Variance
Journal of Statistics and Its Applications
P-ISSN: 2685-8738 E-ISSN: 2685-872X

Variance: Journal of Statistics and Its Applications
Volume 7 Issue 2 | October 2025
10.30598/variancevol7iss2page155-166

COMPARISON OF THE CHAIN LADDER AND BORNHOUTTER-FERGUSON METHODS IN CALCULATING CLAIM RESERVES FOR REINSURANCE COMPANY IN INDONESIA

Tiara Yulita[1*], Dila Tirta Julianty[2], Inaya Sathrani Aprilia[3], Larasati Nurul Inayah[4]
[1,2,3,4]Actuarial Science Study Program, Faculty of Science, Institut Teknologi Sumatera
Jl. Terusan Ryacudu, Way Huwi, Jati Agung, South Lampung, 35365, Lampung, Indonesia

***Corresponding Author's Email**: tiara.yulita@at.itera.ac.id*

Abstract: *In the insurance industry, calculating claims reserves plays a crucial role in managing both risk and the financial stability of an insurance company. When a claim is filed, the insurer must allocate a reserve fund to anticipate potential future losses. In general insurance, claim settlements are often not completed immediately because there is usually a time gap between the occurrence of an incident and the reporting of the claim. Unresolved claims create liabilities or obligations for the insurance company. These allocated funds are referred to as claim reserves, which are generally categorized into two types: Incurred but Not Reported (IBNR) and Reported but Not Settled (RBNS). This research focuses on determining estimates of claim reserves using the Chain Ladder and Bornhuetter-Ferguson methods for loss insurance data for the property business class of reinsurance companies in Indonesia for the period 2011 to 2021. The results show that the claims reserves for each method are IDR 2,499,456,710,993 and IDR 2,266,000,657,647 with MAPE values of 1.38% and 2.10%. The results of the MAPE value calculation show that the claim reserves estimate using the Chain Ladder method is better than the Bornhuetter-Ferguson method.*

Keywords: *Bornhoutter-Ferguson, Chain Ladder, claim reserves, reinsurance.*

1. INTRODUCTION

Humans will always face risks in life. Risk can come from anywhere and at any time. No one knows when the risk will occur, and the amount of risk depends on the activities carried out. Therefore, insurance is now present as a protection against risks that may occur. Based on Law No. 2 of 1992 on Insurance Business, insurance is defined as a contract between two or more parties, in which the insurer agrees to compensate the insured in exchange for premium payments. This compensation covers losses, legal liabilities to third parties, or other damages that may arise from uncertain events. Additionally, the agreement may include payments related to the life or death of the insured individual [1]. There are several types of risks that insurance companies can cover, ranging from loss of life to health. The value of each risk varies greatly depending on the condition of the object insured. Insurance companies can share the risks borne by their companies with other companies (reinsurance companies) to minimize the risks and protect the stability of their income levels. Law No. 2 of 1992 on Insurance Business defines reinsurance as an activity that provides insurance coverage to insurance companies themselves, protecting them against potential losses or risks arising from life insurance operations [2].

Based on the flow of the insurance company mechanism, the insured party can register with the insurance company through an insurance agent directly or through an insurance brokerage company. Insurance brokerage companies cannot register themselves directly with reinsurance companies because insurance brokerage companies connect the insured party (customer) to the insured party (insurance company). The insurance company will then share part of the risk with the reinsurance company, either directly or through a reinsurance broker. The insured is required to fulfill their obligation by paying premiums and adhering to the agreed terms and conditions to receive their entitlement to claim payments when a loss-causing event occurs [3]. In the process of filing a claim, the insurer is obliged to provide reserves to the insured party to prepare for the risk of loss occurring in the future. Technical reserves are generally divided into premium reserves and claim reserves. The premium reserve is the amount collected by the insurance company from the difference between the value of the claim and the present value when the claim is paid to prepare for claim payments. Claim reserves are amounts set aside by

 Submitted: 2024-07-10 *Accepted: 2025-11-04*

insurance companies to cover future payments related to claims that have not been paid or settled as of a certain date [4].

Payment of insurance claims is made after the claim is reported to the insurance company. Claim payments made in one payment and within a short time from the reporting date are common in health insurance. However, in some types of long-tailed business insurance, especially general insurance, claim payments are made more than once and take a long time from the date of the claim until it is resolved. Delays in claim payments occur because of the time lag between when a claim is reported and when it is finally settled [4]. The period between the occurrence of a claim and its delayed settlement is referred to as outstanding claim liability. Accurate estimation of outstanding claims is essential for insurance companies to ensure that adequate reserves are available to cover future claim payments. Claim reserves are generally categorized into two types: Incurred but Not Reported (IBNR) reserves, which represent claims that have occurred but have not yet been reported, and Reported but Not Settled (RBNS) reserves, which refer to claims that have been reported but are still in the process of settlement [5]. Proper estimation of these reserves plays a crucial role in evaluating an insurance company's financial strength and its ability to fulfill future claim obligations [6].

