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Original Article

Application of Bootstrap and Deterministic Methods for Reserving Claims in Private Health Insurance

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Abstract *- Private health insurance plays a crucial role in the financing of healthcare in numerous states. Health insurance providers offer a diverse range of coverage options to ensure financial protection against unexpected losses caused by accidents or diseases. An event that prompts the insured to file a claim is known as a claim event. An insurance firm must set aside enough money to pay current and future claims for active policies to guarantee that all claims are fulfilled. The aim of this paper is to investigate whether deterministic methods and the bootstrap method can be used effectively to forecast claim reserves for a health insurance portfolio. The study is divided into two parts, each with its own specific objective. The first part presents and analyzes two different techniques utilized in estimating loss reserves: the chain ladder method and the Bornhuetter-Ferguson method. The second part focuses on employing the bootstrap method to generate an approximate predictive distribution for future random losses. The data utilized in this research paper comprises secondary data acquired from the personal sickness portfolio of an Albanian insurance company for the period spanning from 2018 to 2022. The reserves calculated using the Bootstrap method is lower than those computed using CL and BF methods. This conclusion suggests that the insurance company can consider alternative ways to allocate its funds instead of maintaining a large claim reserve. The prediction of reserves for all events up to the next 4 periods is accomplished through the use of CL and bootstrap methods.*

Keywords *– Bootstrap, Bornhuetter-Ferguson, Chain ladder, Claims, Private Health Insurance.*

1. Introduction

Private health insurance plays a crucial role in the financing of healthcare in numerous states. According to statistics from the Organization for Economic Cooperation and Development (OCED), it is projected that approximately 10% of total health expenditure across OECD countries will be covered by private health insurance in 2022. In addition to government schemes, social health insurance, and out-of-pocket payments, private health insurance serves as a significant contributor to healthcare financing in several OECD countries. [1] The insurance companies offered supplementary coverage that exceeded the provisions of the public healthcare system. For health insurance policies, the duration is typically short-term, and insurance providers offer a diverse range of coverage options to ensure financial protection against unexpected losses caused by accidents or diseases. The payments received for this particular insurance coverage are usually based on the actual loss experienced rather than a fixed sum predetermined in advance. [2] The determination of the reserved and outstanding loss amounts is a significant actuarial issue as it impacts both the process of reserving for losses and the adjustment of premium rates in non-life insurance policies. An event that prompts the insured to file a claim is known as a claim event. An insurance firm must set aside enough money to pay current and future claims for active policies to guarantee that all claims are fulfilled. While excessive reserves may result in uncompetitive premium rates, insufficient reserves may cause financial instability. These funds are commonly referred to as claims reserves. [3] The claims reserve comprises provisions for unreported IBNR claims (incurred but not reported), as well as for claims that have been reported but are still under RBNS claims (reported but not settled). When losses are reported to an insurance company but remain unresolved by the end of the accounting period, they are classified as reported but not settled (RBNS). The term IBNR signifies an incident that has occurred in the past but is yet to be reported. [4] According to the technical specifications of Solvency II, it is mandatory to employ traditional actuarial techniques in order to assess the best estimate for provisions concerning non-life insurance obligations. [5] Generally, the problem of predicting outstanding claims utilizes the run-off triangle, which is used to analyze the relationship between claims payments that have been made over the past few years. Determining the length of development as well as the claim's ultimate worth on the settlement date is necessary for estimating the claim reserve. Furthermore, it is imperative to assess the value at risk (VaR) to quantify the extent of possible financial losses within a portfolio. The extent of research exploring the efficacy of deterministic models in private health insurance (PHI) is limited. Previous studies have predominantly focused on the utilization of deterministic models in the motor portfolio of insurance companies. The absence of research on deterministic methods in private health insurance can be attributed to various reasons. Firstly, the ethical implications associated with obtaining data from insurance companies pose a significant challenge. The strict code of ethics that governs these companies makes it difficult to acquire the necessary data. Secondly, private health insurance is considered a short-tail portfolio, meaning that claims are typically resolved within a short period of time. However, in cases where claims are reopened, the maximum settlement period can extend up to 5 years. The aim of this paper is to investigate whether deterministic methods and the bootstrap method can be used effectively to forecast claim reserves for a health insurance portfolio. The study is divided into two parts, each with its own specific objective. The first part presents and analyzes two different techniques utilized in estimating loss reserves: the chain ladder method and the Bornhuetter-Ferguson method. The second part focuses on employing the bootstrap method to generate an approximate predictive distribution for future random losses. The data utilized in this research are real data obtained from an Albanian private insurance company. The structure of the paper is as follows: In Section 2, a comprehensive analysis is presented, focusing on a recent study that explores the application of actuarial methods in claim reserving. Section 3 presents the methodology utilized in this research, including the CL and BF methods and the bootstrap method. Section 4 outlines the results obtained from the utilization of these methods with real data. Finally, Section 5 concludes the paper with some closing remarks.

