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ESTIMATION OF CLAIM RESERVES USING THE CHAIN LADDER METHOD

Abdan Maulana Rohat Yoisangaji [1*], Shelma Maharani Pelu[2], Jofie Wijaya[3]

[1,2] *Master of Actuarial Program, Faculty of Mathematics and Natural Sciences, Institut Teknologi Bandung*
Jln. Ganesha No 10, Bandung 40132, Indonesia
[3]*Master of Science in Actuarial Science, Columbia University*
203 Lewisohn Hall, 2970 Broadway, MC 4119, New York 10027, United States of America
*Corresponding author's e-mail: * abdanmaulana05@gmail.com*

ABSTRACT

One form and effort in dealing with all the risks that might occur in the future is insurance. In managing premiums paid by insurance participants, insurance companies must also consider unexpected claims that may occur in the future. Therefore, a method is needed that can be used by insurance companies to prepare claim reserves for the future. One method that is often used is the Chain Ladder method. This research aims to estimates the size of claim reserves that may occur in 2020 from insurance claim data from 2013 to 2019 released by the National Association of Insurance Commissioners (NAIC) in 2020. The amount of claim reserves in 2020 that must be prepared by the company according to the Chain Ladder method was obtained at USD 1,110,879.

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1. INTRODUCTION

In everyday life, humans are faced with various risks that can cause physical and material losses. Therefore, an effort is needed that can be used to minimize the risks that may occur, one of which is through insurance. According to the Commercial Code paragraph 246 [1], Insurance or coverage is an agreement between two parties, namely, the insurer (*assurandeur*) will compensate the insured if a particular event occurs; otherwise, the insured will pay a premium to the insurer.

The estimation of loss reserves is a fundamental process in the management of insurance companies. It consists of setting a prudent value on claims not yet made on active policies, which will ultimately impact the financial statements and the required capital to continue with the current insurance portfolio [2].

Insurance companies, when paying claims due to claims from policyholders, are often faced with problems in the process of paying or submitting claims, namely delays in claim payments for specific periods [3]. Delays in receiving claim reports from customers and delays in processing claim payments by the company can both lead to delays in the disbursement of payments. To anticipate this, insurance companies need to prepare claim reserves and a certain amount of money to deal with many claims and claim payments in the future [4]. The relationship between time delays and claim payments is referred to as outstanding claims or unsettled claims [5]. There are two types of outstanding claims, namely IBNR (Incurred but Not Reported) and RBNS (Reported but Not Settled) [6].

A Run-off triangle is a collection of many claims data in a triangular matrix. It is arranged based on the claim development and occurrence periods. Run-off triangle data based on data periods can be monthly, quarterly, and annual, depending on the insurance company policy that manages it. In addition, run-off triangle data based on the form of data can be the claims amount or number of claims with either incremental or cumulative data [7].

The literature on the variability of loss reserves starts from a scheme used in practice that allows loss reserves to be obtained as a point value. A very common scheme for calculating the value of reliable mathematical reserves is the chain-ladder (CL) method, or variants of this method, such as the London CL or the Bornhuetter–Ferguson methods [8]. The chain-ladder method has been the subject of adaptations that allow modeling of the variability of reserves stochastically but also with possibility distributions [9]. Practitioners most widely use the chain ladder method to estimate claim reserves. This method is a gold standard because of its everyday use and ease of application [10]. This research aims to estimate many outstanding claim reserves in general insurance using the Chain Ladder method [11].

2. RESEARCH METHODS

2.1 Claim Reserve

Claim reserve is a fund that must be provided by the insurer (Company) which will be used to pay losses suffered by the insured party (customer). A claim hearing is an estimate of the amount of money that must be spent by an insurance company in settling claims that have occurred [12]. There are two types of claims reserves, namely claims reserves in the process of settlement (reported claims) and reserves claims that have occurred but have not been reported (unreported claims). The claims data used to estimate the size of claim reserves in this study is insurance claim data from 2013 to 2019 released by NAIC in 2020 [13].

