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RISK MANAGEMENT OF INSURANCE COMPANIES WITH THE IMPLEMENTATION OF THE MUNICH CHAIN LADDER METHOD IN CLAIM RESERVE ESTIMATION

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ABSTRACT

Reserve management is a crucial component in corporate risk management. Claims provision refers to funds allocated by the Company to cover claims that may arise from either Incurred But Not Reported (IBNR) or Reported But Not Settled business activities of the Company. (RBNS). There are several different methods commonly used in carrying out the calculation of company claims reserves and one of them is the method munich chain ladder which is the development of chain ladders method. The aim of the study is to apply the munich chain ladder method in calculating the reservation of motor vehicle insurance claims using the motor vehicle insurance claims data from the insurance company PT ABC during the period 2011-2023. The results of the research showed that the method of munich chain ladder can be used to generate more accurate reservation projections of motor vehicles insurance claim compared to the chain ladders method. This study has made an important contribution to the insurance industry in improving the accuracy of the calculation of reservation claims for motor vehicles. By using the munich chain ladder method, insurance companies can make more accurate projections to control risk and manage finances more effectively.

KEYWORDS *Claims Reserve, Munich Chain Ladder*

INTRODUCTION

Risk is the likelihood of an undesirable event occurring that can cause loss or negative impact or in the context of management, risk is often associated with uncertainty in achieving a desired goal or outcome. (Hull, 2018)

One mechanism in risk management that is often used as an alternative to mitigate risk is insurance, where insurance will provide protection for the insured

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object if it experiences loss or damage guaranteed in the policy. In Indonesia in 2023 there are 78 general insurance companies with gross premium income that continues to increase every year and according to the Indonesian General Insurance Association (AAUI) recorded an increase in premium income of 15.3% throughout 2023, to Rp 103.86 trillion and one of the main contributors is motor vehicle insurance which reached Rp 19.49 trillion, up 7.4% yoy.

Motor vehicle insurance is one of the main contributors to the growth of general insurance in Indonesia. This is in line with the growth in the number of motorized vehicles in Indonesia. The large number of motorized vehicles in Indonesia can be seen in the data presented by the Central Bureau of Statistics that in 2022, the number of motorized vehicles was 148,261,817 units. (BPS, 2023)

The large role of motor vehicle insurance needs attention in terms of the readiness of the company to provide services and the financial ability to settle all obligations to the insured through the claims submitted. On average, every year from 2018-2022 the ratio of motor vehicle insurance claims is above 40% and in 2021 it is slightly below that caused by the covid 19 pandemic situation where the government has launched restrictions on human movement to minimize the development of the covid 19 virus. (OJK, 2018-2022)

Motor vehicle insurance claims will be a potential problem that will be faced by insurance companies when the company does not have sufficient funds because for every loss or damage to the insured object and fulfill the provisions of the policy contract, the company must prepare sufficient funds to pay the claim. Therefore, motor vehicle insurance companies need to carry out effective risk management to minimize financial risks and ensure business continuity. One of the important risk management for insurance companies is the accurate estimation of reserves for potential motor vehicle insurance claims.

Insurance companies need to make projections of the estimated total claims that may arise in the future, considering that every reported claim received by the company cannot always be resolved and paid quickly by the company. Time delays in claim settlement generally occur for several reasons such as validation of submitted claims, completeness of documents, and disputes over the value of claims. It is this delay that makes the company have to prepare sufficient reserves to settle all these claims in time and this is called *outstanding claims*. (Reavis, 2012).

Referring to the provisions contained in the Circular Letter of the Financial Services Authority No. 27 of 2015 concerning Guidelines for the Establishment of Technical Reserves for Insurance Companies that the Company must implement an adequate mechanism in order to gain confidence if: "the quality of data presented by the Company is complete, accurate, and reliable; and the current central estimate or best estimate assumptions used by the Company are current assumptions and consider the Company's experience/data between the last 3 (three) years to 5 (five) years".

In projecting claims reserves, insurance companies generally use the *run-off triangle,* which is a two-dimensional matrix to track and analyze historical claims data over time. This *triangle* displays the progression of claims by accident year and development period, providing insight into how claims develop and settle over time to obtain an accurate value. (Mack, 1993). Furthermore, the *run off triangle* is based on the *chain ladder* method, which uses the *run off triangle* to calculate loss estimates by analyzing the pattern of losses paid and losses incurred over different time periods. Basically, the *chain ladder* method relies on historical data represented in the *run off triangle* to estimate future claims and establish reserves in insurance companies. (Mack, 1993). This method has become very popular in the calculation of IBNR claim reserve estimation because it is simple and easy to apply, this method is often used as a *gold standard* (*benchmark*). (Taylor, 2003) However, because the *chain ladder* method is just a simple claim reserve estimation method, it is not enough to solve the problem, so the company cannot withdraw other important information or facts because this *chain ladder* method, which is often referred to as a deterministic method, cannot model the claim variation. (Mario V Wuthrich, 2008)

In practice, the *chain ladder* method has a weakness because the *chain ladder* method is just a simple claim reserve estimation method, it is not enough to solve the problem, so the company cannot withdraw other important information or facts because this *Chain Ladder* method which is often also referred to as a deterministic method cannot model the variation of the claim. (Mario V Wuthrich, 2008). The same thing was also conveyed by Miranda (2012) which states that although it is easy to operate, there are weaknesses in the *chain ladder* method, namely this method does not take into account the possibility of a time delay between reported claims and claim payments. so that it often causes problems with differences between estimated claim reserves and paid claims.

The most recent method is the *munich chain ladder* which was first developed by Quarg & Mack (2008) as a development of the *chain-ladder* method and several other methods showing that the *munich chain ladder* method can minimize the *gap* between the IBNR projection of paid losses and incurred losses. This method is also considered to help reduce the gap or difference between the projected loss paid and the actual loss incurred. The *munich chain ladder* method shows that there is almost always a relationship between paid losses and actual incurred losses. By applying this holistic approach, insurance companies can improve their ability to manage risk and ensure adequate claims reserves.

This study aims to compare the results of projection calculations on estimated claims paid and reported using 2 (two) different methods, namely *chain ladder* and *munich chain ladder*. Furthermore, the *Mean Absolute Error* (MAPE) value of each method will be calculated to determine the accuracy of each method, so that the validity of the method can be determined and used by the Company in estimating motor vehicle insurance claim reserves.

