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Evaluation Model for Risk Insurance Premiums of Building Damage Caused by Flood: Case Study in Citarum Watershed, Southern Bandung, Indonesia

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Abstract: The impact of the financial economics of damage to buildings caused by natural disasters flooding from year to year has been increasing. Thus, the role of insurance companies is one of the important things and periodically they evaluate the large proportion of the premiums charged to insurance participants. In this study, the model calculation and evaluation of insurance premiums as the main component in flood risk management was analyzed. The analysis begins with determining the annual average of the compensation index, calculate the premium per unit of insurance on the basis of parameters of disparate and then determine the proportion of premiums, reserves as well as reinsurance in order to meet payment of the amount of the claims when losses houses damaged by the floods occurred. The case study was carried out on the flood disaster in the Citarum watershed in Southern Bandung, Indonesia. The analysis showed that the greater the initial backup along with an increase in quotas on reinsurance during the period before the disaster and the increase in the value of premiums, all of these strategies can form a scheme whereby the insurance company to cover the financial losses caused by floods.

Key words: The flood disaster, the compensation index, insurance premiums, reserves, reinsurance, company

INTRODUCTION

Generally, the effects of flooding can be direct or indirect. The direct impact is relatively more predictable than the indirect impact. Impact experienced by urban areas which are dominated by residential areas is also different from the impact experienced by rural areas dominated by agricultural area (Priyadarshinee *et al*., 2015; Turnbull *et al*., 2013). Flooding is also a relative disaster at most result in losses. Losses caused by the flooding, particularly indirect losses. Floods that surge an area can damage the house became messy, causing loss (Karamouz *et al*., 2009). Handling costs of floods thorough and sustainable become the duties and responsibilities of all parties, technical institutions and other relevant institutions as well as communities. Floods occur regularly in the Citarum watershed in Southern Bandung, Indonesia became increasingly widespread and cause greater damage to homes (Sagala *et al*., 2014).

In order to perform the recovery rebuilding of housing, the government and humanitarian organizations provided funding. However, the funding which is provided by the government and humanitarian organizations is not fully able to meet all the cost of construction of houses needed (Jonkman *et al*., 2008; Paudel *et al*., 2013). Therefore, the public awareness in the area of Southern Bandung in anticipation of providing funds to cope with the cost of rebuilding homes damaged by flooding should be increased (Sagala *et al*., 2014). One alternative of anticipation provision of funds that can be taken is to be a participant flood insurance. Indeed, the flood insurance products are now widely offered and some communities in Southern Bandung affected areas had also become participant flood insurance. Thus, when the flood occurred, the victim can request financial payments to replace and rebuild their destroyed homes. Insurance is a mechanism to deal with risks and allows activities such as compensation payments promised. Characterized in that insurance is a management mechanism that acts after disasters (Kousky and Shabman, 2014; Landry and Parvar, 2011).

Furthermore, a matter that needs to be done by the insurance company is periodically need to evaluate the calculations of determination of the amount of premium. This is important so that it can be kept a balance between participants of insurance and insurance companies (Paudel *et al*., 2013). That is the amount of the premium is not burdensome insurance participants and insurance companies also do not suffer losses as a result of a number of claims filed (Ermolieva *et al*., 2013).

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Therefore, the evaluation model of risk insurance premiums of buildings damaged caused by flood was analyzed in study. This study was conducted by referring the research of Mircea entitled: On Some Evaluation Methods of Insurance Premiums for Catastrophic Risks. As a case study is the insurance of building damage due to floods in the Citarum watershed in Southern Bandung, Indonesia. The objective is to evaluate the amount of the proportion of premiums, reserves and reinsurance to sufficient amount of claims filed flood victims.

MATERIALS AND METHODS

In order to analyse about the evaluation model of risk insurance premiums of buildings damaged caused by flood, the mathematical models relevant was discussed. Let F be the set of non-negative random variable defined on a probability space (Ω, K, P). The random variable is referred to as the risks faced by the insurer. Suppose H is also the basis for calculating the premium which means it is a mapping of the set F with values in the set of non-negative real numbers. In this case, the function H represents a value of a variable risk which is the insurance premium (Daniel *et al*., 2011). Referring to Mircea this function H has the basic properties as follows:

