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Determination Of Natural Disaster Insurance Premi-Ums In Bengkulu Province Using Standard De-Viation Approach

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Abstract: Insurance premium is the cost associated with the transfer of risk from the policyholder to the insurance company. This research aims to determine the insurance premium for natural disasters in the Province of Bengkulu. Data was obtained from National Disaster Management Agency (BNPB) for the years 2000-2020. Insurance premium method that will be used is from standard deviation. The results from insurance premium starts from Rp351.978.101.983,63 until Rp359.354.025.436,30 with factor loading 1-10%. Therefore, residents of Bengkulu Province suggested that they have insurance for natural disasters.

Keywords: Premium Insurance; Natural Disasters; Standard Deviation

1. Introduction

Bengkulu Province is a disaster-prone area including earthquakes, floods, landslides, tornadoes, and so on. Bengkulu is a province in Sumatra bordering West Sumatra (North), Lampung (South), Indian Ocean (West), and Jambi and South Sumatra (East). With an area of about 19,796 square kilometers, Bengkulu is home to a variety of ecosystems, including tropical rainforests, mountains, and enchanting beaches. Its geographical diversity creates diverse climatic conditions, forming a rich and abundant ecosystem. The Barisan Mountains that cross the province provide interesting topographic characteristics. High peaks and verdant valleys create spectacular natural panoramas and provide habitat for abundant endemic flora and fauna.

According to Sugiharto (2022), along the coast in Bengkulu there is a potential tsunami threat that has been mapped. Indonesia has Sumatran plate faults, namely Ketahun (7.3), Musi (7.2), North Komering (7.5). In addition, the sea area has Mentawai megatrast (8.2), and Enggano (7.6) (Perdana et al., 2022). With so many natural disasters that occur, of course, it has an impact on the lives of people

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in Bengkulu Province. Starting from the damaged environment, declining economy, to the destruction of high-value buildings.

Natural disaster insurance is a guarantee intended to compensate losses caused by natural disasters (Kalfin et al., 2022). Thus, natural disaster insurance can be a solution to the loss of destruction of public assets caused by natural disasters. Bengkulu, as one of the provinces in Indonesia, often experiences a significant risk of natural disasters. Earthquakes, floods, landslides, and tsunamis are some of the threats that can cause huge losses both in terms of life and economy. Therefore, having natural disaster insurance is a crucial need for Bengkulu residents. Natural disaster insurance not only provides financial protection during disasters but also helps people to deal with the long-term impact of the event. By having insurance, Bengkulu residents can better recover their lives after experiencing losses due to natural disasters.

In a previous study conducted by (Kalfin et al., 2020), it was found that if the damage caused by natural disasters is large, the insurance premium will be higher. The study observes the damage caused by natural disasters and also observes it through the perspective of the community. Therefore, this study determines how much the premium price is suitable for the people in Bengkulu Province so that the premiums determined by the insurance company have a reference to determine pure premiums for the local community.

The importance of natural disaster insurance can be seen from several advantages it offers. First, insurance can provide financial compensation that can be used to repair or rebuild homes and businesses damaged by disasters. Second, insurance can help reduce the financial burden of individuals and communities in the recovery process. In addition, natural disaster insurance can also motivate residents to implement safety and risk mitigation practices. With insurance, people tend to be more aware of potential disaster risks and more proactive in involving themselves in prevention efforts.

Through this approach, this paper will explain why Bengkulu residents need to understand the importance of having insurance of natural disaster as a strategy to protect themselves, their families, and their assets. This understanding not only provides financial security but also becomes a proactive step in building community resilience to the threat of natural disasters that may occur.

Based on the identified problem formulation, this study aims to know how to determine insurance premiums in Bengkulu Province using the standard deviation approach. Knowing the influence of loading factors on the amount of natural disaster insurance premiums in Bengkulu Province. This study helps insurers in improving risk management strategies and reducing uncertainty (something unpredictable). Increase public awareness about the importance of disaster insurance in dealing with natural disasters and help community planning and preparation to better deal with natural disasters.

2. Literature Review

The first thing to do is to look for a model for the large distribution of disaster losses. It is necessary to know what data distributes are because each distribution has a different formula. After the data has been known what distribution, it will continue to find the value of expectations and variances.