Literature Review

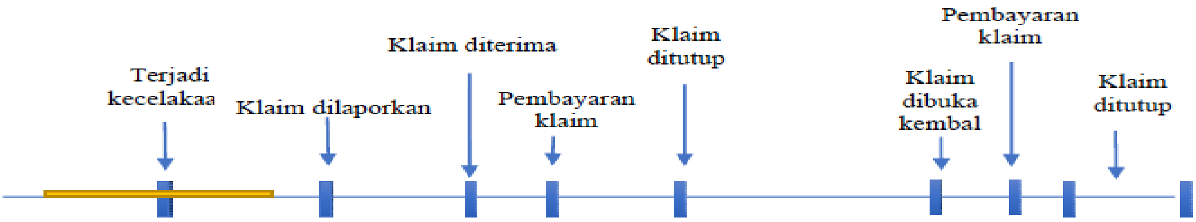
Risk is the likelihood of an event occurring that can cause a negative impact or loss. In a financial, business or insurance context, risk is often measured as how much uncertainty or potential loss may occur. Risk can relate to various aspects such as financial, operational, reputational, legal, or environmental. (Hull, 2023). Insurance is the most common risk management mechanism used by individuals, businesses, and organizations.

Claims and Claims Reserves

An insurance claim is a process in which the policyholder submits a request to the insurer to obtain compensation for financial losses covered by the insurance policy.

Claims Reserve

The amount of money that must be spent by the insurer (insurance) to settle claims that have occurred and will be used by the insured (customer) to pay a certain amount for the misfortune experienced by the insured (insurance) is known as the claim reserve. (Reavis, 2012)



Claim Scheme
Source: Wuthrich & Merz (2008)

Incurred but Not Reported (IBNR)

IBNR is a type of reserve account used by insurance companies to compensate for claims that have not been reported to the insurance company. The IBNR claim is a latent liability, and the company must calculate an appropriate estimate of funds to be held in reserve.

Run-off triangle

Run-off triangle (or *triangle of loss*) is a table or matrix used in the insurance industry to represent the development of claims or losses over time. This matrix depicts the claims that occur in a certain period of time and the way these claims develop over time. The *run-off triangle is* often used in actuarial and risk management contexts to analyze and project *outstanding* claims. The matrix typically has two dimensions: one dimension covers the time period, while the other covers the stage of claim development. The stage of development can include phases such as claim reporting, claim settlement, and claim payment. By looking at the *run-off triangle*, insurance companies can identify claim patterns and project future risk reserves.

Suppose that in the *run-off triangle* data, $C_{(i,j)}$ is a random variable indicating the claim amount. This data is incremental data with event period $1 \leq i \leq n$, development period $1 \leq j \leq n$, and condition $i+j \leq n+1$. We will use this data as the basis to calculate the remaining claim reserves.

Data Klaim		Periode Pengembangan				
		1	$\cdots$	j	$\cdots$	n
Periode Kejadian	1	$C_{1,1}$	$\cdots$	$C_{1,j}$	$\cdots$	$C_{1,n}$
	$\vdots$	$\vdots$	$\vdots$	$\vdots$	$\iddots$	
	i	$C_{i,1}$	$\cdots$	$C_{i,j}$		
	$\vdots$	$\vdots$	$\iddots$			
	n	$C_{n,1}$				

Triangle Run-off Data in the form of Incremental Data

To estimate the outstanding claims reserve, a cumulative *run-off triangle* is constructed from the incremental data. This run-off *triangle* figure shows the magnitude of incremental claims incurred in event period i and paid out in development period *j*. In the *run-off triangle* data, suppose the random variable $D_{i,j}$ denotes the magnitude of the claim. There are event periods $1 \leq i \leq n$, development period $1 \leq j \leq n$, and condition $i + j \leq n + 1$ in this cumulative data. This random variable is calculated using the following equation:

$$D_{i,j} = \sum_{k=1}^{j} C_{i,k} \qquad (1)$$

The equation above shows the cumulative *run-off triangle* data, with D_i denotes the cumulative claim amount incurred in event period *i* and paid in development period *j*.

Chain Ladder Method (Mack Model)

The *chain ladder* method is one of the commonly used methods for calculating claims reserves in insurance. This method is used to project *outstanding* ***claims*** based on known claims in the previous period.

1. Creating a *Run-off Triangle*
2. Determining the Growth Factor
3. Determining the Average Flower Factor
4. Applying the Growth Factor
5. Preparation of Claims Reserves

Mack (1993) introduced a way to estimate claim reserves based on paid claims and incurred claims using the *chain ladder* method. The *chain ladder* method is based on the assumption that the trend of claims development in the past will continue in the future. Therefore, this method tends to give good results when the trend is stable. This method goes through several stages, namely forming a cumulative *run off triangle* to determine the amount to be paid in the delay period. Let C_(i,j) denote the accumulated total value of claims in event year i, for i=1,2,.....,n reported or paid up to *development period* - j, for j=1,2,.....,n. C_(i,j) is considered as a run-off triangle when i=1,2,.....,n and j=1,2,.....,n-i +1.

The basic assumption of the *chain ladder* method is to calculate the value of the development factor in the form of $\lambda_1, \lambda_2, \lambda_1 ..., \lambda_n$ with the following equation:

$$E\left(C_{i,j+1} \middle| C_{i,1}, C_{i,2} \dots C_{i,j}\right) = C_{i,j}\lambda_j$$

$i = 1, 2, \dots.., n$ and $j = 1, 2, \dots.., n - i + 1$.

The projection of claim reserves for future periods in the *run off triangle* can be said to be a development factor denoted by $\hat{\lambda}_j$ and with the following equation:

$$\hat{\lambda}_j = \frac{\sum_{i=1}^{n-j+1} C_{i,j}}{\sum_{i=1}^{n-j+1} C_{i,j-1}} \text{ to } 1 \leq j \leq n-1$$

Furthermore, based on the *development factor*, it can be used to see the total claims obtained from the cumulative *run off triangle* up to the jth development. To get the equation can be explained by the following equation:

$$\hat{C}_{i,j} = \hat{C}_{i,j-1}\, \hat{\lambda}_{j-1}$$

Equation $\hat{C}_{i,j}$ is the total *paid* claims reserve reported in year *i*. The total claims value up to the *jth* development period can be used to calculate an estimate of the claims reserve for the *Ith* event period for $2 \leq i \leq n$. Furthermore, the estimated claim reserves are calculated using equation :

$$\hat{R}_i = \hat{C}_{i,j} - C_{i,n+1-i}$$

Munich Chain Ladder Method

Quarg & Mack (2008) introduced a claim reserve calculation based on the ratio of paid losses to incurred losses, called the *munich chain ladder* method. The advantage of the *munich chain ladder* method is that it can narrow the gap between paid losses and incurred losses in IBNR claim reserve projections compared to using the *chain ladder* method.