- The independence, it means that H[X] only depends on the cumulative distribution function of the random variable X
- Loading risiko, it means that $H[X]\geq E[X]$ for each $X\epsilon F$ where E[X] the expected value of the random variable X
- Maximum loss, it means that $H[X]\leq H[\sup[X]]$ for each $X\epsilon F$ so that the premium can not be greater than the value of the calculation basis for the likely size of the loss
- Translational invariance, it means that $H[X+a] = H[X]+a$ for each $X\epsilon F$ and for each $a\geq 0$
- Scale invariance or homogeneity of degree one, it is stated that $H[bX] = bH[X]$ for each $X\epsilon F$ and for each $b\geq 0$
- Monotonicity, it means that if $X(\omega)\leq Y(\omega)$ for each $\omega\epsilon\Omega$, then $H[X]\leq H[Y]$
- The first order stochastic dominance, it means that if $S_X(X)\leq S_Y(t)$ for each $t\geq 0$ then $H[X]\leq H[Y]$ where $S_X(t) = P_r(X>t)$ is a function of survival
- Continuity, it means

$$\lim_{a\to 0^+} H[\max(X\text{-}a;\,0)] = H[X]$$

And:

$$\lim_{a\to\infty} H[\max(X,\,a)] = H[X]$$

Furthermore, for the premium calculation can be done using several methods of approach. Referring to Mircea the calculation of the expectation value of the premium can be done by using the equation:

$$H[X] = (1+\theta)E[X],\ \theta>0 \quad (1)$$

While the magnitude of the variance value of the premium can be calculated using the Eq. 2:

$$H[X] = E[X]+\lambda\,(\mathrm{Var}[X]),\ \lambda = 0 \quad (2)$$

Thus, the value of the premium standard deviation is calculated using the Eq. 3:

$$H[X] = E[X]+\eta\sqrt{\mathrm{Var}[X]},\ \eta>0 \quad (3)$$

The premium calculation with Esscher method is performed by using the Eq. 4:

$$H[X] = \frac{E\left[X\times e^{\lambda X}\right]}{E\left[e^{\lambda X}\right]} \quad (4)$$

Based on proportional-hazards approach, the premium is a function of the form:

$$H[X] = \int_0^\infty [S_X(t)]^c\,dt,\ 0<c<1 \quad (5)$$

with $S_X(t)$ is survival function. In the principle of equality of utility stated that:

$$u\,(w) = E[u\,(w\text{-}X+H)] \quad (6)$$

Where:

u (.) = Utility function (not decreasing and convex) of the insurer
w = Backup (endowment) early

This principle is based on the assumption that H is a minimum premium of insurance companies are willing to cover the acceptance of risk posed by the insured. The right side is the expected value of the utility of insurance in case he accepted to take (cover) X for risk premiums H. The calculation of premiums according to Wang's models is written as follows:

$$H[X] = \int_0^\infty g[S_X(t)]dt \quad (7)$$

where, g: [0, 1]→[0, 1] is ride function and convex. Meanwhile, premium calculation with the Swiss model can be described as follows:

$$E[u(X-pH)] = u((1-p)H) \tag{8}$$

where, function u (.) has the characteristics of a utility function which is non-decreasing and convex and parameters p∊(0, 1). Furthermore, the premium calculation of Dutch models, it is stated as follows:

$$H[X] = E[X]+\theta E[(X-\lambda E[X])_+]\ \lambda>0 \text{ and } 0<\theta\le 1 \tag{9}$$

Random variable X can have different interpretations such as: the amount of loss, the size of the compensation of damages, compensation index (i.e., the ratio between the number of reimbursement claims and the insurance). In this study, we will consider the risk of disasters in the year k.

The amounts of money, all were expressed in the same monetary unit, the monetary unit (mu). Furthermore, premiums evaluation was performed using the following equation (Mircea *et al*., 2008):

$$(1-\gamma_k)n_k v_k - R_c(k) - (1-\gamma_k)cN_k V_k \Pi_k = \sum_{j=k+1}^{k+n} \beta_j N_j V_j p_j (1-\gamma_j)\frac{1}{(1+i)^{j-k-1}} \tag{10}$$

Where:

$$R_c(k) = u_0 + \sum_{j=1}^{k-1} \beta_j N_j V_j \Pi_j (1-\gamma_j)(1+i)^{k-j-1}$$

Where:

- π_j = Premium unit (usually for the insurer 1 monetary unit) for the year j
- $R_c(j)$ = Provision that reserves accumulated by the year j to cover the risk of damage to buildings caused by flooding
- λ = Declared the part of calculation from premiums, its relationship to add the reserve funds
- u_0 = The initial reserve (endowment)
- γ = The risk quota was used (taken) on reinsurance
- c = The proportion of premiums received (cash) in the year k is given for the payment of compensation
- N_j = The number of insurance contracts in the years j
- V_j = The average value of a contract in the year j
- n_j = The amount of the claim reimbursements given (offered) in a year j
- v_j = The expected value of a compensation payment and i is the annual interest rate.