2. Literature Review

One of the most widely used techniques for estimating outstanding claims reserves is the classical chain-ladder (CL) method proposed by Mack (1993) and the Bornhuetter-Ferguson (BF) method based on the ideas put forth by Bornhuetter and Ferguson (1972). They employed the chain-ladder algorithm, which is comprehensively explained in the study [3], offering a practical guide on utilizing the CL method to calculate claims reserves. There has been discussion of a number of statistical models that are backed by the chain-ladder method and that make it easier to look at the variability associated with reserve estimates. The chain-ladder method in the study [6] was analyzed using the robust chain ladder reserving method, concluding that the chain-ladder reserving method demonstrates superior effectiveness when compared to the robust chain ladder reserving method in handling datasets that do not contain outliers. The model was further discussed in studies [7, 8], which demonstrate the incorporation of external data regarding the correlation between the average claim severity and the year of development as well as the percentage of claims that are resolved without any payment. They conclude that the chain ladder method for reserving is solely dependent on the past loss triangle; however, it can be affected by unpredictable loss fluctuations in recent years. Several research studies have been conducted to assess the claim reserve. Study [9] employed the Bornhuetter-Ferguson model to estimate the claim reserves, while study [10] compared the CL method and BF method with other prediction methods for short-term insurance claim reserves and concluded that the Bornhuetter-Ferguson method is particularly suitable in cases where there is an irregular distribution of reported claims. Moreover, the relevant issues concerning loss reserving, specifically those based on the chain-ladder method, have been effectively addressed. The study [11] discussed the challenges associated with the application of the CL method by analyzing the uncertainties in the CL predictions for the ultimate claims. The classical chain ladder structure has been analyzed and understood better by [4], which concluded that the variation between the total prediction of claim reserves using the DCL (Double Chain Ladder) method and the overall claim reserve method of CL may be due to the zero values present in the incremental run-off triangle. In the research conducted by [12], an approach for planning reserves was examined, specifically focusing on the implications CL method to predict reserves only for IBNR. The research conducted by [13] highlights the benefits of employing the bootstrap method for estimating claim reserves. By utilizing this method, we are able to derive not only single-point estimates but also interval estimates for the parameters of interest. The robust methodology, as stated by [14], allows for an effective analysis of reserve estimates to identify claims that have a notably significant impact. When utilizing the bootstrap method, it is important to carefully consider multiple possibilities. Studies conducted by [15] have indicated that reserves derived from the bootstrap method tend to be lower compared to those obtained from the classical chain ladder method. By utilizing a range of robust bootstrap procedures, the [16, 17] studies investigate their performance in the claims reserving framework on both real and simulated data and reveals that the aggregate prediction is greatly affected by the model selection when employing the bootstrap procedure. The study [18] reveals that the variance in reserve estimation between the bootstrapping model and the chain ladder model is minimal. It is necessary to investigate alternative methods and pertinent statistical models in situations when the conventional chain-ladder algorithm may produce irrational results.

3. Materials and Methods

The data utilized in this research paper comprises secondary data acquired from the personal sickness portfolio of an Albanian insurance company for the period spanning from 2018 to 2022. The sickness portfolio used in this study encompasses around 22,000 insured individuals. The mean value of these claims amounted to 57,007,000 Albanian lek (ALL).This dataset encompasses both insurance claims data and coverage data. Each row corresponds to an accident year, while each column represents a development year. The cumulative losses are represented by the data in the form of a development triangle (Run-off triangle) and values are expressed in thousands ALL. Initially, the accident years {2018, 2019, ..., 2022} will be converted to accident years {0, 1, ..., 4} to obtain the standard form of the development triangle. Subsequently, the development months {12, 24, ..., 60} will be converted to development years {0, 1, ..., 4}. Lastly, the modified data will be utilized for the calculation of claim reserves. In the analysis of a given dataset, both the Chain Ladder [20] and the Bornhuetter/Ferguson (BF) model [21] are taken into account. After performing the calculations using the chain ladder and (BF) method, we will proceed to assess and examine the variability of these reserves using bootstrap model.

3.1. The Chain Ladder Method

The Chain Ladder model, widely recognized in loss reserving, is commonly described as a non-parametric approach that employs a simple algorithm to accurately estimate the claims reserve. Table 1 provides a comprehensive overview of the uses of accumulative claims. Each row represents the period of occurrence i ∈ {1, . . ., n}, while each column represents the development year j ∈ {1, . . . , n}. The period of occurrence (accident year) represents the losses incurred during a specific period, whereas the development year denotes the cumulative number of years elapsed since the accident until compensation was provided. The observed data is presented in the upper left triangle, while the lower right triangle contains the future triangle data that is yet to be estimated. LetY_{ij} be a random variable that represents the total amount of claims that occurred in period i, with $i \epsilon \{1, \dots, n\}$, and were paid in the delay period j, with $j \epsilon \{0, \dots, n-1\}$. Therefore, we can define the aggregate claim set as $\{Y_{ij} : i = 1, \dots, n; j = 0, \dots, n-1\}$. According to the study of [22] the random variable C_{ij} represents the cumulative amount of claims that have occurred in period i and have been paid with a delay period j, which is defined by the formula:

$$C_{ij} = \sum_{k=0}^{n} Y_{ij} \quad (1)$$

Where j =0,…, n and $i = 2, \dots, n-j$

Table 1. Run-off triangle in the form of cumulative losses.