Here are the general steps in using the *munich chain-ladder* method:

1. Collect reported claims data from previous years. This data should include information such as the year the claim was reported, the year the claim occurred, the number of claims reported, and the number of claims paid.
2. Calculate the *development* factor for each year. The development factor is the ratio of the number of claims reported in a given year to the number of claims reported in the previous year. For example, the development factor for year 2 versus year 1 is the number of claims reported in year 2 divided by the number of claims reported in year 1.
3. Using the calculated progression factor, project the number of unreported claims in the future. For example, if the number of claims reported in year 1 is 100, and the progression factor from year 1 to year 2 is 1.2, then the estimated number of unreported claims in year 2 is 100 x 1.2 = 120.
4. Repeat steps 2 and 3 for each subsequent year. Using the previously calculated progression factors, project the number of unreported claims in the following years.
5. Add up all the estimated unreported claims to get the total future unreported claims.

It is important to note that the *Munich chain ladder* method is one of several methods used in *reserving* analysis and may not always be the best choice in every situation. The use of this method should be based on a good understanding of the characteristics of the available claims data and other relevant considerations.

Here are some advantages of the Munich Chain Ladder method compared to the standard Chain Ladder method:

1. Reducing the IBNR Gap:

The munich chain ladder method is specifically designed to overcome one of the main weaknesses of the standard *chain ladder* method, namely the IBNR gap.

This IBNR gap is the difference between projected IBNR (*Incurred But Not Reported*) reserves calculated based on paid claims data and projections calculated based on incurred claims data.

The munich chain ladder method considers the correlation between paid claims data and incurred claims data, resulting in a more accurate projection of IBNR reserves and reducing the IBNR gap.

2. Improving the Accuracy of Reserve Projections:

By reducing the IBNR gap, the *munich chain ladder* method overall produces more accurate claim reserve projections. It is important for insurance companies to ensure that they have sufficient reserves to fulfill their future claim obligations.

3. More Flexible:

The munich chain ladder method is more flexible than the standard *chain ladder* method. This is because the *munich chain ladder* method can be modified to take into account various factors, such as claim trends and changes in market conditions.

4. Easy to use:

The munich chain ladder method is relatively easy to use and understand. This makes it a good choice for insurance companies that do not have the resources or expertise to implement more complex claim reserve methods.

Parameter Estimation

In calculating residuals and estimating the delay factor, it is necessary to calculate all parameters in the *munich chain ladder* model.

Using the assumption that every t = s + 1, then determine the development factors $f^{P}_{s\to t}$ and $f^{I}_{s\to t}$ for s = 1, ..., n-1 can use *chain ladder* in estimating:

$$\widehat{f^{P}_{s\to t}} = \frac{1}{\sum_{i=1}^{n-s} P_{i,s}} \sum_{i=1}^{n-s} P_{i,s} \frac{P_{i,t}}{P_{i,s}} = \frac{\sum_{i=1}^{n-s} P_{i,t}}{\sum_{i=1}^{n-s} P_{i,s}}$$

$$\widehat{f^{I}_{s\to t}} = \frac{1}{\sum_{i=1}^{n-s} I_{i,s}} \sum_{i=1}^{n-s} I_{i,s} \frac{I_{i,t}}{I_{i,s}} = \frac{\sum_{i=1}^{n-s} I_{i,t}}{\sum_{i=1}^{n-s} I_{i,s}}$$

Next is to calculate the conditional standard deviation parameter for s = 1, ..., n - 2, the parameter σ can also be estimated by

$$(\widehat{\sigma^{P}_{s\to t}})^2 = \frac{1}{n-s-1} \sum_{i=1}^{n-s} P_{i,s} \left(\frac{P_{i,t}}{P_{i,s}} - \widehat{f^{P}_{s\to t}}\right)^2$$

$$(\widehat{\sigma^{I}_{s\to t}})^2 = \frac{1}{n-s-1} \sum_{i=1}^{n-s} I_{i,s} \left(\frac{I_{i,t}}{I_{i,s}} - \widehat{f^{I}_{s\to t}}\right)^2$$

***Munich Chain Ladder* Model Parameters**

Calculating the conditional residuals of the ratios (P/I) and (I/P), requires projections for the conditional expected values of $E\left(Q_{i,s}\middle|\mathcal{I}_{i,}(s)\right)$ and $E\left(Q_{i,s}\middle|\mathrm{P}_{i,}(s)\right)$ and the conditional standard deviations $\sigma\left(Q_{i,s}\middle|\mathcal{I}_{i,}(s)\right)$ and $\sigma\left(Q_{i,s}^{-1}\middle|\mathrm{P}_{i,}(s)\right)$.

For s = 1,2, ..., n, the following assumptions for the conditional expected value and conditional variance of the ratio (P/I). The estimated conditional expected value for $E\left(Q_{i,s}\middle|\mathcal{I}_{i,}(s)\right)$ i.e:

$$\widehat{q_s} = \frac{1}{\sum_{j=1}^{n-s+1} I_{j,s}} \cdot \sum_{j=1}^{n-2+1} I_{j,s} \cdot Q_{j,s} = \frac{\sum_{j=1}^{n-s+1} P_{j,s}}{\sum_{j=1}^{n-s+1} I_{j,s}}$$

applies equally to all *accident* years. While $\sigma\left(Q_{i,s}\middle|I_{i,s}(s)\right)$ can use the estimator:

$$\frac{\widehat{\rho_s^I}}{\sqrt{I_{i,s}}}$$

and $\widehat{\rho_s^I}$ defined

$$\widehat{\rho_s^I}^2 = \frac{1}{n-s} \sum_{i=1}^{n-s+1} I_{i,s}\left(Q_{j,s} - \widehat{q_s}\right)^2$$

For each s = 1, 2, ..., n, with $\widehat{\rho_s^I}$ is independent of the i-th *accident* year.

