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RESEARCH PAPER

Claim Reserve Estimation Using Double Chain Ladder Method

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ABSTRACT

One of the problems by insurance companies, especially for the business class with a long tail, is the length of the claim settlement period until the claim is paid off because there are procedures that must be carried out, such as analyzing and justifying the claims submitted. The claims still in the process are divided into two: claims that were reported but have not been settled (RBNS) and claims that incurred but have not been reported (IBNR). One method that is often used in estimating claim reserves is the Chain Ladder Method. However, this method is only able to estimate the IBNR claim reserve. In 2012, Martinez-Miranda, Nielsen, and Verrall developed a method that can generate predictions of claim reserves for IBNR and RBNS separately, namely the Double Chain Ladder method. This study uses simulation data to determine the stages of calculating the estimated claim reserves using the Double Chain Ladder (DCL) method. The calculation results show that the Double Chain Ladder (DCL) method can estimate IBNR and RBNS claim reserves clearly and separately with a total estimated RBNS claim reserve of 101,492,792 (in a million rupiahs), and the estimated IBNR claim reserve is 29,172,880 (in a million rupiah).

KEYWORDS: *RBNS; IBNR; Double chain ladder; Claims reserve; Run-Off triangle.*

1. Introduction

Risk is an uncertain situation that all humans will always face in all their life activities; both personal and business activities will occur an adverse event [2]. There are several ways to manage risk, such as avoiding, controlling, accepting, and transferring risk. Transferring risk here means an attempt to manage risk by transferring or delegating financial responsibility to other parties, such as insurance.

According to the Law of The Republic of Indonesia, Number 40 of 2014, insurance is an agreement between two parties, namely the insurance company and the policyholder, which is the basis for receiving premiums by the insurance company in return for providing compensation to the insured or policyholder due to loss, damage, costs incurred, lost profits, or legal liability to third parties that may be suffered by the insured or the policyholder due to the occurrence of an uncertain event [3]. Based on the type, insurance itself can be divided into two, namely general insurance and life insurance.

A General Insurance Company is a company that carries out a risk coverage service business that provides compensation to the insured or policyholder due to loss, damage, costs incurred, loss of profit, or legal liability to third parties, which may be suffered by the insured or policyholder due to an uncertain event [7]. Insurance can be classified as a short-tail business and a long-tail based on the time the claim is paid. A short-tail business is an insurance business that takes less than one year to settle claims starting from the occurrence of adverse events until they are paid in full. At the same time, the long-tail business is an insurance business that takes more than one year from when the adverse event occurs until it is paid in full.

The type of insurance with a long-tail business requires a long time to process claims because several procedures must be carried out, such as analysis and justification of the submitted claims. Apart from that, this insurance business usually involves significant amounts of money, so it takes time to pay until it can be paid off by

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the insurance company [5]. Some examples of business lines that have long tails are fire insurance, earthquake insurance, and marine insurance. This problem is the cause of delays in submitting and paying claims for a long time. Claims that are still in process are called outstanding claims. Outstanding claims are divided into two types: incurred but not reported (IBNR) and Reported But Not Settled (RBNS).

It is important for insurance companies to establish RBNS and IBNR reserves because, following POJK Number 27/SEOJK.05/2018, technical reserves in the form of claim reserves are at least calculated as the sum of claim reserves in the settlement process, claims incurred but not reported (IBNR) reserves, claim reserves for claims that have been approved, and the payment of benefits is not all at once (RBNS) [8].

There are several methods of calculating claims reserves, namely the Chain Ladder Method; Bornhuetter-Ferguson method, which is a development of the Chain-Ladder method and is calculated based on the pattern of claims that have been paid and also based on premiums [1]. The Chain-Ladder method is superior, and many practitioners have used it to estimate claims reserves. Mack introduced this method in 1993 [4]. The chain ladder method is one of the most well-known methods of estimating outstanding liabilities in non-life insurance that operates on aggregate loss data, that is, on sums of individual paid (or incurred) claims [6]. It was developed when computers were not readily available, and it was important to have simply closed-form expressions. Since then, the Chain Ladder Method has retained its appeal because it is a simple method that is intuitively appealing and often gives good results [6]. However, the Chain Ladder method cannot estimate the IBNR and RBNS claim reserves separately because the data used is only data on sums of individual paid (or incurred) claims.

