Determining Sustainable Rice Farming through Supply Chain Risk Management: A Case Study in Central Java, Indonesia

Agung Prabowo[1], Budi Pratikno[1], Jumadil Saputra[*2], Sukono[3]

[1]*Department of Mathematics, Faculty of Mathematics and Natural Sciences, University as Jenderal Soedirman, Indonesia*
[2]*School of Social and Economic Development, University Malaysia Terengganu, 21030 Kuala Nerus, Terengganu, Malaysia*
[3]*Department of Mathematics, Faculty of Mathematics and Natural Sciences, University as Padjadjaran, Indonesia*

Abstract- The government through the Department of Agriculture has been cooperating with Indonesian Insurance Services orPT. AsuransiJasa Indonesia (PT. Jasindo), to implement an insurance program for farmers throughout the country known as rice farming insurance (RFI).The supply chain efficiency and risk management may be two causal factors to uplift the economic conditions of the agricultural communities. The premium rate for 1 hectare of land designated at 3% of the maximum benefit value of IDR 6,000,000. Consequently, the premium received by PT. Jasindo for each hectare is IDR 180,000 of which the Government subsidy pays IDR 144,000,andfarmers will pay the remaining IDR 36,000 of the premium. This research will determine the actuarially fair premium rate, both theoretically and using the data of rice harvest yield in Central Java Province from 1990-2017. The calculation, employing the rice harvest yield data, results in the premium rate. The farmers must pay for each hectare from IDR 56,000 (minimum) to IDR 161,600 (maximum) with an average value of IDR 110,750.Meanwhile,the standard deviation principle used, the premium results between IDR 78,151 and IDR 143,349. The rate of IDR 208,458 per hectare has theoretically generated if there are 100 participants per regency (city) or in size of 3,500 hectares throughout Central Java Province and IDR 182,846 per hectare if there are 10,000 participants or about 350,000 hectares. These values are not much different from RFI premium currently applied to farmers throughout Indonesia.

Keywords- *Agricultural, supply chain management, Risk management, Benefit, Farmer, Insurance, Premium.*

1. Introduction

Supply chain management has become a major part of companies/firms management systems due the numerous benefit associated to supply chains in todays' business environment. However, although such supply chain design changes and supply chain management initiatives have great potential to make operations leaner and more efficient in a stable environment, they simultaneously increase the fragility and vulnerability of supply chains to disruptions. Most of the rice farmers in Java and Bali Islands are smallholders with averagely 0.3 hectares of land [1] so that any slightest harvest failure will significantly impact on them. Such a loss significantly influences some farmers' survivability. One of the solutions to overcome loss for harvest failure is to implement agricultural insurance. Before this agricultural insurance is applied, trials need to be performed first. These trials aim at preparing appropriate agricultural insurance concept. An examination of agricultural insurance implementation has been conducted in the planting season from October 2012 to March 2013 in West Java, East Java and South Sumatera provinces. The trial is held on respectively 1000 hectares of the farm by involving PT. Jasindo to be the insurer. PT can only perform the prosecution. Jasindo on 623.12 hectares of rice farm, which is still far from the expected 3000 hectares for the three provinces. The premium rate applied in the trial is IDR 180,000 per hectare (farmers pay only IDR 36,000,and the Government pays the remaining) with a total maximum benefit of IDR 6,000,000. With the total size of land on which trial has conducted of 623.12 hectares, the total premium received by PT. Jasindo is IDR 112,161,600. The premium received can only cover 18 claims for compensation, each of which is 1 hectare in size and receives maximum compensation (benefit) of IDR 6,000,000. Thus, with the premium it has received, it is certain that PT. Jasindo will suffer a loss since it is quite

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impossible that harvest failure will occur only on 18 hectares out of 623.12 hectares. Harvest failure occurs on 87.28 hectares of land. Consequently, PT. Jasindo must pay the claims for 87.28 x IDR 6,000,000 = IDR 523,680,000 or 467% of the premium value it has received. In this trial, PT. Jasindo suffers loss for IDR 523,680,000 – IDR 112,161,000 = IDR 411,519,000.

