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Comparison of Agricultural Insurance Premium Prices Based on Rainfall Index and Based on Corn Commodity Production Prediction Index in Grobogan District

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Abstract

In running an agricultural business, there is a big risk because farmers' productivity is very dependent on nature, and to reduce the risk of crop failure, the government provides a program to minimize losses from crop failure, namely agricultural insurance, through Law Number 19 of 2013. This article aims to compare agricultural insurance premium prices based on the rainfall index and the production prediction index for corn commodities in Grobogan Regency. The results of this article are based on the reference used of 3% of compensation, namely IDR 344,872.5, and the results that are close to the reference are the price of insurance premiums based on the 5th simple average method corn production prediction index of IDR 356,433.58. However, the premium price used as a reference previously was the gross premium price from AUTP, so the insurance premium price for Corn Farmers (AUTJ) was obtained, namely IDR 310,385.25. As a result, we obtained premium price results that were closest to the reference from AUTJ, namely at the 4th percentile, when the agricultural insurance premium price based on the rainfall index was IDR 330,155.76 per planting season.

Keywords: Corn crops, agricultural insurance, black-csholes equation, linear regression equation, simple average method.

1. Introduction

Indonesia is a country known as an agricultural country because the majority of the Indonesian population works in the agricultural sector. The agricultural sector plays an important role in Indonesia's development and economy. Apart from rice and wheat, corn plants have an important role for Indonesian people as a food commodity (Rozi et al., 2023; Darma et al., 2022). Currently, many corn plants are used as energy and raw materials for other industries, which always increases every year (Ariningsih et al., 2021). Corn plants are very suitable for the climate and weather conditions in Indonesia. Several corn producing regions in Indonesia are East Java Province, Central Java Province and Lampung Province (Irawati and Wibawa, 2021).

Grobogan Regency Government data from the Regional Planning and Development Agency (BAPPEDA) for the 2020 fiscal year explains that Grobogan Regency is one of the food baskets of Central Java Province and nationally as well as the largest contributor to corn commodity production in Central Java Province in terms of corn commodities with production of 771,837 tons or 21.8 % of Central Java's total corn production in 2018 (Grobogan Regency Government Regional Planning and Development Agency (BAPPEDA, 2020).

According to the Ministry of Agriculture, the Directorate General of Food Crops, almost every year most of the Grobogan Regency, Central Java Province always experiences drought because the weather in Grobogan Regency is generally very hot and the rainfall is low intensity throughout the year. Of course, this will cause farmers to experience large losses, so to overcome farmers' losses caused by crop failure, the government issued a policy regarding agricultural insurance, namely Law Number 19 of 2013 concerning Farmer Protection and Empowerment, which was followed up with the issuance of Regulation of the Minister of Agriculture Number 40 of 2013. 2015 concerning Agricultural Insurance Facilities (Purnamasari and Hestyara, 2021).

Research relevant to determining premium prices for agricultural insurance has been conducted by Anggraeni et al., (2018), Roji (2022), and Togatorop & Maruddani (2022). In determining the premium price for agricultural insurance, Anggraeni et al., (2018) used rice commodity data in the Denpasar city area, Roji (2022) used rice commodities in the

Bogor Regency area, and Togatorop and Maruddani (2022) used cayenne pepper commodity data in the area. Salatiga City. This reference uses the same method, namely the Black-Scholes method which is based on the rainfall index.

According to Putri et al., (2017) the Black-Scholes method can be used to determine or calculate insurance premiums when production results decrease below standard because they are influenced by rainfall and can also determine option prices. Apart from that, linear regression and simple average methods are also used to make predictions on corn production which will be used in determining agricultural insurance premium prices based on the production prediction index.

Based on these facts, researchers are interested in comparing premium prices obtained using linear regression and simple average methods for agricultural insurance based on rainfall indices and prediction indexes for corn commodities.

2. Research Methods

The method used in this research is literature study and secondary data collection. The data used is monthly rainfall data and corn production data for Grobogan Regency from 2018 to 2022. Data obtained from the Grobogan District Agriculture Service. Data analysis was carried out with the help of software, namely Microsoft Excel, R Studio program, and SPSS. The research steps used are as follows:

1) Calculate agricultural insurance premium prices based on rainfall index.
   a. collecting data and resampling data using the bootstrap method for corn production and monthly rainfall data for Grobogan Regency from 2018-2022 into a 30 year range, namely 1992-2023;
   b. accumulating monthly rainfall data and monthly corn production data for Grobogan Regency from 2018-2022 with a quarterly distribution over 4 consecutive months;
   c. calculate the correlation value between rainfall and corn production data in quarters I, II, and III, and determine quarters as an index;
   d. determine the quarterly period of the rainfall index that is most strongly correlated with corn production data;
   e. carry out a normality test on the natural logarithm of the rainfall index selected as a requirement to fulfill the Black-Scholes equation using the Kolmogorov-Smirnov test;
2) Calculate agricultural insurance premium prices based on the rainfall index using the Black-Scholes equation using the rainfall index selected in step 1 part d. In this research, the Black-Scholes equation used to calculate the premium with a cash-or-nothing put option is as follows:

$$Pr = Me^{-rT}N(-d_2) \tag{1}$$

with

Pr : price of agricultural insurance premiums
M : Insurance price
r : The risk-free interest rate
T : The time when it matures, namely the time of harvest
$N(-d_2)$: Mark standard normal cumulative function distribution when$z \leq -d_2$

To calculate agricultural insurance premium prices based on corn production predictions, you can use two methods, namely:

a. Simple linear regression method
   (i) Determine the regression equation between the rainfall index and corn production in the selected rainfall quarter; In this research, the simple linear regression equation used is as follows:

$$P\hat{Y} = a + bX \tag{2}$$

   with
   $\hat{Y}$: line (predicted variable),
   a : Parameter intercept,
   b : Parameter slope (gradient of the regression line),
   X : Independent variable.

   (ii) calculate the predicted results of corn production in quarters based on the regression equation.
   (iii) determine the prediction index and test normality for the natural logarithm of the selected corn production prediction index;
   (iv) count mean, variance and calculate the insurance premium price that must be paid based on the corn production prediction data that has been obtained.

b. Simple average method
   Steps (i) – (iv) listed in step a are used in this step, for the next steps, namely:

(i) Determine the regression equation using the simple average estimation method. In this research, the simple average method equation used to calculate the premium price is as follows:

$$Y = a_{SA} + \bar{b}_{SA}X \tag{3}$$

(ii) Calculate the results of corn production predictions and determine the selected corn production prediction index based on quarters in step 1;

(iii) Calculate the mean, variance and calculate the insurance premium price that must be paid based on the corn production prediction data that has been obtained;

3. Results And Discussion

3.1. Insured value of grobogan regency corn crops

In this research, the production costs per planting season (M) used are based on research conducted which can be seen in Table 1.

Table 1: Insured value of grobogan regency corn crops

Inputs	Unit	Vol.	Price (IDR)	Value (IDR)
Cost				
- Fixed cost				4,130,000
Land lease	Ha	1	4,000,000	4,000,000
Tool Preparation	IDR	xxx	xxx	130,000
Variable Costs				7,365,750
Seed	Kg	15	65,000	975,000
Fertilizer				1,338,750
Urea	Kg	275	2,250	618,750
NPK	Kg	300	2,400	720,000
Pesticide				432,000
Herbicide	Ltr	8	54,000	432,000
Labor				4,620,000
Tillage	Wholesale		xxx	1,000,000
Plant	HOK	20	60,000	1,200,000
Fertilization	HOK	15	60,000	900,000
Sprinkling	HOK	4	60,000	240,000
Harvest (pick + transport)	Wholesale	xxx	xxx	440,000
Drying	IDR/ton	4	150,000	600,000
Shelling	IDR/kg	60	4,000	240,000
Total cost				11,495,750

Source: Primary Data Analysis (2020)

This research will look for the most reasonable premium amount based on the Rice Farming Business Insurance (AUTP) which calculates the premium price for one hectare of land per planting period at 3% of the AUTP (Sukono et al., 2023), with a reference of 3% of the compensation of IDR 11,495,750 obtained a reasonable result for the premium price, namely IDR 344,872.5.

3.2. Data

The data used in this research is rainfall and corn production data in Grobogan Regency for 2018-2022 which can be seen in Attachments 1 and 2. In Appendix 1, the highest rainfall in Grobogan Regency occurred in January 2021, namely 408 mm/month and the lowest rainfall occurred in July 2018 and September 2018, namely 0 mm/month. In Appendix 2, the largest corn production in Grobogan Regency occurred in February 2020 amounting to 37,068 tons/month and the smallest corn production occurred in November 2020, namely 170 tons/month.

The data used are monthly rainfall data and monthly corn production for Grobogan Regency from 2018-2022, resampled to 1993-2023, which can be seen in Attachments 3 and 4. As a result, all the data used in this research are monthly rainfall and corn production data. monthly in Grobogan Regency from September 1993 to August 2023 is the result of data resampling using the bootstrap method using R Studio software.