Yuciana et al [7] stated that there are generally two approaches to estimating the amount of claim reserves, namely deterministic methods and stochastic methods. The deterministic approach includes the Chain Ladder (CL) and Bornhuetter-Ferguson (BF) methods. These methods are commonly used in practice because they are straightforward and yield reliable results. On the other hand, stochastic approaches are categorized into two types: Frequentist and Bayesian. Among the various techniques for estimating claim reserves, the Chain Ladder (CL) method is the most widely utilized due to its simplicity and independence from specific statistical distributions [8]. This method operates as an aggregate approach, summarizing individual claim data into an aggregated form presented in a run-off triangle. This run-off triangle will contain information about claim reserves. The information obtained will be compiled in a cumulative form, which will serve as the main material for actuaries in calculating claim reserves.

2. METHODOLOGY

2.1. Research Data

In this research, the data used to estimate claims reserves are premium, paid, and outstanding claim data for general insurance products, for the class of business property, for the period 2011 to 2021, with a unit of research time of years. This research employs Microsoft Excel to estimate claim reserves using the Chain Ladder and Bornhuetter-Ferguson methods. Both methods are used to analyze which method is the most effective and provides a prediction value with the smallest prediction error. Variables that were used in the study include:

Table 1. Description of Research Variable

No	Variable	Symbol	Description
1	Incremental claims data	$Y_{i,j}$	The amount of claims to be paid by the insurance company in the i-th and j-th development period.
2	Cumulative claims data	$D_{i,j}$	Total claims to be paid by the insurance company in the i-th period of event and j-th development period.
3	Year of event	X_i	The year in which the claim is reported to the insurance company.
4	Year of delay	X_j	The time range between claim reporting and claim payment by the insurance company.

The flow of the insurance mechanism between insurance and reinsurance is shown in Figure 1.

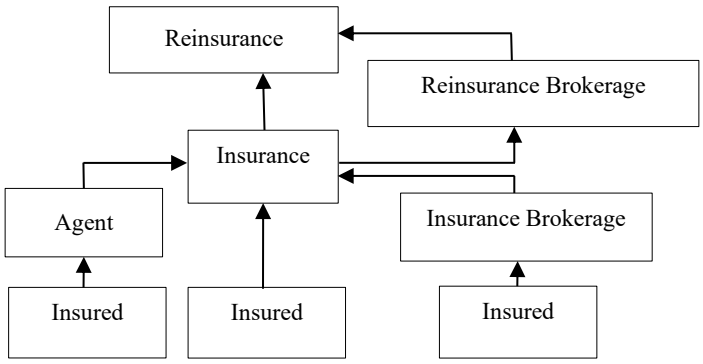

Figure 1. Flow of Insurance Mechanism

2.2. Research Methods

2.2.1. Run-Off Triangle

According to Mutaqin et al., stated that [9] run-off triangle data is often used as a basis for estimating the proportion of losses of general insurance companies in long-term business classes. The run-off triangle represents a consolidated summary of all claims in aggregate form, derived from individual claim data. Typically, the information presented in the run-off triangle includes either the claim amount (total value of claims) or the number of claims, which can be displayed in either cumulative or incremental form [10].

Table 2. Incremental Aggregate Run-Off Triangle

Accident Period	Development Period						
	1	2	...	j	...	$n-1$	n
1	$Y_{1,1}$	$Y_{1,2}$	...	$Y_{1,j}$	...	$Y_{1,n-1}$	$Y_{1,n}$
2	$Y_{2,1}$	$Y_{2,2}$	...	$Y_{2,j}$	...	$Y_{2,n-1}$	$Y_{2,n}$
...	...	...	...	...	...	...	...
i	$Y_{1,i}$	$Y_{i,2}$	...	$Y_{i,j}$	...	$Y_{i,n-1}$	$Y_{i,n}$
...	...	...	...	...	...	...	...
$n-1$	$Y_{n-1,1}$	$Y_{n-1,2}$	...	$Y_{n-1,j}$	...	$Y_{n-1,n-1}$	$Y_{n-1,n}$
n	$Y_{n,1}$	$Y_{n,2}$	...	$Y_{n,j}$	...	$Y_{n,n-1}$	$Y_{n,n}$

According to Table 2, $Y_{i,j}$ is a random variable that states the amount of the claim that happened in the i^{th} period and was paid in the j^{th} development period which is observed when $i + j \leq n + 1$ and is not observed when $i + j > n + 1$. The cumulative run-off triangle can be derived from incremental data using the following relationship [10].

$$D_{i,j} = \sum_{i=1}^{j} Y_{i,j};\ for\ 1 \leq i \leq n, 1 \leq j \leq n. \quad (1)$$

Here, $D_{i,j}$ represents the cumulative value of claims that originated in accident period i and were paid up to development period j [11].

2.2.2. Chain Ladder Methods

The Chain Ladder approach is used to estimate future claim reserves by utilizing data summarized within the aggregate run-off triangle [8]. The initial stage in determining claims reserve estimates using the chain ladder method is to form a run-off triangle using the Equation (2).

$$D_{i,j} = \sum_{i=1}^{j} Y_{i,j} \quad (2)$$

with $i \in \{1,2, \dots, n\}$ and $j \in \{1,2, \dots, n - i + 1\}$. The random variable $D_{i,j}$ represents the cumulative value of claims that originated in i^{th} accident period and were paid up to the j^{th} development period.