Even if it suffers loss, the percentage of harvest failure is only (87.28/623.12) x 100% = 14%. [1], estimates that from 1989-1991, the rate of rice harvest failure caused by flood, dry and pest is respectively 0.21%, 0.50% and 0.06 % of total planting area. The percentage of harvest failure in this trial is deemed as within reasonable limit; thus the agricultural insurance may be implemented. With a premium of IDR 180,000 and benefit (coverage) of IDR 6,000,000, then 34 farmers are needed to be participants. From the 34 participants, the collected premium will be 34 x IDR 180,000 = IDR 6,120,000,and there will be a difference of IDR 120,000 from the coverage value of IDR 6,000,000. It means that from 34 participants, only one farmer may suffer harvest failure; thus the harvest failure probability is 1/34 = 0.02941 = 0.03. An analogue calculation gives a number that from 100 participants, only three farmers may suffer harvest failure. Thus the harvest failure probability is 3 hectares out of 100 hectares. Theseare a break-even, in which the company neither gain profit nor suffer loss. The number of 34 participants has surpassed the number 30 as required in the law of large numbers. Thus the premium calculation may be based on a normally distributed harvest yield data.

[2]have discussed normal curve method. This method assumes that harvest yield distribution is normal [3,4,5].Furthermore, some authors [4], [6,7,8]—studied the empirical natured method that based on the relationship between the average of observed loss and the coverage value. Meanwhile, there are several authors, namely [9,10, 11, ,7] used the parametric and non-parametric method in calculating agricultural insurance premium. In the parametric approach, a farming harvest yield assumption follows specific distribution such as usual, beta or gamma, while non-parametric method used histogram and kernel estimator to estimate the distribution of the farming harvest yield. The rice farming insurance (RFI) premium rate for Central Java province will be determined in this research. The RFI premium rate is theoretically calculated using the short-term individual risk theory and the trial yield data. Also, the premium rate will be calculated using the data of rice harvest yield in Central Java from 1990-2017 (Central Bureau of Statistics), which fulfilnormal distribution hypothesis. The RFI premium calculation result may be taken as supporting calculation standard or baseline that the currently designated premium rate of RFI is reasonable. However, if the premium calculation result is much different from current premium calculation, then the results of this research may become material for review or revision in determining actuarially and practically fairer RFI premium rate.

2. Material and Methods

The premium rate is normally determined in two ways, theoretically and application on harvest yield data. This study employs secondary data and its analysis through a quantitative approach. Here, the data are annual rice harvest yield from 1990-2017 in 35 regencies/cities in Central Java Province, and 6 of which are central cities.The premium rate is theoretically calculated using short-term individual risk theory [12] to obtain an actuarially fair premium rate. The practically fair premium rate is computed using normally distributed harvest yield data. For example, S it represents the total aggregate claims the company must pay to participants with harvest failure. Following [12,13], the RFI premium rate is calculated using an expectation value principle,

$$P = (1+\theta)\cdot E[S] \tag{1}$$

Whereas, θ represented as relative security loading. The θ is then determined using the equation (1)

$$P_r\left(S \le (1+\theta)\cdot E[S]\right) = 0.95$$

And then it is solved using the law of large numbers approach [12]:

$$P_r\left(\frac{S-E[S]}{\sqrt{Var(S)}} \le \frac{\theta\cdot E[S]}{\sqrt{Var(S)}}\right) = 0.95 = P_r\left(Z \le 1.645\right) \tag{2}$$

From (equation 2), we then obtained

$$\theta = 1.645\cdot\frac{\sqrt{Var(S)}}{E[S]} \tag{3}$$

Expectation and variance of total aggregate claim S are calculated using the equations (4) and (5):

$$E[S]=\sum_{j=1}^{n}E[X_j]=\sum_{k=1}^{35}n_k\cdot b_k\cdot q_k \quad (4)$$

$$Var(S)=\sum_{j=1}^{n}Var(X_j)=\sum_{k=1}^{35}n_k\cdot b_k^2\cdot q_k\cdot(1-q_k) \quad (5)$$

