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Comparison of Chain Ladder Method and Cape Cod Method in Reinsurance Incurred But Not Reported (IBNR) Reserve Estimation

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Abstract— In the era of globalization, there are a lot of risks that surround individuals and companies, including insurance companies. The necessity of risk management becomes important, and risk transfer through reinsurance is crucial in managing the company's risk profile. As stated in the Financial Services Authority (OJK) Regulations, reinsurance companies are obliged to establish technical reserves, in which one of the components is Incurred But Not Reported (IBNR) reserve. Considering there is inconsistency from past studies and the importance of accurately calculating IBNR reserves. Therefore, this study aims to compare the results of IBNR reserves using the Chain Ladder method and the Cape Cod method. This study utilizes the Chain Ladder and Cape Cod models applied in Microsoft Excel to calculate the IBNR reserves. The secondary data used in this study is the Paid & Reported Loss Triangle 2013-2022 from Munich Reinsurance's Financial Results. The result of this study shows that the value of IBNR claim reserves generated using the Chain Ladder gives better accuracy, with a 12.8% relative error compared to the Cape Cod method's 26.9%. Based on the assumptions made, the Chain Ladder model is suitable for portfolios that are just starting or have sufficient amounts of data. Meanwhile, the Cape Cod model is ideal for portfolios operating for a long period.

Keywords— Reinsurance; Incurred But Not Reported; Chain Ladder Method; Cape Cod Method

I. INTRODUCTION

In today's world of globalization and modernization, every individual is exposed to multiple risks. It happens with insurance businesses as well, as taking risks is their primary business. Insurance businesses incur debt by selling policies, making the debt risky due to the erratic time and magnitude of the claims. This model business exposes the firms to financial difficulties and insolvency, demanding risk management. Among several risk management strategies, risk transfer via reinsurance plays an essential role in enhancing the company's overall risk profile. Therefore, the relationship between insurance and reinsurance is multifaceted and has significant implications for insurance firms' financial stability and performance. In general, reinsurance is a contractual agreement between an insurance company (the ceding party) and a reinsurance firm wherein the ceding party allocates some of the insured risk to the reinsurance party. Reinsurance can be categorized into different forms, including facultative reinsurance and treaty reinsurance.

According to the Otoritas Jasa Keuangan (OJK) Regulations Number 71 of 2016 Article 19 Paragraph (2) requires insurance and reinsurance companies to establish a technical reserve based on the types of insurance products. The technical reserve is further clarified in the Otoritas Jasa Keuangan (OJK) Circular Letter Number 27 of 2017, which states that one of the claim reserve components that both insurance and reinsurance firms must calculate is the Incurred But Not Reported (IBNR) reserve. The IBNR reserve is the expected amount needed to pay claims that have happened but have not yet been notified to the insurer. Accurate calculation of IBNR reserves is critical for reinsurance companies' financial stability, and actuaries are becoming more frequently employed to help determine their sufficiency.

In general, approaches for estimating claim reserves can be divided into: deterministic and stochastic. The Chain Ladder approach is one of the most prominent deterministic methods for calculating outstanding claims and has been considered as a benchmark because of its general and easy application [7]. Chain Ladder uses a run-off triangle, which examines data from claims to predict loss. On the other hand, the Cape Cod model is part of the stochastic reserving methods. The Cape Cod approach intends to overcome a few limitations of the Chain Ladder approach. The Cape Cod approach used the ultimate loss ratio and considered premium in the calculation. In past studies, several researchers used a variety of methodologies to estimate claim reserves. According to Asdianti's study, comparing the Bornhuetter Ferguson and Cape Cod methods in IBNR claim reserve calculation indicated that the Bornhuetter Ferguson method has a closer IBNR value to the actual claim value compared to Cape Cod method [3]. Prajitno found that the IBNR claim reserves using the Cape Cod method have better accuracy compared to the Chain Ladder [10]. However, in comparison analysis of Bornhuetter Ferguson and the basic Chain Ladder models undertaken by Motanya concluded the usage of the basic Chain Ladder model is quite significant in forecasting the IBNR claim reserve [9].

