Determination of Farming Business Insurance Premium Prices with the Variance Premium Principle and Standard Deviation Premium Principle Methods

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Abstract

The agricultural sector is one of the most important economic sectors in Indonesia, however, agricultural business can also pose a risk of loss resulting in a decrease in agricultural production. This is caused by several factors such as plant pests, weeds, and rainfall. Therefore it is necessary to make an effort to reduce the risk of losses that occur, one of which is by implementing an insurance policy. The risk experienced by farmers is assumed to be a random variable that has a certain distribution. So that the calculation of this risk is related to the probability model, one of which is the aggregate loss model. Then applied the principle of variance premium, and standard deviation premium to calculate the amount of insurance premiums. The amount of premium generated for each of these principles is 2,396,277 and 2,012,839. So it can be said that with the same risk, the standard deviation premium principle produces a premium price that is more economical than the variance premium principle. So that if this principle is applied, farmers will benefit more if they insure their agricultural businesses.

Keywords: Agricultural business, risk of loss, random variable, principle of variance premium, standard deviation premium

1. Introduction

Indonesia is an agrarian country, where most of the population live as farmers. So that the agricultural sector is one of the most important economic sectors in Indonesia (Joen, 2013; Nabhani et al., 2016; Ustriyana and Dewi, 2017). The agricultural sector is also a sector that plays a role in meeting food needs for all Indonesian people. However, agricultural business can pose a risk of loss to farmers, which results in a decrease in agricultural production. This is caused by several factors such as plant pests, weeds, and rainfall (Khumairoh et al., 2018; Fujisaka et al., 1993; Mariyono, 2007). Unstable rainfall results in sub-optimal yields. Plant pests such as rats and leafhoppers can also cause crop yields to decrease. Therefore it is necessary to make an effort to reduce the risk of losses that occur, one of which is by implementing agricultural insurance policies for farmers. With insurance, farmers will get compensation for the risk of loss experienced(Fadhliani et al., 2019; Fadhil et al., 2021; Haryastuti et al., 2021).

The risk experienced by farmers is assumed to be a random variable that has a certain distribution. So that the calculation of this risk is related to the probability model, one of which is the aggregate loss model. Then the amount of insurance premiums can be determined through several principles, including the principle of pure premium, expected premium, variance premium, standard deviation premium, and so on(Lesmana et al., 2018; Guerra et al., 2010; Sari et al., 2020). In this study, applied the principle method of variance premium, and standard deviation premium to determine the amount of insurance premiums on agricultural business results. Then analyzed the results of the two methods so that it can be applied in determining insurance premiums for farmers(Schurle, 1996; Roberts et al., 2006; Tack et al., 2018).

2. Reserch Method

The data used in this study are secondary data, namely land area data and farming costs. The number of claims is assumed to be calculated per square meter of agricultural land. So the land area can be expressed as the number of claims (*N*). Then the claims or losses experienced are assumed to be equal to the production costs incurred by

farmers. So that production costs or farming costs can be expressed as the amount of claims or losses (S). The variables and data structures in this study are presented in Table 1 and Table 2.

Table 1. Research Variables

Variable	Description
N	Land area (multiple claims)
X	Farming costs (big claim/loss)

Table 2. Research Data Structure

Observation	N	X
1	N_1	X_1
2	N_2	X_2
$\vdots$	$\vdots$	$\vdots$
100	N_{100}	X_3

The methods and stages carried out in this research include the following:
1) Analyzing descriptive statistics on research variables which include mean, standard deviation, maximum value, and minimum value.
2) Conduct a normality test for each research variable using the Kolmogorov-Smirnov test.
3) Perform distribution fittings for each research variable to determine the appropriate distribution for each research variable using the Kolmogorov-Smirnov Goodness of Fit.
4) Substituting the expectation and variance formulas from a certain distribution based on the results in step (3) on each research variable.
5) Substituting the expected and variance formulas from the aggregate loss model based on the results in step (4).
6) Perform large calculations of insurance premiums with the variance premium principle and standard deviation principle. In this study, a loading factor of 0.2 was taken.
7) Analyze the results of premium calculations.
8) Draw conclusions.

3. Literature Review

3.1. Kolmogorov-Smirnov Goodness of Fit

Kolmogorv-Smirnov test is a statistical test used to determine whether a sample comes from a population with a certain distribution. Given sorted data $X_1, X_2, \ldots, X_n$, the empirical distribution function is defined as (Fadhil et al., 2021).

$$En = \frac{n(i)}{N}$$

With $n(i)$ the number of points less than $x(i)$ and $x(i)$ sorted to the greatest value. The hypothesis of the Kolmogorov_Smirnov test:
H_0 : data follows a certain distribution
H_1 : data does not follow a certain distribution
The Kolmogorov-Smirnov statistical test is defined as follows:

$$D = Max \left(F(Xi \frac{i-1}{N}), \frac{i}{N} F(Xi) \right)$$

is the theoretical cumulative distribution. 0 is rejected if > (Kolmogorov-Smirnov table).

