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Optimization of Retention Levels Using the Pentikäinen Method: A Case Study on Unit-Linked Insurance Product

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ABSTRACT

This study evaluates the adequacy of surplus reinsurance retention for unit-linked insurance products in Indonesia under changing market and regulatory conditions. Using 2024 portfolio statistics of Insurance X, the study applies the Pentikäinen method, which is grounded in ruin theory, to determine model-based retention levels and compare them with the company's actual retention policy. The analysis incorporates premium income, claim experience, reserve considerations, and security loading assumptions. The results show that the company's actual retention of IDR 500,000,000 is higher than the retention levels generated by the Pentikäinen model, namely IDR 275,000,000 at 0% loading, IDR 305,000,000 at 10% loading, and IDR 335,000,000 at 20% loading. Simulation results further indicate that lower retention reduces the insurer's net retained claims and improves financial stability, as reflected in a decline in the loss ratio from 6.75% under the actual retention to 6.12%, 5.95%, and 5.74%, respectively. However, lower retention also increases reinsurance premium cessions, implying a trade-off between risk reduction and cost efficiency. The findings suggest that the retention range of IDR 305,000,000 to IDR 335,000,000 provides a more balanced outcome than both the current retention and the lowest simulated retention. This study contributes to the literature by providing an empirical application of the Pentikäinen method in surplus reinsurance for unit-linked products in Indonesia and offers a more objective basis for retention policy adjustment.

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1. INTRODUCTION

In recent years, Indonesia's life insurance market has experienced a structural shift in unit-linked business performance, accompanied by tighter governance and product oversight. This transition has altered insurers' risk profiles and challenged the adequacy of existing reinsurance retention policies. According to data from the Indonesia Financial Services Authority (OJK), as of September 2024, unit-linked premiums contributed only 27.3%, or approximately IDR 37.21 trillion, a drastic decrease compared to 2021, when they contributed 62.9%, or IDR 127.7 trillion [1]. This downward trend marks a structural shift in the Indonesian life insurance industry, which previously relied heavily on unit-linked products as the primary contributor to premium income. This decline reflects a shift within the life insurance industry, which in turn affects companies risk management strategies.

This sharp decline did not occur suddenly, but rather resulted from the impact of two major regulations issued by the OJK Circular Letter (SEOJK) No. 5/2022, which regulates the marketing and transparency of PAYDI products, and POJK No. 22/2023, which regulates insurance company governance [2],[3]. These two policies were issued to strengthen consumer protection following a surge in misselling cases and disputes related to unit-linked products. These regulations require companies to implement more transparent, documented, and tailored sales processes to customer risk profiles, including the requirement to maintain records during the offering process. While well-intentioned, these regulations also increase operational complexity and restrict the flexibility of salespeople, ultimately leading to a decline in product sales.

For life insurance companies, the decline in revenue from unit-linked products has forced a restructuring of their risk management strategies. While unit-linked products previously provided ample scope for companies to generate revenue from fund management fees, acquisitions, and investment features, with the decline in demand, companies must now be more careful in managing liquidity, investment assets, and reserve composition. Companies are shifting their focus to traditional products such as whole-life and endowment funds, which offer income stability but carry higher risks in terms of long-term liabilities. The Financial Services Authority (OJK) and the Indonesian Financial Services Authority (AAJI) report show that in the second half of 2024, premiums for traditional products actually increased by 18.6% year-on-year (YoY), indicating a product portfolio substitution [3].

Under these conditions, risk management strategies become critically important. The greater the benefits offered, the higher the risks that must be managed. If submitted claims exceed capacity and are not adequately anticipated, a company's financial condition could be jeopardized, potentially leading to a failure to meet its obligations. Generally, insurance companies utilize risk transfer mechanisms to reinsurance companies. In short, reinsurance is essentially protection for insurance companies, allowing them to cede a portion of the risks they bear [4]. Besides functioning as a risk transfer mechanism, reinsurance also helps to spread risks, so they are not concentrated within a single company. This assists companies in maintaining financial stability and fulfilling their obligations to policyholders.

In practice, for commercial reasons, insurance companies often purchase more or less reinsurance protection than they need, resulting in over or under-protection that impacts the company's financial stability [5]. Therefore, determining the risk limit that will remain the responsibility of the insurance company before being transferred to a reinsurance company is an essential aspect. This risk limit, which is the responsibility of the insurance company, is known as retention. In several cases, the retention limits set by insurance companies are often determined by underwriters based on their knowledge, experience, and judgment, without considering probabilistic analysis and mathematical approaches [5].

The setting of the retention level is directly related to a company's risk management and financial stability. Insurance companies are required to implement their own retention for every risk managed. Determining retention in reinsurance is a crucial aspect of maintaining a balance between the insurance company's profitability and protection against risk. In Indonesia, the amount of retention has limits as regulated in SEOJK Number 31/SEOJK.05/2015. For life insurance, the minimum limit for retention is IDR 150 million, and the maximum limit is 10% of the company's own capital [6].