Next, the assumption is made that if the estimate of the (P/I) ratio holds equal to the conditional expected value and variance of the (I/P) ratio for $E\left(Q_{i,s}^{-1}\middle|\mathrm{P}_i(s)\right)$ then the equation will be obtained:

$$\widehat{q_s^{-1}} = \frac{1}{\sum_{i=1}^{n-s+1} P_{i,s}} \sum_{i=1}^{n-s+1} P_{i,s} Q_{i,s}^{-1} = \frac{\sum_{i=1}^{n-s+1} I_{i,s}}{\sum_{i=1}^{n-s+1} P_{i,s}}$$

and $\sigma\left(Q_{i,s}^{-1}\middle|\mathrm{P}_i(s)\right)$ i.e.

$$\frac{\widehat{\rho_s^P}}{\sqrt{P_{i,s}}}$$

With $\widehat{\rho_s^P}$ defined

$$\widehat{\rho_s^P}^2 = \frac{1}{n-s} \sum_{i=1}^{n-s+1} P_{i,s}\left(Q_{i,s}^{-1} - \widehat{q_s^{-1}}\right)^2$$

The next step is to calculate the correlation parameter between λ^P and λ^I then it is necessary to calculate the residual *triangles* over $\widehat{res}\left(P_{i,t}\right)$, $\widehat{res}\left(I_{i,t}\right)$, $\widehat{res}\left(Q_{i,s}^{-1}\right)$, and $\widehat{res}\left(Q_{i,s}\right)$ using the following equation:

$$\widehat{res}\left(P_{i,t}\right) = \frac{\frac{P_{i,t}}{P_{i,s}} - \widehat{f^{P}_{s\to t}}}{\widehat{\sigma^{P}_{s\to t}}}\sqrt{P_{i,s}}$$

$$\widehat{res}\left(I_{i,t}\right) = \frac{\frac{I_{i,t}}{I_{i,s}} - \widehat{f^{I}_{s\to t}}}{\widehat{\sigma^{I}_{s\to t}}}\sqrt{I_{i,s}}$$

$$\widehat{res}\left(Q^{-1}_{i,s}\right) = \frac{Q^{-1}_{i,s} - \widehat{q^{-1}_{s}}}{\widehat{\rho^{P}_{s}}}\sqrt{P_{i,s}}$$

$$\widehat{res}\left(Q_{i,s}\right) = \frac{Q_{i,s} - \widehat{q_{s}}}{\widehat{\rho^{I}_{s}}}\sqrt{I_{i,s}}$$

Next, calculate the correlation parameters λ^{P} and λ^{I} by using the following equation:

$$\lambda^{P} = \frac{1}{\sum_{i,s}\widehat{res}\left(Q^{-1}_{i,s}\right)^{2}}\sum_{i,s}\widehat{res}\left(Q^{-1}_{i,s}\right)^{2} = \frac{\widehat{res}\left(P_{i,t}\right)}{\widehat{res}\left(Q^{-1}_{i,s}\right)} = \frac{\sum_{i,s}\widehat{res}\left(Q^{-1}_{i,s}\right)\widehat{res}\left(P_{i,t}\right)}{\sum_{i,s}\widehat{res}\left(Q^{-1}_{i,s}\right)^{2}}$$

$$= \frac{\sum_{i,s}\widehat{res}\left(Q^{-1}_{i,s}\right)\widehat{res}\left(P_{i,t}\right)}{\sum_{i,s}\widehat{res}\left(Q^{-1}_{i,s}\right)^{2}}$$

$$\lambda^{I} = \frac{1}{\sum_{i,s}\widehat{res}\left(Q_{i,s}\right)^{2}}\sum_{i,s}\widehat{res}\left(Q_{i,s}\right)^{2} = \frac{\widehat{res}\left(I_{i,t}\right)}{\widehat{res}\left(I_{i,s}\right)} = \frac{\sum_{i,s}\widehat{res}\left(Q_{i,s}\right)\widehat{res}\left(I_{i,t}\right)}{\sum_{i,s}\widehat{res}\left(Q_{i,s}\right)^{2}}$$

$$= \frac{\sum_{i,s}\widehat{res}\left(Q_{i,s}\right)\widehat{res}\left(I_{i,t}\right)}{\sum_{i,s}\widehat{res}\left(Q_{i,s}\right)^{2}}$$

Based on the assumptions of PQ and IQ, we will then get a recursive formula to determine $P_{i,t}$ and $I_{i,t}$:

$$\widehat{P_{i,t}} = \widehat{P_{i,s}}\left(\widehat{f^{P}_{s\to t}} + \widehat{\lambda^{P}}\frac{\widehat{\sigma^{P}_{s\to t}}}{\widehat{\rho^{P}_{s}}}\left(\frac{\widehat{I_{i,s}}}{\widehat{P_{i,s}}} - \hat{q}^{-1}_{s}\right)\right)$$

$$\widehat{I_{i,t}} = \widehat{I_{i,s}}\left(\widehat{f^{I}_{s\to t}} + \widehat{\lambda^{I}}\frac{\widehat{\sigma^{I}_{s\to t}}}{\widehat{\rho^{I}_{s}}}\left(\frac{\widehat{P_{i,s}}}{\widehat{I_{i,s}}} - \widehat{q_{s}}\right)\right)$$

for $s \geq n - i + 1$ with $\widehat{P_{i,s}} = P_{i,s}\ dan\ \widehat{I_{i,s}} = I_{i,s}$

1. Mean Absolute Percent Error (MAPE)

Relative error is measured by MAPE. MAPE is the percentage error of the estimated results against the actual demand over a certain period, which will provide information on whether the percentage error is too large or small. MAPE is mathematically calculated as follows. (Nasution and Prasetyawan, 2008).

$$M = \frac{1}{n}\sum_{t=1}^{n}\left|\frac{A_t - F_t}{A_t}\right|$$

Description:
M= mean absolute percentage error
n= number of times the summation iteration occurs
A_t = actual value
F_t = forecast value

A lower MAPE value shows that the ability of the estimation model used is better. The range of values for MAPE can be used as a measure of the ability of the forecasting model, and this range of values will be displayed in the following table;

MAPE Range Table

MAPE Value	Interpretation
≤ 10	Highly accurate forecasting results
10 - 20	Good forecasting results
20 - 50	Forecasting results are feasible (good enough)
> 50	Inaccurate forecasting results

RESEARCH METHOD

This research uses a descriptive case study using primary data from PT Asuransi ABC. This quantitative data consists of the number of annual claims, presented in the form of an incremental run-off triangle for the 2011-2023 event period.