After obtaining expectations and variances from the large distribution model of disaster losses, it can be continued by finding the value of expectations and variances from the frequency model of many disaster events. All these expectations and variances will look for a model of collective disaster risk. The disaster collective risk model is used to find a pure premium model. A pure premium model that will use the standard deviation principle. The pure premium generated will be compared to a loading factor of 1-10%.

3. Materials and Methods

3.1. Materials

The first thing to do is to look for a model of the large distribution of disaster losses. It is necessary to know what distributed data because each distribution has a different formula. After the data has been known what distribution, it will continue to find the value of expectations and variances.

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3.2. Methods

3.2.1. Large Distribution Model of Disaster Losses

In this study, the normality test or Shapiro-Wilk Test will use R coding software using `shapiro.test()`. `shapiro.test()` uses *p-value* for a race to prove that the analyzed sample is normally distributed. Where $p\text{-value} < \alpha(0.05)$ it means that the sample is not normally distributed, while $p\text{-value} > \alpha(0.05)$ means that the sample is normally distributed (Monter-Pozos and González-Estrada, 2024).

3.2.2. Multi-Disaster Event Frequency Model

Modeling the frequency of many natural disaster events can use the Poisson process. The poisson process is the process of calculating events at certain intervals. Calculates the number of natural disaster events in the poisson process using mean and variance. If Y is a random variable and is a poisson-distributed with parameter λ , then it applies $\mu = E(Y) = Var(Y) = \sigma^2 = \lambda$. In the Poisson distributed test, the applicable hypotheses are:

H_0 : Normal distributed data ($p\text{-value} > \alpha$).

H_1 : The data is not normally distributed ($p\text{-value} \leq \alpha$).

The mean and variance formulas are as follows (Wackerly et al., 2008):

$$E(N(t)) = Var(N(t)) = \lambda t \quad (1)$$

$$\lambda = \frac{1}{n} \sum_{i=1}^n y_i \quad (2)$$

Information:

$E(N(t))$: Expectations of disaster events

λ : Average occurrence of natural disasters

t : value for prediction of how many years in the future

n : number of data or rows

y_i : Second observation value

i : numeric value 0,1,2,...,n

3.2.3. Disaster Collective Risk Model

Collective disaster risk modeling uses risk assessment and analysis of the potential impact of a disaster that occurs in an area or occurs to a group. This modeling will include many factors including geography, weather, infrastructure, population, and many other factors. The formula of the disaster collective risk model is as follows (Sumaryana et al., 2018):

$$\begin{aligned} E((S(t))^2) &= E[E((S(t))^2 | N(t) = n)] \\ &= Var(X(t))E(N(t)) + (E(X(t)))^2 E((N(t))^2) \end{aligned} \quad (3)$$

3.2.4. Pure Premium Model Standard Deviation Principle

There are many ways to calculate a pure premium model. According to Djuric 2013, there are principles that can be used to calculate a pure premium model. These principles are the expectation principle, the expectation value principle, the standard deviation principle and the variance principle. In this study will use the principle of standard deviation. As for the pure premium model formula, the standard deviation principle follows.

$$p(t) = E(S(t)) + \tau \sqrt{Var(S(t))} \text{ with } 0 \leq \tau \leq 1 \quad (4)$$

Information:

$p(t)$: The amount of premium is purely the principle of standard deviation

$E(S(t))$: Collective risk expectations

τ : Loading factor

$Var(S(t))$: Collective risk variance

4. Results and Discussion

Table 1. Natural Disasters Losses in Bengkulu Province

Year	Natural Disaster Losses	Event
2000	IDR 13,555,298,411.19	11
2001	IDR 11,029,916,950.18	12
2002	IDR 15,975,856,772.64	13
2003	IDR 15,410,902,354.27	17
2004	IDR 18,985,203,518.50	19
2005	IDR 17,557,268,711.70	18
2006	IDR 10,848,969,106.01	10
2007	IDR 17,395,018,451.02	11
2008	IDR 17,187,708,349.74	14
2009	IDR 19,927,948,832.11	20
2010	IDR 30,431,913,005.97	22
2011	IDR 19,079,543,271.32	21
2012	IDR 18,862,604,188.69	22
2013	IDR 8,834,824,847.88	23
2014	IDR 13,231,795,220.00	23
2015	IDR 23,703,573,276.09	25
2016	IDR 15,743,863,219.87	31
2017	IDR 17,353,216,866.92	34
2018	IDR 22,655,839,742.87	25
2019	IDR 23,433,580,384.88	19
2020	IDR 21,056,987,987.80	26

The first thing to do is to determine whether the distribution model of large natural disaster losses is normally distributed or not. Normal assumption tests can be seen through descriptive analysis using boxplot visualization. The result of the boxplot visualization is like the visualization below.