Table 3. Cumulative Aggregate Run-Off Triangle

Accident Period	Development Period						
	1	2	…	j	…	$n-1$	n
1	$D_{1,1}$	$D_{1,2}$	…	$D_{1,j}$	…	$D_{1,n-1}$	$D_{1,n}$
2	$D_{2,1}$	$D_{2,2}$	…	$D_{2,j}$	…	$D_{2,n-1}$	$D_{2,n}$
…	…	…	…	…	…	…	…
i	$D_{1,i}$	$D_{i,2}$	…	$D_{i,j}$	…	$D_{i,n-1}$	$D_{i,n}$
…	…	…	…	…	…	…	…
$n-1$	$D_{n-1,1}$	$D_{n-1,2}$	…	$D_{n-1,j}$	…	$D_{n-1,n-1}$	$D_{n-1,n}$
n	$D_{n,1}$	$D_{n,2}$	…	$D_{n,j}$	…	$D_{n,n-1}$	$D_{n,n}$

The total future claims are shown by the brown bottom of the triangle. To obtain estimation results for the bottom of the run-off the triangle, development factor calculations are carried out. The calculation of the j^{th} development factor can be calculated using the Equation (3):

$$\widehat{\lambda_j} = \frac{\sum_{i=1}^{n-j} D_{i,j+1}}{\sum_{i=1}^{n-j} D_{i,j}} \tag{3}$$

with $j \in \{1,2, \dots, n - 1\}$. Then, the development factor is applied to project claim amounts in the unobserved (gray) section of the cumulative run-off the triangle up to the j^{th} development period, using the following equation.

$$\widehat{D}_{i,j} = D_{i,j-1}\hat{\lambda}_{i,j} \tag{4}$$

for $i \in \{2,3, \dots, n\}$ and $j \in \{n - i + 2, \dots, n\}$. Apart from that, the total claim can also be obtained for the i^{th} event period, $i \in \{2,3, \dots, n\}$, namely by the Equation (5).

$$\hat{R}_i = \widehat{D}_{i,j} - \widehat{D}_{i,j-1} \tag{5}$$

Thus, the total future claims obtained are:

$$\hat{R} = \sum_{i=2}^{n} \hat{R}_i \tag{6}$$

2.2.3. Bornhuetter-Ferguson Methods

Unlike the Chain Ladder method, which creates a model based on claims experience in previous periods, the Bornhuetter-Ferguson method creates a claims reserve model based on the company's exposure to losses or claims. The process of calculating the amount of claim reserves using the Bornhuetter-Ferguson method involves earned premiums. The amount of premium income referred to is Earned Premium and Unearned Premium [12]. In this method, the claims reserve from the i^{th} event year at time i^{th} can be calculated using the Equation (7).

$$\hat{R}_i = \hat{\mu}_i\left(1 - \hat{\beta}_i\right) \tag{7}$$

where $\hat{\mu}_i$ is the estimated claims at the end of the year for the i^{th} even and $\hat{\beta}_i$ is estimated cumulative claim delay pattern. $\hat{\mu}_i$ is usually estimated with an initial estimate $\hat{\mu}_i^{\alpha} = p_i\hat{\theta}_i$, where p_i is the premium income in the i^{th} year and $\hat{\theta}_i$ is the initial estimate of the expected loss ratio in the i^{th} event year [13]. In practice, the majority of $\hat{\mu}_i^{\alpha}$ determinations come from information available in the pricing and planning process. $\hat{\mu}_i^{\alpha}$ should not change during the claim delay period in subsequent years. However, the value of $\hat{\mu}_i$ in (7) changes every subsequent year. This process is called repricing. The assumptions that must be met before calculating claims reserve estimates using the Bornhuetter-Ferguson method are [14]:

1) All incremental claims $S_{i,j}$ are independent.

2) There unknown parameters, namely x_i and β_i with $E(S_{i,j}) = x_i\beta_i$ and $\beta_1 + \beta_2 + \cdots + \beta_{n+1} = 1$ with $E(U_i) = x_i$.
3) There is a constant S_j^2 which is proportional to $Var(S_{i,j}) = x_i S_j^2$.

From these assumptions, it can be concluded that the expected claims reserve, namely [14]

$$E(R_i) = x_i(\beta_{n+2-i} + \cdots + \beta_{n+1}) = x_i(1 - b_{n+1-i}) \tag{8}$$

with $b_j = \beta_1 + \cdots + \beta_j$. Then for claim reserves variation is

$$Var(U_i) = Var(S_{i,1} + \cdots + S_{i,n+1}) = x_i(S_{n+2-i}^2 + \cdots S_{n+1}^2) \tag{9}$$

with parameter β_j can be determined from

$$\hat{\beta}_j = \frac{\sum_{i=1}^{n+1-j} S_{i,j}}{\sum_{i=1}^{n+1-j} x_i} \tag{10}$$

$\hat{\beta}_j$ is unbiased parameter of β_j for $1 \le j \le n$. Next the constant S_j^2 is estimated with the equation

$$\hat{S}_j^2 = \frac{1}{n-1}\sum_{i-1}^{n+1-j} \frac{\left(S_{i,j} - x_i\hat{\beta}_j\right)^2}{x_i} \tag{11}$$

and $\hat{S}_j^2$ is the unbiased parameter of S_j^2 for $1 \le j \le n-1$. Then $\hat{S}_n^2$ and $\hat{S}_{n+1}^2$ are obtained using the regression model.