The rice harvest yield data has given in quintal unit per hectare, taken from Central Java in number from 1991-2017. The normality test of the harvest yield datatested for data normality using Kolmogorov-Smirnov test [14,15].When the harvest yield data follows the normalityassumption, then the RFI premium rate for all regencies/cities in Central Java could be calculated using three formulas established above. After that, a single and equal RFI premium rate for Central Java can be determined using the mean method. The normality test of rice harvest yield data in 35 regencies and cities in Central Java is tested using the Kolmogorov-Smirnov test. In this test, the null hypothesis is the rice harvest yield of each regency/city in Central Java Province are normally distributed. Note that the hypothesis test is a two-sided test. Here, the null hypothesis is accepted when the Kolmogorov-Smirnov value higher than Kolmogorov-Smirnov table $D_{\alpha;n}$.Following [2], it assumed that agricultural harvest yield normally distributed with parameter μ and σ^2. If the variation coefficient is equal to 0.25 or $\sigma=0.25\mu$,then the insurance premium rate for the scope of $\alpha\times100\%$ is

$$P_1=\Phi\left(\frac{\alpha\mu-\mu}{0,25\mu}\right)\cdot(\alpha\mu-\mu)+\phi\left(\frac{\alpha\mu-\mu}{0,25\mu}\right)\cdot 0,25\mu \quad (6)$$

Since $\sigma=0.25\mu$ equation (6) shall become

$$P_1=(\mu(\alpha-1))\cdot\Phi\left(\frac{\mu(\alpha-1)}{\sigma}\right)+\sigma\cdot\phi\left(\frac{\mu(\alpha-1)}{\sigma}\right) \quad (7)$$

With $\Phi(z)$ is the cumulative distribution function of which values viewed in Standard Normal Table, and $\phi(z)=\frac{1}{\sqrt{2\pi}}e^{-\frac{1}{2}z^2}$ is the standard normal distribution probability density function. The estimated premium is calculated using the average and standard deviation of a sample. Thus equation (7) shall become

$$P_1=(\bar{x}(\alpha-1))\cdot\Phi\left(\frac{\bar{x}(\alpha-1)}{s}\right)+s\cdot\phi\left(\frac{\bar{x}(\alpha-1)}{s}\right);\ \text{for}\ 0<\alpha\le1. \quad (8)$$

Note that one of the authors [16] have proposed a formula of actuarially fair AUTP premium rate as follows

$$P_2=6\cdot\Phi\left(\frac{-0.75\mu}{\sigma}\right)-8\frac{\sigma}{\mu}\left[\phi\left(\frac{-0.75\mu}{\sigma}\right)-\frac{1}{\sqrt{2\pi}}\right] \quad (9)$$

It is reasonable that all regencies/cities in Central Java uses single premium price with an equal rate. The simplest way to calculate the single premium is to take the average of all premium values [13]:

$$\bar{P}=\frac{1}{n}\sum_{i=1}^{n}P_i \quad (10)$$

With P_i is the premium price for each regency/city. The other single premium rate is computed using the standard deviation principle. The variance of premium rate is

$$\sigma_P^2=\frac{1}{n-1}\sum_{i=1}^{n}(P_i-\bar{P})^2 \quad (11)$$

For a 95% level of significance, the confidence interval of the premium rate is

$$\left(\bar{P}-1.645\cdot\sigma_p\ ;\ \bar{P}+1.645\cdot\sigma_p\right) \quad (12)$$

3. Result and Discussion

3.1. The Determination of Rice Farming Insurance Premium Analysison Trial

With RFI premium rate of IDR 180,000 and the coverage of IDR 6,000,000, the trial needs 34 farmers to be participants. Maximum 1 out of 34 participants may suffer harvest failure, or the harvest failure probability is 1/34 = 0.03. For example, for each regency/city in Central Java, the condition is assumed to be homogenous. Therefore, there will be $k = 1, 2, ..., 35$ samples of regency/city and the harvest failure probability for each regency/city is $q_k = 0.03$ with a maximum benefit of $b_k = 6$ (IDR 6,000,000). For example, n_k = 100 participants taken for each regency/city, which k is some regency/city. Using the equations (4) and (5) for $n = 3{,}500$ farmers:

$$E[S] = \sum_{j=1}^{3500} E[X_j] = \sum_{k=1}^{35} n_k \cdot b_k \cdot q_k = 35 \cdot 100 \cdot 0.03 \cdot 6 = 630,$$