One of life insurances in Indonesia, Insurance X, has set a retention policy of IDR 500,000,000, with a limit of 10 lines above the retention, for unit-linked insurance products based on an agreement between Insurance X, Reinsurance ABC, and Reinsurance KLM. The form of reinsurance used in this collaboration is proportional surplus reinsurance, a mechanism where the insurance company and reinsurance company share risks and premiums proportionally. In this scheme, the insurance company bears the risk up to the determined retention limit, and the excess is ceded to the reinsurer. The excess ceded to the reinsurer is also proportionally shared, where Reinsurance ABC, as the pool leader, bears 60% of the excess claims above retention, and the remaining is borne by Reinsurance KLM as a pool member. However, this retention determination needs to be re-adjusted to current market conditions, such as fluctuations in claim numbers, reserve amounts, and premium income. In an effort to respond to industry developments, company finances, and current economic conditions, Insurance X and Reinsurance ABC need to review the established retention. The retention setting must be able to balance the number of claims with the company's financial stability. Generally, there are four common methods for evaluating previously set retentions: Ratio Method, Office Projection Model, Rosenthal's Approximation, and Pentikäinen's Method [7].

The urgency of this study lies in the financial consequences of retention miscalibration. If retention remains too high, insurers face greater claim volatility, heavier net claim burdens, and higher pressure on reserves and solvency. Conversely, if retention is set too low, excessive risk cession increases reinsurance costs and weakens underwriting profitability. Therefore, failing to recalibrate retention in response to market and regulatory change may reduce both financial resilience and operational efficiency.

Ruin theory is a branch of actuarial science that focuses on the probabilistic analysis of the likelihood of financial failure (ruin) of an insurance company. This failure is generally defined as a situation where the total claims paid exceed the total assets or reserves available, rendering the company unable to meet its financial obligations to policyholders [8]. The ruin probability is the probability that reserves U(t) become negative at any given time. This basic model is known as the Cramér-Lundberg model, which assumes that claims occur randomly following a Poisson process and that claim sizes follow a specific distribution, such as exponential or gamma [9]. In practice, ruin theory is used to evaluate a company's initial capital adequacy, determine safe premium levels, design optimal retention and reinsurance structures, and assess a company's financial resilience to extreme loss events. Although developed within a theoretical framework, ruin theory has been widely adopted in insurance industry practice as a basis for solvency assessment and risk management. Methods such as the Pentikäinen model use principles from ruin theory to evaluate retention structures in reinsurance contracts with a more quantitative and data-driven approach [10].

The Pentikäinen Method is highly relevant in the context of surplus reinsurance because it allows insurance companies to estimate retention more objectively based on a statistical approach [11],[12],[13]. By utilizing concepts from ruin theory, this method helps to determine the retention level by considering claim variability, premium income, reserve size, and the security loading factor. This is important to ensure that insurance companies do not set retention too high, which could jeopardize their financial condition, or too low, which could reduce profits due to large reinsurance premium burdens.

The Pentikäinen method has been widely used in the international literature for reserve and retention analysis, but there are limited empirical studies examining its application to surplus reinsurance practices in emerging markets, including Indonesia [14][15]. This is despite the fact that insurance markets in emerging markets tend to face higher claims volatility and data limitations, necessitating an adaptive and precise quantitative approach. Many insurance companies still set retention rates and reinsurance structures subjectively, based on historical experience or internal policies, without considering systematic risk simulations based on ruin theory. This leaves a gap between theoretical statistical approaches and actual managerial practices in the insurance industry.

Most literature uses ruin theory for proportional retention or excess-of-loss, but not many have specifically explored the application of Pentikäinen in surplus reinsurance schemes, which have different characteristics, especially in the influence of variability in sum insured on the distribution of claims between the ceding company and the reinsurer. This research offers a novel contribution by adapting and reformulating the Pentikäinen Method specifically for surplus reinsurance schemes, taking into account policy risk characteristics and variable retention charges. This has not been formally explored in the academic literature. By incorporating actual data from the Indonesian insurance market, this research provides practical value in the form of model parameterization that aligns with the local market structure, making it more applicable and relevant for industry players and national regulators. This approach enables the creation of a more objective, systematic, and transparent retention determination system, which insurance companies can use as a basis for developing data-driven risk management strategies and reinsurance structures.