2.2.4. Prediction Error

Prediction error is the difference between the predicted value made by some model and the actual value. One way to determine prediction error is to use Mean Squared Percentage Error (MAPE). MAPE is defined as the average of the absolute differences between the actual and predicted values, divided by the actual values and then normalized by the total number of observations [13]. From this formula, it can be written as in Equation (12).

$$MAPE = \frac{1}{n}\sum_{t=1}^{n} \left|\frac{y_t - \hat{y}_t}{y_t}\right| \times 100\% \tag{12}$$

where y_t is actual data in period t, for $\hat{y}_t$ is prediction data for the period t, and n is all data.

The forecasting performance is considered better when the resulting MAPE value is smaller. The classification criteria for MAPE values are presented as follows [15].

Table 4. Cumulative Aggregate Run-Off Triangle

Value of MAPE	Criteria
$x < 10\%$	Forecasting ability is very good
$10\% \le x < 20\%$	Forecasting ability is good
$20\% \le x < 50\%$	Forecasting ability is quite good
$x > 50\%$	Forecasting ability is bad

2.3. Stages of Analysis

Calculations in the study used Microsoft Excel. There are several steps that must be followed before obtaining the final estimated value of claim reserves.

1) First, determine the incremental run-off triangle and cumulative run-off.
2) Estimate the development factor value of each delay period.
3) For the Chain Ladder method, the estimated value of claim reserves can be calculated directly based on the value of the cumulative run-off triangle and development factor, while the Bornhuetter-Ferguson method requires the earned premium and loss ratio values in the calculation.

4) The result of the claim reserve estimation is then used to calculate the prediction error (MAPE).
5) From the two methods, the value of estimated claim reserves can be compared, which can be selected as the result of estimating claim reserves based on the smallest MAPE value.

Flowchart from stages of analysis is below.

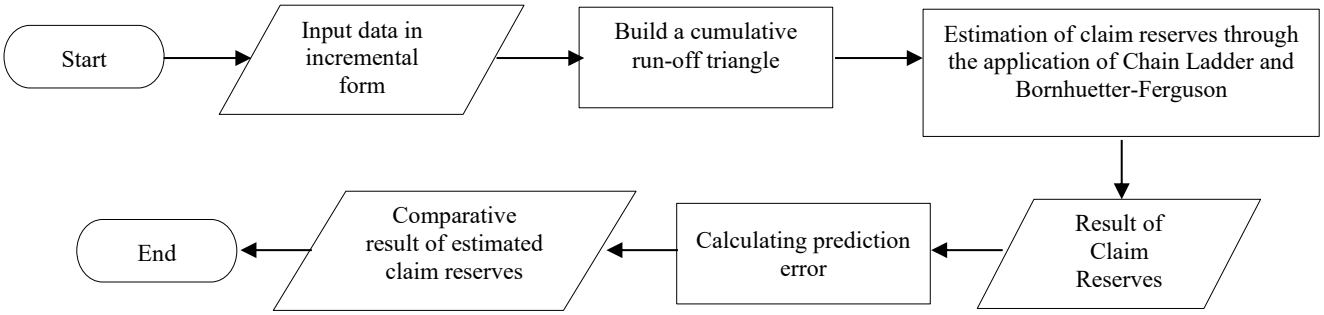

Figure 2. Flowchart

3. RESULTS AND DISCUSSION

The data used in determining claims reserve estimates is data on paid claims and outstanding claims. This data consists of the date of the incident, settlement date, and claim amount. The study utilizes secondary data sourced from PT Reinsurance National Indonesia. This data contains information regarding loss insurance claim data by property business class from 2011 to 2021.

3.1. Data Characteristics

To estimate the claim reserve value using the Chain Ladder and Bornhuetter-Ferguson methods, several steps must be performed, including constructing both the incremental and cumulative run-off triangles.