And,

$$Var(S) = \sum_{j=1}^{3500} Var(X_j) = \sum_{k=1}^{35} n_k \cdot b_k^2 \cdot q_k \cdot (1 - q_k)$$
$$= 35 \cdot 100 \cdot 1.0476 = 3{,}666.60$$

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From equation (3), the θ is 0.1581 and actuarially fair RFI premium rate is then calculated using the equation (1):

$$P = (1+\theta) \cdot E[S] = 1.1581 \cdot 630 \cdot \text{IDR}\,1{,}000{,}000$$
$$= \text{IDR}\,729{,}603{,}000.$$

The RFI premium for each participant is IDR 729,603,000 / 3,500 = IDR 208,458.The calculation results are not much different from the RFI premium rate designated by the Government. Adding more participants may be made to achieve a premium close to the premium. For example, the number of participants for each regency/city is 10,000 farmers or totally $n =$ 350,000 throughout Central Java, the expectation and variance of total aggregate claim S calculated using equations (4) and (5) are $E[S] = 63{,}000$, and $Var(S) = 366{,}660$ the relative security loading is $\theta = 0.01581$ calculated using equation (3). The RFI premium rate calculated using the equation (1) is given as

$$P = 1.01581 \cdot 63{,}000 \cdot \text{IDR}\,1{,}000{,}000 = \text{IDR}\,63{,}996{,}030{,}000$$

The RFI premium for each participant is IDR 63,996,030,000 / 350,000 = IDR 182,846. This number is quite close to the premium of IDR 180,000.

3.2. The Rice Farming Insurance Scheme

The program of RFI is a mandate from the law the Government must implement and is also a form of Government's concern and alignments to the economically weak community. RFI program is mandated by article 37-39, Law No. 19 of 2013 concerning on The Farmer Protection and Empowerment [17]. The RFI has been implemented by the Government (Department of Agriculture) in cooperation with PT. Jasindo. The premium rate and benefit do not vary with the premium rate and benefit during the trial. One of the reasons why RFI is necessary is the results of Agricultural Census 2013 [15]. This Agricultural Census, conducted by [18], generates data that about 79.8% of households who work on food crops are those who work on a rice farm. [19,14] illustrates that RFI is limitedly designed to replace planting expenses incurred during a planting season, thus in case of 100% harvest failure, the farmers will neither gain profit nor suffer loss. The illustration also clarifies that the maximum RFI benefit of IDR 6,000,000 is a *fair* benefit value.

There are essential matters related to the scheme of RFI,i.e. (i) Every RFI participant mayreceive only a maximum of 2 hectares of land insured. (ii) The maximum coverage value and benefit participant may receive IDR 6,000,000 per hectare. (iii) The RFI insurance premium is established to be 3% of coverage value or IDR 180,000 per hectare, with 80% is subsidised/paid by the Government (IDR 144,000 per hectare),and the remaining 20% shall be paid by the farmer (IDR 36,000 per hectare). Thus, the farmer shall pay the premium only 0.6% of the coverage value. (iv) The insurable risks include drought, flood, and Plant Invading Organism (OPT) attack. (v) The insurance coverage period shall apply to one planting season. (vi) The farmer who harvests maximum only 25% of the planted area will receive full compensation (IDR 6,000,000). Other cases shall depend on the damage level and farming life [1].

3.3. The Rice Farming Insurance Premium Calculations

One of the principles used in determining the premium rate is the fairness principle, which is fair for both farmers and the insurer [14]. The designated premium should neither be too high (which will overburden farmers) nor too low (which will cause the insurer's loss). Premium rate appropriate designation requires an actuarial method to calculate the premium rate. The parametric method assumes that harvest yield follows certain distribution such as normal, beta or gamma [21]. Harvest yield loss probability is the area below probability density function curve when harvest yield is lower than the insured return.From