In 2012, Martinez-Miranda, Nielsen, and Verrall developed a method that can estimate IBNR and RBNS claim reserves separately, namely the Double Chain Ladder method [6]. The Double Chain Ladder method, which combines the observed incurred count data claims with the observed paid data claims, can separate between Reported But Not Settled (RBNS) and Incurred But Not Reported (IBNR) reserves.

Based on this background, this study will be given simulations for the calculation of reported but not resolved (RBNS) and incurred but not reported (IBNR) claim reserves using the Double Chain Ladder (DCL) method. The purpose of this study is to find out how the stages of calculating the estimated reserves of Reported But Not Settled (RBNS) and Incurred But Not Reported (IBNR) claims using the Double Chain Ladder (DCL) method.

2. Literature Review

2.1. Run-Off triangle

We need claim experience data presented in the run-off triangle to estimate claim reserves. Claim data in the run-off triangle can be in the form of incremental or cumulative.

Supposed $X_{i,j}$ is the random variable that states the number of claims in incremental form for claims that occur in accident year i with $1 \leq i \leq m$ and the payment is paid off in development year j with $0 \leq j \leq m-1$. The run-off triangle data in the incremental form is presented in Table 1.

Tab. 1. Run-Off triangle

Accident Year (i)	Development Year (j) 0	1	…	j	…	$m-1$
1	$X_{1.0}$	$X_{1.1}$	…	$X_{1.j}$	…	$X_{1.m-1}$
2	$X_{2.0}$	$X_{2.1}$	…	$X_{2.j}$	…	
…	…	…	…	…		
i	$X_{i.0}$	$X_{i.1}$	…			
…	…	…				
m	$X_{m.0}$					

2.2. Chain ladder method

The Chain Ladder (CLM) method is one method that can be used in estimating claim reserves in the future. Supposed, D_{ij} is a random variable that states the cumulative claim size for claims that occur in accident year i and is paid up to development year j, which is defined by:

$$D_{ij} = \sum_{l=0}^{j} X_{i,l} \tag{1}$$

A development factor value is required to estimate the value in the cells below the cumulative run-off triangle. Assuming that the payment pattern is stable per development year, then the estimated development factor for $j = 1, \dots, m-1$, is determined by:

$$\hat{\lambda}_j = \frac{\sum_{i=1}^{m-j} D_{i.j}}{\sum_{i=1}^{m-j} D_{i.j-1}} \text{ untuk } j = 1. \dots . m-1 \tag{2}$$

$\hat{\lambda}_j$ is an unbiased estimator for λ_j [4]. The estimated Ultimate Claim on the CLM method is expressed as follows:

$$\widehat{D}_{i,m-1} = D_{i,m-1} \prod_{u=m+1-i}^{m-1} \hat{\lambda}_u \tag{3}$$

The estimated Outstanding Claim Reserve for an accident year *i* is stated as:

$$\hat{R}_i = \widehat{D}_{i,m-1} - \widehat{D}_{i,m-i} \tag{4}$$

$\hat{R}_i$ is an unbiased estimator for R_i [4].

2.3. Double chain ladder method (DCL)

The Double Chain Ladder (DCL) method is a development of the CLM. The application of this method, as the name suggests, namely the CLM technique, will be carried out twice on the run-off triangle of the claim amounts Δ_m and the claim counts $\aleph_m$. The following are several steps to calculate claim reserves using the DCL method:

1. Form two run-off triangles (incremental and cumulative) of the claim amount $\boldsymbol{\Delta_m}$ and the claim counts $\boldsymbol{\aleph_m}$.
2. Using CLM's formula, estimate the value of development factor $\left(\boldsymbol{\hat{\lambda}_j}\right)$ for claim counts and $\left(\boldsymbol{\hat{\hat{\lambda}}_j}\right)$ for claim amounts.
3. Complete the data for each cell in the bottom of the run-off triangle cumulative for claim counts and amounts using the estimated Ultimate Claim value.
4. Estimate the value of $\boldsymbol{\hat{\alpha}_i, \hat{\beta}_j}$ with the run-off triangle of the claim counts $\boldsymbol{\aleph_m}$ and the value of $\boldsymbol{\hat{\hat{\alpha}}_i, \hat{\hat{\beta}}_j}$ with the run-off triangle of the claims amount $\boldsymbol{\Delta_m}$ using the following formulas [5]:

$$\hat{\beta}_0 = \frac{1}{\prod_{l=1}^{m-1} \hat{\lambda}_l} \tag{5}$$

$$\hat{\beta}_j = \frac{\hat{\lambda}_j - 1}{\prod_{l=j}^{m-1} \hat{\lambda}_l} \tag{6}$$

$$\hat{\alpha}_i = \sum_{j=0}^{m-i} N_{ij} \prod_{j=m-i+1}^{m-1} \hat{\lambda}_j \tag{7}$$

$$\hat{\hat{\beta}}_0 = \frac{1}{\prod_{l=1}^{m-1} \hat{\hat{\lambda}}_l} \tag{8}$$

$$\hat{\hat{\beta}}_j = \frac{\hat{\hat{\lambda}}_j - 1}{\prod_{l=j}^{m-1} \hat{\hat{\lambda}}_l} \tag{9}$$

$$\hat{\hat{\alpha}}_i = \sum_{j=0}^{m-i} X_{ij} \prod_{j=m-i+1}^{m-1} \hat{\hat{\lambda}}_j \tag{10}$$

1) Estimate the value of parameter $\hat{p}$ for payment delay $(\hat{p}_0, \dots, \hat{p}_d)$ (Verrall, Nielsen, & Jessen, 2010). After estimating $\beta\{\beta_l : l = 0, \dots, m-1\}$ from the two run-off triangles (Δ_m and $\aleph_m$), then determine the value of parameter $\pi\{\pi_l : l = 0, \dots, m-1\}$ which can be estimated by solving the following linear equation:

$$\begin{pmatrix} \hat{\hat{\beta}}_0 \\ \vdots \\ \hat{\hat{\beta}}_{m-1} \end{pmatrix} = \begin{pmatrix} \hat{\beta}_0 & \cdots & 0 \\ \vdots & \ddots & \vdots \\ \hat{\beta}_{m-1} & \cdots & \hat{\beta}_0 \end{pmatrix} \begin{pmatrix} \pi_0 \\ \vdots \\ \pi_{m-1} \end{pmatrix} \tag{11}$$

The value of $\hat{\pi}$ represents the solution of the above linear equation, with its components represented by $\hat{\pi}_l$. The value of $\hat{\pi}_l$ can be negative, and the sum of all values can be more than one. So, it is necessary to make adjustments to the value of $\hat{\pi}_l$ by estimating the maximum period for payment delay, *d*, by calculating the sequential amount $\hat{\pi}_l > 0$ that satisfies $\sum_{l=0}^{d-1} \hat{\pi}_l < 1 \leq \sum_{l=0}^{d} \hat{\pi}_l$. Then estimate the parameters for payment delay with the following formula:

$$\hat{p}_l = \hat{\pi}_l, l = 0, \dots, d-1 \tag{12}$$

$$\hat{p}_d = 1 - \sum_{l=0}^{d-1} \hat{p}_l \tag{13}$$

So that $\hat{p} = \left(\hat{p}_0, \dots, \hat{p}_{d-1}, 1 - \sum_{l=0}^{d-1} \hat{p}_l\right)$.