Table 5. Incremental Run-Off Triangle (IDR)

Loss Year	Development Year					
	1	2	3	4	5	6
2011	-	-	33,982,975,774	25,669,404,589	5,874,140,082	2,392,239,020
2012	-	28,592,063,524	40,419,127,887	6,254,448,471	3,315,398,432	7,381,396,259
2013	12,480,667,101	97,125,090,159	40,797,439,782	21,256,600,378	15,831,232,251	8,183,656,593
2014	37,911,248,320	137,662,695,330	87,366,716,445	85,543,801,430	8,845,638,345	3,176,086,430
2015	21,696,617,259	**148,985,058,099**	169,786,871,540	70,190,805,002	27,969,714,670	11,211,497,994
2016	15,411,360,331	112,002,348,089	91,019,125,894	30,847,802,423	26,110,760,693	24,459,302,139
2017	103,710,812,946	288,458,508,611	150,537,523,343	67,138,368,860	46,167,387,428	-
2018	443,595,409,551	698,339,094,469	506,785,327,062	320,273,669,428	-	
2019	231,986,175,064	429,237,599,584	302,685,958,461	-		
2020	428,240,769,971	791,757,628,025	-			
2021	202,927,494,339	-				
2022	-					

Table 6. Continued Incremental Run-Off Triangle (IDR)

Loss Year	Development Year					
	1	2	3	4	5	6
2011	3,533,268,538	1,459,079,353	147,196,412	406,871,110	382,575,958	
2012	4,328,487,995	3,247,223,774	871,493,631	706,512,795	-	
2013	1,196,233,745	545,820,602	552,601,639	-		
2014	2,885,801,756	3,025,569,970	-			
2015	5,907,456,151	-				
2016	-					
2017						
2018						

Loss Year	Development Year					
	1	2	3	4	5	6
2019						
2020						
2021						
2022						

Table 5 and Table 6 show that the year of delay is 12 years. It means that the claims that occurred in 2013 were not settled immediately. However, some claims were settled in the 2nd year to the 11th year with details as shown in Table 5 and Table 6. The claim amount of IDR 148,985,058,099 in the yellow table can be interpreted as the total claims incurred in 2015 and settled in 2016, or in other words, it took 1 year to settle the claim. If we observe that the available information is limited to 2022. Furthermore, the claims information data in the incremental run-off triangle can be form into cumulative.

Table 7. Cumulative Run-Off Triangle (IDR)

Loss Year	Development Year					
	1	2	3	4	5	6
2011	-	-	33,982,975,774	59,652,380,364	65,526,520,445	67,918,759,465
2012	-	28,592,063,524	69,011,191,411	75,265,639,881	78,581,038,314	85,962,434,572
2013	12,480,667,101	109,605,757,261	150,403,197,042	171,659,797,420	187,491,029,671	185,868,293,132
2014	37,911,248,320	175,573,943,650	262,940,660,095	348,484,461,525	301,860,107,300	301,689,633,338
2015	21,696,617,259	170,681,675,358	340,468,546,898	336,738,941,109	313,307,275,946	315,243,960,804
2016	15,411,360,331	127,413,708,420	167,475,777,082	155,778,647,991	159,896,683,862	160,125,193,751
2017	103,710,812,946	322,526,974,967	276,339,553,437	291,118,715,220	296,314,568,468	**265,036,255,713**
2018	443,595,409,551	732,970,616,122	799,088,515,976	792,084,959,499	**510,961,894,559**	
2019	231,986,175,064	480,995,289,656	633,738,659,472	**495,768,161,954**		
2020	428,240,769,971	939,131,512,546	**556,572,219,867**			
2021	202,927,494,339	**32,635,786,347**				
2022	-					

Table 8. Continued Cumulative Run-Off Triangle (IDR)

Loss Year	Development Year					
	1	2	3	4	5	6
2011	71,452,028,003	71,129,418,684	70,554,946,686	70,565,298,522	70,544,991,397	**70,253,955,535**
2012	85,508,925,842	86,633,211,717	86,698,962,580	86,730,759,618	**86,066,343,791**	
2013	181,174,282,957	181,194,694,101	181,206,377,993	**180,653,776,353**		
2014	302,331,050,427	302,601,445,319	**299,591,020,574**			
2015	315,309,741,906	**309,436,678,634**				
2016	**139,771,716,335**					
2017						
2018						
2019						
2020						
2021						
2022						

Table 7 and Table 8 show the cumulative value of each delay period, respectively. If we look at the information above, the cumulative value each delay period varies according to the total count of claims that occurred in the event period. We can also observe if the greater the number of delay periods, the smaller the amount of claims will be from the period of the event year because part of the amount of the claim value has been paid in the delay period of the previous year. Based on the yellow table in the cumulative run-off triangle, it can be interpreted as the cumulative value of each event period that must be completed in the development period.

3.2. Estimation of Claim Reserves Using the Chain Ladder

Calculation of estimated claim reserves using the Chain Ladder method is a deterministic calculation of claim reserves based on development factors. The development factor value is obtained based on the calculation in Equation (3). The following shows the results of the development factor calculation of each claim based on the occurrence period and delay period.