2. RESEARCH METHOD

This study employed the Pentikäinen method to evaluate retention settings. The research was systematically conducted through the following stages:

a. Data Analysis
The initial phase of this study involved a comprehensive data analysis, commencing with the determination of the data distribution. The spread of each variable was meticulously examined using QQ plots, and the p-values for each dataset were assessed with the statistical software namely RStudio. This foundational step was essential for accurately calculating the expected values across all datasets.

b. Retention Calculations Using the Pentikäinen Method
In this study, the Pentikäinen method is applied in the context of surplus reinsurance for unit-linked products. The method is operationalized by estimating the relevant portfolio parameters from 2024 data, including premium income, number of claims, claim severity, and reserve amount, and then calculating retention under alternative security loading assumptions. The resulting retention values are subsequently compared with the company's actual retention policy.

Ruin theory analyzes the probability that an insurance company's reserves will become negative over a period of time due to accumulated claims exceeding premium income. This model is crucial for determining retention and reinsurance structures, as well as planning minimum reserve capital.

The risk reserve at time t is formally defined as follows [16].

$$U(t) = u + K(t) + \lambda m - X(t) \quad (1)$$

Where
u = Risk reserve at time t, t = 0
K(t) = Expected amount of claims or net risk premium
λ = Security loading factor
m = Expected number of claims
X(t) = Aggregate claims amount, a random variable

Pentikäinen developed a practical approach to applying ruin theory to the evaluation of retention and reinsurance strategies, premium adequacy measurement, and solvency control.

He proposed stochastic models that estimate the probability of ruin based on the frequency and severity of claims, and analyzed the influence of parameters such as retention levels, initial capital, and reinsurance costs [10].

For diverse types of insurance portfolios, Pentikäinen mapped the logarithm of the ratio of the retention limit to the average number of claims, M/p1, against the logarithm of j [16].

$$j = \frac{u' + \lambda m}{[p1.K'(1)]^{\frac{1}{2}}} \quad (2)$$

M = Retention limit
u' = Risk reserve as of January 1st
K'(1) = Expected amount of claims
λ = Security loading factor
m = Expected number of claims

Pentikäinen observed that the values established for the ruin probability across various portfolios exhibit proximity for $\frac{M}{p1}$ values up to 50. Assuming a 1% ruin probability within a single year, a linear curve was identified,

$$\log j = \frac{1}{2}\left[\log\left(\frac{M}{p1}\right) + \log 1.9\right] = \log 1,9\left(\frac{M}{p1}\right)^{1/2} \quad (3)$$

This formula can be expressed more concisely as:

$$M = \frac{(u' + \lambda m)^2}{4K'(1)} \quad (4)$$

3. RESULT AND DISCUSSION

3.1. Data Analysis Premium Data

Premium data plays a vital role in determining the optimal retention level using the Pentikäinen method. This dataset includes the number of active policies and the corresponding annual premium income. Both variables are essential for calculating security loading, one of the main components in the Pentikäinen formula.

The analysis uses 2021-2024 portfolio-level unit-linked data obtained from the company's internal underwriting and reinsurance records. The dataset was extracted from reconciled underwriting and reinsurance records used for internal reporting/audit purposes. Due to confidentiality and reporting constraints, micro-level transaction data were not available for all variables and the observation period was limited; this was addressed by parameter estimation using portfolio-level descriptive statistics and cross-checking totals across premium, claims, reserve, and sum assured summaries. Data quality was assessed through consistency checks across premium, claims, reserve, and policy-count summaries. Expected values used in the Pentikäinen calculation were estimated from observed portfolio statistics and were treated as actuarial input parameters rather than direct replacements for raw micro-level data. Because the study relies on aggregated one-year data, the results should be interpreted as portfolio-based simulation outcomes. This limitation is acknowledged, but the available data remain sufficient for evaluating retention scenarios under the scope of this study.

Table 1. Premium Data for Unit-Linked Insurance Products (2021-2024

Year	Policies		Total Policies	Premium Income (In Thousand UDR)
	New Business	Inforce		
2021	271.433	251.648	523.081	1.209.145.000
2022	8.754	452.710	461.464	2.576.739.000
2023	2.527	309.270	311.797	1.767.841.000
2024	326	200.052	200.052	1.152.198.000

To determine the expected values of policy number and premium amount, a distribution fitting analysis was conducted using RStudio. Because the policy count series consists of only four annual observations (2021–2024), formal goodness-of-fit tests provide limited statistical power and should not be interpreted as strong evidence of normality. Accordingly, the annual totals are treated descriptively, and the expected number of policies is estimated using the sample mean across the observation window. The resulting expected value is 374,180 policies, which is subsequently used for parameterization in the retention calculation.

For the same reason, the annual premium income series is not used to infer a parametric distribution. Instead, the expected premium income is estimated using the sample mean across 2021–2024, yielding IDR 1,676,480,750,000. Next, the security loading per policy is calculated using this expected value as an input to the Pentikäinen framework. The calculation was performed using the following formula:

$$\lambda = Net\ Premium \cdot Loading\ rate \quad (5)$$
$$\lambda = 4{,}480{,}413 \cdot Loading\ rate \quad (6)$$

This value is subsequently used to determine the security loading for Unit-Linked products at Insurance X.