3.2. Gamma Distribution and Beta Distribution

The probability density function for the gamma distribution is as follows (Fadhliani et al., 2019).

$$F(x) = \frac{1}{\beta^\alpha \Gamma(\alpha)} x^{\alpha-1} e^{-\frac{x}{\beta}}, x > 0$$

and $(x) = 0$ for x another with α , $\beta > 0$, and with

$$E\ (x) = \alpha\beta \tag{1}$$
$$\text{Var}\ (x) = \alpha^2\beta \tag{2}$$

While the probability density function for the beta distribution is as follows (Fadhliani et al., 2019).

$$F(x) = \frac{1}{B(a,b)}\, x^{\alpha-1}\,(1-x)^{b-1}$$

$$B\ (a,b) = \int_0^1 x^{a-1}\,1 - x^{b-1}\ dx$$

Where $a,b > 0$, and

$$E\ (x) = \frac{a}{a+b} \tag{3}$$

$$\text{Var}\ (x) = \frac{ab}{(a+b+1)(a+b)^2} \tag{4}$$

3.3. Aggregate Loss Model

Given that N is a random variable that indicates the number of claims, indicates the amount of individual claims or losses, and indicates aggregate losses, then the amount of aggregate losses can be calculated through the following equation (Fadhliani et al., 2019).

$$E(S) = E(N)E(X) \tag{5}$$

$$Var(S) = E(N)Var(X) + E(X)^2 Var(N) \tag{6}$$

3.4. Variance Premium Principle and Standard Deviation Premium Principle

There are several principles in calculating the amount of premium, one of which is the variance premium principle and the standard deviation premium principle. The variance premium principle has the following formula (Guerra & Centeno, 2010):

$$\prod\nolimits_s = E(S) + \theta V(S) \tag{7}$$

$$\prod\nolimits_s = E(S) + \theta \left[V(S)^{\frac{1}{2}} \right] \tag{8}$$

where $\theta > 0$, where θ is the loading factor which is proportional to the standard deviation .

4. Results and Discussion

4.1. Descriptive Analysis

Based on table 3, it can be seen that the variable N has a mean value of 6,298.0 and a standard deviation of 3,700.7 with a minimum value of 1,000 and a maximum value of 18,000. While the variable X has a mean value of 5,957,798.5 and a standard deviation of 3,619,791.5 with a minimum value of 920,500 and a maximum value of 16,569,000.

Table 3. Descriptive Statistics of Research Data

Variabel	Mean	StDev	Min	Max
N	6,298.0	3,700.7	1.000	18,000
X	5,957,798.5	3,619,791.5	920,500	16,569,000

4.2. Normality Test

At this stage, the variables and are identified whether they meet a normal distribution or not. The normality test used in this study is the Kolmogorov-Smirnov test. The results of the Kolmogorov-Smirnov normality test are presented in Figure 1.
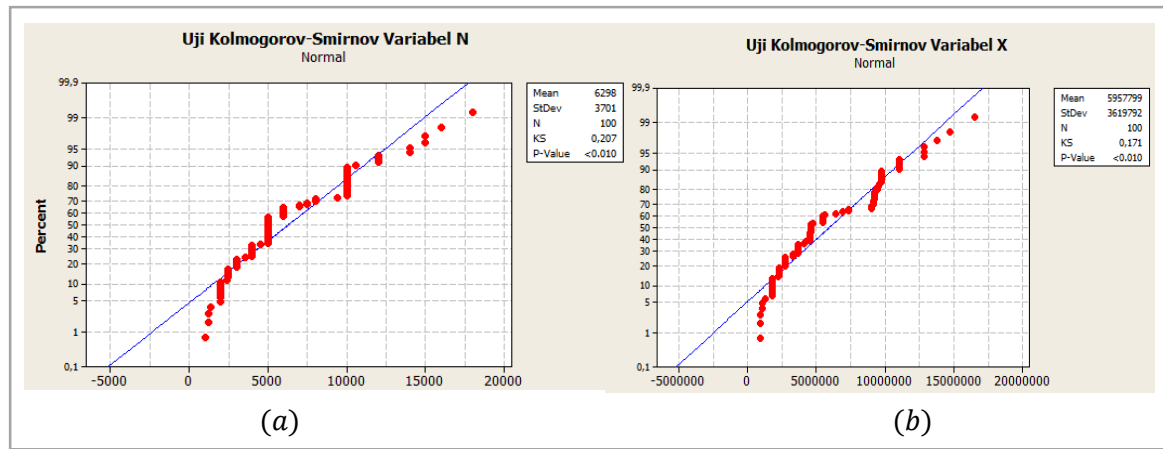

Figure 1. Normality Test Plot of: (a) Variable *N*, (b) Variable *X*

Based on Figure 1, the p-value for each variable shows a value less than $\alpha = 0.05$. So it can be concluded that the variables *N* and *X* do not meet the assumption of a normal distribution. The next step is fitting distribution, which is finding the appropriate distribution for each research variable.

4.3. Kolmogorov-Smirnov Goodness of Fit

The results of the fitting distribution using the Kolmogorov-Smirnov goodness of fit test on the research variables are presented in Table 4.

