International Journal of Natural and Engineering Sciences
E-ISSN: 2146-0086 14(2): 54-63, 2020
Research Article

UNCERTAINTY OF THE CLAIMS DEVELOPMENT RESULT

Rümeysa Karataş [1,a,*]

[1]*Karamanoglu Mehmetbey University, , Faculty of Economics and Administrative Sciences, 70100 Karaman, Turkey*

**Corresponding Author:*
E-mail: rumeysakaratas@kmu.edu.tr

(Received 23rd December 2019; accepted 13th May 2020)

a: ORCID 0000-0001-6810-3357

ABSTRACT. Claims development result is difference between two consecutive estimates for total ultimate loss. Claims development result appear in the profit and loss acount at the end of period concerned. It is very important for insurance companies to calculate and determine these values. In this study, we analyze claims development result and its prediction uncertainty. We calculate reserves for two different reserve methods (chain ladder and additive loss reserving method). In conclusion, we compare results for these reserve methods.

Keywords: *Stochastic loss reserving, claims development result, chain ladder method, loss experience, ultimate claim, solvency*

INTRODUCTION

Claims development result is defined for the first time in Merz and Wüthrich [1] as the difference between two consecutive estimates of the final loss estimate. In the study, short-term and long-term comparisons are made in the calculation of loss reserves, and the importance of the short-term is emphasized. This study, in which observable claims development results for each accident year are obtained with the chain ladder method, is considered as the main source for the claims development results. In the study of Bühlmann, Felice, Gisler, Moriconi, Wüthrich [2], 1-year short-term claims development results are obtained using the Bayesian chain ladder method, and the mean square error of these results is calculated. In the study of Dahms, Merz, Wüthrich [3], the conditional mean squared error of the 1-year claims development result is calculated using the complementary loss ratio method for incurred claims and paid claims.

Along with ORSA (own risk and solvent assessment), which is recommended under Solvency II and is a part of the risk management system, it has been pointed out that companies take into account not only their current risks but also the risks they will face in the long term [2]. In addition, non-life insurance companies; A multi-year evaluation is required in order to make more accurate strategic decisions on issues such as how much of it can meet its obligations without the need for an additional resources or how much capital it needs to survive [4]. While making annual and multi-year evaluations, the changes that ocur with the updating of the loss reserves from year to year are used. These changes are called claims development results and are one of the main risk factors taken into account when examining the profit and loss status of the insurance company [5].

There are many methods by which unpaid loss estimates are determined using past experience. Among these methods, the Chain Ladder Method is the most widely used because it is independent of distribution and simple to application. However, the Chain Ladder method; There are some deficiencies that may cause deviations that may occur in the estimation, such as the necessity of homogeneity of the data, the inadequacy of the development factor to give the correct estimation value, and the fact that the first observations in the accident years do not represent the claims development values properly [6].

In addition, different methods have been started to be used, based on the idea that more accurate results will be obtained for making estimations by considering other variables as well as loss development triangle data. One of these methods is the additive loss reserve method. The additive loss reserve method is a method that uses both the loss development triangle data and a priori information such as the number of policies for accident years or the premium obtained [7]. In this study, chain ladder and additive loss reserve method is used.

For solvency purposes, it is important to make prediction uncertainty as well as to determine claims development results. In this study, the calculations are made by using the loss development triangle and premium data for seven years of an insurance company serving in the compulsory traffic insurance branch in Turkey. We analyze the uncertainty of claims development result.

CLAIMS DEVELOPMENT RESULT

Claims Development Result (CDR) Definition

The claims development result is the change in claims reserves over time and is one of the main risk factors in an insurance company's profit and loss statement [8]. The importance of the claims development results in the income-expense table is explained with the help of Table 1.

Table 1. *Income-Expense Table*

	Estimated values on January 1 for year I	Observed values on December 31 for year I
Earned premiums	4 000 000	4 020 000
Losses at accident year I	-3 200 000	- 3 240 000
Loss experience for previous accident years	0	-40 000
Expenses	-1 000 000	-990 000
Investment income	600 000	610 000
Income before taxes are paid	**400 000**	**360 000**

In Table 1; For the year I, the values on 1 January are the estimated values for the next calendar year (I,I+1], and the values on 31 December are the actual values for the same year [4].