Annual Claims Data

Claims data is a key input for estimating potential future claim liabilities, thereby enabling the insurer to formulate appropriate risk management strategies. For Insurance X's Unit- Linked products, claims are categorized into death benefits, health claims, and cash value withdrawals

Table 2. Unit Link Insurance Claim Incurred Data for 2021 - 2024

Year	Claims Withdrwals (in IDR)		
	Health	Dealth	Cash Value
2021	455.900.000	163.692.101.428	10.773.101.428
2022	367.400.000	100.312.919.303	6.722.219.303
2023	1.586.986.647	96.871.865.242	7.280.951.889
2024	2.123.064.472	81.909.700.704	8.142.635.176

Health and death claims are aggregated to estimate the expected value required in the Pentikäinen method calculation. The expected claim amount is IDR 111.829.984.449.

In the ruin-theoretic setting underpinning the Pentikäinen approach, claim arrivals are typically modeled as a counting process with independent increments; the classical Cramér–Lundberg model assumes a Poisson process for claim frequency. Consistent with this framework, the expected number of claims (m) is estimated from historical observations as the sample mean over 2021–2024, resulting in m = 1,034.

Unlike annual aggregates, individual claim amounts are generally right-skewed and can exhibit heavy tails; therefore, assuming normality may underestimate tail risk that is critical for retention and solvency analysis. Accordingly, claim severity was fitted to several candidate actuarial distributions (Normal, Exponential, Gamma, Lognormal, and Pareto) and evaluated using a combination of goodness-of-fit (Kolmogorov–Smirnov, Cramér–von Mises, and Anderson–Darling) statistics and information criteria (AIC/BIC). Figures 1, 2, 3, 4 and 5 summarize these diagnostics which explained that the Pareto specification consistently provides the most favorable fit (lowest GOF statistics and lowest AIC/BIC), indicating pronounced tail behavior in the unit-linked claim severity data. For the Pentikäinen formula, the expected claim amount $K'(1)$ is parameterized using the empirical mean, which equals IDR 111.829.984.449.

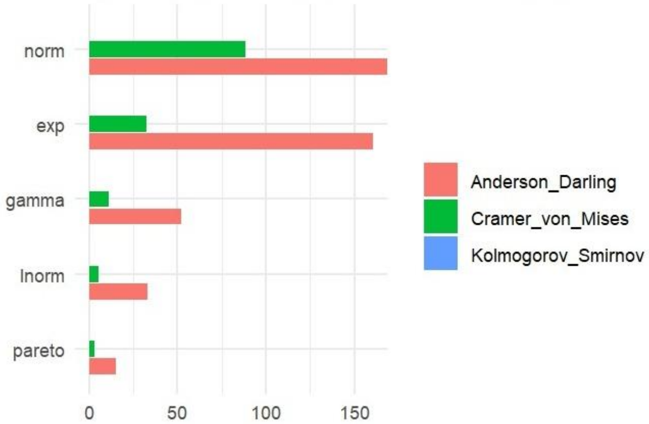

Figure 1. Goodness-of-Fit Statistics for Candidate Claim Severity Distributions (lower is better)

Figure 1 shows a clear separation among candidate distributions. The Normal and Exponential models produce substantially larger GOF statistics (especially AD and CvM), indicating that these light-tailed assumptions struggle to represent the observed claim distribution. In contrast, the Pareto model yields the smallest GOF values, followed by Lognormal and Gamma, suggesting that the claim data are better characterized by right-skewed and potentially heavy-tailed distributions. Importantly, the Anderson–Darling (AD) statistic, known to be more sensitive to deviations in the distribution tail, also favors Pareto, reinforcing the interpretation that the upper tail is a critical feature of the claim severity profile.

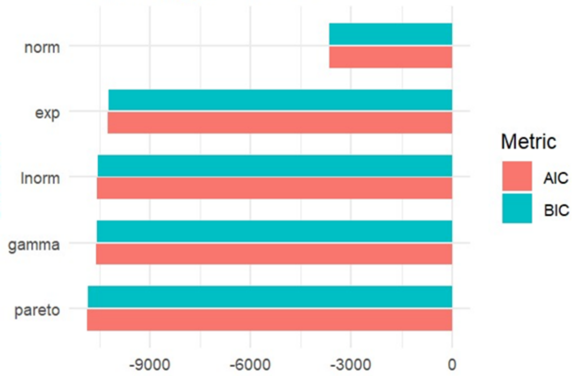

Figure 2. Information Criteria Comparison (AIC/BIC) for Candidate Claim Severity Distributions (lower is better)

Figure (AIC/BIC comparison) provides complementary evidence through likelihood-based metrics. The Pareto distribution achieves the most favorable (lowest) information criteria values, indicating the best balance between model fit and complexity among the tested candidates. Lognormal and Gamma appear competitive, but the information-criterion ranking still points to Pareto as the most efficient representation of the claim severity data under the fitted specifications. Meanwhile, the Normal model is comparatively weak, aligning with the GOF diagnostics.