Several approach methods above were used to calculate and evaluate the premium in case studies carried out following studies.

RESULTS AND DISCUSSION

In this study, the flood insurance data on the Citarum watershed in Southern Bandung Indonesia was analyzed. The flood insurance data was obtained from one insurance company branch office in Bandung during the period 2008-2015. The data analyzed include the number of insurance contracts in the years j(N_j), the average value of the contract value in the year j(V_j), the amount of the claim reimbursements given (offered) in a year j(n_j) and the average value of compensation payments in the year j(v_j) (Table 1).

Furthermore in order to calculate the insurance premiums of flood insurance, we begin by calculating the average annual compensation index, denoted by I. This study reviewed the data flood that occurred in 2014. The annual compensation index is calculated at the end of 2013 by using the Eq. 11:

$$I_j = \frac{n_j v_j}{N_j V_j} \text{ and } p_j = \frac{n_j}{\sum_{j=1}^{6} n_j} \text{ with } j = 1,2,...,6 \tag{11}$$

The calculation results I_j and p_j until the end of 2013, respectively given in Table 2 column I_j and $\dot{p}_j$. In Table 2 p_j is probability calculated until after the floods in 2014 and 2015.

Based on the results of the calculation are given in Table 2 until the end of 2013 can be obtained magnitude E [I] = 0.0318228 and Var [I] = 0.0318228 thus Std [I] = 0.0131386. Thus, the overall index (global) are:

$$I_{global} = \frac{\sum_{j=1}^{6} n_j v_j}{\sum_{j=1}^{6} N_j V_j} = 0.0311473 \approx 3.1147307\% \tag{12}$$

Using formulas discussed in the previous study and variable I, we calculate insurance premiums Π for different units (different village) different parameter values. First, we calculate the expected premium value by using Eq. 1 in

Table 1: Data of contracts and insurance claims

j	Years	N_j	V_j	n_j	v_j
1	2008	270	31	34	5.1
2	2009	251	35	41	5.5
3	2010	293	37	45	5.9
4	2011	286	45	57	6.5
5	2012	338	53	50	7.5
6	2013	435	42	75	13.2
7	2014	530	65	87	13.5
8	2015	481	56	52	15.2

Table 2: Compensation of index and probability

j	Years	I_j	$\dot{p}_j$	$\ddot{p}_j$
1	2008	0.0207168	0.1497797	0.0770975
2	2009	0.0256688	0.1806167	0.0929705
3	2010	0.0244904	0.1982379	0.1020408
4	2011	0.0287879	0.2511013	0.1292517
5	2012	0.0209333	0.2202643	0.1133787
6	2013	0.0541872	0.1928021	0.1700680
7	2014	0.0340929		0.1972789
8	2015	0.0293436		0.1179138

Table 3: Expected premium value principle

θ	Π≤2013	Π≥2014
0.05	0.0334139	0.0441090
0.10	0.0350050	0.0462094
0.15	0.0365962	0.0483099
0.20	0.0381873	0.0504103
0.25	0.0397785	0.0525107
0.30	0.0413696	0.0546112
0.35	0.0429607	0.0567116
0.40	0.0445519	0.0588120
0.50	0.0477341	0.0630129
0.60	0.0509164	0.0672137

Table 4: Variance premium principle

α	Π≤2013	Π≥2014
0.01	0.0318245	0.0420117
1	0.0319954	0.0423162
10	0.0335490	0.0450851
20	0.0352752	0.0481616
30	0.0370015	0.0512381
50	0.0404539	0.0573910
100	0.0490851	0.0727735
200	0.0663475	0.1035384
500	0.1181345	0.1958332
1000	0.2044462	0.3496578

Table 5: Standard deviation premium principle

β	Π≤2013	Π≥2014
0.01	0.0319541	0.0421840
0.1	0.0331366	0.0437626
0.5	0.0383921	0.0507786
1	0.0449614	0.0595485
3	0.0712386	0.0946284
6	0.1106545	0.1472482
9	0.1500704	0.1998680
10	0.1632090	0.2174079
20	0.2945952	0.3928072
50	0.6887540	0.9190052

which the parameters θ for each of the 10 villages and the results of the calculation of insurance premiums units are given in Table 3.

Where $\Pi \leq 2013$ is an insurance premium unit was calculated until the end of 2013. While $\Pi \leq 2014$ is insurance premium unit is calculated after the floods in 2014 and 2015.

Second, we calculate the value of the premium variance by using Eq. 2 where the parameter α for each of the 10 villages and the results of the calculation of insurance premiums units are given in Table 4.

