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Determining the Price of Fisherman Micro Insurance Premiums Using the Aggregate Risk Model Approach in Cirebon Regency

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Abstract

Catastrophe such as hurricanes, heavy rains, and similar occurrence pose serious threats and risks to fishermen's livelihoods as well as losses from damage to their assets. Therefore, it is necessary to have special insurance to protect the fishermen's assets from financial losses due to the risks that can occur, namely Fisherman Micro Insurance. Micro-insurance is an insurance product that is intended for low-income people with features and administration that are simple, easy to obtain, economical prices and immediately in the completion of the provision of compensation. Fisherman's micro insurance guarantees assets in the form of fishing equipment in the occurrence of a risk of an accident causing damage, this insurance product protects against worries without a large premium burden. This study aims to calculate the premium price with an aggregate risk model approach. The data used is data on fisherman's losses if they did not go to sea which obtained by surveys. The occurrence data follows the Poisson distribution, and the loss data follows the Exponential distribution. Parameter Estimation was carried out using the Maximum Likelihood Estimation. The estimation results from numbers of occurrence and the amount of losses are used to estimate the collective risk model. Estimators of the average and variance of the aggregate risk are used to determine the premium. The results of the premium selection in this study amounted to IDR 153.861.958.00. The premium amount is a collective premium which is the result of a calculation based on the standard deviation principle.

Keywords: Non-life Insurance, premium determination, aggregate risk model, exponential distribution, Poisson distribution

1. Introduction

Potentially, Indonesia's fisheries are the largest in the world, many Indonesians live as fishermen. One of them is in the coastal areas of West Java, especially Cirebon Regency. It is noted that there are 17,192 people in Cirebon Regency who make a living as fishermen (Central Statistics Agency, 2018). Fishermen's activities at sea have a high risk of causing fishermen's failure to go to sea. Therefore, work as a fisherman deserves special attention to increase the protection of fishermen from the risk of failure, namely through the fisherman's insurance program.

This research on micro insurance was previously conducted by Tietze and Anrooy (2018) with the title Assessment of Insurance Needs and Opportunities in The Caribbean Fisheries Sector which explained the needs and opportunities for insurance for fishermen in the Caribbean and fishermen's assets that can be guaranteed, as well as Djuric (2013) with the title Collective Risk Model in Non-Life Insurance explains the application of the Aggregate Risk Model in non-life insurance using the Poisson distribution and the Exponential distribution.

Based on the explanation above, the purpose of this research is to determine the estimated number of incidents of fishermen failing to go to sea and the losses caused by not fishing, and to determine the amount of micro insurance premiums for fishermen to be paid using the aggregate risk model approach. The results of this study can be used by insurance companies as consideration for determining the amount of fisherman insurance premiums in Cirebon Regency.

2. Literature Review

2.1 Micro Insurance

Micro insurance is an insurance product designed to provide protection against financial risks faced by low-income people.

2.2 Pricing Micro insurance

Pricing is an activity to determine the premium rate for an insurance product. In general, the premium rate must be set so that the present value of all premiums collected during the coverage period will be sufficient to fund claims costs in the future.

2.3 Risk and Aggregate Risk

Risk is a form of uncertainty about a situation that will occur later (future) with decisions taken based on considerations. Estimated aggregate loss is the average aggregate loss that occurs in a certain period.

2.4 The Poisson Distribution

1) The random variable N has a Poisson distribution with λ as a parameter, the probability function:

$$P(\mathrm{N} = x) = e^{-\lambda}\frac{\lambda^x}{x!} \quad (1)$$

2) For the moment generating function:

$$M_N(t) = \exp\{\lambda(e^t - 1)\} \quad (2)$$

3) The expectation is the first derivative of the moment generating function with $t = 0$

$$E(N) = \lambda \quad (3)$$

4) For the variance:

$$Var(N) = \lambda \quad (4)$$

2.5 The Exponential Distribution

1) The random variable X has a Poisson distribution with μ as a parameter, the probability function:

$$f(x) = \mu e^{-\mu x} \quad (5)$$

2) The moment generating function:

$$M_X(t) = \frac{\mu}{\mu - t} \quad (6)$$

3) For the expectation equation:

$$E(X) = \frac{1}{\mu} \quad (7)$$

4) For the variance equation

$$Var(X) = \frac{1}{\mu^2} \quad (8)$$

2.6 Kolmogorov-Smirnov Distribution Conformity Test

The Kolmogorov-Smirnov test is the largest absolute difference between $F_0(x)$ which is the cumulative distribution function of the population and $F_k(x)$ which is the empirical distribution function of the sample

$$D = \max\{|F_k(x) - F_0(x)|\} \quad (9)$$

The hypothesis:
H_0 : data has the same distribution as theoretical distribution
H_1 : the data is not distributed the same as the theoretical distribution