2) Estimate the value of parameters $\hat{\mu}$ and $\hat{\gamma}_i$ using the equation:

$$\hat{\mu} = \frac{\hat{\hat{\alpha}}_1}{\hat{\alpha}_1} \tag{14}$$

$$\hat{\gamma}_i = \frac{\hat{\hat{\alpha}}_i}{\hat{\alpha}_i \hat{\mu}}, i = 1, \dots, m \tag{15}$$

3) After obtaining all the required parameters, the value of the RBNS and IBNR claim reserves can be estimated by ignoring the tail using the equation [5]:

$$\hat{X}_{ij}^{RBNS} = \sum_{l=i-m+j}^{j} N_{i,j-l}\hat{p}_l\hat{\mu}\,\hat{\gamma}_i \qquad (16)$$

$$\hat{X}_{ij}^{IBNR} = \sum_{l=0}^{i-m+j-1} \hat{N}_{i,j-l}\hat{p}_l\hat{\mu}\,\hat{\gamma}_i \qquad (17)$$

3. Methodology

In this research, the authors conduct quantitative research using dummy data for the claim counts and claim amounts. The data that will be used in this research is data on claims settlement in the form of incremental from 2013-2019 payment delay from 0 - 6 years. The method used in this study is the Double Chain Ladder (DCL).

4. Results and Findings

1) Form two run-off triangles (incremental and cumulative) of the claim amount Δ_m and the claim counts $\aleph_m$.

This research data consists of two incremental run-off triangles on the observed incurred count data. The claims amount (in a million rupiahs) paid from 2013-2019 with the year of delay in payment from 0 - 6 years are presented in the tables below:

Tab. 2. Run-Off triangle incremental of claim counts

Accident Year (i)	Development Year (j)						
	0	1	2	3	4	5	6
2013	230	100	40	10	3	2	1
2014	200	110	32	5	2	1	
2015	212	85	25	9	2		
2016	265	130	50	15			
2017	240	100	45				
2018	285	135					
2019	240						

Tab. 3. Run-Off triangle incremental of claims amount

Accident Year	Development Year (j)						
(i)	0	1	2	3	4	5	6
2013	8.200	7.500	7.000	6.650	6.300	5.500	5.000
2014	7.900	7.400	6.900	6.550	6.250	5.450	
2015	8.300	7.700	7.200	6.750	6.400		
2016	9.000	7.800	6.950	6.500			
2017	8.700	7.500	7.000				
2018	9.400	8.200					
2019	8.500						

Table 2 is run-off triangle data in the incremental of the claims count, and Table 3 is run-off triangle data in the incremental amount of the claim. From the run-off triangle incremental for the observed incurred count data and the claim amount, a run-off triangle can then be formed cumulative of the number of claims and the number of claims paid obtained from equation (1). The results are as in the tables below:

Tab. 4. Run-Off triangle cumulative of claim counts

Accident Year (i)	Development Year (j)						
	0	1	2	3	4	5	6
2013	230	330	370	380	383	385	386
2014	200	310	342	347	349	350	
2015	212	297	322	331	333		
2016	265	395	445	460			
2017	240	340	385				
2018	285	420					
2019	240						

Tab. 5. Run-Off triangle cumulative of claim amounts

Accident Year (i)	Development Year (j)						
	0	1	2	3	4	5	6
2013	8.200	15.700	22.700	29.350	35.650	41.150	46.150
2014	7.900	15.300	22.200	28.750	35.000	40.450	
2015	8.300	16.000	23.200	29.950	36.350		
2016	9.000	16.800	23.750	30.250			
2017	8.700	16.200	23.200				
2018	9.400	17.600					
2019	8.500						

2) Using CLM's formula, estimate the value of development factor $(\hat{\lambda}_j)$ for claim counts and $(\hat{\hat{\lambda}}_j)$ for claim amounts.

By using equation (2), it can be obtained the estimated development factor for the data on the claim counts and the claim amounts as shown in the table below:

Tab. 6. Development factor estimation for claim counts and claim amounts

j	1	2	3	4	5	6
$\hat{\lambda}_j$	1,46089385	1,11483254	1,02636917	1,00661626	1,00409836	1,0025974
$\hat{\hat{\lambda}}_j$	1,89514563	1,438125	1,28796952	1,21521863	1,15498938	1,12150668

3) Complete the data for each cell in the bottom of the run-off triangle cumulative for claim counts and amounts using the estimated Ultimate Claim value.