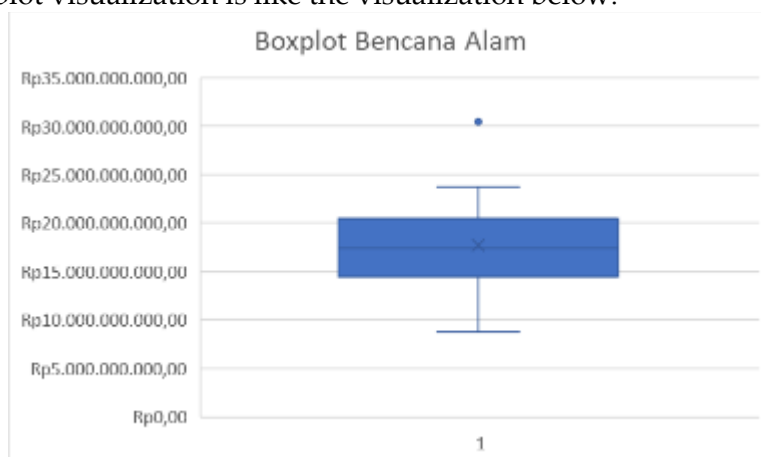


Figure 1. Boxplot of Natural Disasters

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Shapiro-wilk normality test

data:  c(13555298411, 11029916950, 15975856772, 15410902354, 18985203
518, 17557268711, 10848969106, 17395018451, 17187708349, 19927948832,
30431913005, 19079543271, 18862604188, 8834824847, 13231795220, 23703
573276, 15743863219, 17353216866, 22655839742, 23433580384, 210569879
87)
w = 0.97089, p-value = 0.7527
    