Table 9. Development Factor Based on Event Period and Delay Period

Loss Year	Development Year										
	1 TO 2	2 TO 3	3 TO 4	4 TO 5	5 TO 6	6 TO 7	7 TO 8	8 TO 9	9 TO 10	10 TO 11	11 TO 12
2011			1.7554	1.0985	1.0365	1.0520	0.9955	0.9919	1.0002	0.9997	0.9959
2012		2.4137	1.0906	1.0441	1.0939	0.9947	1.0132	1.0008	1.0004	0.9923	
2013	8.7820	**1.3722**	1.1413	1.0922	0.9913	0.9748	1.0001	1.0001	0.9970		
2014	4.6312	1.4976	1.3253	0.8662	0.9994	1.0021	1.0009	0.9901			
2015	7.8667	1.9948	0.9891	0.9304	1.0062	1.0002	0.9814				
2016	8.2675	1.3144	0.9302	1.0264	1.0014	0.8729					
2017	3.1099	0.8568	1.0535	1.0179	0.8944						
2018	1.6523	1.0902	0.9912	0.6451							
2019	2.0734	1.3176	0.7823								
2020	2.1930	0.5927									
2021	0.1608										
2022											

Table 9 shows each of the estimated development factors based on the event period and the delay period. The calculation is done by dividing the size of the claim in each delay period, so that the ratio of the division results is obtained. For example, in the yellow table, the development factor obtained is the ratio of the cumulative claim amount in the 2nd delay period to the 1st delay period, with the incident period in 2013. The actual calculation that will be used in the calculation of estimated claim reserves is use the average development factor value.

Table 10. Delay Year Factor Calculation Results

λ_1	λ_2	λ_3	λ_4	λ_5	λ_6	λ_7	λ_8	λ_9	λ_{10}	λ_{11}
1.7783	0.9152	0.9238	0.7453	0.8944	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

After obtaining the development factor, calculate the projected value of each claim amount to be paid for each delay year. The estimated projected value for each claim amount can be calculated by multiplying the cumulative value by the development factor.

Table 11. Result of Claims Reserve Estimation Using The Chain Ladder Method

Loss Year	Development Year					
	1	2	3	4	5	6
2011	-	-	33,982,975,774	59,652,380,364	65,526,520,445	67,918,759,465
2012	-	285,920,635,24	69,011,191,411	75,265,639,881	78,581,038,314	85,962,434,572
2013	12,480,667,101	109,605,757,261	150,403,197,042	171,659,797,420	187,491,029,671	185,868,293,132
2014	37,911,248,320	175,573,943,650	262,940,660,095	348,484,461,525	301,860,107,300	301,689,633,338
2015	21,696,617,259	170,681,675,358	340,468,546,898	336,738,941,109	313,307,275,946	315,243,960,804
2016	15,411,360,331	127,413,708,420	167,475,777,082	155,778,647,991	159,896,683,862	160,125,193,751
2017	103,710,812,946	322,526,974,967	276,339,553,437	291,118,715,220	296,314,568,468	265,036,255,713
2018	443,595,409,551	732,970,616,122	799,088,515,976	792,084,959,499	510,961,894,559	457,025,883,155
2019	231,986,175,064	480,995,289,656	633,738,659,472	495,768,161,954	369,479,884,166	330,478,401,946
2020	428,240,769,971	939,131,512,546	556,572,219,867	514,175,618,676	383,198,362,881	342,748,788,284
2021	202,927,494,339	32,635,786,347	29,868,897,903	27,593,650,043	20,564,649,778	18,393,890,673
2022	-	-	-	-	-	-

Table 12. Continued Result of Claims Reserve Estimation Using Chain Ladder Method

Loss Year	Development Year					
	7	8	9	10	11	12
2011	71,452,028,003	71,129,418,684	70,554,946,686	70,565,298,522	70,544,991,397	70,253,955,535
2012	85,508,925,842	86,633,211,717	86,698,962,580	86,730,759,618	86,066,343,791	86,066,343,791
2013	181,174,282,957	181,194,694,101	181,206,377,993	180,653,776,353	180,653,776,353	180,653,776,353
2014	302,331,050,427	302,601,445,319	299,591,020,574	299,591,020,574	299,591,020,574	299,591,020,574
2015	315,309,741,906	309,436,678,634	309,436,678,634	309,436,678,634	309,436,678,634	309,436,678,634
2016	139,771,716,335	139,771,716,335	139,771,716,335	139,771,716,335	139,771,716,335	139,771,716,335
2017	265,036,255,713	265,036,255,713	265,036,255,713	265,036,255,713	265,036,255,713	265,036,255,713
2018	457,025,883,155	457,025,883,155	457,025,883,155	457,025,883,155	457,025,883,155	457,025,883,155
2019	330,478,401,946	330,478,401,946	330,478,401,946	330,478,401,946	330,478,401,946	330,478,401,946
2020	342,748,788,284	342,748,788,284	342,748,788,284	342,748,788,284	342,748,788,284	342,748,788,284
2021	18,393,890,673	18,393,890,673	18,393,890,673	18,393,890,673	18,393,890,673	18,393,890,673
2022	-	-	-	-	-	-

After obtaining the number of claims in Table 8 and Table 9, it can be seen that claim reserves needed by the insurance company are for each year of the event. The blue table can be read as a reserve claim in the 12th development period that occurred in 2012 was IDR 86,066,343,791.

Table 13. Claims Reserve Using the Chain Ladder Method

Loss Year	Claim Reserves
2011	70,253,955,535
2012	86,066,343,791
2013	180,653,776,353
2014	299,591,020,574
2015	309,436,678,634
2016	139,771,716,335
2017	265,036,255,713
2018	457,025,883,155
2019	330,478,401,946
2020	342,748,788,284
2021	18,393,890,673
2022	-

The total claim reserve obtained is IDR 2,499,456,710,993. It can be concluded that by using the Chain Ladder method, the total of claims that must be prepared by the insurance company in 2022 is of IDR 2,499,456,710,993.