This case study will discuss how the *munich chain ladder* method is implemented at PT Asuransi ABC and compared with the *chain ladder method* in projecting claim reserves and comparing the results of the two methods by calculating the *gap* between projected claims reported and actual claims. Furthermore, the accuracy of the calculation results will be tested by *Mean Absolute Percent Error* (MAPE).

The data is presented in the form of a run-off triangle in the form of cumulative claims. The number of rows or event years i and columns or delay years are 1 to 12, where 2011 is declared as the 1st event year and 2022 is declared as the 12th event year.

RESULT AND DISCUSSION

The data used in this study is a data description of the state of insurance claims from the company PT ABC. This research is conducted to predict insurance claims that will be given by the company. The data used is data from 2011-2023 to be able to provide a more precise picture of whether the method used provides accurate results.

Chain Ladder Method

Table 1 *Run off triangle* data on claims *paid* - in million rupiahs

Accident Period	Development Period												
	0	1	2	3	4	5	6	7	8	9	10	11	12
1	1.058.59	1.997.54	2.120.42	2.176.17	2.282.03	2.455.93	2.478.22	2.493.79	2.495.25	2.512.64	2.514.86	2.516.42	2.519.57
2	4.542.93	10.470.90	10.587.11	10.803.81	10.817.56	10.906.48	10.912.29	10.923.12	10.924.81	10.929.26	10.934.13	10.934.34	
3	12.385.36	19.042.31	19.356.76	19.718.24	19.875.74	19.977.53	19.993.37	20.005.48	20.007.55	20.007.81	20.008.06		
4	13.280.06	19.046.36	19.207.88	19.342.96	19.376.54	19.403.51	19.429.25	19.466.01	19.470.16	19.470.59			
5	7.782.66	12.722.77	12.998.69	13.146.98	13.160.73	13.180.77	13.194.57	13.211.98	13.213.36				
6	8.151.26	13.372.57	13.551.60	13.757.53	13.774.10	14.035.17	14.048.60	14.058.89					
7	8.082.27	14.415.91	14.528.32	14.698.84	14.860.38	15.021.89	15.032.57						
8	11.657.63	22.394.46	22.409.54	22.448.01	22.505.53	22.830.32							
9	13.555.89	24.848.22	25.376.59	25.473.61	25.494.96								
10	9.109.66	19.786.39	19.945.75	20.056.10									
11	5.719.00	10.762.97	11.363.65										
12	5.364.14	14.313.74											
13	6.977.06												

Table 2 *Run off triangle* data on claims *incurred* - in million rupiahs

Accident Period	Development Period												
	0	1	2	3	4	5	6	7	8	9	10	11	12
1	1.058.59	2.797.54	3.020.42	3.074.48	3.076.17	3.101.57	3.134.07	3.156.57	3.158.02	3.263.88	3.437.78	3.460.07	3.465.47
2	4.542.93	10.470.90	10.553.10	10.635.34	10.649.09	10.674.09	10.674.63	10.680.87	10.681.92	10.772.78	10.891.34	10.892.98	
3	24.270.72	31.651.22	32.058.57	32.130.35	32.146.34	32.149.34	32.162.18	32.162.93	32.198.23	32.321.73	32.469.34		
4	31.303.13	34.068.39	32.487.93	32.491.44	32.491.26	32.518.23	32.492.49	32.492.49	32.493.49	32.493.49			
5	19.245.01	21.332.63	20.781.35	20.781.36	20.781.36	20.761.32	20.761.32	20.761.32	20.761.32				
6	20.761.33	22.633.74	21.702.87	21.708.79	21.692.22	21.692.22	21.692.22	21.692.22					
7	19.339.41	22.529.91	22.610.59	22.540.08	22.540.08	22.540.08	22.540.08						
8	26.258.62	35.403.40	36.067.17	36.075.64	36.080.16	36.080.16							
9	28.607.89	40.348.38	39.932.48	39.939.50	39.941.63								
10	20.698.55	31.205.74	30.055.40	30.165.75									
11	12.413.80	17.143.24	17.082.65										
12	11.813.81	19.886.18											
13	15.042.98												

Tables 1 and 2 are *run off triangle* tables of paid and reported claims data for 2011 to 2023 shown in the *accident period* and development period (years) columns, starting from year 0 to 12.

Table 3 Development factors on *claims* paid

Development Factor	1.892	1.02057	1.0122	1.0085	1.0171	1.0021	1.0020	1.0002	1.0019	1.0004	1.0003	1.0012

Table 4 Development factor on reported *claims (claims incurred*)

Development Factor	1.5029	0.9962	1.0029	1.0002	1.0013	1.0014	1.0013	1.0003	1.0115	1.0230	1.0033	1.0016

After knowing the value of the development factor in each period, the next step is to estimate the total claims in the *run off triangle* table starting from year 0 to year 12 by multiplying the development factors in tables 1 and 2 with the data in tables 3 and 4 so as to obtain the cumulative estimated value as shown in tables 5 and 6.