In this table, earned premiums represent premium income, expenses are commissions paid, investment income is financial returns from assets. Although all these concepts and the situations the involve are easier to understand, the concept of "loss experience for previous accident years" is less understandable than the others. This concept expresses the difference between the claims reserve in the I calendar year and the claims reserve in the I+1 calendar year for the claims in the calendar years before the I calendar year.

Claims reserve for calendar year I+1 is an adjusted loss reserve obtained by taking into account the claims payments incurred during the calendar year (I,I+1), profit and loss status for previous years, development of claims for payments in previous years are used, but a specific term is not widely used with the study of Merz, Wüthrich and Lysenko [9], this difference started to be expressed as “claims development result”.

As these results are included in the balance sheet of the insurance company and directly affect the financial strength of the company, it is one of the leading areas of interest for evaluations under Solvency [3].

One Year CDR

Taking the short-term into account when calculating the loss reserves-making calculations for the 1-year period-is a perspective that has been encouraged by Solvency II and has started to take place in the literature recently. The following definition has been made regarding the Solvency Capital Requirement: “The Solvency Capital Requirement corresponds to the capital an insurance or reinsurance agreement must have for the probability of bankruptcy to be fixed at 0.5% (bankruptcy occurs once every 200 years). This amount of capital is calculated taking into account all possible losses over the next 12 months. Solvency Capital Requirement; It reflects the impact of risk mitigation techniques as well as the actual risk profile of the insurance or reinsurance agreement and that all measurable risks have been taken into account.”

“Solvency Capital Requirement; It should be determined by taking into account the situation in which all the risks to which an insurance or reinsurance agreement is exposed are taken into account in the calculations made. As a result of this situation unexpected loss should also be considered. This capital requirement corresponds to the value-at-risk of an insurance or reinsurance company's own capital at a confidence level of 99.5% over a 1-year period [10].”

With these definitions and explanations, the time period is taken as 1 year and the loss reserve is re-estimated at the end of the year using the loss information observed during the year [11]. In this way, possible changes in the loss reserve estimates of companies aredetermined. In the studies carried out with a 1-year time interval to determine these changes, 1-year claims development results are taken into account while examining theprofit-loss status of the company.

One-year claims development result for a specific beginning year is calculated as follows:

R_0 : Initial estimate of reserve amount
R_1 :Reserve estimate for a year from now
C_1 :Loss payments to be made within one year
CDR_1 :Claims development result
U_0 :Initial estimate of ultimate loss
U_0 :Ultimate loss estimate for a year from now

$CDR_1=R_0-C_1-R_1=U_0-U_1$ equality refers to one year claims development result.

As can be seen from the equation, the claims development result is the difference between two consecutive estimates of the ultimate loss amount [12]. It is seen how sufficient the reserves are until the end of this period, taking into account the 1-year claim development result and the claims payments to be made within the 1-year period.

The traditional method, which is frequently used in the literature and is one of the main loss reserve methods, deals with the estimation of the volatility in claims payments. The short-term perspective, which takes into account the 1-year period, deals with the estimation of the volatility in reserves [13].

CDR Calculation with Chain Ladder Method

The chain ladder method is the most widely used method for calculating loss reserves. The main reason for this is that the method is simple, independent from distribution and can be used almost without any assumptions [14].

Several different forms of loss data can be used when constructing loss reserve models that are used to estimate the total amount of ultimate loss. These are cumulative loss data, paid or incurred loss data, loss number data, etc. Chain ladder method is applicable to cumulative payments and incurred claims data. It is a highly preferred method in practice, as reliable loss reserves can be obtained when appropriate estimates of chain ladder factors are used. The shortcomings of the model are as follows [10]:

- Data must be homogeneous. Development factors should not contain any volatility.
- For the last accident years, the development factor may be insufficient to give the correct estimation value. For example, let the number of accident years be until 2011 and the number of development years be as large as 20. In this case, estimating the development value 19-20 years later for the last accident years, the development factor may be insufficient.
- The first observations in the accident years may sometimes not represent the claims development values well, which can cause problems for the last accident years.