Occurrence Period	Development year k						
	0	1	…	j	…	n-1	n
1	$C_{1,0}$	$C_{1,1}$	…	$C_{1,j}$	…	$C_{1,n-1}$	$C_{1,n}$
2	$C_{2,0}$	$C_{2,1}$	…	$C_{2,j}$	…	$C_{2,n-1}$	$C_{2,n}$
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
i	$C_{i,0}$	$C_{i,1}$	…	$C_{i,j}$	…	$C_{i,n-1}$	$C_{i,n}$
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
n-1	$C_{n-1,0}$	$C_{n-1,1}$	…	$C_{n-1,j}$	…	$C_{n-1,n-1}$	$C_{n-1,n}$
n	$C_{n,0}$	$C_{n,1}$	…	$C_{n,j}$	…	$C_{n,n-1}$	$C_{n,n}$

The development factors $\hat{\lambda}_j$ that are utilized for forecasting future claims are called CL factors or age-to-age factors. The CL factors is defined by the formula (2):

$$\hat{\lambda}_j = \frac{\sum_{i=1}^{n-j} C_{i,j}}{\sum_{i=1}^{n-i} C_{i,j-1}} \quad (2)$$

Given the values$C_{i,0}$,$C_{i,1}$,$C_{i,n-1}$, the estimator for the cumulative claim can be expressed by formula (3) :

$$\hat{C}_{i,j} = \hat{\lambda}_j C_{i,j} \quad (3)$$

The expectation of all outstanding claims for period i can be calculated by taking the product of all $\hat{\lambda}_j$values for j = 1 to n-1, where i+j ≤ n, and multiplying it with$C_{i,n-1}$. This can be represented as:

$$E[C_{i,n-1}] = \left(\prod_{i=n-i+1}^{n-1} \lambda_j\right) C_{i,n-1} \quad (4)$$

On the other hand, for i=1,…, n the claim reserve pertaining to accident year i can be expressed as,

$$R_i = \hat{C}_{i,n} - \hat{C}_{i,n-1} \quad (5)$$

Hence, the total claim reserve is determined by,

$$R = \sum_{i=1}^{n} R_i \quad (6)$$

3.2. Bornhuetter-Ferguson Method

The method proposed by Bornhuetter/Ferguson (1972) was introduced to estimate claim reserve R_i, aiming to address a significant limitation of the CL method. BF method is a distribution-free method based on the cumulative losses $C_{i,i}$ that are already known in the development triangle. This method primarily aims to forecast the claim reserve for accident year i and the cumulative losses $\hat{C}_{i,j}$ of different accident year, which must be independent random variables. Let π_i denote the premium volume, U_i the ultimate claims amount and $q_i = U_i/\pi_i$ the ultimate claims ratio of accident year i.

The prediction of the Ultimate claims is given by the formula:

$$\hat{U}_i = \pi_i \hat{q}_i \quad (7)$$

where $\hat{q}_i$ is the estimator of development cumulative factors.
Based on the research of [22] the Bornhuetter-Ferguson predictor of outstanding claims is defined as follow:

$$C_{i,j}^{BF} = C_{i,j-1} + \hat{U}_i \cdot (\hat{\gamma}_j^{CL} - \hat{\gamma}_{j-1}^{CL}) \quad (8)$$

Where $\hat{\gamma}_j^{CL} = \prod_{j=i}^{n-1} \frac{1}{\hat{\lambda}_j^{CL}}$ and $\hat{\lambda}_j^{CL}$ is the chain ladder estimator of development factors.Equations 9 and 10 define the claim reserve for accident year i and the total claim reserve, respectively.

$$R_i^{BF} = C_{i,n}^{BF} - C_{i,n-i+1}^{BF} \quad (9)$$

$$R^{BF} = \sum_{i=1}^{n} R_i^{BF} \quad (10)$$

3.3. Bootstrap Method

The technique of bootstrapping is widely used in stochastic claims reserving due to its simplicity and adaptability. Our application of bootstrapping involves the estimation of prediction error and the approximation of predictive distribution. Considering the study of [23] bootstrapping can be utilized to produce a distribution for the reserve, and this can be achieved through either parametric or non-parametric methods. The Pearson residuals are frequently utilized in model diagnostics and are essentially rescaled versions of the response residuals. They are defined as:

$$r_{ij} = \frac{c_{ij} - \mu_{ij}}{\sqrt{\mu_{ij}}} \quad (11)$$

for $1 \leq i, j \leq n$ and $i + j \leq n + 1$, the values of μ_{ij} are replaced with their estimates $\hat{\mu}_{ij} = e^{x_{ij}^t \hat{\theta}}$