Third, we calculate the standard deviation value of premium by using Eq. 3 where parameter β for each of the 10 villages and the results of the calculation of insurance premiums units are given in Table 5.

Table 6: Escher premium principle

α	Π≤2013	Π≥2014
0.01	0.0241195	0.0297786
1	0.0241287	0.0298810
1.5	0.0241333	0.0299333
2	0.0241379	0.0299861
3	0.0241471	0.0300928
5	0.0241656	0.0303111
10	0.0242119	0.0308868
20	0.0243049	0.0321682
30	0.0243983	0.0336225
40	0.0244921	0.0352365
50	0.0245861	0.0369812
100	0.0250551	0.0458481
1000	0.0285972	0.0541872
10000	0.0287879	0.0541872

Table 7: The number of years

Unit	γ_a	n (1) (years)	n (2) (years)
0	0.4	18.9	12.8
100	0.4	18.3	12.2
500	0.4	16.8	11.4
0	0.6	12.1	7.9
100	0.6	11.5	7.3
500	0.6	9.6	6.8
0	0.8	8.7	5.9
100	0.8	8.1	5.4
500	0.8	6.9	4.8

Fourth, we calculate the value of the premium Escher by using Eq. 4 where the parameter α for each of the 14 villages and the results of the calculation of insurance premiums units are given in Table 6.

Based on the results of the calculation unit of insurance premiums in the tables above, we conclude that the values most appropriate parameter θ, α and β appears in different calculation methods. We see stability premium is calculated based on the Esscher principle when the values of the parameters change.

If we do an evaluation at the end of 2013, after the disaster occurred, we get a value of E [I] = 0.0319783, Var [I] = 0.0001199 thus, Std [I] = 0.0109513 as well as $I_{globel} = 0.0315294 \approx 3.1529371\%$. Therefore, it appears that in this case that only use the index average annual compensation this seemed to increase in global compensation index by 10 times which makes the insurance companies are not attractive.

In this situation, we will determine the value of the insurance premiums unit based on Eq. 10. Set interest rates i = 0.03, parameter α = 0.07, parameter c = 0.6 and parameter β = 0.3 as well as reinsurance quota after a disaster γ_p = 0.3. We also determine the amount of insurance premium unit 0.4% before the disaster and the aftermath of a 0.6% (case 1) and 0.8% (for case 2). The results of calculations are given in Table 7 shows the number of years (n) which required insurance companies to take payment of the claims, the value obtained for different initial reserves and reinsurance quota before the disaster γ_a.

We can conclude that the initial reserve is greater, together with an increase in quotas on reinsurance during the period before the disaster and diminished after the disaster (in order to increase the revenue earned from premiums) as well as the increase in the value of the premium (which is still competitive), all this strategy is expected to form a scheme in which an insurance company may cover immediate financial losses caused by floods. The model recommended in Eq. 10, concerning the calculation of insurance premiums unit for flooding risk is a useful tool for insurance companies. On the other hand, in Indonesia, event management, flood and other natural phenomena is a priority. In Indonesia, the relationship between private insurers and the government has not so together as far as the subject of this study. Some of the latest information on climate changes state that the floods in future will increase in frequency and expanding area affected.

This fact should be taken into consideration that the flood risk management should be an important instrument for the coming years both geographically in certain areas and temporal, before, during and after the occurrence of floods. It is necessary to evaluate the importance of insurance activities as a component of the management processes of prevention regarding flood risk at the level of all stakeholders and other parties involved and affected like the people who live in areas that have the potential for flooding. In estimating and understanding this relationship, insurance business activities are fundamental components of a strategy for flood risk management. So that, people who have household and property that have been damaged by the floods can obtain financial reimbursement.

Understanding of connectivity is also important to ensure that the business of insurance as part of the management of floods. Thus, the calculation of insurance premiums unit that competitive in every different area is far more effective for insurance companies. In Indonesia, information about the area of risk, frequency and size of flood events do not have the accessibility of all interested parties in the management of risk.

CONCLUSION

In this study, we analyzed the evaluation model of the risk insurance premiums building damage due to flooding: a case study Citarum watershed in Southern Bandung Indonesia. Based on the analysis it can be concluded that the calculation of insurance premiums units by using the Escher principle more stable relative to any parameter changes. Based on the results of the evaluation at the end of 2013 and after the flood of 2014, the global index has increased to 10 times the number of insurance premiums units. The analysis also shows that the larger the initial reserve, along with an increase in quotas on reinsurance during the period before the disaster and the increase in the value of the premium, the strategy could form a scheme whereby the insurance company can cover the financial losses caused by floods. In this regard, the insurance business activities are fundamental components of a strategy for flood risk management.

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