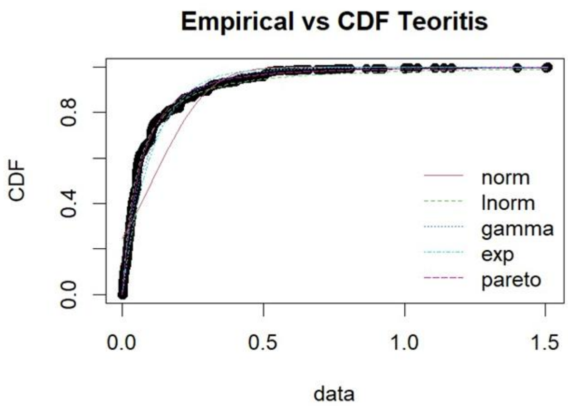

Figure 3. Empirical vs Theoretical CDF for Candidate Claim Severity Distributions

The Empirical and Theoretical CDF plot shows that all candidate models track the empirical CDF reasonably well in the lower-to-middle range, where the majority of claims are concentrated. However, small but systematic deviations appear as the CDF approaches one (upper quantiles), where model accuracy becomes most relevant for large-loss behavior. The Normal specification visibly departs more from the empirical curve in the earlier range, while Pareto, Lognormal, and Gamma follow the empirical curve more closely overall consistent with the GOF results.

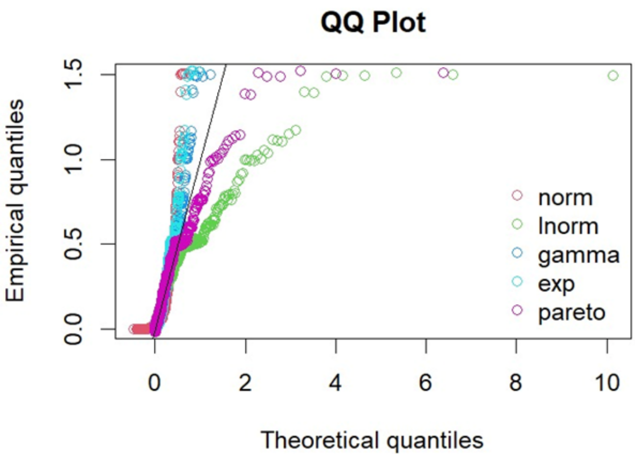

Figure 4. QQ Plot Comparison for Candidate Claim Severity Distributions

The QQ plot is particularly informative for assessing tail fit. The Normal and Exponential models diverge markedly from the reference line at higher quantiles, illustrating under- or mis-representation of extreme claims. In contrast, Pareto exhibits the most stable alignment in the upper tail region relative to other candidates, indicating a stronger ability to capture the distribution of large claims. Since reinsurance pricing and retention adequacy are highly sensitive to tail losses, this result is crucial for downstream retention simulations.

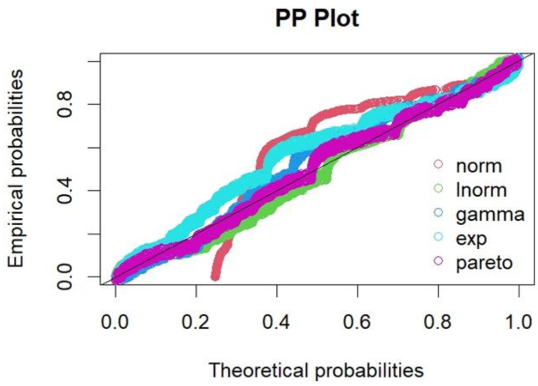

Figure 5. PP Plot Comparison for Candidate Claim Severity Distributions

The PP plot further confirms the global calibration pattern. The Pareto curve stays closest to the diagonal line across a broad probability range, while Normal shows more pronounced curvature and deviation, indicating systematic misfit. Lognormal and Gamma remain reasonable alternatives, but overall, Pareto provides the most consistent alignment between empirical and theoretical probabilities.

Annual Premium Reserve Data

Premium reserves for Unit-Linked products are calculated using the Unearned Premium Reserve (UPR) method, which represents the portion of premiums not yet recognized as income. The reserve values at the beginning of each year (January) are shown below.

Table 3. Unit Link Insurance Premium Reserve Data for 2021 - 2024

Year	Premium Reserve (in IDR)
2021	8.677.210.830
2022	12.786.772.064
2023	13.396.829.819
2024	9.456.913.691

The decreasing trend in premium reserves is attributed to a decline in policy count and premium income. To support further analysis, the calculation of expected values was performed using RStudio software.