In this study, $i \in \{0,\dots,I\}$ shows accident years and $j \in \{0,\dots,J\}$ shows development years.

$C_{i,j}=\sum_{i=1}^{j}X_{i,j}$ in this equation, $C_{i,j}$ is cumulative loss amount for accident year, $C_{i,J}$ is nihai loss amount, $f_0,f_1,\ldots,f_{j-1}$ shows development factors for chain ladder method. The estimation for $C_{i,j}$ random variable is given in equality; $E\left[C_{i,j}\middle|C_{i,j-1}\right]=f_{j-1}C_{i,j-1}$. For convenience, we assume I=J for loss data. For accident year i $\in\{0,\ldots,I\}$; unpaid loss amount at time t=I and unpaid loss amount at time t=I+1 is calculated respectively with following equations:

$$R_i^I=C_{i,J}-C_{i,I-i} \qquad \text{(t=I)}$$
$$R_i^{I+1}=C_{i,J}-C_{i,I-i+1} \qquad \text{(t=I+1)}$$

At t=I observation values: $D_I=\left\{C_{i,j};i+j\le I,i\le I\right\}$. One year later, at t=I+1 observation values: $D_{I+1}=\left\{C_{i,j};i+j\le I+1,i\le I\right\}=D_I\cup\left\{C_{i,I-i+1},i\le I\right\}$.

For accident year i $\in\{0,\ldots,I\}$ and calendar year (I, I+1] observable claims development result is calculated as:

$$C\hat{D}R_i\left(I+1\right)=\hat{R}_i^{D_I}-\left(X_{i,I-i+1}+\hat{R}_i^{D_{I+1}}\right)=\hat{C}_{i,J}^{I}-\hat{C}_{i,J}^{I+1}$$

Total observable claims development result is calculated with equation: $\sum_{i=1}^{I}CDR_i\left(I+1\right)$

Table 2. *Claims development result for accident years*

Ay (i)			$CDR_i(I+1)$
0	0	0	0
1	2.132.242	2.104.352	27.890
2	6.313.453	5.892.361	421.183
3	7.351.321	9.426.252	-2.074.931
4	6.362.448	5.321.550	4.040.898
5	9.632.221	11.352.226	-1.990.005
6	10.352.093	13.422.561	-3.070.468
total	41.873.778	47.519.302	**-5.645.524**

In Table 2, second column includes outstanding claims for t=I and third column includes outstanding claims for t=I+1 and observable claim amount for I-i+1. The last column of Table 2 shows claims development results for accident years. The resulting value of -5.645.524 units is the total claims development result for all accident years. As a result of the claims development found, when viewed from the time t = I = 1, it shows that the reserves are not sufficient for all accident years at time t = I and there is a shortage of 5.645.524 units.

CDR Calculation with Additive Loss Reserving Method

In the additive loss reserve method, incremental payments for each development year and the loss payments for the next years are estimated with the help of the development factors found by using the volume measurement parameter for that period. These development factors are called incremental loss ratio.

The method has two parameters (m_j and s_j^2) that provide $E\left[X_{i,j}\right]=v_i m_j$ and $V\left[X_{i,j}\right]=v_i s_k^2$ equations for each j development year.

For T=n, unbiased estimators of method's parameters are given in following equations [6]:

$$^{(n)}\hat{m}_j := \frac{\sum_{i=1}^{n+1-j} X_{i,j}}{\sum_{i=1}^{n+1-j} v_i} \quad , \ j \in \{1,\ldots,n\}.$$

$$\hat{s}_j^2 := \frac{1}{n-j}\sum_{i=1}^{n+1-j} v_i \left(\frac{X_{i,j}}{v_i} - {}^{(n)}\hat{m}_j\right)^2 \quad , \ j \in \{1,\ldots,n-1\}.$$

The method has two parameters (m_j and s_j^2) that provide $E\left[X_{i,j}\right]=v_i m_j$ and $V\left[X_{i,j}\right]=v_i s_k^2$ equations for each j development year.