2.2 Run-off Triangle

Run-off triangle data contains an aggregate picture of claims and provides a summary of a data set of individual claims [14]. The data in the run-off data triangle is usually the number of claims and also the number of claims, both of which are presented in incremental or cumulative form. Suppose, $\boldsymbol{c_{i,j}}$ Declare a random variable in claim size (in incremental form) for claims that occurred in the period of event i and paid in the period of delay j, with $\boldsymbol{1 \leq i \leq n}$ and $\boldsymbol{1 \leq j \leq n}$ [15].

Table 1. **Run-off Triangle and Future Triangle Data in Incremental Form**

Claims Data (USD)		**Development Period (*j*)**						
		1	**2**	**...**	$\boldsymbol{j}$	**...**	$\boldsymbol{n-1}$	$\boldsymbol{n}$
Period of Occurrence (i)	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
	i	$C_{i,1}$	$C_{i,2}$	$\cdots$	$C_{i,j}$	$\cdots$	$C_{i,n-1}$	$C_{i,n}$
	⋮	⋮	⋮	$\cdots$	⋮	$\cdots$	⋮	⋮
	$n-1$	$C_{n-1,1}$	$C_{n-1,2}$	$\cdots$	$C_{n-1,j}$	$\cdots$	$C_{n-1,n-1}$	$C_{n-1,n}$
	n	$C_{n,1}$	$C_{n,2}$	$\cdots$	$C_{n,j}$	$\cdots$	$C_{n,n-1}$	$C_{n,n}$
Claims Data (USD)		**Development Period (*j*)**						
		1	**2**	**...**	$\boldsymbol{j}$	**...**	$\boldsymbol{n-1}$	$\boldsymbol{n}$
Period of Occurrence (i)	1	$C_{1,1}$	$C_{1,2}$	$\cdots$	$C_{1,j}$	$\cdots$	$C_{1,n-1}$	$C_{1,n}$
	2	$C_{2,1}$	$C_{2,2}$	$\cdots$	$C_{2,j}$	$\cdots$	$C_{2,n-1}$	$C_{2,n}$

The "Period of Occurrence" refers to the specific time period during which the claims were incurred. It is usually denoted by i, and it indicates the year or period in which an event happened that led to an insurance claim. The "Development Period" refers to the number of periods (often years) since the occurrence of the claim, during which the claim is developed or reported. It is denoted by j, and it tracks how the claim amount evolves over time as more information becomes available or as the claim matures. For example, $j = 1$ represents the first year after the claim was incurred, $j = 2$ the second year, and so on [16].

Based on Table 1 Run-off triangle incremental data, to form Run-off triangle cumulative can be formed using $C_{i,j}$. In the table above, $C_{1.2}$ is a random variable that states the number of claims that occurred in the first period and were paid in the second period. Therefore, a cumulative Run-off triangle can be formed based on the Run-off triangle of incremental data through the following relationship:

$$\boldsymbol{D_{i,j} = \sum_{k=1}^{j} C_{i,k}} \tag{1}$$

for $\mathbf{1} \leq \boldsymbol{i} \leq \boldsymbol{n}, \mathbf{1} \leq \boldsymbol{j} \leq \boldsymbol{n}$ **and** $\boldsymbol{i} + \boldsymbol{j} \leq \boldsymbol{n} + \mathbf{1}$.

With $\boldsymbol{D_{i,j}}$ is the cumulative claim amount for claims that occurred in the period of the $\boldsymbol{i^{th}}$ event and paid until the period of the $\boldsymbol{j^{th}}$ delay.

Table 2. **Run-off Triangle and Future Triangle Data in Cumulative Form**

Claims Data (USD)		**Development Period (*j*)**						
		1	**2**	**...**	$\boldsymbol{j}$	**...**	$\boldsymbol{n-1}$	$\boldsymbol{n}$
Period of Occurrence (i)	1	D	$D_{1,2}$	$\cdots$	$D_{1,j}$	$\cdots$	$D_{1,n-1}$	$D_{1,n}$
	2	$D_{2,1}$	$D_{2,2}$	$\cdots$	$D_{2,j}$	$\cdots$	$D_{2,n-1}$	$D_{2,n}$
	⋮	⋮	⋮	$\cdots$	⋮	$\cdots$	⋮	⋮
	i	$D_{i,1}$	$D_{i,2}$	$\cdots$	$D_{i,j}$	$\cdots$	$D_{i,n-1}$	$D_{i,n}$
	⋮	⋮	⋮	$\cdots$	⋮	$\cdots$	⋮	⋮
	$n-1$	$D_{n-1,1}$	$D_{n-1,2}$	$\cdots$	$D_{n-1,j}$	$\cdots$	$D_{n-1,n-1}$	$D_{n-1,n}$
	n	$D_{n,1}$	$D_{n,2}$	$\cdots$	$D_{n,j}$	$\cdots$	$D_{n,n-1}$	$D_{n,n}$