Table 5 Cumulative estimates of *claims paid*

Accident Period	0	1	2	3	4	5	6	7	8	9	10	11	12
1	1.058.59	1.997.54	2.120.42	2.176.17	2.282.03	2.455.93	2.478.22	2.493.79	2.495.25	2.512.64	2.514.86	2.516.42	2.519.57
2	4.542.93	10.470.90	10.587.11	10.803.81	10.817.56	10.906.48	10.912.29	10.923.12	10.924.81	10.929.26	10.934.13	10.934.34	10.948.01
3	12.385.36	19.042.31	19.356.76	19.718.24	19.875.74	19.977.53	19.993.37	20.005.48	20.007.55	20.007.81	20.008.06	20.014.45	20.039.46
4	13.280.06	19.046.36	19.207.88	19.342.96	19.376.54	19.403.51	19.429.25	19.466.01	19.470.16	19.470.59	19.479.32	19.485.54	19.509.89
5	7.782.66	12.722.77	12.998.69	13.146.98	13.160.73	13.180.77	13.194.57	13.211.98	13.213.36	13.237.84	13.243.78	13.248.00	13.264.56
6	8.151.26	13.372.57	13.551.60	13.757.53	13.774.10	14.035.17	14.048.60	14.058.89	14.062.15	14.088.21	14.094.53	14.099.02	14.116.65
7	8.082.27	14.415.91	14.528.32	14.698.84	14.860.38	15.021.89	15.032.57	15.062.20	15.065.69	15.093.61	15.100.38	15.105.20	15.124.08
8	11.657.63	22.394.46	22.409.54	22.448.01	22.505.53	22.830.32	22.877.42	22.922.52	22.927.84	22.970.32	22.980.62	22.987.95	23.016.69
9	13.555.89	24.848.22	25.376.59	25.473.61	25.494.96	25.930.64	25.984.14	26.035.36	26.041.39	26.089.64	26.101.35	26.109.67	26.142.31
10	9.109.66	19.786.39	19.945.75	20.056.10	20.226.09	20.571.73	20.614.17	20.654.81	20.659.59	20.697.87	20.707.16	20.713.76	20.739.66
11	5.719.00	10.762.97	11.363.65	11.502.15	11.599.64	11.797.87	11.822.21	11.845.51	11.848.26	11.870.21	11.875.53	11.879.32	11.894.17
12	5.364.14	14.313.74	14.608.19	14.786.24	14.911.56	15.166.38	15.197.67	15.227.63	15.231.16	15.259.38	15.266.23	15.271.10	15.290.19
13	6.977.06	13.197.66	13.469.15	13.633.31	13.748.87	13.983.82	14.012.67	14.040.29	14.043.55	14.069.57	14.075.88	14.080.37	14.097.97

Table 6 Cumulative estimates of reported claims (*claims incurred*)

Accident Period	0	1	2	3	4	5	6	7	8	9	10	11	12
1	1.058.59	2.797.54	3.020.42	3.074.48	3.076.17	3.101.57	3.134.07	3.156.57	3.158.02	3.263.88	3.437.78	3.460.07	3.465.47
2	4.542.93	10.470.90	10.553.10	10.635.34	10.649.09	10.674.09	10.674.63	10.680.87	10.681.92	10.772.78	10.891.34	10.892.98	10.910.00
3	24.270.72	31.651.22	32.058.57	32.130.35	32.146.34	32.149.34	32.162.18	32.162.93	32.198.23	32.321.73	32.469.34	32.577.05	32.627.94
4	31.303.13	34.068.39	32.487.93	32.491.44	32.491.26	32.518.23	32.492.49	32.492.49	32.493.49	32.493.49	33.239.22	33.349.48	33.401.58
5	19.245.01	21.332.63	20.781.35	20.781.36	20.781.36	20.761.32	20.761.32	20.761.32	20.761.32	20.999.36	21.481.30	21.552.56	21.586.23
6	20.761.33	22.633.74	21.702.87	21.708.79	21.692.22	21.692.22	21.692.22	21.692.22	21.699.53	21.948.33	22.452.05	22.526.53	22.561.72
7	19.339.41	22.529.91	22.610.59	22.540.08	22.540.08	22.540.08	22.540.08	22.569.33	22.576.94	22.835.80	23.359.89	23.437.37	23.473.99
8	26.258.62	35.403.40	36.067.17	36.075.64	36.080.16	36.080.16	36.132.41	36.179.30	36.191.50	36.606.46	37.446.59	37.570.80	37.629.50
9	28.607.89	40.348.38	39.932.48	39.939.50	39.941.63	39.994.37	40.052.29	40.104.27	40.117.79	40.577.77	41.509.04	41.646.73	41.711.79
10	20.698.55	31.205.74	30.055.40	30.165.75	30.171.63	30.211.47	30.255.22	30.294.48	30.304.70	30.652.16	31.355.63	31.459.65	31.508.79
11	12.413.80	17.143.24	17.082.65	17.132.66	17.136.00	17.158.62	17.183.47	17.205.77	17.211.57	17.408.91	17.808.45	17.867.53	17.895.44
12	11.813.81	19.886.18	19.811.44	19.869.44	19.873.30	19.899.55	19.928.36	19.954.23	19.960.96	20.189.82	20.653.18	20.721.69	20.754.06
13	15.042.98	22.607.36	22.522.39	22.588.32	22.592.71	22.622.55	22.655.31	22.684.71	22.692.36	22.952.54	23.479.31	23.557.19	23.593.99

Table 7 *Ultimate Claim Incurred and Claim Paid*

Accident Period	Ultimate Claim Incurred	Ultimate Claim Paid	Gap
1	-	-	-
2	17.02	13.67	3.35
3	158.60	31.40	127.20
4	908.09	39.31	868.79
5	824.91	51.20	773.70
6	869.50	57.75	811.75
7	933.91	91.51	842.40
8	1.549.34	186.36	1.362.97
9	1.770.16	647.35	1.122.81
10	1.343.04	683.56	659.48
11	812.79	530.52	282.26
12	867.88	976.45	(108.57)
13	8.551.01	7.120.91	1.430.10
Total	**18.606.25**	**10.430.00**	**8.176.25**

Table 7 shows the results of the calculation of the *ultimate claim incurred* and *claim paid* using the *chain ladder* method. The result is that there is a difference of Rp8,176.25 million between the projected claims reported and the claims paid.

Munich Chain Ladder Method

The *munich chain ladder* method is a development of the *chain ladder* method developed by Quarg & Mack (2008) and uses the same research data as presented in tables 1 and 2. The next stage is to calculate the estimated development factor for claims *paid* and *incurred* claims using $\widehat{f^P_{s\to t}}$ and $\widehat{f^I_{s\to t}}$. After that, it is continued with the calculation of the conditional standard deviation parameters $(\widehat{\sigma^P_{s\to t}})^2$ and $(\sigma^I_{s\to t})^2$.