Considering the inconsistent conclusion of IBNR reserves estimation from past studies. Also developing robust methodologies for IBNR reserve estimation is important to mitigate financial risk, ensure company solvency, and meet regulatory requirements. Therefore, the authors are interested in comparing the results of Chain Ladder and Cape Cod methods in IBNR reserves.

II. Literature Review

A. Reinsurance

Reinsurance is an agreement between two or more companies: the reinsured or ceding firm and the reinsurer(s) [2]. The reinsurer takes on a certain percentage of the reinsured risks according to the contract's terms and conditions. It enables the ceding party to reduce its exposure to large claims payouts while remaining solvent by recovering some or all of the funds paid out. In this contract, the ceding firm pays a reinsurance premium in exchange for the right to replace a portion of future losses. Reinsurance can be divided into two types: facultative and treaty.

B. Incurred But Not Reported (IBNR) Claim

The claim payment might be paid immediately after it is reported, or it may take longer, causing some delays. The outstanding claim refers to the relationships between the incidence and the subsequent delays. Outstanding claims are classified into: Incurred But Not Reported (IBNR) and Reported But Not Settled (RBNS). IBNR is defined as the amount of claims that have occurred but have yet to be notified to the insurance company. IBNR claims in reinsurance can arise from a variety of reasons, including the ceding firm being uninformed of the loss and failing to notify the reinsurance firms. IBNR claims can have a major impact on a reinsurance company’s financial performance.

C. Incurred But Not Reported (IBNR) Reserve

Technical reserves are funds that are required to be established by managing premiums to meet obligations to the policyholders. According to the Otoritas Jasa Keuangan (OJK) Circular Letter Number 27 of 2017, technical reserves are classified into several types, including the IBNR reserve. The Incurred But Not Reported (IBNR) reserve is an estimate of the unpaid obligation for run-out claims. The reserve is established using a development and projection technique, which also includes evaluating historical data and utilizing actuarial methods to estimate the amount of potential claims. In the reinsurance industry, an article on IBNR reserve typically presents a projected amount of paid or reported claims [17]. Estimating the IBNR reserve is critical for financial reporting and risk management in reinsurance firms.

D. Run-Off Triangle

Run-off triangles are two-dimensional matrices containing claims based on the accident and development periods. The accident or policy years describe the periods during which the claims occurred, whereas the development periods represent the time intervals between when the claims were initially reported and when they were settled. Let a collection of random variables $\{S_{i,k}\}_{i,k\in\{0,1,\ldots n\}}$ to generate cumulative losses. $S_{i,k}$ represents the cumulative loss of accident year i and development year k. $S_{i,n-i}$ implies to cumulative claim for the current calendar year n, whereas $S_{i,n}$ refers to the cumulative ultimate claim [15]. The observed cumulative losses form a run-off triangle, as seen as in Table 1. The cumulative loss can be generated from incremental $Z_{i,k}$ loss by the following equation.

$$S_{i,k} = \sum_{l=0}^{k} Z_{i,l} \tag{1}$$

Table 1. Run-off Triangle in Cumulative Data

	Claim Data	**Development Year**								
		0	**1**	**…**	$\boldsymbol{k}$	**…**	$\boldsymbol{n-i}$	**…**	$\boldsymbol{n-1}$	$\boldsymbol{n}$
Accident Year	0	$S_{0,0}$	$S_{0,1}$	…	$S_{0,k}$	…	$S_{0,n-i}$	…	$S_{0,n-1}$	$S_{0,n}$
	1	$S_{1,0}$	$S_{1,1}$	…	$S_{1,k}$	…	$S_{1,n-i}$	…	$S_{1,n-1}$	
	⋮	⋮	⋮		⋮		⋮			
	i	$S_{i,0}$	$S_{i,1}$	…	$S_{i,k}$	…	$S_{i,n-i}$			
	⋮	⋮	⋮		⋮					
	$n-k$	$S_{n-k,0}$	$S_{n-k,1}$	…	$S_{n-k,k}$					
	⋮	⋮	⋮							
	$n-1$	$S_{n-1,0}$	$S_{n-1,1}$							
	n	$S_{n,0}$								

