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An Actuarial Approach to Determining the Optimal Premium for Car Accident on Claim Frequency and Severity Data

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Abstract

The determination of car accident insurance premiums requires a model capable of capturing variations in claim frequency and claim severity to ensure fairness and competitiveness. This study employs aggregate claim distributions Negative Binomial Exponential and Negative Binomial Gamma under two approaches: the Pure Premium Principle and the Expected Value Principle. the analysis indicates that the Expected Value Principle is more optimal, as it incorporates a premium loading factor (ψ) to account for additional risk adjustments. The calculations yield premiums of IDR 2,802,908,472.03 for the Negative Binomial Exponential model and IDR 5,566,024,615.90 for the Negative Binomial–Gamma model. The Negative Binomial Gamma model was selected as the optimal premium calculation model, resulting in a final premium of IDR 4,619,107.565 after dividing by the total claim frequency of 1,205. These findings confirm that the choice of aggregate claim distribution significantly affects the premium amount and provides a stronger foundation for insurance companies to establish sound and competitive pricing.

Keywords: Car Accident Insurance, Claim Frequency, Claim Severity, Aggregate Claim Distribution, Optimal Premium

1. Introduction

Actuarial science is a discipline that combines mathematics, statistics, and probability theory to measure and estimate future financial risks, particularly in the insurance and financial industries. In the context of insurance, actuarial science plays a crucial role in premium calculation, claims management, and technical reserve estimation, enabling insurance companies to operate in a sound and sustainable manner (Embrechts, 2022). Actuarial science has developed significantly in Indonesia since the early 21st century, marked by the establishment of formal academic programs and an increasing research focus on long-term financial risk management. Today, this discipline is applied across various insurance products, including motor accident insurance, which is complex in terms of claim frequency and claim severity (Aklilu, 2022).

Specifically, in car accident insurance, claim frequency and claim severity data are key factors in determining the premium charged to policyholders. A major challenge faced by insurance companies is the high variability of claims, which can disrupt financial stability if premiums are not accurately determined. In Indonesia, the rapid growth of motor vehicles and the high rate of traffic accidents have intensified the need for premium-setting models capable of accommodating fluctuations in risk (Molnar-Tanaka, 2025). Accurate modeling of claim frequency and claim severity can help insurance companies determine the optimal premium, ensuring that the premiums applied are fair and competitive while maintaining the company's solvency.

In both local and national contexts, regulations issued by the Otoritas Jasa Keuangan (OJK) and government policies require insurance companies to apply actuarial calculations in reporting technical reserves and determining premium rates. However, most insurance companies in Indonesia still rely on conventional approaches that are less dynamic in assessing risks based on limited historical data, resulting in suboptimal performance when dealing with changes in claim patterns and fluctuating macroeconomic conditions (Hassan, 2023). This situation presents a significant opportunity for research that integrates actuarial approaches with modern statistical modeling to determine optimal premiums for automobile insurance.

This research is important due to the existing gap between current practices and the potential application of more accurate and adaptive scientific methods in determining motor vehicle insurance premiums in Indonesia. Previous studies have generally focused on a single aspect either claim frequency or claim severity without integrating both variables into a comprehensive model that accounts for local characteristics. The novelty of this study lies in the application of a modern actuarial approach that simultaneously combines claim frequency and severity data to achieve a more accurate understanding of risk. This enables the determination of premiums that balance company profitability with policyholder affordability. Therefore, the findings of this research are expected to make a significant contribution to the development of motor vehicle insurance in Indonesia and serve as a reference for future regulatory frameworks and business strategies within the insurance industry (Hassan, 2023).

2. Literature Review

2.1. Insurance

Insurance is one of the key instruments in risk management. According to Giancaspro, insurance is a business agreement that involves the transfer of risk from one party to another in exchange for a premium. In this contract, the insurance company (insurer) is obligated to provide compensation to the insured party (insured) in the event of specific occurrences as stipulated in the policy (Gupta, 2024).