Because the premium reserve series is also an annual aggregate with four observations, distributional assumptions are not emphasized. The expected reserve value (u′) is therefore estimated using the sample mean across 2021–2024, yielding IDR 11,079,431,601, which is used as the initial risk reserve input in the Pentikäinen calculation.

3.2 Retention Calculations Using the Pentikäinen Method

Retention in reinsurance refers to the portion of risk that an insurance company chooses to retain on its own balance sheet before ceding the excess to reinsurers. The choice of retention level is critical to balancing profitability, risk appetite, and solvency. This study presents a comparative simulation based on actual and modeled retentions using the Pentikäinen method, which incorporates probabilistic ruin theory to determine optimal retention.

The expected values derived from the above analyses are then applied to the Pentikäinen formula:

$$M = \frac{(u' + \lambda m)^2}{4K'(1)}$$

where,

M = Retention limit
u' = Risk reserve as of January 1st K'(1) = Expected amount of claims
λ = Security loading factor
m = Expected number of claims

To evaluate the impact of different loading rates, three scenarios were considered: 0%, 10%, and 20%, as the current product structure does not incorporate security loading.

Table 4. Expected Value of Key Variables in Retention Calculations

Variable	Description		$E[X]$ (in IDR)
u’	Premium Reserve		11,079,431,601
	0%	0	
□01Security loading		10%	448,041
		20%	896,083
m	Number of Claims		1,304
K(1)	number of Claims		111,829,984,449

Scenario 1: Security Loading 0%

$$M = \frac{(\ 11.079.431.601 + 0 \cdot 1.304)^2}{4 \cdot\ 111.829.984.449}$$

$$M = \frac{(\ 11.079.431.601\ )^2}{447.319.937.796}$$

$$M = \ 274.420.597$$

$$M \cong 275.000.000$$

Scenario 2: Security Loading 10%

$$M = \frac{(11.079.431.601 +\ 448.041\ \cdot 1.304)^2}{4 \cdot 111.829.984.449}$$

$$M = \frac{(11.659.271.826)^2}{447.319.937.796}$$

$$M = \ 304.125.434$$

$$M\ \cong 305.000.000$$

Scenario 2: Security Loading 10%

$$M = \frac{(11.079.431.601 +\ \ 896.083\ \cdot 1.304)^2}{4 \cdot 111.829.984.449}$$

$$M = \frac{(\ 12.247.923.182\ )^2}{447.319.937.796}$$

$$M = \ 335.159.012$$

$$M \cong 335.000.000$$

Discussion

To provide a structured analysis of the impact of each retention scheme, a comparison is presented between the actual retention of IDR 500,000,000 and the retention schemes derived from the Pentikäinen method calculations, namely IDR 335,000,000, IDR 305,000,000, and IDR 275,000,000. This simulation scheme uses statistical data of unit-linked products in 2024.

Table 5. Comparison of Surplus Reinsurance Retention Schemes

Description	Actual Retention (500 million)	Simulation Retention (335 million)	Simulation Retention (305 million)	Simulation Retention (275 million)
Premium Income	1,152,198,282	1,152,198,282	1,152,198,282	1,152,198,282
Reinsurance Premium	2,294,301	4,904,087	5,520,583	6,338,487

Net Retained Premium	1,149,903,981	1,147,294,195	1,146,677,699	1,145,859,795
Claims Incurred	84,032,765	84,032,765	84,032,765	84,032,765
Reinsurance Claims	6,429,315	13,830,171	16,188,202	18,282,923
Net Retained Claims	77,603,449	70,202,593	67,844,562	65,749,841
Loss Ratio	6.75%	6.12%	5.95%	5.74%

The application of the Pentikäinen method to Insurance X's unit-linked portfolio produced retention levels that differ materially from the company's current practice. While the company currently applies an actual retention of IDR 500,000,000, the model generated three lower retention alternatives depending on the security loading assumption (Table 5).

a. Actual retention: IDR 500,000,000
b. Pentikäinen retention at 0% loading: IDR 275,000,000
c. Pentikäinen retention at 10% loading: IDR 305,000,000
d. Pentikäinen retention at 20% loading: IDR 335,000,000

These results indicate that the model-based retention range lies below the company's current retention level. The finding suggests that the existing policy may expose the insurer to a larger net claim burden than is implied by the current portfolio risk structure. At the same time, the increase in retention values as security loading rises confirms that security loading is a key determinant of risk-bearing capacity in the Pentikäinen framework.

To evaluate the practical implications of these retention alternatives, simulations were performed using the 2024 statistical profile of unit-linked products. The comparison shows that reducing retention increases the reinsurance premium ceded to reinsurers, but also decreases the insurer's net retained claims and improves the loss ratio.

