on effects of inflations on claim reserve for further studies.

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