Table 1, we see that the harvest yields for 32 regencies/cities in Central Java followa normal distribution. However, the coefficient of variation values remain below 0.25; thus equation (8) is inapplicable. If all farms are insured ($\alpha = 1$), then $\Phi\left(\frac{\bar{x}}{s}(\alpha-1)\right) = \Phi(0) = 0.5$ and $\phi\left(\frac{\bar{x}}{s}(\alpha-1)\right) = \phi(0) = \frac{1}{\sqrt{2\pi}}$ = 0.399 hence equation (8) shall become

$$P_1 = 0.399 \cdot s \tag{13}$$

The computation results using the equation (13) is given in Table 1 Column 6.Here, we replace formula (9) with [16] is:

$$P_2 = 6 \cdot \Phi\left(\frac{-0.75\mu}{\sigma}\right) - \left(8\frac{\sigma}{\mu}\left[\phi\left(\frac{-0.75\mu}{\sigma}\right) - \frac{1}{\sqrt{2\pi}}\right] \times \frac{1}{2}\right)$$

The premium estimation is calculated using the average and standard deviation of the sample. Since the estimated population variance $\hat{\sigma}^2$ is not biased, then

$$P_2 = 6 \cdot \Phi\left(\frac{-0.75 \cdot \bar{x}}{s}\right) - 4\frac{s}{\bar{x}}\left[\phi\left(\frac{-0.75\bar{x}}{s}\right) - \frac{1}{\sqrt{2\pi}}\right] \tag{14}$$

The numbers in Table 1 column 3 are the average yield from 1991-2017 for all districts/cities in Central Java. If x_i stating the harvest yield for the year, then the average yield is obtained by the formula $\bar{x} = \frac{1}{27}\sum_{i=1}^{27} x_i$. The numbers in Table 1 column 4 state the standard deviation of harvest yield from 1991-2017 for all districts/cities in Central Java. These numbers are obtained using a formula $s = \sqrt{\frac{1}{26}\sum_{i=1}^{27}(x_i - \bar{x})^2}$. The quotient between the standard deviation and the average is called the coefficient of variance and given in Table 1 column 5. Table 1 Column 3, 4 and fiveare obtained with the help of SPSS.The numbers in Table 1 column 6 stated the magnitude of the Kolmogorov-Smirnov value obtained by SPSS and used to reject or accept the null hypothesis. The null hypothesis states that the yields for the regencies/cities that are determined to follow the normal distribution. Therefore, Kolmogorov-Smirnov value for Batang, Kudus and Magelang Districts is more than the Kolmogorov-Smirnov value table $D_{\alpha=0.05;n=27} = 2.54$, then the distribution of the harvest does not follow the normal distribution. In calculating the premium in Table 1 column 7, 8 and nine, the two districts were excluded.

Analysis of the harvest yield data used in this research results in variation coefficient value $\frac{s}{\bar{x}}$ which is relatively low or close to 0 (Table 1 column 5). Consequently, the data of harvest yield in all regencies/cities in Central Java may be declared as quite normal. Relatively low coefficient of variation causes $\frac{\bar{x}}{s}$ high, and the value $-0.75 \cdot \frac{\bar{x}}{s}$ is unavailable in Standard Normal Table. Consequently $\Phi\left(\frac{-0.75 \cdot \bar{x}}{s}\right) \approx 0$ and $\phi\left(\frac{-0.75 \cdot \bar{x}}{s}\right) \approx 0$ thus equation (11) becomes

$$P_2 = \frac{4}{\sqrt{2\pi}}\frac{s}{\bar{x}} = 1.60 \cdot \frac{s}{\bar{x}} \tag{15}$$

Equation (15) explains that the higher the coefficient of variation, the higher the premium rate is. Premium calculation using equations (14) or (15) is given in Table 1 column 8. Equation (15) also explains that in case harvest yield is normally distributed with variation coefficient close to 0, then the premium price determining model shall depend only on the variation coefficient and may be determined without a standardnormal table. In equation (14), the cumulative value is calculated in assistance of Standard Normal Table $Z \sim N(0,1)$. Almost all Standard Normal Tables only attach value up to $z = 3.99$. The complete table puts value z up to z = 4.99. Meanwhile, the calculation using the data results in value z> 5, thus the use of Standard Normal Table results in $\Phi(z) \approx 0$ and $\phi(z) \approx 0$.