3.3. Estimation of Claim Reserves Using the Bornhuetter-Ferguson Method

The estimation of claim reserves using the Bornhuetter-Ferguson method is the calculation of claim reserves by multiplying the claim at the end of the i^{th} event year (μ_i) by the cumulative claim delay pattern ($1 - \beta_i$). In the calculation of estimated claim reserves using the Bornhuetter-Ferguson method using earned premium and loss ratio data in the calculation. The first step is to determine the claim at the end of the i^{th} event year (μ_i). μ_i is estimated with an initial estimate of $\mu_i = p_i\theta_i$, with p_i as the earned premium in year i and θ_i as the initial estimate of the expected loss ratio in year i.

Table 14. Earned Premium Data

Loss Year	Earned Premium
2011	-
2012	-
2013	-
2014	-
2015	-
2016	-
2017	195,862,468,214
2019	1,662,836,326,264
2020	1,639,078,282,830
2021	1,746,886,771,238

Based on Table 13, earned premium data for the years 2011 to 2016 were not obtained. Therefore, we assume that the earned premium data for that year is not available. Next, we will determine the loss ratio value in each year of the i^{th} event with $\theta_i = \frac{Claim\ incurred}{Earned\ Premium}$.

Table 15. Loss Ratio Calculation Results

Loss Year	Loss Ratio
2011	0%
2012	0%
2013	0%
2014	0%
2015	0%
2016	0%
2017	135%

Loss Year	Loss Ratio
2018	31%
2019	20%
2020	21%
2021	1%

Based on the table above, the loss ratio value from 2011 to 2016 is 0% because the earned premium value in that year is not available. After obtaining the earned premium and loss ratio values, the value of the claim at the end of the year of the i^{th} event can then be determined with an initial estimate, namely $\mu_i = p_i\theta_i$. The table shows the results of the claim value at the end of the year of the i^{th} event.

Table 16. Calculation Results of Claim Value in the i^{th} Event Year

Loss Year	$\hat{\mu}_i$
2011	70,253,955,535
2012	86,066,343,791
2013	180,653,776,353
2014	299,591,020,574
2015	309,436,678,634
2016	139,771,716,335
2017	265,036,255,713
2018	510,961,894,559
2019	495,768,161,954
2020	556,572,219,867
2021	32,635,786,347

In determining claim reserves through the Bornhuetter-Ferguson method, the first step is to identify the development pattern of cumulative claims.

Table 17. Cumulative Claims Delay Pattern

$\hat{\beta}_1$	$\hat{\beta}_2$	$\hat{\beta}_3$	$\hat{\beta}_4$	$\hat{\beta}_5$	$\hat{\beta}_6$	$\hat{\beta}_7$	$\hat{\beta}_8$	$\hat{\beta}_9$	$\hat{\beta}_{10}$	$\hat{\beta}_{11}$
100%	100%	100%	100%	100%	100%	100%	111.80%	150.02%	162.38%	177.43%

In the delay period 2011 to 2016, the delay pattern is not available because the earned premium value is not obtained so that the delay pattern is 100%. Whereas in other years, the delay pattern varies according to the earned premium value and loss ratio.

Table 18. Claims Reserve Using Bornhuetter-Ferguson Method

Loss Year	Claim Reserves
2011	70,253,955,535
2012	86,066,343,791
2013	180,653,776,353
2014	299,591,020,574
2015	309,436,678,634
2016	139,771,716,335
2017	265,036,255,713
2018	450,660,612,755
2019	247,808,234,689
2020	209,355,290,023
2021	7,366,773,245
2022	-

The total claim reserve obtained is IDR 2,266,000,657,647. It can be concluded that by using the Bornhuetter-Ferguson method the total of claims that must be prepared by the insurance company in 2022 is Rp 2,266,000,657,647.

3.4. Prediction Error

This study employs the Mean Absolute Percentage Error (MAPE) as a measure of prediction error, where a lower MAPE value indicates higher accuracy. The estimated claim reserves obtained from the Chain Ladder and Bornhuetter-Ferguson methods are then compared in this analysis. The comparison can be seen based on the MAPE value to determine the method that has the smallest error.

Table 19. MAPE Value

CL	BF
1.38%	2.10%

The MAPE values for the Chain Ladder and Bornhuetter-Ferguson methods are 1.38% and 2.10%, respectively, which means that the Chain Ladder method has a smaller calculation error than the Bornhuetter-Ferguson method on loss insurance with property class of business from 2011 to 2021 at Reinsurance Companies in Indonesia.

The actual data generated is IDR 2,946,747,809,662. Meanwhile, the results of the estimated value of claim reserves from each of the Chain Ladder and Bornhuetter-Ferguson methods are IDR 2,499,456,710,993 and IDR 2,266,000,657,647. Subsequently, the projected results from each method are compared with the actual values to determine the most accurate approach for estimating claim reserves in insurance losses. The comparison reveals that the Chain Ladder method produces the smallest prediction error, at 1.38%, outperforming the Bornhuetter-Ferguson method. So, based on the results of the prediction error value, the method chosen in the estimation of loss insurance claim reserves for property business classes at Reinsurance Companies in Indonesia is the Chain Ladder method.