The main simulation outcomes are summarized below:

a. Loss ratio under actual retention (IDR 500,000,000): 6.75%
b. Loss ratio under simulated retention of IDR 335,000,000: 6.12%
c. Loss ratio under simulated retention of IDR 305,000,000: 5.95%
d. Loss ratio under simulated retention of IDR 275,000,000: 5.74%

The loss ratio in this study is calculated as the ratio of net retained claims to net retained premium. This indicator reflects the proportion of retained premium that is absorbed by claims after reinsurance. A lower loss ratio therefore indicates that the insurer bears a smaller claims burden relative to its retained premium, which generally supports greater short-term underwriting stability. In this sense, the decline in loss ratio across the simulated scenarios suggests that lower retention improves the company's financial stability by reducing the volatility and pressure associated with retained claims.

In financial terms, the loss ratio improvement can be expressed through changes in net retained claims and the implied underwriting margin (net retained premium minus net retained claims). Based on the simulation results, lowering retention from IDR 500 million to IDR 335/305/275 million reduces net retained claims from IDR 77.60 million to IDR 70.20/67.84/65.75 million. Over the same scenarios, reinsurance premium increases from IDR 2.29 million to IDR 4.90/5.52/6.34 million. These movements highlight the economic trade-off which is lower retention improves stability by reducing the immediate claim burden borne by the insurer (thereby easing short-term reserve and capital strain in adverse claim scenarios), but it also increases the cost of risk transfer via higher ceded premiums. Therefore, the interpretation of stability should be made jointly with cost efficiency, rather than relying on loss ratio alone.

The present findings are broadly consistent with the optimization literature showing that retention decisions are sensitive to the statistical characteristics of claim losses. Mao and Ostaszewski (2023) similarly report that increases in the mean and volatility of claim losses lead to higher optimal retention and premium levels, underscoring the importance of selecting an appropriate claim severity distribution [17].

However, the interpretation of loss ratio should not be separated from cost efficiency considerations. Although the lowest simulated retention of IDR 275,000,000 produces the smallest loss ratio, it also requires the highest reinsurance premium cession. This implies that a mechanically lower loss ratio does not automatically represent the most efficient retention policy. Excessive cession may reduce the insurer's exposure to claims, but it can also weaken underwriting profitability by transferring too much premium income to the reinsurer.

From this perspective, the results show that retention levels of IDR 305,000,000 and IDR 335,000,000 provide a more balanced outcome. Both scenarios improve the loss ratio relative to the actual retention, while avoiding the excessive premium transfer associated with the lowest retention option. Thus, the findings suggest that financial stability should be interpreted not only as lower claim burden, but also as the insurer's ability to maintain an appropriate balance between risk transfer and retained profitability.

Table 6. Distribution of Sum Assured and Claim Data for Unit Link Products in 2024

Sum Assured (IDR)	Number of Policyholders	Number of Claim Incurred
0 – 275,000,000	181,256	659
275,000,000 – 305,000,000	5.160	10
305,000,000 – 335,000,000	191	15
335,000,000 – 400,000,000	3,805	11
400,000,000 – 500,000,000	6,523	16
500,000,000 – 600,000,000	651	20
600,000,000 – 750,000,000	632	4
750,000,000 – 1,000,000,000	1,494	4
1,000,000,000 – 2,000,000,000	554	4
2,000,000,000 – 10,000,000,000	112	1

Based on table 6, in an effort to tailor risk management strategies through an optimal surplus retention approach, analyzing the distribution of the number of insured and actual claims based on sum assured provides important insights into the efficiency and proportionality of risk transfer. Based on 2024 unit-linked data, it appears that the majority of policyholders are in the low sum assured category (below IDR 275 million), but claims are not always distributed proportionally to the policy amount.

Mathematically, a retention of IDR 275 million indicates the highest level of financial stability in the previous simulation because it produces the lowest loss ratio. However, claims distribution data reveals that this retention is practically inefficient. There were only 10 claims in the IDR 275 million–305 million coverage range, despite the number of policies in this group exceeding 5,000. This suggests that the company would be transferring too much premium to reinsurers for a risk that is actually very low in reality. In the long term, this strategy will result in lost potential underwriting revenue and negatively impact the company's profit margin.

Retention at the IDR 305 million and IDR 335 million levels represents the best compromise between protection and efficiency. In these two groups, the number of claims is relatively higher compared to the previous group (15 claims for the IDR 305–335 million group and 11 claims for the IDR 335–400 million group), while the number of policyholders remains manageable.

Although reinsurance premiums increased in these two schemes, this was accompanied by a significant decrease in the company's net claim expense, as reflected in the decline in claim ratios to 5.95% and 6.12%. However, the implementation of these schemes must account for an additional security loading factor in the premium calculation, which is approximately 10–20%, as formulated in the Pentikäinen model. This additional cost must be carefully evaluated to ensure that the risk reduction benefits remain in line with total cost efficiency.