Following [20] and the equation (13) for $z \geq 5.5$, we then get

$$\Phi(z) = 1 - \frac{1}{\sqrt{2\pi}}\exp\left(-\frac{1}{2}z^2 - \frac{94}{100}z^{-2}\right) \quad ; \ z \geq 5{,}5 \tag{16}$$

Following the equation (16), we get the results as

$$\Phi(-z) = 1 - \Phi(z) = \frac{1}{\sqrt{2\pi}}\exp\left(-\frac{1}{2}z^2 - \frac{94}{100}z^{-2}\right) \tag{17}$$

Furthermore, the equation (17) is used to approach the value $\Phi\left(\frac{-0.75 \cdot \bar{x}}{s}\right) = \Phi(-0.75 \cdot z)$ on the equation

(15),with $z = \frac{\bar{x}}{s}$ because the valueof $\phi\left(\frac{-0.75 \cdot \bar{x}}{s}\right) \approx 0$, then the equation (11) is written as

$$P_3 = 6 \cdot \Phi\left(\frac{-0.75 \cdot \bar{x}}{s}\right) + 1.60 \cdot \frac{s}{\bar{x}} \quad (18)$$

Moreover, the premium rate is then computed using the equation (18) as given in Table 1 column 9. Here, the column (9) of Table 1 is the same as the column (8). It is due to the value $\frac{-0.75 \cdot \bar{x}}{s}$ is quite low, thus $\Phi\left(\frac{-0,75 \cdot \bar{x}}{s}\right) \approx 0 \cdot$

Table1. RFI Premium Rate (in IDR) in Central Java Province

No	Regency(es)	$\bar{x}$	s	$\frac{s}{\bar{x}}$	K-S	P1	P2	P3
						Eq. 13	Eq. 15	Eq. 18
						(IDR)	(IDR)	(IDR)
1	Banjarnegara	55.38	3.9	0.07	0.135	1,556,100	112,000	112,000
2	Banyumas	54.124	2.455	0.045	0.126	979,545	72,000	72,000
3	Batang	48.632	2.98	0.061	0.271	1.189.00	97600	97600
4	Blora	49.613	2.223	0.045	0.17	886,977	72,000	72,000
5	Boyolali	54.279	3.582	0.066	0.134	1,429,218	105,600	105,600
6	Brebes	56.744	3.047	0.054	0.125	1,215,753	86,400	86,400
7	Cilacap	55.334	3.188	0.058	0.177	1,272,012	92,800	92,800
8	Demak	52.394	6.991	0.133	0.186	2,789,409	212,800	212,800
9	Grobogan	55.696	4.014	0.072	0.131	1,601,586	115,200	115,200
10	Jepara	52.447	2.592	0.049	0.161	1,034,208	78,400	78,400
11	Karanganyar	57.822	2.817	0.051	0.125	1,123,983	81,600	81,600
12	Kebumen	55.104	3.817	0.069	0.186	1,522,983	110,400	110,400
13	Kendal	54.843	4.08	0.074	0.189	1,627,920	118,400	118,400
14	Klaten	57.798	4.387	0.076	0.148	1,750,413	121,600	121,600
15	Magelang City	52.926	2.776	0.052	0.228	1,107,624	83,200	83,200
16	Pekalongan City	51.725	4.383	0.085	0.194	1,748,817	136,000	136,000
17	Salatiga City	51.109	5.142	0.101	0.176	2,051,658	161,600	161,600
18	Semarang City	47.802	4.587	0.096	0.192	1,830,213	153,600	153,600
19	Surakarta City	55.769	5.229	0.094	0.106	2,086,371	150,400	150,400
20	Kota Tegal	55.887	3.829	0.069	0.11	1,527,771	110,400	110,400
21	Kudus	52.63	3.333	0.063	0.269	1.329.87	100,800	100,800
22	Magelang	54.124	3.622	0.067	0.256	1,445,178	107,200	107,200
23	Pati	50.503	3.939	0.078	0.207	1,571,661	124,800	124,800
24	Pekalongan	48.07	2.959	0.062	0.101	1,180,641	99,200	99,200
25	Pemalang	51.7	2.138	0.041	0.136	853,062	65,600	65,600
26	Purbalingga	53.391	3.73	0.07	0.192	1,448,270	112,000	112,000
27	Purworejo	54.758	3.298	0.06	0.148	1,315,902	96,000	96,000
28	Rembang	50.3	3.575	0.071	0.211	1,426,425	113,600	113,600
29	Semarang	49.772	4.227	0.085	0.123	1,686,573	136,000	136,000
30	Sragen	55.204	3.69	0.067	0.152	1,472,310	107,200	107,200
31	Sukoharjo	58.765	5.038	0.086	0.236	2,010,162	137,600	137,600
32	Tegal	54.454	2.617	0.048	0.15	1,044,183	76,800	76,800