3.3. Accumulated rainfall data

Calculation of quarterly rainfall and corn production data is obtained by adding up monthly rainfall data over a period of 4 months. The first quarter is the accumulation of rainfall data for September-December. The second quarter is the accumulation of rainfall data for January-April. The third quarter is the accumulation of rainfall data for May-August. The results of calculating rainfall data and quarterly corn production for Grobogan Regency from 1993 to 2022 can be seen in Attachments 5 and 6.

3.4. 3.4 Determination of rainfall index

Determination of the rainfall index is then used in calculating insurance premiums, which can be seen in Table 2.

Table 2: Correlation value of rainfall and corn production

Rainfall	Corn Production		
	Quarter I	Quarter II	Quarter III
Quarter I	0.152637	0.027173	0.229034
Quarter II	-0.289952	0.233549	-0.045145
Quarter III	-0.240573	0.171964	0.668837

Based on Table 2, it can be seen that the correlation value of rainfall data for quarter III with corn production data for quarter III has a value closest to number one, namely 0.668837, meaning that rainfall data for quarter III and corn production data for quarter III have a very strong relationship.

3.5. Normality test

The normality test in this study used the Kolmogorov-Smirnov test which was carried out with the help of the SPSS program.

H_0 : data lnThe second quarter rainfall is normally distributed
H_1 : data lnThe second quarter rainfall is not normally distributed

The level of significance used is $\alpha = 5\%$the decision criteria if $D < D$ table and p-value $\geq \alpha$then it H_0 cannot be rejected. This means that the third quarter rainfall data is normally distributed.ln

Based on the results of calculations with SPSS obtained a D of 0.095 and a p-value of 0.2. Because $D = 0.095 <$ Dtable =0.288146 and p-value =0.2 > $\alpha = 0.05$ then H_0it cannot be rejected, meaning that the third quarter rainfall data $ln$is normally distributed.

3.6. Calculation of premiums based on rainfall index

The calculation of the premium based on the rainfall index will be carried out using the Black-Scholes equation for the European type of cash-or-nothing put option using equation (1) with quarterly data III. According to Filiapuspa et al., (2019) , the parameters $\tilde{\mu}$and $\tilde{\sigma}$are respectively the mean and standard deviation of the lognormal distribution. Parameter values $\tilde{\mu}$and $\tilde{\sigma}$can be calculated by:

$$\tilde{\mu} = \frac{1}{n-1} ln\left(\frac{R_b}{R_1}\right) T = \frac{1}{30-1} \; ln\left(\frac{580}{820}\right) 0.333 = -0.003976$$

$$\tilde{\sigma} = \sqrt{\frac{1}{n-2}\sum_{i=2}^{n}(u_i - \bar{u})^2}\,\sqrt{T} = \sqrt{\frac{1}{30-2}(5.082112)}\sqrt{0.333} = 0.245847$$

Next determine the value $N(-d_2)$, for example the calculation for the value $d_2$carried out at the 4th percentile can be calculated using the following formula:

$$d_2 = \frac{ln\left(\frac{R_b}{R_c}\right) + \tilde{\mu}}{\tilde{\sigma}} = \frac{ln\left(\frac{580}{395.6}\right) + -0.003976}{0.245847} = 1.540177$$

$$N(-d_2) = 0.061758$$

Production costs per planting season $M$are IDR. 11,495,750, the time period Tused in this research is 0.333 with a risk-free interest rate $r$of 2.2992346%, then the premium size for the 4th percentile using equation (1) is obtained

$$Pr = Me^{-rT}N(-d_2)$$

=IDR 11,495,750 (0.465034) (0.061758)

=IDR 330,155.8

So, the premium must be paid at the 4th percentile when the trigger value $R_c$of 395.6 mm is IDR 330,155.8. For premium sizes at percentiles 5 and 6, see Appendix 7.

3.7. Simple linear regression equation least squares method approach

The results of the correlation value from rainfall data for quarter III and predictions of corn production for quarter III obtained a correlation value of 0.669 and a coefficient of determination of 0.447. This means that the correlation coefficient value for the third quarter rainfall and corn production data has a strong level of relationship between variables because the correlation coefficient value (R) $\geq$ is 0.60. However, in agricultural insurance statistics, the coefficient of determination value in this study cannot be used by insurance companies because the coefficient of determination value (R^2)< 0.80) means that other variables besides rainfall can be added, such as temperature, air humidity and altitude. However, Mathematically, the coefficient of determination value in this research can be used to calculate premium prices using regression, namely the least squares and simple average methods to predict production.