In order to achieve (approximately) equal variance, it is necessary to make adjustments to the Pearson residuals. A suggestion was made by [15] to modify the residuals $r = \{ r_{ij} | 1 \leq i,j \leq n; i+j \leq n+1 \}$ multiplying them with a correction factor:

$$r^E = \sqrt{\frac{N}{N-p}} \quad (12)$$

The sample size can be represented as N = n(n + 1)/2, while the number of estimated parameters is p = 2n – 1. The "hat" matrix of the model is frequently employed to standardize the Pearson residuals in accordance with the classical linear model. These residuals are presented as.

$$r_{ij}^p = \frac{r_{ij}}{\sqrt{1-h_{kk}}} \quad (13)$$

The value of h_{kk} represents the element on the diagonal of the hat matrix H, which can be expressed as $H = W^{1/2}X(X^TWX)^{-1}X^TW^{1/2}$. In this equation, W represents a diagonal matrix with elements $\{\mu_{ij} | 1 \leq i, j \leq n; i + j \leq n + 1\}$ placed on the diagonal. The expectation and variation of Pearson residuals can be expressed using general formulas:

$$E[r] = diag\left(-\frac{1}{2}(I - H)HW^{-\frac{1}{2}}\right) \quad (14)$$

$$Var[r] = diag(I-H) \quad (15)$$

By incorporating these correction terms, the residuals are adjusted as follow:

$$r^C = \frac{r - E[r]}{\sqrt{Var[r]}} \quad (16)$$

Once the residuals are obtained, the subsequent bootstrap iterations are carried out numerous times, such as for b = 1, ...,999. To create a new pseudo-history, the new residuals $r^{(b)}$ must be back transformed.

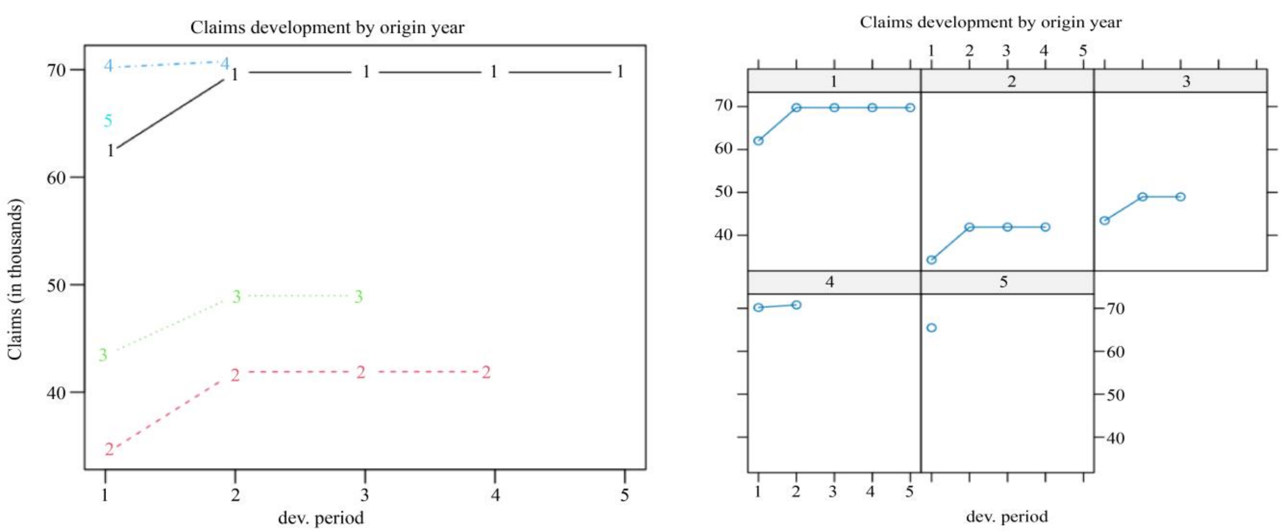
$$y^{(b)} = r^{(b)} \cdot \sqrt{\mu} + \mu \quad (17)$$

The R software (R Development Core Team, 2023) by [24] was utilized to carry out the calculations.

4. Results and Discussion

4.1. Results

The chain ladder and bootstrap techniques are employed to estimate the claim reserves of a short-tail insurance company specializing in health insurance. The accumulated payment for any claim is visually represented in Figure 1 through a series of plot drawings. Each plot corresponds to an incident that occurred from the first to the last period.