33	Temanggung	55.8	4.731	0.085	0.206	1,887,669	136,000	136,000
34	Wonogiri	53.933	3.66	0.068	0.127	1,460,340	108,800	108,800
35	Wonosobo	51.276	1.785	0.035	0.202	712,215	56,000	56,000
	Total premium (IDR)						3,544,000	3,544,000
	Pure premium principle (IDR)					3,544,000/32 = 110,750		
	Deviation standard principle (IDR)					(78,151 ; 143,349)		

3.4. The RFI Premium Calculation for Central Java Province

The results in the premium rate of the farmers in Central Java Province must pay for each hectare from IDR 111,650 (minimum) to IDR 322,190 (maximum). It is reasonable that all regencies/cities in Central Java uses single premium price with anequal rate. Therefore, a single premium will be calculated for Central Java Province. The simplest way is to take the average of all premium values using equation (10). This method is called a pure *premium principle*.Using equation (10), the single premium rate generated for Central Java Province is $\overline{P} = \frac{\text{IDR}\,3{,}544{,}000}{32} =$ IDR 110,750. The other single premium rate calculation uses standard deviation principle. The variance of premium rate is calculated from equation (11)

$$\sigma_P^2 = \frac{1}{31} \times 32{,}943{,}554{,}816 = 1{,}062{,}695{,}317.$$

With the level of significance 95%, the premium rate calculates with equation (12) is atthe interval (IDR 78,151; IDR 143,349).

4. Conclusions

In this paper sustainable rice farming through supply chain risk management was determined.The use of the equation (9) which requires the coefficient of variation of 0.25 produces a very high premium price. In Central Java case, equation (9) cannot be implemented since the coefficient of variation of harvest yield is close to 0 (even if the results presented). The RFI premium rate for 1 hectare of land designated at 3% of the maximum benefit value of IDR 6,000,000,i.e. IDR 180,000. According to the calculation results, the lowest RFI premium is IDR 56,000 in Wonosobo Regency, and the highest premium is IDR 161,600 in Salatiga City. The fair RFI premium rate for Central Java Province, when the *pure premium principle* is used to calculate, is IDR 110,750. Meanwhile, when the standard deviation principle is used, the premium has resulted between IDR 78,151 and IDR 143,349. The theoretical calculation showed the premium value of IDR 208,458 per hectare when there are only 100 participants per regency (city) and IDR 182,846 per hectare if there are 10,000 participants per regency (city). These numbers are not much different from the currently implemented premium rate.

References

[1] Pasaribu SM, "*Developing rice farm insurance in Indonesia*", Agriculture and Agricultural Science Procedia I, pp: 33-41, 2010. doi:10.1016/j.aaspro.2010.09.005.

[2] Bharamappanavara SC, Hasanabadi MS, Handigol JA, Yeledalli RA, "*Alternative model for crop insurance: A case of onion crop (alliumcepa)*" Proceedings of the International Conference on Applied Economics – ICOAE, pp: 85-90, 2010.

[3] Babcock BA, "*Using Prospect Theory to Explain Anomalous Crop Insurance Coverage Choice*", Paper to be Presented at the 2015 ASSA meetings, Boston. MA, 2017.

[4] Goodwin BK, "*An empirical analysis on the demand for multiple peril crop insurance: Reply*", American Journal of Agricultural Economics, 76, pp: 952-953, 1994.

[5] Pongpullponsak A, Sarikavanij S, Jiarasuksakun T, "*Mathematical Modelling for the Estimation of Crop Insurance Premium: A Case Study of Total Premium Equal Damage Compensation*", Journal of Statistics: Advances in Theory and Applications, 4(2), pp: 73-89, 2010.