E. Chain Ladder Method

The Chain Ladder method was introduced in 1934 by Tarbell [13]. The Chain Ladder approach outlines the process of calculating claims growth or the factor that relates the number of claim losses experienced from one period to the next in a particular claim dataset. The key assumption given in the Chain Ladder approach is that there is a consistent time pattern of postponing the payment of insurance claims in claim reporting. The Chain Ladder method estimates claims unreported claims by combining historical claims data with delays in reporting and paying claims. assumes that cumulative losses $S_{i,k}$ are observable for $i + k \leq n$ and future loss for $i + k \geq n + 1$. The Chain Ladder model predicts future loss by using development factor. For each development year $k \in \{1, \dots, n\}$, the development factor φ_k can be computed by

$$\varphi_k^{CL} = \frac{\sum_{i=0}^{n-k} S_{i,k}}{\sum_{i=0}^{n-k} S_{i,k-1}} \tag{2}$$

The development factor is the ratio of cumulative loss development year k to the development year k-1 for the same accident year. For each accident and development year, the chain ladder estimator projects the future cumulative claim $S_{i,k}$

$$\hat{S}_{i,k}^{CL} = S_{i,n-i} \prod_{l=n-i+1}^{k} \varphi_l^{CL} \tag{3}$$

and the future outstanding liabilities L for each accident year is determined by.

$$\hat{L}_i = \hat{S}_{i,n}^{CL} - \hat{S}_{i,n-i} \tag{4}$$

The amount of IBNR claim reserve estimation that must be provided by the reinsurance company until all claim settled is the sum of outstanding liabilities:

$$R^{CL} = \sum_{i=0}^{n} \hat{L}_i \tag{5}$$

F. Cape Cod Method

Bühlmann and Straub developed the Cape Cod model in 1983 [13]. The Cape Cod methodology was developed to overcome some of the drawbacks from the Chain Ladder and Bornhuetter Ferguson approaches, which are the two most widely used claims reserve estimating methods. Contrary to the Chain Ladder approach, the Cape Cod model includes premium information in its computation. As a result, the Cape Cod predictor is not only reliant on claims data, and even in the presence of an outlier, the Cape Cod prediction produces satisfactory outcomes.

The Cape Cod is the prediction method that uses earned premiums or other volume measures $v_0, v_1, \ldots, v_n$ are known over all the accident years. Also assumes the parameters $\gamma_0, \gamma_1, \ldots, \gamma_n$ form a development pattern for quotas [11]

$$\gamma_k = \prod_{l=k+1}^{n} \frac{1}{\varphi_l} \tag{6}$$

with φ_l from the Chain Ladder model. The Cape Cod model predicts the future claims using priori estimators $\hat{\gamma}_0 < \hat{\gamma}_1 <, \ldots, < \hat{\gamma}_n$, with $\hat{\gamma}_n = 1$ of the development pattern for quotas $\gamma_0, \gamma_1, \ldots, \gamma_n$. The expected ultimate loss ratio k^{CC} can be calculated using the Cape Cod ultimate loss ratio

$$k^{CC} = \frac{\sum_{j=0}^{n} S_{j,n-j}}{\sum_{j=0}^{n} v_j \hat{\gamma}_{n-j}} \tag{7}$$

where it is identical for every accident year. Hence, the Cape Cod predictors for calculating future cumulative claims $S_{i,k}$ with $i + k \geq n + 1$ can be defined as

$$\hat{S}_{i,k}^{CC} = S_{i,n-i} + (\hat{\gamma}_k - \hat{\gamma}_{n-i}) v_i k^{CC} \tag{8}$$