Table 2 form the development of triangular claims. The one specified on the vertical axis is called the event period and the horizontal axis is called the delay period. Claim development is divided into two parts, namely the upper triangle and the lower triangle. The upper segment contains the projected value of claims paid, while the lower triangle contains the value of claims that must be paid in the future.

2.3. Chain Ladder Method

The Chain Ladder method is one of the methods used to find reserves claim. The Chain Ladder method has several stages, namely forming a cumulative run-off triangle where to find out the amount to be paid in the postponement period [17]. Suppose $\boldsymbol{D_{i,j}}$ is the cumulative claim amount that occurred in the period of the

$\boldsymbol{i^{th}}$ event and paid in the $\boldsymbol{j^{th}}$ delay period with $\boldsymbol{i, j} \in \{\boldsymbol{1, 2, 3, \dots, n}\}$. Estimated claim reserves for future periods in the run-off triangle are defined as delay factors $(\widehat{\boldsymbol{\lambda}}_{\boldsymbol{j}})$ which uses the following equation **[18]:**

$$\hat{\boldsymbol{\lambda}}_{\boldsymbol{j}} = \frac{\sum_{i=1}^{n-j} \boldsymbol{D}_{\boldsymbol{i,j+1}}}{\sum_{i=1}^{n-j} \boldsymbol{D}_{\boldsymbol{i,j}}} \ \textbf{for } \boldsymbol{1 \le j \le n-1} \tag{2}$$

From the equation of development factors, it is used to see the total claims obtained from the lower cumulative run-off triangle to the j^{th} development period. Therefore, to get the estimated results can be explained based on the following equation [18]:

$$\widehat{\boldsymbol{D}}_{\boldsymbol{i,j}} = \widehat{\boldsymbol{D}}_{\boldsymbol{i,j-1}} \hat{\boldsymbol{\lambda}}_{\boldsymbol{j-1}} \tag{3}$$

With $\widehat{D}_{i,j}$ can represent the total cumulative claim reserve payment reported in the i^{th} year. The total value of claims up to the j^{th} development period is used to estimate claim reserves for the i^{th} event period for: $2 \le i \le n$. The estimated claim reserve can be calculated using [18]:

$$\widehat{\boldsymbol{R}}_{\boldsymbol{i}} = \widehat{\boldsymbol{D}}_{\boldsymbol{i,j}} - \widehat{\boldsymbol{D}}_{\boldsymbol{i,n-i+1}} \tag{4}$$

With $\hat{R}_i$ is the estimated value of the claim reserve obtained per event. After obtaining a per-event claim reserve estimate, the next stage, namely the final stage of this method, is to calculate the total final claim reserve which can use the following equation [18]:

$$\boldsymbol{R}^* = \sum_{\boldsymbol{i=1}}^{\boldsymbol{I}} \widehat{\boldsymbol{R}}_{\boldsymbol{i}} \tag{5}$$

The type of research in this study is a case study using the Chain Ladder method to estimate the amount of outstanding claims reserves in general insurance with secondary data sources from the National Association of Insurance Commissioners.

3. RESULTS AND DISCUSSION

Based on the data obtained from the National of Insurance Commissioners (NAIC), the accumulated claims that occurred in the period 2010 to 2019 (in USD) are as follows:

Table 3. Run-off Triangle and Future Triangle Data in Incremental form

Claim Data (USD)		Development Period									
		1	2	3	4	5	6	7	8	9	10
Period of Occurrence	2010	4,824,018	919,739	68,180	33,571	35,711	17,382	6,350	5,910	6,231	13,099
	2011	6,399,906	1,016,613	84,225	56,012	34,551	4,320	624	6,606	4,098	
	2012	5,060,717	1,070,206	98,024	64,077	5,455	4,989	36	2,436		
	2013	3,847,217	729,180	90,165	16,390	5,686	7,276	1,647			
	2014	4,132,835	799,247	61,709	25,107	11,436	4,542				
	2015	3,861,168	820,468	73,971	26,411	11,139					
	2016	4,207,734	851,089	85,724	19,858						
	2017	4,848,869	1,136,409	128,773							
	2018	4,467,030	1,041,322								
	2019	4,119,658									

Table 3 presents the claim data in the form of a run-off triangle and future triangle in incremental format for claim periods from 2010 to 2019. This table displays the claims data that occurred during the development period of up to 10 years, allowing the observation of how claims develop over time.

Each row in the table represents a specific claim year (the period of occurrence), and the columns show the accumulated claim amounts in the following years (development periods). For example, for claims that occurred in 2010, was claimed in the first year, then \$919,739 in the second year, and so on up to the tenth year.

This table is commonly used in insurance to project future liabilities and calculate the necessary claim reserves to cover the claims that are still developing from previous claim periods. Each number in the table represents the additional claims that occurred in that year compared to the previous year, allowing analysis of how claims evolve over time. The data are presented in **Table 3** is the data that will be used to estimate claim reserves.

3.1 Calculate Cumulative Run-off Triangle Data

To get the value of the cumulative run-off triangle used **Equation (1)** with the following calculation:

$$D_{1,2} = C_{1,1} + C_{1,2} = \text{USD } 4{,}824{,}018 + \text{USD } 919{,}739 = \text{USD } 5{,}743{,}757$$
$$D_{1,3} = C_{1,2} + C_{1,3} = \text{USD } 5{,}743{,}757 + \text{USD } 68{,}180 = \text{USD } 5{,}811{,}937$$
$$D_{1,4} = C_{1,3} + C_{1,4} = \text{USD } 5{,}811{,}937 + \text{USD } 33{,}571 = \text{USD } 5{,}845{,}508$$

Based on the calculation above, the results for the cumulative run-off triangle are more complete as follows:

Table 4. Run-off Data Triangle Accumulates Many Claims

Claim Data (USD)	Development Period									
Period of Occurrence	1	2	3	4	5	6	7	8	9	10
2010	4,824,018	5,743,757	5,811,937	5,845,508	5,881,219	5,898,601	5,904,951	5,899,041	5,892,810	5,879,711
2011	6,399,906	7,410,519	7,494,744	7,550,756	7,585,307	7,589,627	7,590,251	7,583,645	7,579,547	
2012	5,060,717	6,130,923	6,228,947	6,293,024	6,298,479	6,303,468	6,303,504	6,305,940		
2013	3,847,217	4,576,397	4,666,562	4,682,952	4,688,638	4,695,914	4,694,267			
2014	4,132,835	4,932,082	4,993,791	5,018,898	5,030,334	5,025,792				
2015	3,861,168	4,681,636	4,755,608	4,782,019	4,793,158					
2016	4,207,734	5,058,823	5,144,547	5,164,405						
2017	4,848,869	5,985,278	6,114,051							
2018	4,467,030	5,508,352								
2019	4,119,658									

3.2 Calculating Claim Development Factors

The average ratio of claim progression factors will be calculated using **Equation (2)** with reference to the magnitude of the claim. In the Chain Ladder method, the average used is the weighted average as follows:

$$\hat{\lambda}_j = \frac{\sum_{i=1}^{n-j} D_{i,j+1}}{\sum_{i=1}^{n-j} D_{i,j}} \text{ for } 1 \le j \le n-1$$

For example, the ratio of claim development factor for the first development period will be calculated as follows:

$$\hat{\lambda}_1 = \frac{D_{1,2} + D_{2,2} + D_{3,2} + \cdots + D_{9,2}}{D_{1,1} + D_{2,1} + D_{3,1} + \cdots + D_{9,1}}$$

$$= \frac{5743757 + 7410519 + 6130923 + 4576397 + 4932082 + 4681636 + 5058823 + 5985278 + 5508352}{4824018 + 6399906 + 5060717 + 3847217 + 4132835 + 3861168 + 4207734 + 4848869 + 4467030}$$
$$= 1.201161$$