[6] Mortensen E, Block P, "*ENSO Index-Based Insurance for Agricultural Protection in Southern Peru*", Geosciences, 8, 64, 2018. doi:10.3390/geosciences8020064.

[7] Reyes CM, Agbon AD, Mina CD, Arboneda A, "*Crop Insurance Program of the Philippine Crop Insurance Corporation (PCIC): Integrative Report from the Five Case Regions in the Philippines*", Discussion Paper Series No. 2017-39. Philippine Institute for Development Studies, (2017).

[8] Hatt, M., Heyhoe, E., and Whittle, L. *Options for Insuring Australian Agricultural. Department of Agricultural, Fisheries and Forestry, Australian Bureau of Agricultural and Resources Economics and Sciences* (*ABARES*), 2012. Tersedia: http://www.daff.gov.au/SiteCollection. Diakses 29 Mei 2017.

[9] Gulati A, Terway P, Hussain S, "*Crop Insurance in India: Key Issues and Way Forward*", Working Paper No. 352. Indian Council for Research on International Economic Relations, 2018.

[10] Miao R, Hennessy DA, Feng H, "*The Effects of Crop Insurance Subsidies and Sodsaver on Land-Use Change*", Journal of Agricultural and Resource Economics, 41(2), pp:247–265, 2016.

ISSN 1068-5502. Copyright 2016 Western Agricultural Economics Association.

[11] Ozaki VA, Goodwin BK, Shirota R, "*Parametric and nonparametric statistical modelling of crop yield: implication for pricing crop insurance contracts*", Applied Economics, 48, pp: 1151-1164, 2008.

[12] Bowers Jr NL, Gerber HU, Hickman JC, Jones DA, Nesbitt CJ, *Actuarial Mathematics*, USA: The Society of Actuaries, 1997.

[13] Sukono, Suyudi M, Islamiyati F, Supian S "*Estimation model of life insurance claims risk for cancer patients by using Bayesian method*" Paper presented at the IOP Conference Series: Materials Science and Engineering, 166 (1), 2017. doi:10.1088/1757-899X/166/1/012022.

[14] Prabowo P, Pratikno B, Sulaiman U, Cahyanto WT, Irayani Z, "*The Contribution of Mathematical and Sciences for Developing Quality of Rural Lifestyle (Peran Matematika dan Sains dalam Mendukung Gaya Hidup Perdesaan (Rural Lifestyle) yang Berkualitas)*", Purwokerto: Penerbit UNSOED, 2017.

[15] Prayogo IH, Prabowo A, "*Mathematical Formula for Determining the Premium Rate of Rice Farming Insurance using Normal Distribution (Formula MatematikauntukMenghitungHargaPremiAsuransiPertanianMenggunakanDistribusi Normal)*" Prosiding Seminar National University as Nahdlatul Ulama, Purwokerto, 14 , 2018.

[16] Muttaqin AK, Kudus A, Karyana Y, "*Metodeparametrikuntukmenghitungpremi program asuransiusahatanipadi di Indonesia*", Ethos (Journal Penelitiandan Pengabdian Masyarakat), pp: 318-326, 2016.

[17] Department of Law and HAM RI, "*Law No. 19, 2013 about the Farmer Protection and Empowerment*'', Jakarta: Department of Law and HAM, 2013.

[18] Statistics Bureau of the Central Java Province, "Central Java in the Number 1991-2017", 2017.

[19] Smith VH, "*The US Federal Crop Insurance Program: A Case Study in Rent-Seeking*" *Mercatus Working Paper*, MercatusCenter at George Mason University, Arlington, VA, pp. 1-52, 2017.

[20] Johnson NI, Kotz S, Balakrishnan N, *Continuous Univariate Distribution*, John Wiley & Sons, 1994.

[21] Bahram, Mirzamasoumzadeh,vahid ,Mollasadeghi. *Effects of osmotic stress on chlorophyll and proline different wheat cultivars*, UCT Journal of Research in Science , Engineering and Technology, Issue 4,pp.12-13, 2013.