After obtaining the future cumulative losses for all development years, to calculate the future outstanding liabilities for every accident year i could be estimated by

$$\hat{L}_i = \hat{S}_{i,n}^{CC} - \hat{S}_{i,n-i} \tag{9}$$

and the Cape Cod estimation for IBNR reserves is:

$$R^{CC} = \sum_{i=0}^{n} \hat{L}_i \tag{10}$$

G. Relative Error

Claim reserving is an example of predictive progress where researchers attempt to project future claims using historical data. The researcher refers to predicted value as the Chain Ladder and Cape Cod reserves. In this study, the researcher employed relative error for the comparison. The relative error is defined as the differences between the predicted value and actual value, which is then taken into absolute error, and divided by the actual value [6]. The relative formula can be written as follows:

$$Relative\ Error = \frac{|V_{actual} - V_{predicted}|}{V_{actual}} \times 100\% \tag{11}$$

III. METHODOLOGY

A. Research Design

The data used in this study is quantitative data. This study will use secondary data which is Paid & Reported Loss Triangle with period 2013-2022 obtained from Munich Reinsurance's Financial Results 2022. The data will be processed using Microsoft Excel. To compare the results of the IBNR reserve estimation using the Chain Ladder and Cape Cod models, the steps that must be taken in the form of a flowchart as follows.