Table 8 Development factor and Parameter σ

Parameter	0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	10-11	11-12
$\widehat{f^P_{s\to t}}$	1.81920	1.01531	1.00962	1.00411	1.00994	1.00113	1.00129	1.00016	1.00043	1.00022	1.00013	1.00125
$\widehat{f^I_{s\to t}}$	1.31390	0.98801	1.00109	1.00010	1.00034	1.00014	1.00024	1.00039	1.00408	1.00949	1.00167	1.00156
$\widehat{\sigma^P_{s\to t}}$	29.71266	1.76411	0.86053	0.87108	1.43662	0.16588	0.12927	0.01232	0.19444	0.03563	0.02715	0.05613
$\widehat{\sigma^I_{s\to t}}$	34.30837	4.12763	0.48312	0.06886	0.20359	0.24605	0.17777	0.07806	1.07847	1.87968	0.32370	0.00635

Next is to calculate the estimator for the conditional expectation $E\left(Q_{i,s} \middle| I_{i,}(s)\right)$ that each period can use the ratio pattern approach $q\left(=\frac{P}{I}\right)$, followed by calculating the conditional standard deviation $\sigma\left(Q_{i,s} \middle| I_{i,s}(s)\right)$ in each period, so that the ratio pattern q and parameter ρ are formed as a whole as shown in the following table:

Table 9 Pattern of q ratio and ρ parameter

	0	1	2	3	4	5	6	7	8	9	10	11
$\widehat{q_s}$	0.4570	0.633	0.644	0.648	0.648	0.656	0.663	0.663	0.666	0.671	0.715	0.937
$\widehat{q_s^{-1}}$	2.1860	1.5803	1.6779	1.5440	1.5435	1.5238	1.5087	1.5088	1.5019	1.4900	1.3988	1.0671
$\widehat{\rho_s^I}$	13.289	13.704	13.209	14.249	15.207	16.689	18.125	20.242	23.347	27.910	35.029	0.73
$\widehat{\rho_s^P}$	31.847	23.254	27.382	22.617	24.071	26.221	28.329	31.589	36.413	43.641	52.724	50.21

The next step is to calculate the required parameters, namely the residual value. $\widehat{res}(P_{i,t}), \widehat{res}(I_{i,t}), \widehat{res}(Q_{i,s})$, dan $\widehat{res}(Q_{i,s}^{-1})$. These parameters will eventually present data on cumulative estimates of claims *paid* and claims *incurred* as shown in the table below.

Table 10 Cumulative estimates of *claims* paid

Accident Period	Development Period												
	0	1	2	3	4	5	6	7	8	9	10	11	12
1	1059	1998	2120	2176	2282	2456	2478	2494	2495	2513	2515	2516	2520
2	4543	10471	10587	10804	10818	10906	10912	10923	10925	10929	10934	10934	10796
3	12385	19042	19357	19718	19876	19978	19993	20005	20008	20008	20008	20051	20085
4	13280	19046	19208	19343	19377	19404	19429	19466	19470	19471	19643	19673	19693
5	7783	12723	12999	13147	13161	13181	13195	13212	13213	13260	13374	13393	13407
6	8151	13373	13552	13758	13774	14035	14049	14059	14064	14118	14245	14266	14281
7	8082	14416	14528	14699	14860	15022	15033	15036	15042	15101	15239	15262	15278
8	11658	22394	22410	22448	22506	22830	22834	22840	22849	22942	23157	23193	23219
9	13556	24848	25377	25474	25495	25502	25504	25509	25518	25615	25845	25884	25911
10	9110	19786	19946	20056	20058	20064	20067	20071	20079	20158	20342	20373	20395
11	5719	10763	11364	11378	11379	11383	11386	11389	11393	11441	11551	11569	11582
12	5364	14314	14138	14156	14157	14163	14166	14170	14176	14237	14374	14397	14413
13	6977	9157	9091	9107	9109	8886	8779	8782	8786	8829	8922	8938	8949

Table 11 Cumulative estimates of reported claims (*claims incurred*)

Accident Period	Development Period												
	0	1	2	3	4	5	6	7	8	9	10	11	12
1	1059	2798	3020	3074	3076	3102	3134	3157	3158	3264	3438	3460	3465
2	4543	10471	10553	10635	10649	10674	10675	10681	10682	10773	10891	10893	10909
3	24271	31651	32059	32130	32146	32149	32162	32163	32198	32322	32469	32469	32508
4	31303	34068	32488	32491	32491	32518	32492	32492	32493	32493	32503	32510	32565
5	19245	21333	20781	20781	20781	20761	20761	20761	20761	20783	20790	20795	20831
6	20761	22634	21703	21709	21692	21692	21692	21692	21696	21711	21717	21721	21758
7	19339	22530	22611	22540	22540	22540	22540	22572	22575	22589	22594	22599	22636
8	26259	35403	36067	36076	36080	36080	36117	36163	36169	36183	36192	36199	36257
9	28608	40348	39932	39939	39942	40437	40493	40554	40562	40590	40602	40610	40679
10	20699	31206	20055	20166	20262	20482	20507	20536	20539	20551	20556	20560	20595
11	12414	17143	15583	15675	15722	15845	15859	15877	15880	15884	15888	15891	15916
12	11814	15886	16140	16233	16277	16394	16407	16425	16428	16432	16435	16438	16464
13	15043	27526	27671	27742	27708	27741	27036	27054	23804	23797	23800	23803	21361

Table 12 *Ultimate Claim Incurred and Claim Paid*

Accident Period	Ultimate Claim Incurred	Ultimate Claim Paid	Gap
1	-	-	-
2	16.22	(138.32)	154.54
3	38.39	76.59	(38.21)
4	71.09	222.57	(151.48)
5	69.76	193.51	(123.74)
6	65.83	222.48	(156.65)
7	96.38	245.50	(149.12)
8	177.26	388.39	(211.14)
9	737.38	415.75	321.63
10	428.56	338.73	89.82
11	333.03	218.13	114.90
12	578.10	99.08	479.02
13	6.317.95	1.971.70	4.346.24
Total	**8.929.95**	**4.254.13**	**4.675.82**

Table 12 shows the results of the calculation of the *ultimate claim incurred* and *claim paid* using the *chain ladder* method. The result is that there is a difference of Rp4,675.82 million between the projected claims reported and the claims paid. The gap generated by the *munich chain ladder* is smaller than the calculation results with the *chain ladder* method.

Mean Absolute Percentage Error (MAPE)

To find out the extent of the results of the estimation of claims paid and those that occur, it is necessary to know the MAPE value.