The decision criterion is if $D < D_{tabel}$ then H_0 is accepted, meaning that the observed sample distribution has the same distribution as the theoretical distribution (Putri, 2020).

2.7 Chi-Square Distribution Conformity Test

The decision making of this test uses the parameter χh^2 with the equation:

$$\chi h^2 = \sum_{i=1}^{G} \frac{(O_i - E_i)^2}{E_i} \tag{10}$$

Explanation:
χh^2 : calculated chi-square parameter
G : number of sub groups
O_i : the number of observation values in subgroup-i
E_i : the number of theoretical values (expected frequency of group-i) in the sub group.

2.8 Maximum Likelihood Estimation (MLE)

Each distribution uses the MLE method to estimate its parameters. From this process, the results obtained are:

1) Poisson distribution parameters

$$\hat{\lambda}_{MLE} = \frac{\sum x_i}{n} \tag{11}$$

2) Exponential distribution parameters

$$\hat{\mu}_{MLE} = \bar{x} \tag{12}$$

2.9 Collective Risk Model

The sum of N individual claims up to time t is defined $S(t)$

$$S(t) = \sum_{i=1}^{N(t)} X_i \tag{13}$$

where N is a random variable that states the number of events that cause losses, and X which states the amount of losses received. Expectations and variances of aggregate losses can be calculated by the following equation:

$$E\big(S(t)\big) = E\big(N(t)\big)E\big(X(t)\big) \tag{14}$$

$$Var\big(S(t)\big) = E(N(t))Var(X(t)) + Var(N(t))(E(X(t)))^2 \tag{15}$$

2.10 Premium Calculation Model

1) Value Expectation Principle
Premium calculation using the principle of expected value is based on the average collective risk or pure premium multiplied by the security loading (loading factor)

$$p(t) = (1 + \alpha)E\big(S(t)\big) \tag{16}$$

with $0 < \alpha < 1$.

2) Standard Deviation Principle
The premium calculation with this principle is based on the pure premium which is added up by the product of the loading factor and the standard deviation of the collective risk

$$p(t) = E(S(t)) + \alpha\sqrt{Var(S(t))} \tag{17}$$

with $0 < \alpha < 1$.

3. Materials and Methods

3.1. Materials

The object of research used in this study is to determine the micro insurance premiums for fishermen in Cirebon Regency using an aggregate risk model approach. The data used is primary data in the form of the loss of fishermen's income if they do not go to sea in Cirebon Regency in December 2020 to November 2021. Data collection is obtained through a survey, namely by distributing questionnaires to fishermen in the Cirebon Regency area.)

3.2. Methods

The initial step taken in this study was to collect data in the form of many incidents of fishermen not going to sea and the large loss of fishermen's income if they did not go to sea that occurred in Cirebon Regency.

Based on the data obtained from the survey results that have been carried out, further data analysis is carried out in the form of the Aggregate Risk Model which is the basis for the method used to calculate the micro insurance premiums for fishermen in Cirebon Regency. Starting with testing the suitability of the existing distribution using the Chi-Square test for continuously distributed data and the Kolmogorov-Smirnov test for discrete distributed data, then proceeding with estimating the data distribution parameters with the Maximum Likelihood function, to get a large premium. Easy fit software and Microsoft Excel are used to speed up and simplify the calculation process. The following is the data on the average number of incidents and the amount of fisherman losses due to not going to sea per month used in this study:

Table 1: Average Number of Incidents and Loss of Fisherman if They Don't go to The Sea Per Month