Meanwhile, in the context of Indonesian law, Otoritas Jasa Keuangan (OJK) defines insurance as an agreement between two or more parties, in which the insurer commits to the insured, in exchange for an insurance premium, to provide compensation for losses, damages, loss of expected profits, or legal liabilities to third parties that may be incurred by the insured as a result of an uncertain event. Both definitions indicate that, from both international and national perspectives, insurance essentially serves as a financial protection mechanism arising from a legal contract.

In principle, insurance protection is divided into two main categories: life insurance and general (or non-life) insurance. Life insurance is a commitment made by an insurance company to provide financial compensation to the insured (policyholder) in the event of death during the policy term. Life insurance products are generally classified into four types, including Whole Life Insurance, Term Life Insurance, and Endowment Insurance (Molnar-Tanaka, 2020).

Meanwhile, non-life insurance, also known as general insurance, is a type of insurance that provides protection or coverage for property against the risk of unforeseen events. More specifically, this type of insurance compensates the insured for losses or damages to their property caused by certain hazards or disasters. One of the products under general insurance is motor accident insurance. Motor accident insurance provides protection against the risks of death or injury resulting from vehicle accidents. The level of coverage provided is determined by the amount of premium paid by the policyholder (Lin, 2022).

2.1.1. Premium

In the insurance business, the premium or price is the amount of money that must be paid by the insured to the insurer as compensation for the risk coverage provided by the insurer for a specific risk, at a certain location, and over a defined period. The amount of premium paid by the insured can be calculated by multiplying the premium rate or tariff by the insured value of the object being covered (Embrechts, 2022). In actuarial theory, premiums are classified into two types: net premium and gross premium.

2.1.2. Net Premium

The net premium represents the expected value of the annual claim cost declared by the policyholder and is obtained by multiplying the expected claim frequency by the expected claim severity. In other words, the net premium reflects the expected value of claims without considering administrative expenses, commissions, or the company’s profit margin. Mathematically, the net premium is expressed as:

$$\Pi_s = E[S] = E[X]E[N] \tag{2.1}$$

where:

(a) Π_s : net premium
(b) $E[X]$: expected claim frequency

(c) $E[N]$: expected claim severity

2.2. Claim Frequency

Claim frequency refers to the number of claims that occur under an insurance policy within a specified period. It indicates how often policyholders file claims during a given timeframe and serves as essential information for insurance companies in determining premium rates and forecasting future risk.

In determining the distribution of claim frequency, the Poisson distribution is initially applied. If the goodness-of-fit test indicates that the data do not conform to the Poisson distribution, the Negative Binomial distribution is then used. When the mean value is approximately equal to the variance of the claim frequency data, the Poisson distribution is appropriate. However, when the mean is smaller than the variance, the Negative Binomial distribution is preferred. After selecting the appropriate distribution, a final validation should be conducted using the Chi-Square or Kolmogorov–Smirnov test to ensure the adequacy of the chosen model.

2.3. Claim Severity

Claim severity refers to the amount of money requested by the policyholder from the insurance company as compensation or reimbursement for losses incurred, in accordance with the terms of the insurance policy. Claim severity represents the financial magnitude of the loss that the insurance company is obligated to cover once the insured risk occurs.

To estimate the parameters of claim severity, the Exponential distribution and the Gamma distribution are used. The equation for the Exponential distribution is expressed as follows:

$$\hat{\theta} = M_1 = \bar{X} \tag{2.2}$$

or

$$\hat{\theta} = \frac{\sum_{i=1}^{n} X_i}{\sum_{i=1}^{n} N_i} = M_1 \text{ dan } \hat{\gamma} = \frac{\sum_{i=1}^{n} X_i^2}{\sum_{i=1}^{n} N_i} = M_2 \tag{2.3}$$

where

(d) $\hat{\theta}$: estimated rate parameter of the exponential distribution
(e) M_1 : first moment
(f) M_2 : second moment
(g) $\bar{X}$: mean value of claim data
(h) X_i : claim severity of the $j-th$ observation
(i) N_i : claim frequency of the $j-th$ observation