4. CONCLUSION

Based on the analysis of the estimated claim reserves, it can be concluded that the calculated reserve amounts using the Chain Ladder and Bornhuetter-Ferguson methods were IDR 2,499,456,710,993 and IDR 2,266,000,657,647, respectively. The corresponding prediction error values for these methods were 1.38% and 2.10%. So, according to the prediction error value, the method chosen in the estimation of loss insurance claim reserves for property business classes at Reinsurance Companies in Indonesia is the Chain Ladder method with an estimated claim reserve value of IDR 2,499,456,710,993.

REFERENCES

[1] D. Guntara, "ASURANSI DAN KETENTUAN-KETENTUAN HUKUM YANG MENGATURNYA," *Jurnal Justisi Ilmu Hukum*, vol. 1, no. 1, pp. 29–46, 2016.

[2] I. Fikma, Sulistiyawati, and Angelina Putri, *HUKUM ASURANSI*, 1st ed. Bandar Lampung: Pusaka Media, 2023.

[3] T. Yulita, M. Patricia, and A. S. E. Hidayat, "PENENTUAN PREMI MURNI DARI DATA KLAIM ASURANSI KENDARAAN RODA EMPAT DENGAN JENIS PERLINDUNGAN COMPREHENSIVE," *VARIANCE: Journal of Statistics and Its Applications*, vol. 6, no. 1, pp. 75–86, Apr. 2024, doi: 10.30598/variancevol6iss1page75-86.

[4] S. M. Maher, S. J. Rulis, and S. P. Melek, "Claim Reserves," in *VALUATION ACTUARY SYMPOSIUM PROCEEDINGS SESSION*, SOA, Jan. 1992, pp. 65–101.

[5] I. B. Hossack, J. H. Pollard, and B. Zehnwirth, *Introductory statistics with applications in general insurance*, 2nd ed. UK: Cambridge University Press, 1999.

[6] T. Yulita and A. R. Effendie, "ESTIMATION OF IBNR AND RBNS RESERVES USING RDC METHOD AND GAMMA GENERALIZED LINEAR MODEL," *MEDIA STATISTIKA*, vol. 15, no. 1, pp. 24–35, Jul. 2022, doi: 10.14710/medstat.15.1.24-35.

[7] Y. Wilandari and A. Ronnie Effendie, "ESTIMASI CADANGAN KLAIM MENGGUNAKAN METODE DETERMINISTIK DAN STOKASTIK," *Statistika*, vol. 9, no. 1, pp. 56–63, May 2021.

[8] T. Mack, "DISTRIBUTION-FREE CALCULATION OF THE STANDARD ERROR OF CHAIN LADDER RESERVE ESTIMATES," *Astin Bulletin*, vol. 23, no. 2, pp. 213–225, 1993.

[9] A. K. Mutaqin, D. R. Tampubolon, and S. Darwis, "Run-Off Triangle Data dan Permasalahannya," *Statistika*, vol. 8, no. 1, pp. 55–59, May 2008.

[10] M. Olofsson, "Stochastic Loss Reserving Testing the new guidelines from the Australian Prudential Regulation Authority (APRA) on Swedish portfolio data using a Bootstrap simulation and the distribution-free method by Thomas Mack," Sweden, May 2006. [Online]. Available: http://www.math.su.se/matstat

[11] J. Friedland and K. Llp, *Estimating Unpaid Claims Using Basic Techniques Casualty Actuarial Society*, 3rd ed. Casualty Actuarial Society, 2010.

[12] R. Amini and Y. Hikmah, "Estimasi Cadangan Klaim IBNR Menggunakan Metode Chain-Ladder dan Bornhuetter-Ferguson pada Produk Indemnity di PT. XYZ," *MAp (Mathematics and Applications) Journal*, vol. 4, no. 1, pp. 50–59, 2022.

[13] T. A. Mulyaningrum, "ESTIMASI CADANGAN KLAIM MENGGUNAKAN METODE BORNHUETTER-FERGUSON (STUDI KASUS: DATA WORKERS COMPENSATION PERIODE 2010-2019)," UIN Syarif Hidayatullah, Jakarta, 2021.

[14] L. Noviyanti and S. Sudartianto, "Prediksi Cadangan Klaim Menggunakan Metode Bornhuetter-Ferguson," in *E-Prosiding Seminar Nasional Statistika| Departemen Statistika FMIPA Universitas Padjadjaran*, 2018, pp. 1–9.

[15] P. England, R. Verrall, P. D. England, R. J. Verrall, P. England1, and R. Verrall2, "STANDARD ERRORS OF PREDICTION IN CLAIMS RESERVING: A COMPARISON OF METHODS WORKSHOP Standard Errors of Prediction in Claims Reserving: Â Comparison of Methods Analytic and bootstrap estimates of prediction errors in claims reserving," Scotland, 1998.