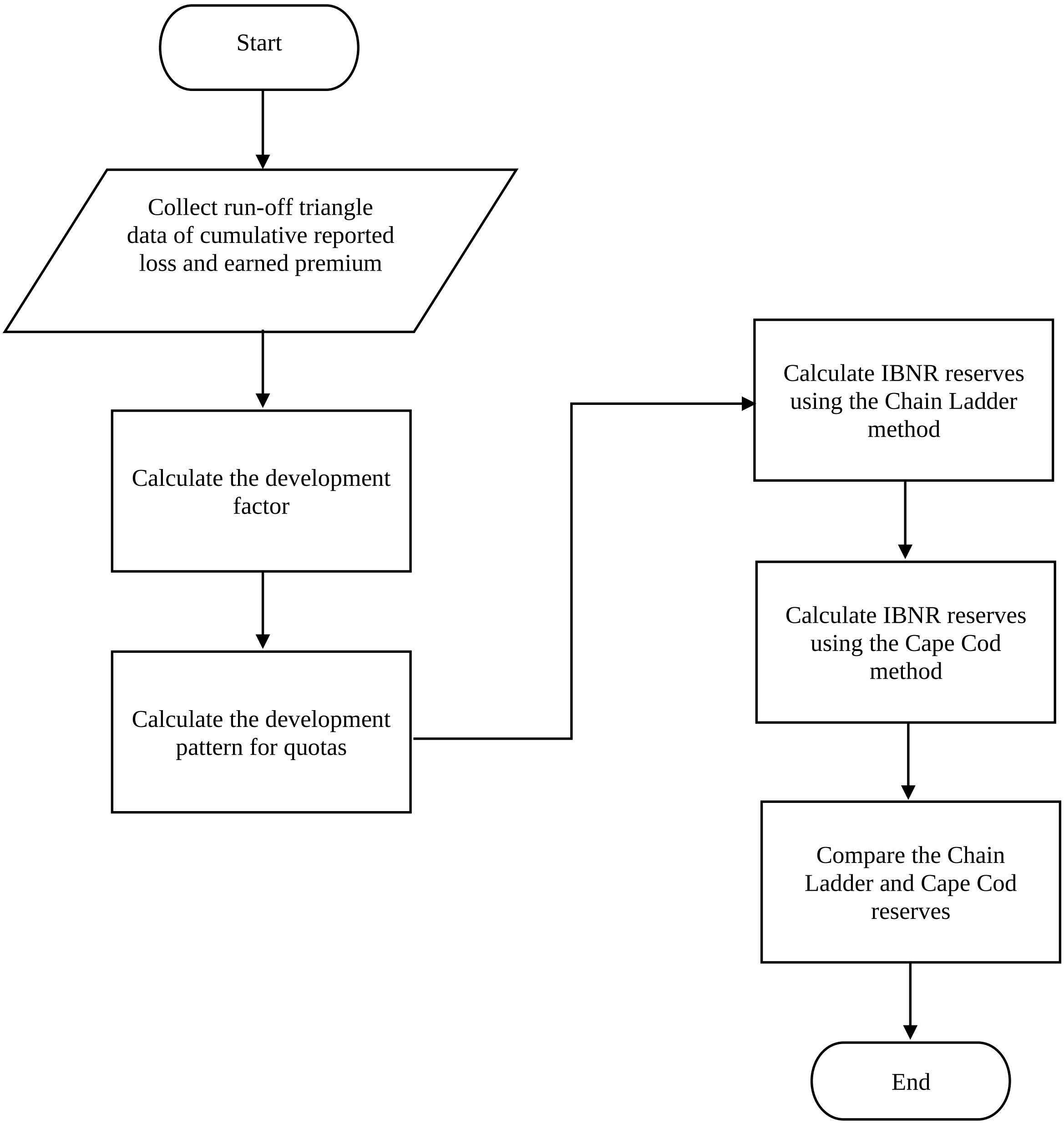

Figure 1. Research Flowchart

IV. RESULT AND ANALYSIS

A. *Data Collection*

The analysis utilizes secondary data from Munich Reinsurance Financial Results 2022, namely the *"Paid & Reported Loss Triangle 2022"* disclosure of Munich Reinsurance Group Property & Casualty. This data set includes the amount of reported loss (in million euros) from 2013 to 2022. The data is displayed in the format of a cumulative run-off triangle as in Table 2.

Table 2. Cumulative Reported Loss Triangle

Claim Data		Development Year									
		1	2	3	4	5	6	7	8	9	10
Accident Year	**2013**	9,231	11,598	11,945	12,127	12,350	12,395	12,399	12,433	12,490	12,519
	2014	8,827	10,947	11,577	11,922	12,039	11,921	12,022	12,096	12,160	
	2015	8,554	10,390	11,112	11,490	11,517	11,754	11,991	12,141		
	2016	9,022	10,525	11,594	11,879	12,044	12,262	12,350			
	2017	9,183	12,897	13,812	14,579	14,906	15,158				
	2018	9,491	13,914	15,204	15,949	16,177					
	2019	8,435	13,954	15,516	16,380						
	2020	8,967	14,498	16,041							
	2021	10,343	16,945								
	2022	11,431									

Along with the reported claim data, the Cape Cod method's calculation will incorporate supporting data, involving earned premium data. These data are published by Munich Reinsurance under the title *"Paid & Reported Loss Triangle 2022"*. The following table displays the earned premium (in million euros) for Munich Reinsurance Group Property & Casualty.

Table 3. Earned Premium

Year		Earned Premium
2013	0	21,627
2014	1	21,658
2015	2	20,434
2016	3	20,897
2017	4	21,294
2018	5	24,372
2019	6	26,169
2020	7	28,704
2021	8	33,673
2022	9	38,678

B. *Development Factors*

The development factor is defined as the ratio of cumulative claims during delay k to delay k-1 for the same accident year. The process of calculating this ratio is derived from Table 2 (cumulative reported loss triangle) and equation (2). The following is an example of the calculation

$$\varphi_1^{CL} = \frac{\sum_{i=0}^{8} S_{i,1}}{\sum_{i=0}^{8} S_{i,0}} = \frac{115{,}668}{82{,}053} = 1.410$$

$$\varphi_2^{CL} = \frac{\sum_{i=0}^{7} S_{i,2}}{\sum_{i=0}^{7} S_{i,1}} = \frac{106{,}802}{98{,}723} = 1.082$$

The calculation is carried out using the same equation until obtaining all development factors value. The following the complete table of development factors.