(a) **(b)**

Fig. 1 The claims development of the accumulated payment. a) with each line representing a specific period of origin .b) with each origin time represented on a separate panel

The data presented in Table 2 illustrates the total amount of claims that incurred in the portfolio of diseases during period i and settled by period j.

Table 2. Run-off triangle data of cumulative claims loss settlement

Cumulative claims loss settlements		Development year j				
		0	1	2	3	4
Accident year i	0	62023	69748	69898	69935	69935
	1	34269	41897	41913	41913	
	2	43425	48975	49356		
	3	70187	77079			
	4	65470				

Source: Authors

The estimation of the total payments on futures triangle necessitates the inclusion of the development factor, $\hat{\lambda}$ which is calculated from equation (2). Table 3 displays the calculation for the cumulative claim estimator.

Table 3. Future triangles accumulation claims reserves calculated by chain ladder method

Observed and estimated cumulative claims loss settlements		**Development year j**				
		0	1	2	3	4
Accident year i	0	62023	69748	69898	69935	69935
	1	34269	41897	41913	41913	41913
	2	43425	48975	49356	49357	49357
	3	70187	77079	77341	77367	77367
	4	65470	74139	74392	74416	74416
Development Factor $\hat{\lambda}$		1.132418	1.003405	1.00033	1	

Source: Authors

For example, the development factor $\hat{\lambda}_1$= (69748+41897+48975+77079)/(62023+34269+43425+70187)=1.132418
Based on equation (3) is possible to estimate the accumulated payments in delay period i and period of occurrence j. The estimator for total payments made during delay period 2 and occurrence period 3 is shown as an example.

$$\hat{C}_{3,2} = \hat{\lambda}_1 \hat{C}_{3,1} = 1.132418 \cdot 77079 = 77341$$

Reserves Requirements = Total Claims - Settled Claims = (69748+41913+49357+77367+74416) - (69935+41913+ 49356+77079+65470) = 9236 (thousands) ALL. The above description indicates that the chain ladder method is applicable for calculating claims reserves. Nevertheless, the claims reserves produced through this approach do not allow for the IBNR claims reserves and RBNS claims reserves. The estimation of the lacking cumulative claim reserves was carried out using the bootstrap CL method and is displayed in table 5. The bootstrap method is employed to analyze the incremental claim data accumulated between 2018 and 2022, as presented in Table 5, through 999 simulations.

Table 5. Cumulative values of claim reserves calculated by Bootstrap method.

		Development year j				
	i	0	1	2	3	4
accident year i	0	62023	69748	69898	69935	69935
	1	34269	41897	41913	41913	41913
	2	43425	48975	49356	49372	49372
	3	70187	77097	77359	77385	77385
	4	65470	74145	74397	74422	74422

Source: Authors

The application of the Bornhuetter-Ferguson technique is evident in the analysis of the data. Table 4 displays the outcomes of the previous development pattern estimator for cumulative quotas $\hat{\gamma}_j^{CL}$ and the anticipated ultimate losses estimator $\hat{U}_i$, moreover displays the claim reserve outcomes for accident year i and the overall claim reserve. As a result, the insurance company must prepare a total claim reserve of 13409 ALL (in thousands) for claim payments.

Table 4. Claim reserving prediction.

Accident year i	$\hat{\lambda}^{CL}$	$\hat{\gamma}_j^{CL}$	$\hat{U}_i$	Claim Reserves
0	1	0	69748	-
1	1	0	47509	0
2	1.00033	0.000329	67381	22
3	1.00373	0.003723	70183	261
4	1.13241	0.116933	112253	13126
			Total	13409

Source: Authors

The comparison between the three methods is outlined in table 6. It is evident that all the disparities indicates that the reserves estimate obtained through the bootstrap method is lower than the reserves estimate obtained through the classical Chain ladder method and Bornhuetter-Ferguson**.** Consequently, when utilizing the bootstrap estimate, the insurance company should consider saving some funds or exploring other profitable investment opportunities.

Table 6. The Ultimate and Claim Reserves- comparison

	Chain Ladder		**Bornhuetter-Ferguson**		**Bootstrap**	
	Ultimate	Claim Reserves	Ultimate	Claim Reserves	Ultimate	Claim Reserves
2018	69935	-	69935	-	69935	-
2019	41913	0	47509	0	41913	0
2020	49356	1	67381	22	49367	16
2021	77097	288	70183	261	77392	288
2022	65470	8946	112253	13126	74543	8900
Total	303771	9235	367261	13409	313150	9204