After getting the development factor for each development year in Table 6, the data for each cell at the bottom of the cumulative run-off triangle (Ultimate Claim) can be calculated for the data on the claim counts. The claim amounts with equation (3) as shown in the tables below.

Tab. 7. Run-Off triangle cumulative-ultimate claim of claim counts

Accident Year (i)	Development Year (j)						
	0	1	2	3	4	5	6
2013	230	330	370	380	383	385	386
2014	200	310	342	347	349	350	351
2015	212	297	322	331	333	334	335
2016	265	395	445	460	463	465	466
2017	240	340	385	395	398	399	400
2018	285	420	468	481	484	486	487
2019	240	351	391	401	404	405	407

Tab. 8. Run-Off triangle cumulative - ultimate claim of claim amounts

Accident Year (i)	Development Year (j)						
	0	1	2	3	4	5	6
2013	8.200	15.700	22.700	29.350	35.650	41.150	46.150
2014	7.900	15.300	22.200	28.750	35.000	40.450	45.365
2015	8.300	16.000	23.200	29.950	36.350	41.984	47.085
2016	9.000	16.800	23.750	30.250	36.760	42.458	47.617
2017	8.700	16.200	23.200	29.881	36.312	41.940	47.036
2018	9.400	17.600	25.311	32.600	39.616	45.756	51.316
2019	8.500	16.109	23.166	29.838	36.259	41.879	46.968

In table 7 and table 8, the shaded value (greyed out) is the estimated Ultimate Claim value for claim counts and amount.

4) Estimate the value of $\hat{\alpha}_i, \hat{\beta}_j$ with the run-off triangle of the claim counts $\aleph_m$ and the value of $\hat{\hat{\alpha}}_i, \hat{\hat{\beta}}_j$ with the run-off triangle of the claims amount Δ_m.

Furthermore, after all the parameters of the Chain Ladder (CLM) method have been estimated, we can continue the calculations for the Double Chain Ladder (DCL) method. The first step is to estimate the parameters of $(\hat{\alpha}_i, \hat{\beta}_j)$ on the run-off triangle of claim counts and the parameter of $(\hat{\hat{\alpha}}_i, \hat{\hat{\beta}}_j)$ on the run-off triangle of claim amounts obtained from equations (5) - (10) that are presented in the following tables.

Tab. 9. Estimation of $(\boldsymbol{\alpha_i}, \boldsymbol{\beta_j})$ from run-off triangle of claim counts

i	$\hat{\alpha}_i$	j	$\hat{\beta}_j$
1	386	0	0,590339
2	351	1	0,272084
3	335	2	0,099034
4	466	3	0,025353
5	400	4	0,006529
6	487	5	0,004071
7	407	6	0,002591

Tab. 10. Estimation of $(\boldsymbol{\alpha_i}, \boldsymbol{\beta_j})$ from run-off triangle of claim amounts

i	$\hat{\hat{\alpha}}_i$	j	$\hat{\hat{\beta}}_j$
1	46.150	0	0,180976
2	45.365	1	0,162000
3	47.085	2	0,150266
4	47.617	3	0,142039
5	47.036	4	0,136724
6	51.316	5	0,119653
7	46.968	6	0,108342

5) Estimate the value of parameter $\hat{p}$ for payment delay $(\hat{p}_0, \dots, \hat{p}_d)$ and the value of parameter $\pi\{\pi_l : l = 0, \dots, m-1\}$.

After obtaining the results of the estimated values (α_i, β_j) for each data in the run-off triangle of claim counts and claim amounts, the next step will be to determine $\hat{\pi}_l : l = 0, \dots, 6$ by solving equation (11). Then adjust the value of $\hat{\pi}_l : l = 0, \dots, 6$ that was obtained using equations (12) and (13) to get the value of $\hat{p}_l, l = 0, \dots, d$. The maximum period for payment delay is obtained d = 6. The values of $\hat{\pi}_l$ and $\hat{p}_l$ obtained are contained in Table 11.