Table 4. Development Factors

Development Factors	φ_1^{CL}	φ_2^{CL}	φ_3^{CL}	φ_4^{CL}	φ_5^{CL}	φ_6^{CL}	φ_7^{CL}	φ_8^{CL}	φ_9^{CL}
	1.410	1.082	1.039	1.014	1.010	1.009	1.007	1.005	1.002

C. *Development Pattern for Quotas*

This section will compute the development pattern for quotas using the development factors obtained from the Chain Ladder model. The development pattern for quotas can be calculated using equation (6) and the following is the calculation example.

$$\gamma_0 = \prod_{l=1}^{9} \frac{1}{\varphi_l} = \frac{1}{\varphi_1\varphi_2\varphi_3\varphi_4\varphi_5\varphi_6\varphi_7\varphi_8\varphi_9}$$
$$= \frac{1}{(1.410)(1.082)(1.039)(1.014)(1.010)(1.009)(1.007)(1.005)(1.002)}$$
$$= 0.602$$

$$\gamma_1 = \prod_{l=2}^{9} \frac{1}{\varphi_l} = \frac{1}{\varphi_2\varphi_3\varphi_4\varphi_5\varphi_6\varphi_7\varphi_8\varphi_9}$$
$$= \frac{1}{(1.082)(1.039)(1.014)(1.010)(1.009)(1.007)(1.005)(1.002)}$$
$$= 0.849$$

In consequence using the same formula, the rest of the development pattern for quotas can be determined in the same way, The results of the development pattern for quotas will be used as the priori estimators $\hat{\gamma}_0 < \hat{\gamma}_1 < , \dots , < \hat{\gamma}_n$, with $\hat{\gamma}_n = 1$ of the development pattern for quotas $\gamma_0, \gamma_1, \dots, \gamma_n$. The full table of priori estimators is shown below.

Table 5. Priori Estimators

Priori Estimators	$\hat{\gamma}_0$	$\hat{\gamma}_1$	$\hat{\gamma}_2$	$\hat{\gamma}_3$	$\hat{\gamma}_4$	$\hat{\gamma}_5$	$\hat{\gamma}_6$	$\hat{\gamma}_7$	$\hat{\gamma}_8$	$\hat{\gamma}_9$
	0.602	0.849	0.918	0.954	0.967	0.977	0.986	0.993	0.998	1

D. *IBNR Reserve using Chain Ladder Method*

The information provided in Table 2 (cumulative reported loss triangle) and Table 4 (development factors) will be used to calculate the loss reserve using the Chain Ladder method. The first step is to calculate future cumulative loss and it is calculate using equation (3). Here is the example of the calculation

$$\hat{S}_{1,9}^{CL} = S_{1,8} \prod_{l=9}^{9} \varphi_l^{CL} = S_{1,8} \times \varphi_9^{CL} = 12{,}160 \times 1.002 = 12{,}188$$

$$\hat{S}_{2,8}^{CL} = S_{2,7} \prod_{l=8}^{8} \varphi_l^{CL} = S_{2,7} \times \varphi_8^{CL} = 12{,}141 \times 1.005 = 12{,}200$$

Based on the previous calculation, the following the complete table of cumulative claims for both observable and non-observable.

Table 6. Cumulative Loss of Chain Ladder Method

Claim Data		Development Year									
		1	2	3	4	5	6	7	8	9	10
Accident Year	**2013**	9,231	11,598	11,945	12,127	12,350	12,395	12,399	12,433	12,490	12,519
	2014	8,827	10,947	11,577	11,922	12,039	11,921	12,022	12,096	12,160	12,188
	2015	8,554	10,390	11,112	11,490	11,517	11,754	11,991	12,141	12,200	12,229
	2016	9,022	10,525	11,594	11,879	12,044	12,262	12,350	12,437	12,498	12,527
	2017	9,183	12,897	13,812	14,579	14,906	15,158	15,293	15,401	15,476	15,512
	2018	9,491	13,914	15,204	15,949	16,177	16,340	16,485	16,602	16,683	16,722
	2019	8,435	13,954	15,516	16,380	16,609	16,776	16,925	17,045	17,129	17,169
	2020	8,967	14,498	16,041	16,671	16,904	17,074	17,226	17,348	17,433	17,474
	2021	10,343	16,945	18,332	19,052	19,318	19,512	19,686	19,825	19,923	19,969
	2022	11,431	16,113	17,432	18,117	18,370	18,555	18,720	18,852	18,945	18,989