Subsequently, the estimation of the Gamma distribution requires two parameters, namely α (shape) or β (scale). The equations used to estimate these parameters are as follows:

$$\hat{\alpha} = \frac{M_1^2}{M_2 - M_1^2} \tag{2.4}$$

$$\hat{\beta} = \frac{M_2 - M_1^2}{M_1} \tag{2.5}$$

where

(j) $\hat{\alpha}$: estimated shape parameter of the gamma distribution
(k) M_1 : first moment
(l) M_2 : second moment

2.4. Negative Binomial Distribution

The Negative Binomial distribution is used as an alternative to the Poisson distribution when the variance exceeds the mean value, a condition known as overdispersion. This distribution is often applied to model claim frequencies in motor insurance, health insurance, or other high-risk insurance products. When claim data follow a purely Poisson pattern, the model can be less flexible because the variance equals the mean. In contrast, the Negative Binomial distribution allows for a larger variance, making it more realistic in representing real-world conditions. The probability mass function of the Negative Binomial distribution is given as follows:

$$p_k = \Pr(N = k) = \binom{k + \alpha - 1}{k} \left(\frac{1}{1+\beta}\right)^{\alpha} \left(\frac{1}{1+\beta}\right)^{k}, k = 0,1,2, \dots, \alpha > 0, \beta > 0 \quad (2.6)$$

The probability mass function of the Negative Binomial distribution is given as follows:

$$\Pr(N = k) = \frac{\Gamma(k+\alpha)}{\Gamma(k+1)\Gamma(\alpha)} \left(\frac{\alpha}{\alpha+\mu}\right)^{\alpha} \left(\frac{\mu}{\alpha+\mu}\right)^{k} \quad (2.7)$$

The expected value and variance of the Negative Binomial distribution are expressed as follows:

$$E[N] = \frac{k(1-p)}{p} \quad (2.8)$$

$$Var(N) = \frac{k(1-p)}{p^2} \quad (2.9)$$

2.5. Exponential Distribution

The Exponential distribution was first introduced by Gupta and Kundu in 1999. This distribution was derived from one of the cumulative density functions used in the mid-19th century (the Gompertz–Verhulst model) to compare mortality tables and estimate population growth rates. Its cumulative distribution function can be defined as follows:

$$F_x(x; \lambda) = 1 - \exp(-\lambda x) \quad (2.10)$$

The probability density function of the Exponential distribution is derived from the derivative of its cumulative distribution function, as follows:

$$f_x(x; \lambda) = \lambda \exp(-\lambda x) \quad (2.11)$$

where $\lambda > 0$.

The Exponential distribution is continuous and non-negative, making it suitable for modeling inter-arrival times. A random variable ϵ_t that follows an Exponential distribution with parameter λ can be expressed as:

$$\epsilon_t \sim EXP(\lambda) \quad (2.12)$$

where the expectation

$$E[\epsilon_t] = \frac{1}{\lambda} \quad (2.13)$$

dan its variance can be expressed as:

$$Var(\epsilon_t) = \frac{1}{\lambda^2} \quad (2.14)$$

2.6. Gamma Distribution

The Gamma distribution is a continuous probability distribution widely used in mathematics and statistics. It is characterized by two main parameters: the shape parameter (α) and the scale parameter (β). The probability density function (pdf) of the Gamma distribution is defined as follows:

$$f(x; \alpha, \beta) = \frac{1}{\Gamma(\alpha)\beta^{\alpha}} x^{\alpha-1} e^{-\frac{x}{\beta}}, x > 0, \alpha, \beta > 0 \quad (2.15)$$

The Gamma distribution is highly flexible and can model various forms of positive-valued data distributions. It also serves as a generalization of the Exponential distribution, where the Exponential distribution is a special case when $\alpha = 1$. The Gamma distribution is widely applied in actuarial science, survival analysis, and reliability modeling.