The IDR 500 million actual retention strategy appears to be the most premium-efficient, as the company only pays a small reinsurance premium (IDR 2.29 million) and retains almost the entire net premium. However, this strategy carries the highest claims risk exposure, particularly in the IDR 500–600 million range, which recorded 20 claims which is the highest number of all coverage categories. This situation demonstrates that the company bears a significant concentration risk in the medium-high coverage group, which could potentially disrupt financial stability if a sudden surge in claims occurs.

The 2024 claims distribution data underscore the importance of a data-driven actuarial approach in determining the optimal retention level. Although the Pentikäinen model mathematically offers a retention formula that achieves financial stability, the final decision must still consider the empirical distribution of claims and the proportion of premium allocated to reinsurance.

Considering the number of policies, actual claim frequency, and implicit costs of risk transfer, a retention range of IDR 305 million to IDR 335 million appears to be the most rational and balanced option. This scheme can reduce claim volatility without burdening the company with disproportionate reinsurance premiums. An overly conservative strategy, such as a retention of IDR 275 million, risks reducing profitability, while a retention that is too high, such as IDR 500 million, opens up exposure to large losses in high coverage groups. Therefore, companies must adopt a holistic, risk-based approach in determining retention, not only based on mathematical models but also on the realities of portfolio distribution.

The findings indicate that retention levels materially affect the balance between underwriting stability and cost efficiency under a surplus treaty [18][19]. In industry practice, retention is often maintained as a relatively fixed underwriting parameter and adjusted only when treaty terms change. However, the results of this study suggest that retention should be treated as a dynamic risk-control variable that must be recalibrated when portfolio composition, claim experience, and regulatory requirements shift [20][21]. For Indonesian life insurers facing declining unit-linked business and tighter governance expectations, a quantitative retention review can help prevent two common outcomes: (i) excessive retained risk that increases net claim volatility and pressures reserves, or (ii) excessive risk cession that erodes underwriting margins through higher reinsurance premiums [22].

From a market and policy perspective, the results support the need for stronger retention governance within the Indonesian insurance ecosystem [20][21]. Insurers may use the proposed scenario-based evaluation (actual retention versus model-based alternatives) as a periodic internal policy tool, embedded into ERM and reinsurance committee processes. For regulators, the findings can inform supervisory guidance that encourages insurers to document and justify retention decisions using risk-based metrics (net retained claims, loss ratio, and distributional diagnostics), rather than relying primarily on historical judgment. This approach would improve transparency and consistency across insurers without requiring a single mandated formula [20].

Several limitations are the analysis relies on portfolio-level statistics and a limited time horizon, which may not fully capture long-term claim cycles or heterogeneity across policyholders. Second, retention outcomes are sensitive to distributional assumptions and parameter estimation; although heavy-tail modeling improves realism, model risk remains a potential source of bias if the claim process changes structurally. Third, the simulation does not incorporate dynamic effects such as changes in pricing, lapses, or investment-side behaviors specific to unit-linked products [23][24][25]. Therefore, the results should be interpreted as a retention policy simulation under observed portfolio conditions rather than as a definitive universal benchmark.

4 CONCLUSION

a. Results show that higher security loading systematically increases the model-implied optimal retention capacity. This confirms that loading is not a technical add-on, but a core control variable that directly affects how much risk can be retained while maintaining financial prudence.
b. Compared with the current actual retention of IDR 500,000,000, the model generates lower retention alternatives under different loading assumptions:
    1) IDR 275,000,000 (0% loading),
    2) IDR 305,000,000 (10% loading), and
    3) IDR 335,000,000 (20% loading).

    This finding indicates that the existing retention setting is likely above the model-based range implied by current portfolio risk characteristics.
c. Simulations results show that decreasing retention reduces net retained claims and lowers the loss ratio, indicating improved short-term risk stability. However, lower retention also increases ceded premium to reinsurers. Therefore, retention should not be minimized mechanically; it must be optimized by balancing solvency protection and underwriting efficiency.
d. The evidence suggests that retention decisions should be periodically reviewed under changing portfolio composition and regulatory conditions. For the observed data structure, the mid-range scenarios (IDR 305–335 million) provide a more balanced outcome than both extremes (too high: 500 million; too low: 275 million), because they improve claim stability without imposing disproportionate reinsurance costs.
e. The findings suggest the importance of encouraging more risk-sensitive approaches to retention setting. Although a single actuarial method should not be mandated uniformly across all insurers, regulators may consider integrating Pentikäinen-like or other quantitative retention assessment frameworks into supervisory guidance, particularly for products with changing risk profiles such as unit-linked portfolios. This would support greater transparency, consistency, and prudential discipline in retention governance.

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