Estimated claims in the 9th development year are referred as the ultimate claims. Moreover, using equation (4), the outstanding liabilities for each accident year i are calculated as the difference between the ultimate claim and the current year claim. The following are examples of how to calculate outstanding liabilities.

$$\hat{L}_1 = \hat{S}_{1,9}^{CL} - \hat{S}_{1,8} = 12{,}188 - 12{,}160 = 28$$

$$\hat{L}_2 = \hat{S}_{2,9}^{CL} - \hat{S}_{2,7} = 12{,}229 - 12{,}141 = 88$$

The following table shows the outstanding liabilities for every accident year.

Table 7. Outstanding Liabilities of Chain Ladder Method

Accident Year	Outstanding Liabilities
2013	-
2014	28
2015	88
2016	177
2017	254
2018	545
2019	789
2020	1,433
2021	3,024
2022	7,558

The project value of outstanding liabilities will be utilized to calculate the IBNR claim reserves. The reserve will be calculated using equation (5) and the estimated IBNR reserves of 2023 from reported loss data 2013-2022 is 13,996 million euros.

E. *IBNR Reserve using Cape Cod Method*

In contrast to the Chain Ladder method, the Cape Cod method includes additional information in the computation, namely the earned premium. To determine the value of IBNR reserve, the ultimate loss ratio must first be determined and will utilize the following table and equation (7).

Table 8. Current Claim, Earned Premium, and Priori Estimators

j	$S_{j,n-j}$	$\hat{\gamma}_{n-j}$	v_j	$v_j\hat{\gamma}_{n-j}$
0	12,519	1	21,627	21,626.676
1	12,160	0.998	21,658	21,607.631
2	12,141	0.993	20,434	20,286.951
3	12,350	0.986	20,897	20,600.464
4	15,158	0.977	21,294	20,806.792
5	16,177	0.967	24,372	23,577.612
6	16,380	0.954	26,169	24,966.949
7	16,041	0.918	28,704	26,351.136
8	16,945	0.849	33,673	28,573.967
9	11,431	0.602	38,678	23,282.957
$\sum$	141,301			231,681.140

Based on the Table 8, it yields ultimate loss ratio of 0.609. Then, we could proceed to compute the future cumulative loss using equation (8). Here is the example of the calculation

$$\hat{S}_{1,9}^{CC} = S_{1,8} + (\hat{\gamma}_9 - \hat{\gamma}_8)v_1 k^{CC} = 12{,}160 + (1 - 0.998) \times 21{,}658(0.609) = 12{,}190$$

$$\hat{S}_{2,8}^{CC} = S_{2,7} + (\hat{\gamma}_8 - \hat{\gamma}_7)v_2 k^{CC} = 12{,}141 + (0.998 - 0.993) \times 20{,}434(0.609) = 12{,}202$$

The computation continues using the same equation until all future cumulative losses are determined. The following is the cumulative claims for both observable and non-observable calculated by the researcher using Microsoft Excel.