For T=n, unbiased estimators of method's parameters are given in following equations [6]:

$$^{(n)}\hat{m}_j := \frac{\sum_{i=1}^{n+1-j} X_{i,j}}{\sum_{i=1}^{n+1-j} v_i} \quad , \ j \in \{1,\ldots,n\}.$$

$$\hat{s}_j^2 := \frac{1}{n-j}\sum_{i=1}^{n+1-j} v_i \left(\frac{X_{i,j}}{v_i} - {}^{(n)}\hat{m}_j\right)^2 \quad , \ j \in \{1,\ldots,n-1\}.$$

Conditional mean square error of the prediction

We measure the prediction uncertainty with conditional mean square error of prediction (MSEP) [1]:

$$msep_{C_{i,J}|D_I}\left(\hat{C}_{i,j}^I\right) = E\left[\left(C_{i,J} - \hat{C}_{i,J}^I\right)^2 | D_I\right] \qquad 1$$

Mean square error of the claims development result

We measure the prediction uncertainty of claims development result with Eq (2) and Eq (3) [1]:

$$msep_{\hat{CDR}_i(I+1)|D_I}(0) = E\left[\left(\hat{CDR}_i(I+1) - 0\right)^2 | D_I\right] \quad 2$$

The Eq (2) gives the prospective solvency point of view. It quantifies the prediction uncertainty in the budget value 0 for the observable claims development result at the end of the accounting period.

$$msep_{\hat{CDR}_i(I+1)|D_I}\left(\hat{CDR}_i(I+1)\right) = E\left[\left(CDR_i(I+1) - \hat{CDR}_i(I+1)\right)^2 | D_I\right] \quad 3$$

The Eq (3) gives the retrospective point of view. It analyzes the distance between the true CDR and the observable CDR.

APPLICATION

The data for numerical examination is given in Table 3. The calculations for application part is made with cumulative loss data. The accident years and development years for run-off triangle are equal (I=J=7). The loss data contains cumulative payments for accident years i ϵ {0,1,2,3,4,5,6} and development years j ϵ {0,1,2,3,4,5,6}.

Table 3. *Run-off triangle (cumulative payments)*

ay/dy	0	1	2	3	4	5	6
0	100.135.660	103.498.165	104.222.521	104.974.070	105.761.850	106.507.427	106.780.991
1	119.534.475	123.778.819	125.072.302	126.310.084	127.499.586	128.040.772	
2	150.457.016	155.151.050	157.208.914	158.818.047	159.767.448		
3	158.252.563	164.020.911	165.898.235	166.931.071			
4	206.770.400	214.421.141	217.008.897				
5	245.846.468	253.747.984					
6	140.588.554						

Premium amounts are needed in order to make calculations with the additive loss reserve method. The premium amounts for the accident years are given in Table 4.

Table 4. *Premium amounts for accident years*

Ay	Premium amounts
0	121.146.337
1	147.316.368
2	172.276.346
3	214.008.876
4	245.534.390
5	372.301.129
6	480.576.069

As can be seen from Table 4, the premium amounts increased with the accident year. The premium amount for the accident year corresponding to 0 is 121.146.337 and the premium amount for the accident year corresponding to the 6 is 480.576.069.

Table 5. *CL reserve estimates and MSEP values for each accident year*

Ay	CL Reserves	MSEP (1)		MSEP(2)	
1	1.583.182	31.664	2,00%	33.592	2,12%
2	4.712.741	157.091	3,33%	163.962	3,48%
3	6.452.825	496.371	7,69%	504.572	7,82%
4	4.999.174	624.897	12,5%	663.281	13,2%
5	8.770.285	797.298	9,09%	810.252	9,24%
6	10.005.583	833.798	8,33%	903.814	9,03%

In Table 5, chain ladder reserve estimates for each accident year and mean square error of prediction values for each accident year are given. The estimated reserve amounts for all accident years are added together and the total reserve amount is found as 36.523.790. MSEP (1) shows estimated mean square error of prediction between true and observable claims development result. The last two columns -MSEP (2)- shows prediction standard deviation of 0 compared to claims development result at t=I+1. We obtain the percentages in the table by dividing the estimation errors by the reserve amounts estimated by chain ladder method.