Next, a simple linear regression equation will be determined using the least squares

$$\hat{Y} = 0.18808 + 68.3189X$$

The calculation results are attached in Appendix 8. The prediction results for quarter III corn production using a simple linear regression equation using the least squares method can be seen in Appendix 9.

3.8. Calculation of Premiums Based on Corn Production Prediction Index Simple Linear Regression Least Squares Method

The premium calculation for agricultural insurance is based on the corn production prediction index using equation (2) with quarterly III data. To determine the parameter values $\tilde{\mu}$and $\tilde{\sigma}$, value $N(-d_2)$, production costs per growing season M, time $T$and risk-free interest rate, $r$you can use the calculations in the previous equation in Section 3.6, then the premium size for the 4th percentile using equation (1) is obtained

$$Pr = Me^{-rT}N(-d_2)$$

= IDR 11,495,750 (0.46503) (0.040924)

= IDR 218,781.12

So, the premium must be paid at the 4th percentile when the trigger value $R_c$amounting to 27,027.16 tons is IDR 218,781.12. For premium sizes at percentiles 5 and 6, see Appendix 10.

3.9. Determination of Agricultural Insurance Premium Prices Based on Corn Prediction Index Using the Simple Average Method

Calculation of the simple average method in equation (3) using Microsoft Excel 2019, so that the regression equation can be written as follows:

$$\hat{Y} = -10025.83 + 103.7341X$$

The calculation results are attached in Appendix 11. The results of quarterly corn production predictions using a simple linear regression equation using the simple average method with the quarter that will be selected for the next calculation, namely quarter III, which was previously selected for the rainfall index, can be seen in Appendix 12.

The premium calculation for agricultural insurance is based on the corn production prediction index using equation (3). To determine the parameter values $\tilde{\mu}$and $\tilde{\sigma}$, value $N(-d_2)$, production costs per growing season M, time $T$and risk-free interest rate, $r$you can use the calculations in the previous equation in Section 3.6, then the premium size for the 4th percentile using equation (1) is obtained

$$Pr = Me^{-rT}N(-d_2)$$
=IDR 11,495,750 (0.46503) (0.053231)
=IDR284,568 .38

So, the premium must be paid at the 4th percentile when the trigger value $R_c$amounting to 31,011.37 tons is IDR 284,568.38. For premium sizes at the 5th and 6th percentiles, see Appendix 13.

3.10. Comparison of Premium Prices from Three Calculation Methods

Plot of data from the results of premium price calculations from the three methods at the 4th, 5th and 6th percentiles can be seen in Figure 1.

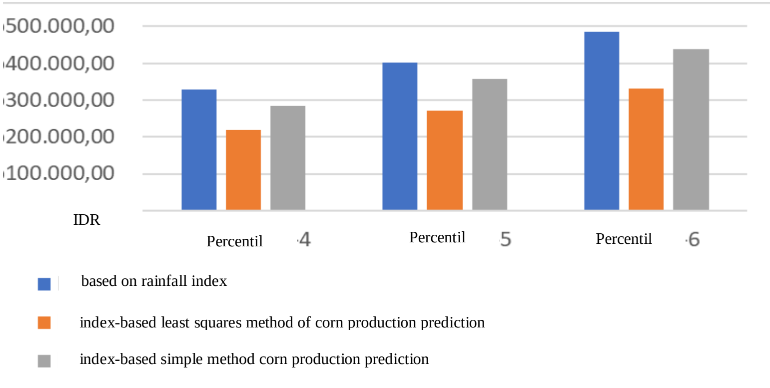

Figure 1: Comparison of agricultural insurance premium price calculation results based on rainfall index and corn production prediction index

4. Conclusions

The calculation results of the three methods in this research produce different premium prices at the 4th, 5th and 6th percentiles. This research aims to compare the amount of the premium based on the reference used of 3% of the compensation to obtain a fair result for the premium price, namely IDR 344,872.5. However, the premium price used as a reference is the gross premium price from AUTP. As a result, to determine the net premium price, it will be assumed to add administration costs, namely 0.3% of the compensation, then subtract the gross premium price to obtain the resulting insurance premium price for Corn Farmers (AUTJ), which is IDR 310,385.25. As a result, we obtained premium price results that were closest to the reference from AUTJ, namely at the 4th percentile when the agricultural insurance premium price based on the rainfall index was IDR 330,155.76 per planting season.

The suggestion that can be made is that for further research, it is hoped that premium research can use original data which is monthly data with a period of more than 5 years and calculate compensation based on rainfall indices and predictions of corn production. Apart from that, for the coefficient of determination value in research, it is recommended for future researchers to add other variables besides rainfall such as temperature, air humidity and altitude.

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