Source: Authors

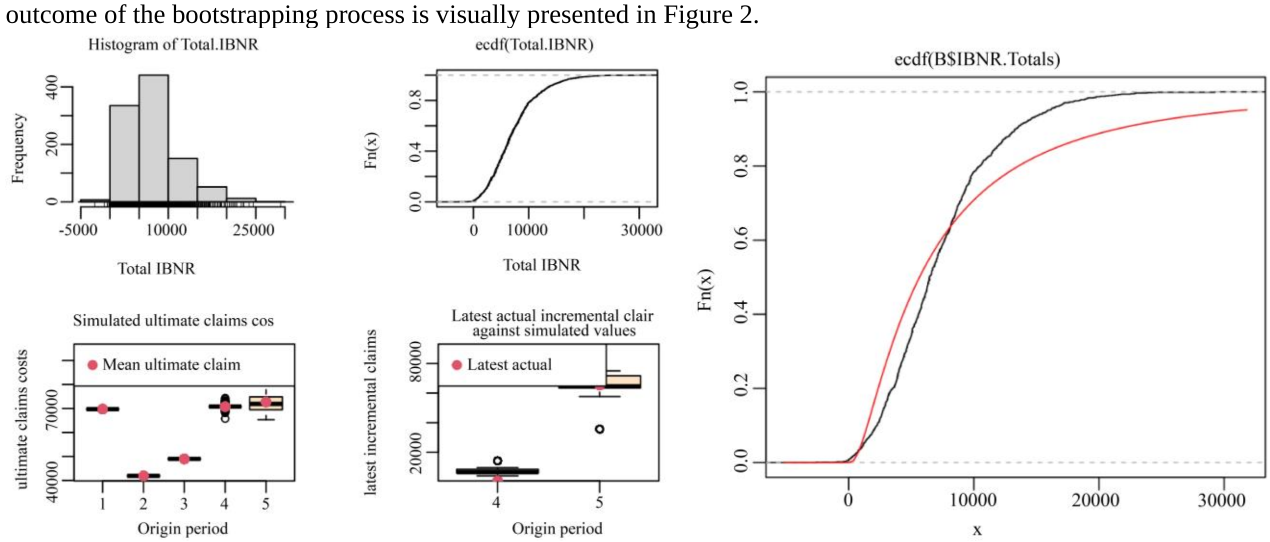
The claim reserves and ultimate value of the claims listed in Table 6 are derived from the data provided in Tables 3, 4, and 5. By subtracting the reported value for a specific accident year in Table 6 from the ultimate claim value, we can determine the claim reserve amount for each corresponding accident year. As an illustration, the computation of the claim reserve value in Table 6 using the Chain Ladder method for the accident year 2022 involves subtracting the values (74416–65470) in Table 3, resulting in a total of 8946 (thousand)ALL. The disparity between the bootstrap and chain ladder techniques is relatively insignificant when contrasted with the distinction between the bootstrap and BF methods. Hence, insurance companies can utilize these two CL and Bootstrap methods to generate a more precise projection of claim reserves. The reserves of claims that the company must allocate for all events up to the next 4 periods are displayed in Table 7.

Table 7. Reserve claims (in thousand) ALL for a total of four periods in the future.

Year	**Chain Ladder**	**Bootstrap**
2023	8953	8932
2024	278	279
2025	25	24
2026	0	0

Source : Authors

The outcome of the bootstrapping process is visually presented in Figure 2.



a) b)

Fig. 2 Bootstrap model's summary of results a) the graph of Ultimate claims and IBNR
b) the graph of fitting a Log-normal distribution to IBNR.

Referring to Table 8, we utilize the bootstrap IBNR quantiles at 75%, 90%, 95%, and 99.5% for the computation of the Value at Risk (VaR). It is important to note that the highest VaR is observed in the last year, which corresponds to 2022.

Table 8. The estimation of value at risk (VaR) varies across different confidence intervals.

Year	IBRN 75%	IBRN 95%	IBRN 99%	IBRN 99.5%
2018	-	-	-	-
2019	0	0	0	0
2020	19	198	441	645
2021	450	1310	2131	2513
2022	10659	13440	15762	16546
Total	11128	14948	18334	19704