No	Month	Average Number of Events	Average Loss Amount
1	December’20	6	3.614.583
2	January’21	5	3.725.500
3	February’21	5	3.390.875
4	March’21	5	3.736.833
5	April’21	5	3.576.833
6	May’21	6	3.428.041
7	June’21	6	3.374.291
8	July’21	7	3.528.875
9	August’21	7	3.433.541
10	September’21	8	3.319.583
11	October’21	8	3.503.83
12	November’21	7	3.410.166

4. Results and Discussion

For data the number of events is assumed to have a Poisson distribution, and the data for the magnitude of losses is assumed to have an exponential distribution. This assumption is proven by modeling the data with histogram graphs using Easy fit software as follows:

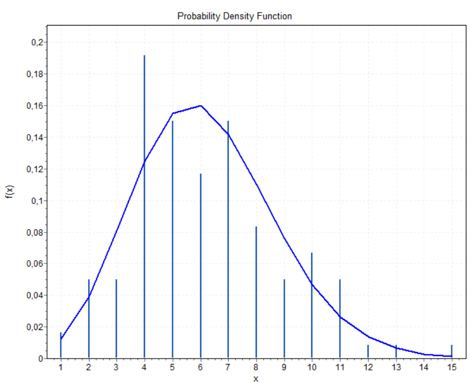

Figure 1: Data on The Number of Events

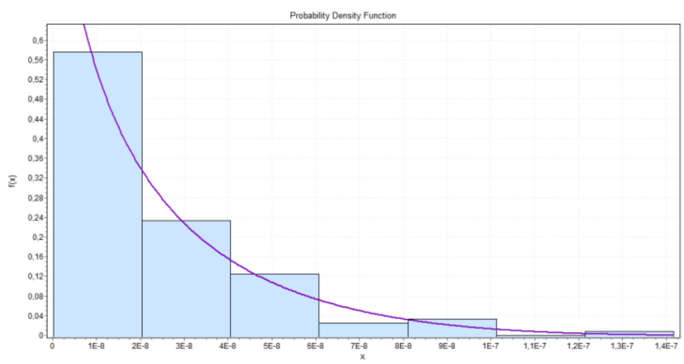

Figure 2: Data Loss Amount

The next step is to estimate the parameters for each data distribution. Parameter estimation was carried out using the Maximum Likelihood Estimation (MLE) method. Parameter λ for estimating many events that cause losses, and parameter μ for estimating the amount of losses received.

$$\hat{\lambda}_{MLE} = \frac{\sum_{i=1}^{120} x_i}{120} \tag{18}$$

$$\hat{\mu}_{MLE} = \bar{x} \quad (19)$$

Based on the data that given in Table 1, the values of each parameter that calculated by using equations (18) and (19) is:

$$\lambda = 6{,}2126$$
$$\mu = 42.042.205$$

After that, the calculation of the amount of individual losses is carried out by estimating the expected value and variance of the data on the amount of loss. For data contained many event that cause losses, $E(N) = \lambda$ and $\mathrm{Var}(N) = \lambda$. For data contained the amount of losses received, $E(X) = \frac{1}{\mu}$ and $Var(X) = E(X^2) - (E(X))^2$. The results are:

$$E(N) = 6{,}2126$$
$$Var(N) = 6{,}2126$$
$$E(X) = \frac{1}{42.042.205}$$
$$Var(X) = \frac{1}{(42.042.205)^2}$$

So, the values of the collective risk model that calculated by using equations (14) and (15) are:

$$E\big(S(t)\big) = 0.000000147770556$$
$$Var\big(S(t)\big) = 0.000000000000004$$

After getting the estimated value of the collective loss risk from the loss data, then it is used to determine the amount of premiums that must be paid by fishermen. The calculation is using two principles, value expectation principle and standard deviation principle based on equation (16) and (17), the results are:

- Value expectation principle:

$$p(t) = 0.000000162547612$$

- Standard deviation principle:

$$p(t) = 0.000000153861958$$

5. Conclussion

The estimation of parameters used for determining the expectation and variance from an individual risk model. After that, the results of that individual risk model is used for find the values of a collective risk model and calculating the premium. The results of the premium calculation are used as a reference for insurance companies in determining the amount of individual micro insurance premiums that must be paid by fishermen. The premium value of IDR 153,861,958,00 was chosen because the value is lower than other calculations, so it can result in lower individual premium prices by insurance companies.

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