Table 9. Cumulative Loss of Cape Cod Method

Claim Data		Development Year									
		1	2	3	4	5	6	7	8	9	10
Accident Year	**2013**	9,231	11,598	11,945	12,127	12,350	12,395	12,399	12,433	12,490	12,519
	2014	8,827	10,947	11,577	11,922	12,039	11,921	12,022	12,096	12,160	12,190
	2015	8,554	10,390	11,112	11,490	11,517	11,754	11,991	12,141	12,202	12,231
	2016	9,022	10,525	11,594	11,879	12,044	12,262	12,350	12,438	12,501	12,530
	2017	9,183	12,897	13,812	14,579	14,906	15,158	15,271	15,361	15,424	15,455
	2018	9,491	13,914	15,204	15,949	16,177	16,322	16,451	16,555	16,627	16,662
	2019	8,435	13,954	15,516	16,380	16,593	16,748	16,887	16,998	17,076	17,113
	2020	8,967	14,498	16,041	16,672	16,905	17,076	17,228	17,350	17,436	17,476
	2021	10,343	16,945	18,371	19,112	19,385	19,585	19,764	19,907	20,007	20,055
	2022	11,431	17,248	18,886	19,737	20,051	20,281	20,486	20,650	20,765	20,820

Once the future cumulative claims for each accident year and development year have been obtained, the outstanding liabilities can be estimated by using the equation (9). The following is the instance of how to calculate outstanding liabilities:

$\hat{L}_1 = \hat{S}_{1,9}^{CC} - \hat{S}_{1,8} = 12{,}190 - 12{,}160 = 30$

$\hat{L}_2 = \hat{S}_{2,9}^{CC} - \hat{S}_{2,7} = 12{,}231 - 12{,}141 = 90$

The following table shows the outstanding liabilities for every accident year.

Table 10. Outstanding Liabilities of Cape Cod Method

Accident Year	Outstanding Liabilities
2013	-
2014	30
2015	90
2016	180
2017	297
2018	485
2019	733
2020	1,435
2021	3,110
2022	9,389

The project value of outstanding liabilities will be utilized to calculate the IBNR claim reserves. The reserve will be calculated using equation (10) and the estimated IBNR reserves of 2023 from reported loss data 2013-2022 is 15,749 million euros.

F. *Comparison Analysis*

To determine the best method for estimating IBNR reserves, we will compare the Chain Ladder and Cape Cod reserves with the actual reserve in the Munich Re Group Annual Report 2023. In the Annual Report 2023, Munich Re Group set aside €12,411 million for property & casualty reserve in 2023. The researcher employed the relative error for the comparison with the actual reserve. The following table is the result of the relative error with respect to the actual reserve in 2023.

Table 11. Relative Error of Chain Ladder and Cape Cod

	Actual	Chain Ladder	Cape Cod
2023	12,411	13,996	15,749
Relative Error		12.8%	26.9%

These two approaches deliver a bigger value of IBNR reserves than the real reserves. It implies a better estimate since both insurance and reinsurance businesses are conservative when calculating their reserves due to concerns about the possible expenses of future claims. According to Table 4.11, the Chain Ladder method achieves better accuracy in IBNR reserving with a 12.8% relative error compared to the Cape Cod approach with a 26.9% relative error. The Chain Ladder model is mostly based on the assumption that can remain true even with limited historical data, namely the amount of losses. Furthermore, the development factors are relatively stable and there are no outliers in the number of claims that would significantly affect the development factors. In addition, it also relies on the size of the company's data for calculating reserves, the more accurate the estimation will be. To ensure the sufficiency of claim reserve estimation, the two models should be implemented cautiously, recognizing the circumstances and the subjective assessment of the respective actuaries.

V. CONCLUSION

The Chain Ladder and Cape Cod methods are methodologies to estimate IBNR claim reserves. These two methods have distinct properties and assumptions. The Chain Ladder's method is only geared from historical data, which is the amount of claims. Meanwhile, Cape Cod's method adds another variable to the calculation, namely earned premium. The Chain Ladder method gives better accuracy in IBNR reserves estimation. The Chain Ladder method has a relative error of 12.8% and the Cape Cod method has a relative error of 26.9%. For further studies, the author suggests to utilize external data such as market statistics or introduce inflation trend in estimating the IBNR reserves.

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