Source: Authors

4.2. Discussion

In accordance with the chain ladder method, the estimated total loss reserves is 9,235,000 ALL, the Bornhuetter-Fergusons method provides an estimate of the total reserves for losses which amount to 13,409,000 ALL and the Bootstrap method provides an estimate of the total reserves for losses 9,204,000ALL. It is evident that the reserves computed using the bootstrap method are less than those calculated using the classical Chain ladder method and Bornhuetter-Fergusons. This finding implies that the insurance company may not need to maintain a large claim reserve and could explore more effective ways to utilize some of its funds. The results of this paper are consistent with study of [3, 9], which they conclude that the utilization of the run-off triangle is essential in predicting outstanding claims. This instrument allows for the analysis of the relationship between past claims payments. The application of the Chain Ladder and Bornhuetter-Ferguson techniques, renowned for their distribution-free approach, was implemented utilizing this valuable tool. In order to obtain the most reliable estimate, is required to compare the diverse outcomes of ultimate losses resulting from each method and make a decision on which method offers the most favorable estimation. The above methods must be employed with caution to ensure the adequacy of loss reserves, while also considering their advantages and disadvantages. The growing demand for enhanced healthcare services has made it imperative for insurance medical providers to adopt a more reliable reserving mechanism. This is necessary to safeguard against unforeseen claims that have the potential to cause financial instability and insolvency. When loss development demonstrates a consistent pattern and a considerable number of claims have been reported, the chain ladder method is an appropriate choice. However, the CL technique has not been successful in distinguishing between IBNR claims reserves and RBNS claims reserves. Furthermore, the estimation is restricted to forecasting solely within the $2n-1$ period. The results of this paper are inconsistent with the study of [6, 17], which emphasizes, that the chain-ladder method's calculation of outstanding claims reserves is greatly influenced by outliers, leading to a notable overestimation of the total reserve estimate. Consequently, the insurance company is compelled to allocate a larger sum of funds than is actually necessary. The results of this paper coincide with the findings of [13, 16, 18], which conclude that the reserves ascertained by the bootstrap method are found to be lower than the reserves determined by the traditional Chain ladder technique.

5. Conclusion

Sustaining solvency in non-life insurance and health insurance companies is heavily predicated on the actuarial methods employed for loss provisioning. The purpose of the paper was to outline different strategies for addressing the challenge of estimating claim and to illustrate the effectiveness of the bootstrap method. The results obtained from the chain ladder method indicate that, the total estimated loss reserves amount to 9,235,000 ALL. On the other hand, the Bornhuetter-Fergusons method estimates the total reserves for losses to be 13,409,000 ALL. Lastly, the Bootstrap method provides an estimate of 9,204,000 ALL for the total reserves for losses. It is clear that the reserves calculated using the Bootstrap method is lower than those computed using the classical chain ladder method and Bornhuetter-Fergusons. This conclusion suggests that the insurance company can consider alternative ways to allocate its funds instead of maintaining a large claim reserve. The prediction of reserves for all events up to the next 4 periods is accomplished through the use of CL and bootstrap methods. Value at Risk was assessed at different levels of confidence, demonstrating increased values, particularly for the upcoming years, with a specific emphasis on the year 2022. This paper is subject to certain limitations, which necessitate the exploration of alternative approaches to overcome the constraints of classical methods, a promising direction for future research is to explore the application of stochastic models and robust chain ladder method in estimating claim reserves.

References

[1] OECD, Private Health Insurance Spending, 2022. [Online]. Available: https://www.oecd.org/health/Spending-on-private-health-insurance-Brief-March-2022.pdf

[2] Hyuk Sung Kwon, and Uy Quoc Vu, "Consideration of a Structural-Change Point in the Chain-Ladder Method," *Communications for Statistical Applications and Methods*, vol. 24, no. 3, pp. 211–226, 2017. [CrossRef] [Google Scholar] [Publisher Link]

[3] F.F. Adam, "Claim Reserving Estimation by Using the Chain Ladder Method," *KnE Social Sciences / The 2nd International Conference on Vocational Higher Education (ICVHE) 2017*, pp. 1192-1204, 2018. [CrossRef] [Google Scholar] [Publisher Link]

[4] F.F. Addini, S. Nurrohmah, and I. Fithriani, "Prediction of the Reported But Not Settled (RBNS) Claims Reserves and the Incurred But Not Reported (IBNR) Claims Reserves Using the Double Chain Ladder Method," *Journal of Physics*: *Conference Series*, *The 2nd Basic and Applied Sciences Interdisciplinary Conference 2018 (2nd BASIC 2018)*, Depok, Indonesia, vol. 1725, 2018. [CrossRef] [Google Scholar] [Publisher Link]

[5] EIOPA (European Insurance and Occupational Pensions Authority) Solvency II Technical Specifications: and Solvency Capital Requirements, 2012. [Online]. Available: https://www.milliman.com/-/media/milliman/importedfiles/uploadedfiles/insight/life-published/eiopasolvencycapitalrequirementspdf.ashx

[6] Jonathan Prasetyo Johan, Felivia Kusnadi, and Benny Yong, "Analysis of Robust Chain Ladder Method in Estimating Australian Motor Insurance Reserves with Outlying Dataset," *Barekeng: Journal of Mathematics and its Applications*, vol. 17, no. 1, pp. 225–234, 2023. [CrossRef] [Google Scholar] [Publisher Link]

[7] Maria Dolores Martínez-Miranda, Jens Perch Nielsen, and Richard Verrall, "Double Chain Ladder and Bornhuetter-Ferguson," *North American Actuarial Journal*, vol. 17, no. 2, pp. 101–113, 2013. [CrossRef] [Google Scholar] [Publisher Link]