Tab. 11. Estimation of $\hat{\boldsymbol{\pi}}_{\boldsymbol{l}} : \boldsymbol{l} = \mathbf{0}, \dots, \mathbf{6}$ and $\boldsymbol{p_l}, \boldsymbol{l} = \mathbf{0}, \dots, \boldsymbol{d} = \mathbf{6}$

Settlement delay (l)	$\hat{\pi}_l$	p_l
0	0,306563	0,306563
1	0,133125	0,133125
2	0,141757	0,141757
3	0,139772	0,139772
4	0,134294	0,134294
5	0,107667	0,107667
6	0,101540	0,036821

6) Estimate the value of parameters $\hat{\mu}$ and $\hat{\gamma}_i$.

The next step is to estimate the average factor $\hat{\mu}$ and the inflation parameter for each accident year, $\hat{\gamma}_i, i = 1, \dots, 7$, which is determined using equations (14) and (15). The results of the calculations are contained in the following table.

Tab. 12. Estimation of average factor $\boldsymbol{\mu}$ and inflation parameter $\hat{\boldsymbol{\gamma}}_{\boldsymbol{i}}, \boldsymbol{i} = \mathbf{1}, \dots, \mathbf{7}$

Accident Year (i)	$\hat{\gamma}_i$
1	1,000000
2	1,081288
3	1,174770

4	0,854379
5	0,982454
6	0,881324
7	0,966282
μ	119,559585

7) Estimate the value of IBNR and RBNS claim reserves by ignoring the tail.

After obtaining all the required parameters, the last step is calculating the estimated reserves for claims for IBNR and RBNS using equations (16) and (17). The results obtained are further grouped into two, namely based on the Future Calendar Year and Accident Year, which are contained in the following tables.

Tab. 13. IBNR and RBNS claim reserves based on future calendar year

Future Calendar Year	Double Chain Ladder		
	RBNS	IBNR	Total
1	32.485,521	6031,221	38516,742
2	26.533,826	4634,816	31168,641
3	20.007,509	4228,503	24236,012
4	13.551,520	4122,367	17673,886
5	7.099,144	4006,262	11105,406
6	1.815,273	3429,315	5244,588
7		1830,783	1830,783
8		588,444	588,444
9		196,942	196,942
10		74,711	74,711
11		25,036	25,036
12		4,480	4,480
Total	101.492,792	29.172,880	130.665,672

Tab. 14. IBNR and RBNS claim reserves estimation based on accident year

Accident Year	Double Chain Ladder		
	RBNS	IBNR	Total
1	1.831,558		1.831,558
2	4.665,116	117,526	4.782,642
3	10.003,423	313,669	10.317,092
4	17.028,948	628,099	17.657,047
5	22.046,277	1.812,923	23.859,200
6	26.690,696	7.059,877	33.750,573
7	19.226,774	19.240,787	38.467,561
Total	101.492,792	29.172,880	130.665,672

Based on the results of the estimated reserves for IBNR and RBNS claims in Tables 13 and 14, the total reserves for RBNS claims are 101.492,792 (in a million rupiahs), and the estimated reserves for IBNR claims are 29.172,880 (in a million rupiahs). Tables 13 and 14 also obtained a total technical reserve of 130.665,672 (in a million rupiahs) with an average factor of 119,559585 (in a million rupiahs).

5. Conclusion

Two run-off triangles of claim counts and amounts are needed to estimate claim reserves using the Double Chain Ladder (DCL) method. By applying the Chain Ladder method twice to the run-off triangles, the Double Chain Ladder (DCL) method can estimate the IBNR and RBNS claim reserves clearly and separately. The simulation results in this study obtained a total estimated RBNS claim reserve of 101,492,792 (in a million rupiah); for IBNR, claim reserves were 29,172,880 (in a million rupiah).

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