We see that sum of MSEP (1) values 2.941.119. This means that CDR is in the range of about ± 5.645.524 (Table 2). Therefore also the knowledge of the true CL factors would probably have led to a negative claims development experience. Moreover, the prediction 0 has a prediction to observable CDR of 3.079.473. This means that it is not unlikely to have an observable CDR in Table 2. In other words solvency risk margin for CDR should directly be related to sum of MSEP (2) values.

Table 6. *Additive method reserve estimates and MSEP values for each accident year*

Ay	Additive Reserves	MSEP (1)		MSEP(2)	
1	3.658.251	94.725	2,59%	99.635	2,72%
2	7.926.450	284.141	3,58%	290.942	3,67%
3	10.048.254	783.913	7,80%	802.741	7,99%
4	7.351.045	995.628	13,5%	1.032.713	14,1%
5	11.728.413	1.253.742	10,7%	1.375.924	11,7%
6	19.471.401	2.462.935	12,7%	2.904.714	14,9%

In Table 6, additive loss reserve estimates for each accident year and mean square error of prediction values for each accident year are given. The estimated reserve amounts for all accident years are added together and the total reserve amount is found as 60.183.814.

We see that sum of MSEP (1) values 5.875.084. This means that CDR is in the range of about ± 5.645.524 (Table 2). We see that estimating reserves using premium amounts give closer results. Tprediction 0 has a prediction to observable CDR of 6.506.669. This means that it is not unlikely to have an observable CDR in Table 2. In other words solvency risk margin for CDR should directly be related to sum of MSEP (2) values.

DISCUSSION

Solvency capital requirement has a time horizon of one year for all risks in budget table. For this reason, it is very important for insurance companies to make the calculations for one-year period. With the innovations brought by Solvency II, claims development result has gained great importance. Calculating claims development result and studying estimation uncertainty is important for insurance companies.

In this study, prediction uncertainty for claim development result for one business line in Turkey has been obtained. The calculations are made using the run-off triangle and the premium amounts for each accident years.

REFERENCES

[1]. Merz, M., Wüthrich, M.V. (2008): Modelling the claims development result for solvency purposes: Casualty Actuarial Society: 542-568.
[2]. Bühlmann, H., De Felice, M., Gisler, A., Moriconi, F., Wüthrich, M.V. (2009): Recursive credibility formula for chain ladder factors and the claims development result. ASTIN Bulletin. 39/1: 275-306.
[3]. Dahms, R., Merz M., Wüthrich, M.V.(2009): Claims development result for combined claims incurred and claims paid data. Bulletin Franc Ais D'actuariat. 9/18: 5-39.
[4]. Diers, D., Linde, M. (2013): The multi-year non-life insurance risk in the additive loss reserving model. Insurance : Mathematics and Economics.
[5]. Merz, M., Wüthrich, M.V. (2010): Full and 1-year runoff risk for credibility-based additive loss reserving method. Applied Stochastic Models in Business and Industry.
[6]. Merz, M., Wüthrich, M.V. (2008): Stochastic Claims Reserving Methods in Insurance. Wiley.
[7]. Merz, M., Wüthrich, M.V. (2009): Prediction error of the multivariate additive loss reserving method for dependent lines of business. Variance 3: 131– 151.
[8]. Merz, M., Wüthrich, M.V., Salzmann, R. (2012): Higher moments of the claims development result in general insurance. ASTIN Bulletin. 42/1: 355-384.
[9]. Merz, M., Wüthrich, M.V., Lysenko, N. (2009): Uncertainty of the claims development result in the chain ladder method. Scandinavian Actuarial Journal. 63-84.
[10]. Directive of the European Parliament. Article 101.
[11]. Bühlmann, H., Wüthrich, M.V. (2008): The one-year runoff uncertainty for discounted claims reserves. Giornale dell Istituto Italiano degli Attuari. Vol. LXXI: 1-37.
[12]. Boisseau, J. (2011): One-year reserve risk including a tail factor: closed formula and bootstrap approaches. Working Paper. No:138.
[13]. Marron, D., Mulligan, R. (2011): Non-life insurance technical provisions prediction errors : 'ultimo' and one-year perspectives.
[14]. Mack, T. (1993): Distribution–free calculation of the standard error of chain-ladder reserves estimates. Astin Bulletin. Vol. 23: No. 2.