[8] Maria Dolores Martínez-Miranda et al., "Double Chain Ladder, Claims Development Inflation and Zero-Claims," *Scandinavian Actuarial Journal*, vol. 2015, no. 5, pp. 383–405, 2015. [CrossRef] [Google Scholar] [Publisher Link]

[9] I.G.C.D. Saputra, S. Nurrohmah, and S.F. Sari, "Claim Reserving Prediction with Bornhuetter-Ferguson Method," *Journal of Physics*: *Conference Series*, *The 2nd Basic and Applied Sciences Interdisciplinary Conference 2018 (2nd BASIC 2018)*, Depok, Indonesia, vol. 1725, 2018. [CrossRef] [Google Scholar] [Publisher Link]

[10] Kočović Jelena, Mitrašević Mirela, and Trifunović Dejan, "Advantages and Disavantages of Loss Reserving Method in Non-life Insurance," *Yugoslav Journal of Operations Research*, vol. 29, no. 4, pp. 553-561, 2019. [CrossRef] [Publisher Link]

[11] Mario V. Wüthrich, Michael Merz, and Hans Bühlmann, "Bounds on the Estimation Error in the Chain Ladder Method," *Scandinavian Actuarial Journal*, vol. 2008, no. 4, pp. 283–300, 2008. [CrossRef] [Google Scholar] [Publisher Link]

[12] Elitsa Raeva, Velizar Pavlov, and Simona Georgieva, "Claim Reserving Estimation by Using the Chain Ladder Method, *AIP Conference Proceedings*, vol. 2321, 2021. [CrossRef] [Google Scholar] [Publisher Link]

[13] Bohdan Linda, Kubanová Jana, and Jindrová Pavla, "Insurance Reserves Estimation by Bootstrap," *Scientific Papers of the University of Pardubice. Series D, Faculty of Economics and Administration*, 2011. [Google Scholar] [Publisher Link]

[14] Kris Peremans et al., "Robust Bootstrap Procedures for the Chain-Ladder Method," *Scandinavian Actuarial Journal*, vol. 10, pp. 870–897, 2017. [CrossRef] [Google Scholar] [Publisher Link]

[15] Liivika Tee, Meelis Käärik, and Rauno Viin, "On Comparison of Stochastic Reserving Methods with Bootstrapping," *Risks*, vol. 5, no. 1, pp. 1-21, 2017. [CrossRef] [Google Scholar] [Publisher Link]

[16] Paulo J.R. Pinheiro, João Manuel Andrade e Silva, and Maria de Lourdes Centeno, "Bootstrap Methodology in Claim Reserving," *The Journal of Risk and Insurance*, vol. 70, no. 4, pp. 701–714, 2003. [CrossRef] [Google Scholar] [Publisher Link]

[17] Tim Verdonck, Van Wouwe Martine, and Dhaene Jan, "A Robustification of the Chain-Ladder Method," *North American Actuarial Journal*, vol. 13, no. 2, pp. 280–298, 2009. [CrossRef] [Google Scholar] [Publisher Link]

[18] Oriana Zaçaj et al., "Bootstrap Methods for Claims Reserving: R Language Approach," *WSEAS Transactions on Mathematics*, vol. 21, pp. 252–259, 2022. [CrossRef] [Google Scholar] [Publisher Link]

[19] Thomas Mack, "Distribution-Free Calculation of the Standard Error of Chain-Ladder Reserve Estimates," *ASTIN Bulletin The Journal of the IAA*, vol. 23, no. 2, pp. 213-225, 1993. [CrossRef] [Google Scholar] [Publisher Link]

[20] Thomas Mack, "The Prediction Error of Bornhuetter/Ferguson," *ASTIN Bulletin: The Journal of the IAA*, vol. 38, no. 1, pp. 87-103, 2008. [CrossRef] [Google Scholar] [Publisher Link]

[21] Mario V. Wüthrich, Michael Merz, and Natalia Lysenko, "Uncertainty of the Claims Development Result in the Chain Ladder Method," *Scandinavian Actuarial Journal*, vol. 2009, no. 1, pp. 63–84, 2009. [CrossRef] [Google Scholar] [Publisher Link]

[22] Michael Radtke, Klaus D. Schmidt, and Anja Schnaus, *Handbook on Loss Reserving*, EAA Series, Springer Cham, pp. 33-42, 2016. [CrossRef] [Google Scholar] [Publisher Link]

[23] Peter England, and Richard Verrall, "Analytic and Bootstrap Estimates of Prediction Errors in Claims Reserving," *Insurance: Mathematics and Economics*, vol. 25, no. 3, pp. 281-293, 1999. [CrossRef] [Google Scholar] [Publisher Link]

[24] Markus Gesmann et al., ChainLadder: Statistical Methods and Models for Claims Reserving in General Insurance_. R package version 0.2.18, 2023. [Online]. Available: https://mages.github.io/ChainLadder/