The expected value and variance of the Gamma Distribution with parameters α and β are given as follows:

$$E[X] = \alpha\beta \quad (2.16)$$

$$Var(X) = \alpha\beta^2 \quad (2.17)$$

2.7. Aggregate Claim

Aggregate claims refer to the total amount of claims arising from a general insurance risk over a short period, typically one year. The term “risk” here may refer to a group of policies with similar characteristics, although it can also pertain to an individual policy. At the beginning of the insurance coverage period, the insurer does not know how many claims will occur or how large those claims will be if they do occur. Therefore, it is necessary to construct a model that can accommodate both sources of variability. For simplicity, the claims discussed herein are assumed to occur within a one-year period, although the time frame can be adjusted as needed.

The random variable S is defined as the total (aggregate) number of claims arising from a particular risk within one year. Let the random variable denote the number of claims that occur from that risk during the one-year period, and let

X_i represent the size of the $i-th$ claim. The aggregate claim amount is the sum of all individual claims and can thus be expressed as:

$$S = \sum_{i=1}^{N} X_i \tag{2.18}$$

With the condition that $S = 0$ if $N = 0$. This means that if no claims occur, the aggregate claim amount equals zero. In this context, individual claim sizes are modeled as non-negative random variables with positive expected values.

2.8. Expected Value

The expected value represents the mean of a random variable, reflecting the central or average tendency of its probability distribution. In the context of insurance, the expected value is often used to estimate the average claim amount or the expected premium, based on the probability distribution of possible claims. This measure is crucial in actuarial science and insurance for determining fair premiums and establishing adequate reserves to manage potential losses.

Mathematically, the expected value $E(X)$ of a random variable X is defined as:

(a) For a discrete random variable:

$$E[X] = \sum_x x \,.\, P(X = x) \tag{2.19}$$

(b) For a continuous random variable:

$$E[X] = \int_{-\infty}^{\infty} x f(x) dx \tag{2.20}$$

where $P(X = x)$ represent the probability that the random variable X takes the value x, and $f(x)$ denotes the probability density function.

3. Materials and Methods

3.1. Materials

The data source used in this study was secondary data obtained from PT Jasa Raharja (Persero) Purwakarta Representative Office, which was published in Fara Lukita Umul Amaliah's research journal entitled "Analysis of the Number of Claims Distributed with Negative Binomial and the Amount of Claims Distributed with Discrete Uniform Using the Convolution Method". This optimal premium calculation was performed using large claim data and claim frequency data from 2020, with a total claim frequency of 1.205. The data contains information on the month, claim frequency, and claim amount.

Table 1. Claim Frequency and Claim Severity Data for 2020

Month	Claim Frequency	Claim Severity (IDR)
January	86	1,599,146,007
February	99	1,773,905,426
March	118	1,609,970,866
April	120	1,935,563,366
May	71	1,591,783,053
June	100	2,424,545,414
July	88	1,987,119,060
August	78	2,233,305,092
September	92	2,482,966,587
October	92	2,150,679,703
November	125	2,355,051,426
December	136	2,674,958,701

3.2. Methods

In completing this research, several methodological steps were taken, as described in the flowchart in **Figure 1**. Based on the research flowchart, the stages carried out are as follows:

1) Collecting secondary data obtained from PT Jasa Raharja (Persero) Purwakarta Representative Office contained in journal reference sources and inputting the data.
2) Testing data fitness with distribution.
3) Calculating the estimated parameter value of Claim Frequency using Negative Binomial Distribution.
4) Calculating the estimated parameter value of Claim Amount using the Exponential Distribution and Gamma Distribution.
5) Calculating the expected value and variance of each of the Negative Binomial, Exponential, and Gamma distributions.
6) Calculating the Expectation and Variance Values of the Aggregate Claim Model for Negative Binomial and Exponential Distributions.
7) Calculating the Expectation and Variance Values of the Aggregate Claim Model for Negative Binomial and Gamma Distributions.
8) Finding the premium value using the pure premium principle.
9) Finding the premium value using the expected value principle.
10) Making conclusions.