```

Figure 2. Normality Test Output

Based on Fig. 1, the distribution data is normal because the median value is similar to the average. When viewed from the skewness, the left and right are almost the same. To ascertain whether the data is normally distributed or not, a statistical assumption test is needed. After testing the normality assumption using the Shapiro-Wilk Test, a p-value of 0.7527 was obtained. Which means the p-value is greater than the significance level of 5%. Then the data is normally distributed.

After knowing the normally distributed data, the next step is the loss of natural disaster events. The results obtained are $E(X) = \text{Rp}17,726,753,975$ and $\text{Var}(X) = \text{Rp}24,819,999,294,230,000,000$. From this result can be continued by finding $E(N)$ and $\text{Var}(N)$. Then, continue by searching for models of the frequency of many natural disasters. The model is Poisson-distributed data; therefore, we will find $E(N)$ and $\text{Var}(N)$ with the Poisson distribution.

One-Sample Kolmogorov-Smirnov Test 2

		VAR00003
N		21
Poisson Parameter ^{a,b}	Mean	19.81
Most Extreme Differences	Absolute	.173
	Positive	.173
	Negative	-.092
Kolmogorov-Smirnov Z		.794
Asymp. Sig. (2-tailed)		.554

a. Test distribution is Poisson.

b. User-Specified

Figure 3. Poisson Distribution Test Output

From the Fig. 3, it is concluded that the data is Poisson distributed ($p\text{-value} > 0.05$). In the Poisson distribution, the expectation value is equal to the variance. The t used is 1 because it will predict the premium for 1 year after 2020, i.e. 2021. The result obtained is $E(N) = \text{Var}(N) = 19.81$.

The collective risk obtained is $E(S) = \text{Rp}351,158,554,933.33$, and $\text{Var}(S) = \text{Rp}6,716,573,676,491,140,000,000$. From the results of the collective risk of natural disasters, it can be continued to determine a pure premium model using the standard deviation principle. In the pure premium model, the standard deviation principle of the loading factor that will be tried is 1-10% to see if there is a sufficient difference between loading factors.

Table 2. Pure Premium Natural Disaster'

Loading factor	Pure Premium
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1%	IDR 351,978,101,983.63
2%	IDR 352,797,649,033.93
3%	IDR 353,617,196,084.22
4%	IDR 354,436,743,134.52
5%	IDR 355,256,290,184.81
6%	IDR 356,075,837,235.11
7%	IDR 356,895,384,285.41
8%	IDR 357,714,931,335.70
9%	IDR 358,534,478,386.00
10%	IDR 359,354,025,436.30

To see the difference even more clearly, here is a pure premium visualization using the standard deviation principle using the loading factor of 1-10% below.

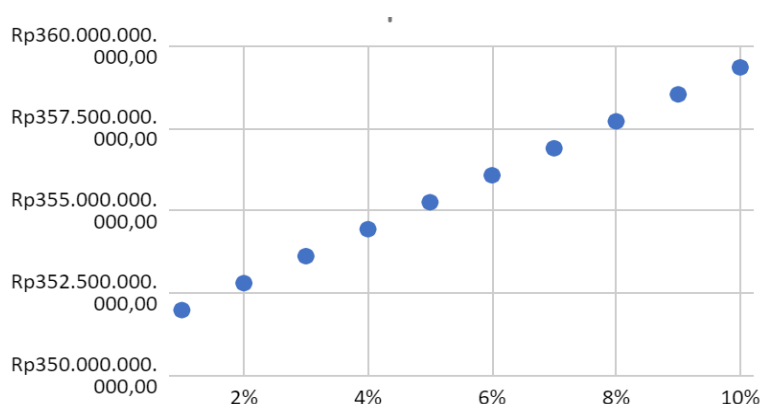


Figure 4. Differences in Premium Insurance using Standard Deviation Method

The difference in pure premium between loading factors is around Rp1,000,000,000. The difference is not too noticeable when compared to the pure premium of Rp300,000,000,000.

5. Conclusions

The normal distributed natural disaster loss model and Poisson distributed natural disaster event model. Expectations and Variances from the Natural Disaster Loss Model are $E(X) = \text{Rp}17,726,753,975$ and $\text{Var}(X) = \text{Rp}24,819,999,294,230,000,000$. In the natural disaster event model, expectations and variances are $E(N) = \text{Var}(N) = 19.81$. In the Poisson distribution the value of expectation is equal to the variance. After obtaining expectations and variances from the loss model and natural disaster events, proceed to calculate the collective risk model. By using the collective risk model, pure premiums are obtained ranging from Rp351,978,101,983.63 to Rp359,354,025,436.30 with a loading factor of 1-10%. Pure premiums are calculated using the standard deviation principle. The pure premium value has a large value, when viewed based on pure premiums, the difference between loading factors reaches Rp1,000,000,000 per 1% loading factor. Although the difference is not too much when compared to pure premiums, Rp1,000,000,000 is quite a big difference. For the next study, it is expected to compare other insurance premium calculation methods. Are there any significant differences between the methods of calculating insurance premiums.

References

- Kalfin, Sukono, Supian, S., & Mamat, M. (2022). Insurance Premium Determination Model and Innovation for Economic Recovery Due to Natural Disasters in Indonesia. *Computation*, 10 (10), 174.
- Kalfin, Sukono, Supian, S., Mamat, M., & Bon, A. T. (2020). A Review Mitigation Efforts and Natural Disaster Insurance Schemes in Indonesia. In *Proceedings of the International Conference on Industrial Engineering and Operations Management, Harare, Zimbabwe* (pp. 1825-1835).
- Monter-Pozos, A., & González-Estrada, E. (2024). On testing the skew normal distribution by using Shapiro–Wilk test. *Journal of Computational and Applied Mathematics*, 440, 115649.
- Perdana, D. D., Adhrianti, L., & Budiman, D. A. (2022). Disaster Communication Through Social Media as A Means of Information and Education for Bengkulu Communities. *Ultimacomm: Jurnal Ilmu Komunikasi*, 14(2), 206-218.
- Sumaryana, A., Utami, S. B., & Pancasilawan, R. (2018). Sosialisasi model kolaborasi dalam manajemen bencana alam di Kabupaten Pangandaran. *Dharmakarya: Jurnal Aplikasi Ipteks Untuk Masyarakat*, 7(2), 134-137.
- Wackerly, D. D., Mendenhall, W., & Scheaffer, R. L. (2008). *Mathematical Statistic with Applications* (7th ed.). Thompson Learning.
- Sugiharto, A. (2022). *BMKG Station Kepahiang Serahkan Peta Rawan Bencana Tsunami* (berita). Radar Bengkulu Online