Obtained $\widehat{\lambda_1} = 1.201161$

The ratio of claim development factor for the second development period is:

$$\hat{\lambda}_2 = \frac{D_{1,3} + D_{2,3} + D_{3,3} + \cdots + D_{8,3}}{D_{1,2} + D_{2,2} + D_{3,2} + \cdots + D_{8,2}}$$

$$= \frac{5811937 + 7494744 + 6228947 + 4666562 + 4993791 + 4755608 + 5144547 + 6114051}{5743757 + 7410519 + 6130923 + 4576397 + 4932082 + 4681636 + 5058823 + 5985278}$$
$$= 1.015516$$

Obtained $\widehat{\lambda_2} = 1.015516$

The ratio of claim development factor for the third development period is:

$$\hat{\lambda}_3 = \frac{D_{1,4} + D_{2,4} + D_{3,4} + \ldots + D_{7,4}}{D_{1,3} + D_{2,3} + D_{3,3} + \ldots + D_{7,3}}$$

$$= \frac{5845508 + 7550756 + 6293024 + 4682952 + 5018898 + 4782019 + 5164405}{5811937 + 7494744 + 6228947 + 4666562 + 4993791 + 4755608 + 5144547}$$

$$= 1.006175$$

Obtained $\widehat{\lambda_3} = 1.006175$

The ratio of claim development factor for the fourth development period is:

$$\hat{\lambda}_4 = \frac{D_{1,5} + D_{2,5} + D_{3,5} + \ldots + D_{6,5}}{D_{1,4} + D_{2,4} + D_{3,4} + \ldots + D_{6,4}}$$

$$= \frac{5881219 + 7585307 + 6298479 + 4688638 + 5030334 + 4793158}{5845508 + 7550756 + 6293024 + 4682952 + 5018898 + 4782019}$$

$$= 1.003043$$

Obtained $\widehat{\lambda_4} = 1.003043$

The ratio of claim development factor for the fifth development period is:

$$\hat{\lambda}_5 = \frac{D_{1,6} + D_{2,6} + D_{3,6} + D_{4,6} + D_{5,6}}{D_{1,5} + D_{2,5} + D_{3,5} + D_{4,5} + D_{5,5}}$$

$$= \frac{5898601 + 7589627 + 6303468 + 4695914 + 5025792}{5881219 + 7585307 + 6298479 + 4688638 + 5030334}$$

$$= 1.000998$$

Obtained $\widehat{\lambda_5} = 1.000998$

The calculation of the ratio of developmental factors is carried out in the same way so as to obtain the value of the developmental factor for the 10^{th} period of development. So that the ratio of development factors is obtained as follows:

Table 5. Claim Development Factor Ratio

Development Period	Development Ratio
1	1.201161
2	1.015516
3	1.006175
4	1.003043
5	1.000998
6	1.000219
7	0.999491
8	0.999234
9	0.997777
10	1.000000

3.3 Calculating Total Claim Estimation and Ultimate Claim Determination

Next, the total claim estimation and determination of the ultimate claim will be calculated from the data in **Table 3** namely the run-off triangle data accumulated many claims, which will then be multiplied by the data in **Table 4**, namely the claim development factor ratio data with **Equation (3)** as follows:

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

For example, we will calculate the estimated total claims for the 1^{st} development period so that it will produce the following estimated total claims for the 2^{nd} and 3^{rd} development periods:

2^{nd} *development period*

$$\widehat{D}_{10,2} = \text{USD } 4.119.658 \times 1{,}201161 = \text{USD } 4.948.374$$

3^{rd} *development Period*

$$\widehat{D}_{10,3} = \text{USD } 4.948.374 \times 1{,}015516 = \text{USD } 5.025.154$$

And so, on is done in the same way, so that the estimated total claim and *ultimate* claim are obtained as follows:

Table 6. Estimated Total Claims and *Ultimate* Claims

Claim Data (USD)		Development Period				
		1	2	3	4	5
Period of Occurrence	**2010**	4,824,018	5,743,757	5,811,937	5,845,508	5,881,219
	2011	6,399,906	7,410,519	7,494,744	7,550,756	7,585,307
	2012	5,060,717	6,130,923	6,228,947	6,293,024	6,298,479
	2013	3,847,217	4,576,397	4,666,562	4,682,952	4,688,638
	2014	4,132,835	4,932,082	4,993,791	5,018,898	5,030,334
	2015	3,861,168	4,681,636	4,755,608	4,782,019	4,793,158
	2016	4,207,734	5,058,823	5,144,547	5,164,405	5,180,119
	2017	4,848,869	5,985,278	6,114,051	6,151,806	6,170,524
	2018	4,467,030	5,508,352	5,593,821	5,628,364	5,645,489
	2019	4,119,658	4.984,374	5,025,154	5,056,186	5,071,570

Claim Data (USD)		Development Period				
		6	7	8	9	10
Period of Occurrence	**2010**	5,898,601	5,904,951	5,899,041	5,892,810	5,879,711
	2011	7,589,627	7,590,251	7,583,645	7,579,547	7,562,699
	2012	6,303,468	6,303,504	6,305,940	6,301,109	6,287,102
	2013	4,695,914	4,694,267	4,692,877	4,688,283	4,677,861
	2014	5,025,792	5,026,893	5,024,333	5,020,484	5,009,324
	2015	4,797,942	4,798,992	4,796,549	4,792,874	4,782,220
	2016	5,185,288	5,186,424	5,183,783	5,179,812	5,168,298
	2017	6,176,683	6,178,035	6,174,890	6,170,159	6,156,444
	2018	5,651,123	5,652,361	5,649,483	5,645,155	5,632,606
	2019	5,076,631	5,077,743	5,075,158	5,071,270	5,059,997

With *ultimate* claims are many claims in the 10^{th} development period for all years in **Table 6.**

3.4 Estimating Outstanding Claim Reserves for Each Event Period.

Estimating outstanding claim reserves for each event period can use equation (4) as follows:

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

For example, the claim reserves for 2016 and 2017 will be calculated as follows:

$$\hat{R}_7 = \widehat{D}_{7,10} - \widehat{D}_{7,4}$$
$$\hat{R}_7 = \text{USD } 5.168.298 - \text{USD } 5.164.405 = \text{USD } 3.893$$

And so on in the same way. Please be aware that when the proposed claim is of negative value, then the proposed claim will be considered zero, until the total proposal of the outstanding claim is obtained as follows:

Table 7. Outstanding Claim Reserves

Period (Year) of Claim Event	Accumulated Many Claims	Ultimate Claims	Claim Reserves
(1)	**(2)**	**(3)**	$(4) = (3) - (2)$
2010	USD 5,879,711	USD 5,879,711	0
2011	USD 7,579,547	USD 7,562,699	0
2012	USD 6,305,940	USD 6,287,102	0
2013	USD 4,694,267	USD 4,677,861	0
2014	USD 5,025,792	USD 5,009,324	0
2015	USD 4,793,158	USD 4,782,220	0
2016	USD 5,164,405	USD 5,168,298	USD 3,893
2017	USD 6,114,051	USD 6,156,444	USD 42,393
2018	USD 5,508,352	USD 5,632,606	USD 124,254
2019	USD 4,119,658	USD 5,059,997	USD 940,339
	Total Claim Reserves		USD 1,110,879

Thus, the claim reserve result was obtained at USD 1,110,879. Based on the calculation of estimated claim reserves, the results obtained mean that the claim reserves that must be provided by related insurance companies are USD 1,110,879 in 2020. In addition, these results serve as a benchmark for the cost budget of related insurance companies in determining claim reserves in the 2020 financial statements. These results indicates that the results of a particular analysis serve as a benchmark for insurance companies when budgeting for claim reserves in their 2020 financial statements. These results guide the companies in determining the appropriate number of reserves needed to cover potential future claims. Essentially, it ensures that the financial provisions made are adequate and aligned with industry standards. The results of the estimate only apply to insurance companies that own the related data studied in this study. This is because each insurance company has different claim data so that the estimated claim reserves produced are certainly different.

4. CONCLUSIONS

Based on claim data issued by the National Association of Insurance Commissioners (NAIC), the amount of claim reserves in 2019 was USD 940,339 and the amount of claim reserves that must be prepared by insurance companies to anticipate claims that may occur in 2020 is USD 1,110,879

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