4. Results and Discussion

4.1. Estimation of Claim Frequency Parameters

In determining the parameter estimate, the number of claims is initially determined using the Poisson distribution. However, the goodness-of-fit test results indicate that the claim frequency data does not follow a Poisson distribution. Therefore, further testing was conducted using the Negative Binomial Distribution, and it was concluded that the claim frequency data was consistent with the Negative Binomial Distribution. Thus, the parameter used is the Negative Binomial Distribution parameter. Estimate the parameters of this distribution with $\hat{p}$ and $\hat{k}$ calculated using the equation (4.1) and (4.2) below:

$$\hat{p} = \frac{M_1}{M_2 - M_1^2} \tag{4.1}$$

dan

$$\hat{k} = \frac{M_1^2}{M_2 - M_1^2 - M_1} \tag{4.2}$$

dengan,

(c) $M_1 = \frac{1}{n}\sum_{i=1}^{n} N_i$
$= \frac{1}{12} \times 1205 = 100.4166667$

(d) $M_2 = \frac{1}{n}\sum_{i=1}^{n} N_i^2$
$= \frac{1}{12} \times 125439 = 10453.25$

maka diperoleh,

(e) $\hat{p} = \frac{100.4166667}{104453.25 - 100.4166667^2} = 0.271584997$

(f) $\hat{k} = \frac{100.4166667^2}{10453.25 - 100.4166667^2 - 1004166667} = 37.43972875$

4.2. Estimation of the Claim Amount Parameter

To determine the estimated claim amount parameters, we can use the exponential distribution and gamma distribution. The parameters of the exponential distribution can be estimated using the equation (4.3) and (4.4) below:

$$\hat{\theta} = \frac{\sum_{i=1}^{n} X_i}{\sum_{i=1}^{n} N_i} = M_1 \tag{4.3}$$

and,

$$\hat{\gamma} = \frac{\sum_{i=1}^{n} X_i^2}{\sum_{i=1}^{n} N_i} = M_2 \tag{4.4}$$

So that:

$\hat{\theta} = \frac{24{,}818{,}994{,}701}{1205} = 20{,}596{,}676$

$\hat{\gamma} = \frac{52,883,125,218,416,000,000}{1205} = 43,886,410,969,639,800$

To estimate the parameters of the Gamma distribution, the following equation can be used (4.5) and (4.6) to calculate $\hat{\alpha}$ and $\hat{\beta}$ below:

$$\hat{\alpha} = \frac{M_1}{M_2 - M_1^2} \tag{4.5}$$

and

$$\hat{\beta} = \frac{M_2 - M_1^2}{M_1} \tag{4.6}$$

So that,

$\hat{\alpha} = \frac{M_1}{M_2 - M_1^2}$

$= \frac{20,596,676}{43,886,410,969,639,800 - 20,596,676^2} = 0.010$

$\hat{\beta} = \frac{M_2 - M_1^2}{M_1}$

$= \frac{43,886,410,969,639,800 - 20,596,676^2}{20,596,676} = 2,110,155,429.515$

4.3. Expectation and Variance Distribution

Based on the results of parameter calculations using moments, it was obtained that:

(a) Claim frequency data follows a negative binomial distribution with parameters:

$$\hat{p} = 0.271584997 \ , \qquad \hat{k} = 37.43972875$$

(b) Claims data follow an exponential distribution with parameters:

$$\hat{\theta} = 2,068,249,558$$

(c) The claim data follows a gamma distribution with parameters:

$$\hat{\alpha} = 0.010 \ , \qquad \hat{\beta} = 2,110,155,429.515$$

The expectation and variance of each distribution can be calculated using the equation (4.7), (4.8), (4.9), (4.10), (4.11), and (4.12) below:

(d) Negative Binomial Distribution

$$E[N] = \frac{k(1-p)}{p} \tag{4.7}$$

$$Var(N) = \frac{k(1-p)}{p^2} \tag{4.8}$$

then obtained:

$E[N] = \frac{k(1-p)}{p}$

$= \frac{37.43972875(1-0.271584997)}{0.271584997} = 100.4166667$

$Var(N) = \frac{k(1-p)}{p^2}$

$= \frac{37.43972875(1-0.271584997)}{0.271584997^2} = 369.7430556$

(e) Exponential Distribution

$$E[X] = \theta \tag{4.9}$$

$$Var(X) = \theta^2 \tag{4.10}$$

Then obtained:

$E[X] = \theta = 20,596,676$

$Var(x) = \theta^2 = 424,223,066,385,404$

(f) Gamma Distribution

$$E[X] = \alpha\beta \tag{4.11}$$

$$Var(x) = \alpha\beta^2 \tag{4.12}$$

Then obtained:

$E[X] = \alpha\beta = 0.010 \times 2,110,155,429.515 = 20,596,676$

$$Var(x) = \alpha\beta^2 = 0.010 \times 2{,}110{,}155{,}429.515^2 = 43{,}462{,}187{,}903{,}254{,}400$$

4.4. Aggregate Claim Model

The aggregate claim model is used to describe the total claims arising from an insurance portfolio during a period. This model is expressed in the equation (4.13) below:

$$S = \sum_{i=1}^{n} X_i \tag{4.13}$$

with,

S : Random variable representing the total (aggregate) claims,

X_i : Random variable representing the size of the *i-th* claim,

N : A random variable that represents the number of claims in a given period.

Based on this model, the following assumptions are used:

(g) Every X_i non-negative, with identical and independent distributions.

(h) Variable N independent of each X_i.

The expected value and variance can be calculated using the equation (4.14) and (4.15) below:

$$E[S] = E[X]E[N] \tag{4.14}$$

$$Var(S) = E[N]Var(X) + (E[X])^2 Var(N) \tag{4.15}$$

Based on the equation (4.14) and (4.15), the expected value and variance of the aggregate model can be found for each distribution:

(a) Binomial Negative Distribution and Exponential Distribution

$$E[S] = E[X]E[N]$$
$$= 20{,}596{,}676 \times 100.4166667 = 2{,}068{,}249{,}558$$
$$Var(S) = E[N]Var(X) + (E[X])^2 Var(N)$$
$$= 100.4166667 \times 424{,}223{,}066{,}385{,}404 + (20{,}596{,}676^2) \times 369.7430556$$
$$= 199{,}452{,}599{,}052{,}021{,}000$$

(b) Binomial Negative Distribution and Gamma Distribution

$$E[S] = E[X]E[N]$$
$$= 20{,}596{,}676 \times 100.4166667 = 2{,}068{,}249{,}558$$
$$Var(S) = E[N]Var(X) + (E[X])^2 Var(N)$$
$$= 100.4166667 \times 43{,}462{,}187{,}903{,}254{,}400 + (20{,}596{,}676^2) \times 369.7430556$$
$$= 4{,}521{,}181{,}568{,}087{,}620{,}000$$

4.5. Net Premium Principle

The net premium is the expected value, or average, of the annual claim cost that the insurance company must pay to the policyholder. This value is obtained by multiplying the average claim frequency by the average claim severity. The net premium can be calculated using the following equation (4.16):

$$\Pi_S = E[S] = E[X] \times E[N] \tag{4.16}$$

Based on equation (4.16), it is obtained that:

(c) Negative binomial-exponential aggregate claim distribution

$$\Pi_S = E[S] = E[X] \times E[N]$$
$$= 20{,}596{,}676.100 \times 100.4166667 = 2{,}068{,}249{,}558$$

$= 20{,}596{,}676.100 \times 100.4166667 = 2{,}068{,}249{,}558$

(d) Negative binomial-exponential aggregate claim distribution

$\Pi_s = E[S] = E[X] \times E[N]$

$= 20{,}596{,}676.100 \times 100.4166667 = 2{,}068{,}249{,}558$

4.6. Expected Value Principle

The Expected Value Principle is used to calculate the premium by adding an additional risk factor called the premium loading factor, which can be defined by the following equation (4.17):

$$\Pi_s = (1 + \psi)E[S] \tag{4.17}$$

The expected value $E[S]$ represents the average total claims, while the factor ψ adds a reserve to anticipate claim amounts that may exceed expectations. To determine ψ, a probabilistic approach is used under the assumptions described in the following equation (4.18):

$$P(S < \Pi_s) = 1 - \alpha^*$$

$$P\left(\frac{S - E[S]}{\sqrt{Var(S)}} < \frac{\Pi_s - E[S]}{\sqrt{Var(S)}}\right) = 1 - \alpha^*$$

$$P\left(Z < \frac{\Pi_s - E[S]}{\sqrt{Var(S)}}\right) = 1 - \alpha^* \tag{4.18}$$

This means that the probability that the total claims S do not exceed the set premium is $1 - \alpha^*$, where α^* is the chosen significance level. With a significance level of $\alpha^* = 0.05$, the probability is 0.95, and the corresponding Z-value from the standard normal distribution table is 1.645. Therefore, we obtain:

(e) For the Negative Binomial–Exponential aggregate claim distribution

$Z = \frac{\psi E[S]}{\sqrt{Var(S)}}$

$1{,}645 = \frac{\psi \times 2{,}068{,}249{,}558}{\sqrt{199{,}452{,}599{,}052{,}021{,}000}}$

$\psi = 0.35520806$

thus, the premium based on the Expected Value Principle for the Negative Binomial–Exponential aggregate claim distribution is:

$\Pi_s = (1 + \psi)E[S]$

$= (1 + 0.35520806) \times 2{,}068{,}249{,}558 = Rp2{,}802{,}908{,}472$

(f) For the Negative Binomial–Gamma aggregate claim distribution

$Z = \frac{\psi E[S]}{\sqrt{Var(S)}}$

$1{,}645 = \frac{\psi \times 2{,}068{,}249{,}558}{\sqrt{4{,}521{,}181{,}568{,}087{,}620{,}000}}$

$\psi = 1.691176504$

thus, the premium based on the Expected Value Principle for the Negative Binomial–Gamma aggregate claim distribution is:

$\Pi_s = (1 + \psi)E[S]$

$= (1 + 1.691176504) \times 2{,}068{,}249{,}558 = Rp5{,}566{,}024{,}615$

Conclussion

The conclusion of this study is that premium calculation can be performed using the Negative Binomial–Exponential and Negative Binomial–Gamma aggregate claim distributions by applying two approaches: the Pure Premium Principle and the Expected Value Principle. The most optimal premium is determined using the Expected Value Principle, as this method incorporates the premium loading factor (ψ) which accounts for additional potential risks. The results indicate that the premium obtained from the Negative Binomial–Exponential model is higher than that from the Negative Binomial–Gamma model. The calculated premiums are IDR 2,802,908,472.03 for the Negative Binomial–Exponential distribution and IDR 5,566,024,615.90 for the Negative Binomial–Gamma distribution. The chosen premium model is the Negative Binomial–Gamma, where the resulting premium is divided by the total claim frequency of 1,205. Therefore, the optimal premium for car accident insurance, based on claim frequency and claim severity data for the year 2020 using the Negative Binomial–Gamma model, is IDR 4,619,107.565.

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