Claim Paid - Chain Ladder

Periode	Total Cadangan Klaim aktual	Total Cadangan Klaim estimasi	$\left[(y-\hat{y})/y\right]$	Nilai MAPE (%)
1	1.059	2.520	0.58	57.99
2	4.543	10.948	0.59	58.50
3	12.385	20.039	0.38	38.20
4	13.280	19.510	0.32	31.93
5	7.783	13.265	0.41	41.33
6	8.151	14.117	0.42	42.26
7	8.082	15.124	0.47	46.56
8	11.658	23.017	0.49	49.35
9	13.556	26.142	0.48	48.15
10	9.110	20.740	0.56	56.08
11	5.719	11.894	0.52	51.92
12	5.364	15.290	0.65	64.92
13	6.977	14.098	0.51	50.51
Akumulasi MAPE				**49.05**

Claim Incurred - Chain Ladder

Periode	Total Cadangan Klaim aktual	Total Cadangan Klaim estimasi	$\left[(y-\hat{y})/y\right]$	Nilai MAPE (%)
1	1.059	3.465	0.69	69.45
2	4.543	10.910	0.58	58.36
3	24.271	32.628	0.26	25.61
4	31.303	33.402	0.06	6.28
5	19.245	21.586	0.11	10.85
6	20.761	22.562	0.08	7.98
7	19.339	23.474	0.18	17.61
8	26.259	37.629	0.30	30.22
9	28.608	41.712	0.31	31.42
10	20.699	31.509	0.34	34.31
11	12.414	17.895	0.31	30.63
12	11.814	20.754	0.43	43.08
13	15.043	23.594	0.36	36.24
Akumulasi MAPE				**30.93**

Claim Paid - Munich Chain Ladder

Periode	Total Cadangan Klaim aktual	Total Cadangan Klaim estimasi		Nilai MAPE (%)
1	1.059	2.520	0.58	57.99
2	4.543	10.796	0.58	57.92
3	12.385	20.085	0.38	38.33
4	13.280	19.693	0.33	32.57
5	7.783	13.407	0.42	41.95
6	8.151	14.281	0.43	42.92
7	8.082	15.278	0.47	47.10
8	11.658	23.219	0.50	49.79
9	13.556	25.911	0.48	47.68
10	9.110	20.395	0.55	55.33
11	5.719	11.582	0.51	50.62
12	5.364	14.413	0.63	62.78
13	6.977	8.949	0.22	22.03
Akumulasi MAPE				**46.69**

Claim Incurred - Munich Chain Ladder

Periode	Total Cadangan Klaim aktual	Total Cadangan Klaim estimasi	$\left[(y-\hat{y})/y\right]$	Nilai MAPE (%)
1	1.059	3.465	0.69	69.45
2	4.543	10.909	0.00	0.08
3	24.271	32.508	0.01	0.70
4	31.303	32.565	0.02	1.62
5	19.245	20.831	0.02	2.00
6	20.761	21.758	0.02	2.03
7	19.339	22.636	0.02	2.03
8	26.259	36.257	0.02	1.99
9	28.608	40.679	0.01	0.58
10	20.699	20.595	0.01	0.69
11	12.414	15.916	0.22	22.00
12	11.814	16.464	0.28	28.25
13	15.043	21.361	0.30	29.58
Akumulasi MAPE				**12.38**

In the table above, we can know the MAPE value for each method. If previously the MAPE value of the value of claims paid between the *chain ladder* and the *munich chain ladder* did not have a significant difference, it was different from the results of the MAPE on the value of claims reported. The *chain ladder* method shows the results of 29.04% and the munich *chain ladder* 12.39%, although in numbers both methods are still included in the good projection category, the *munich chain ladder* method shows that the calculations carried out get much better results.

Based on the calculation of the MAPE value, the *munich chain ladder* method has a small MAPE value compared to the *chain ladder method*, meaning that the *munich chain ladder method is* better than the *chain ladder* method from the results of the MAPE value obtained.

CONCLUSION

Based on the results of the analysis and discussion that has been carried out, several conclusions can be drawn that the use of the *munich chain ladder method* with the intention of minimizing the distance between the forecast of claim reserves for losses incurred and losses that have been paid results in the *chain ladder* method showing the estimated value of claim reserves for losses paid of Rp10,430.00 million and Rp 18,606.25 million for reported claims. While the *munich chain ladder* method obtained an estimated claim reserve value for losses paid of Rp8,929.95 million and Rp4,675.82 million for claims reported.

The calculation results show that the gap between the projection results of the estimated claims paid and the claims reported, the *munich chain ladder* method produces a smaller gap, meaning that it is better when compared to the *chain ladder* method. Based on the MAPE calculation, namely looking at the total reserve value and the total MAPE value of the two different methods, it can be concluded that the *munich chain ladder* method can be used for estimating claim reserves.

Thus the *munich chain ladder* method can be used as a useful tool for insurance company management to improve the accuracy of claims reserve estimates, it can also help Management in decision making, building investor confidence, regulatory compliance, and operational efficiency.

Munich chain ladder as an alternative method in calculating claim reserves also has some drawbacks that need to be considered, among others:

1. Data uncertainty**:** This method relies on the accuracy of available claims data. If the claims data is incomplete or inaccurate, the loss projection results will also be inaccurate.
2. Inability to account for trends: This method cannot account for trends in claim frequency or severity, such as changes in market conditions or new technologies.
3. Inability to account for extreme events: This method cannot account for extreme events, such as natural disasters or epidemics, which can cause significant spikes in claims.
4. Reliance on assumptions: This method relies on some assumptions, such as the stability of the pay-incurred ratio. If these assumptions do not hold, the loss projection results will also be inaccurate.

Next are some suggestions or input for the Company or further research:

a) To produce a proper calculation of the Company's operational and financial risks, the Company must build consistent and valid data so that the results of its calculations can have a positive impact and help determine Company policies.
b) Apply this method to other insurance products other than motor vehicle insurance.

It is important to use the Munich Chain Ladder method along with other methods to project insurance losses, such as statistical analysis and actuarial models such as combining with the *Bayesian* approach to complement the *munich chain ladder* method. The Bayesian approach offers several things that can complement the *munich chain ladder* method in estimating insurance claim reserves. These advantages include more complete information about uncertainty, the ability to model missing claims, flexibility, and the ability to account for complex factors. However, data, skill, and interpretation considerations should be taken into account before choosing this approach.

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