Table 4. Goodness of Fit Test of Research Variables

Variable	Distribution	Parameter	K-S Statistics	*p-value*
N	Gamma	$\alpha = 2.505$ $\beta = 2428.4$	0.1239	0.085
X	Beta	$a = 1.1091$ $b = 2.2576$	0.124	0.084

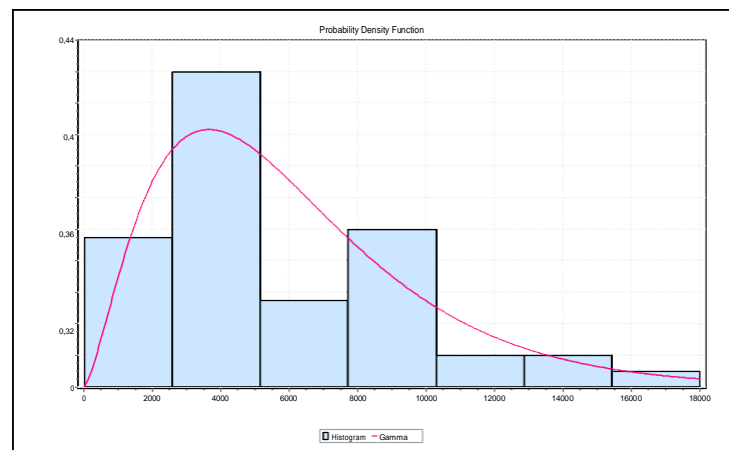The probability density function plots for each research variable are presented in Figure 2 and Figure 3.

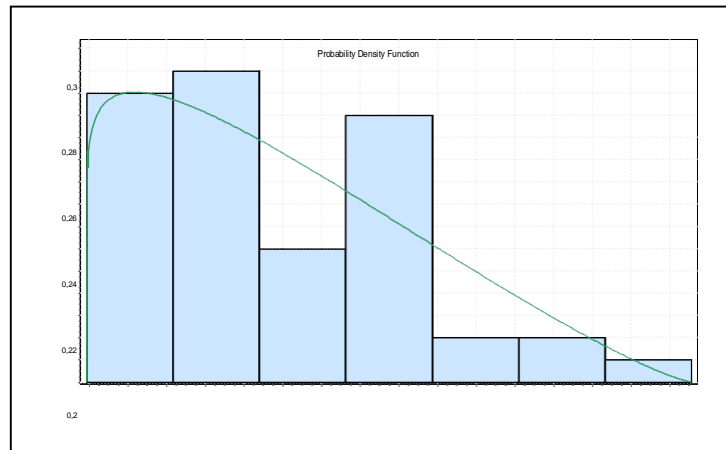**Figure 2.** Plot of Probability Density Function Variable

Figure 3. Plot of Probability Density Function Variable *X*

4.4. Aggregate Loss Model

Then the expected value and variance of the aggregate loss will be searched. Before getting the expected value and variance of aggregate loss, we will first look for the expectation and variance of each variable. Based on the results of the Kolmogorov-Smirnov goodness of fit test in table 4, it is found that the variables *N* and *X* each meet the Gamma distribution and the Beta distribution. The parameter estimation results in the variable obtained the value of = 2,505 and β = 2428.4. So that $N{\sim}G(2.505, 2428.4)$, then based on equations (1) and (2) we get.

$$(N) = 2.505(2428.4) = 6{,}083.14$$
$$V(N) = (2.505)^2(2428.4) = 15{,}238.27$$

While the parameter estimation results for the variable obtained values of $a = 1.1091$ and $b = 2.2576$. So that $X{\sim}Be(1.1091, 2.2576)$, then based on equations (3) and (4) we get

$$E\,(X) = \frac{1.1091}{1.1091+2.2576} = 0.329432$$

$$Var\,(X) = \frac{(1.1091)(2.2576)}{(1.1091 + 2.2576 + 1)(1.1091 + 2.2576)^2} = 0.050589$$

4.5. Variance Premium Principle and Standard Deviation Premium Principle for Aggregate Loss Model

Then the calculation of the amount of insurance premiums with the variance premium principle is carried out based on equation (7), so that

$$\prod\nolimits_s = 2003{,}981 + 0.2(1961{,}479) = 2{,}396{,}277$$

Sedangkan perhitungan premi dengan standart deviation premium principle berdasarkan persamaan (8) didapatkan

$$\prod\nolimits_s = E2003.981 + 0.2\,(1961{,}479^{\frac{1}{2}}) = 2{,}012{,}839.$$

5. Conclusion

The conclusion obtained in this study is the amount of insurance premiums can be calculated from the aggregate losses experienced by farmers. While the aggregate loss is influenced by the number of claims and the amount of individual claims or losses. The application of the same data on several different principles will result in the calculation of the amount of the premium being different. In this study, two principles were applied in calculating farm insurance premiums, namely the variance premium and standard deviation premium principles. From these two principles with the same data, it is found that the value of insurance premiums with the standard deviation premium principle gives a relatively smaller calculation result compared to the variance premium principle. So it can be said that with the same risk, the standard deviation premium principle is more economical than the variance premium principle. So that if this principle is applied, farmers will benefit more if they insure their agricultural businesses.

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