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Insurance Guarantee Schemes Based on Analysis of Probability of Default Using Structural Approach Case Study: General Insurance

Adria Zhara Al Mujadilla [a], Dwi Mahrani *[b]

[a] Actuarial Science Study Program, Faculty of Science, Sumatera Institute of Technology

[b] Actuarial Science Study Program, Faculty of Science, Sumatera Institute of Technology

* Corresponding E-mail: dwi.mahrani@at.itera.ac.id

Abstract: This study examines the design of an insurance policy guarantee scheme by estimating insurers' loss risk based on the probability of default using a structural approach and credit risk exposure in the Indonesian general insurance market. The analysis is conducted on a sample of publicly available financial data from general insurance companies in Indonesia over the period 2013 – 2022. Issues such as insurer default, bankruptcy, financial distress, and the absence of a formal policyholder protection scheme in Indonesia motivate this research. To the best of our knowledge, this study is the first to apply a structural credit risk approach to estimate default probabilities and credit exposure derived from technical reserves for the purpose of designing an insurance guarantee scheme in Indonesia. The probability of default is estimated using the Merton–KMV model, while claim reserves are calculated using the Bornhuetter–Ferguson method. The results indicate that both the level of default probability and the magnitude of claim reserves play a crucial role in determining the size of the ex-ante funding scheme. A decrease in default probability is observed when asset values increase, liabilities decline, and interest rates rise. While the KMV model relies on assumptions such as lognormal asset value dynamics and market efficiency, which may affect default probability estimates, the proposed funding reserve scheme remains sufficient to cover policyholder losses arising from insurer default and can be used to determine the contribution amount payable by insurance companies to the policy guarantee institution.

Keywords: B*ornhuetter-ferguson, Insurance Guarantee Schemes, KMV Merton Model, Probability of Default*

Introduction

The insurance industry plays a fundamental role in supporting economic stability by offering financial protection against potential losses faced by individuals and firms. Despite this critical function, insurance companies are exposed to various financial risks, among which default risk—defined as the inability to meet claim obligations to policyholders, remains one of the most significant. Insurer defaults can severely undermine consumer confidence and threaten the stability of the financial system. Consequently, effective assessment and management of default risk are essential considerations for insurance companies and regulators alike.

One widely adopted approach for measuring default risk is the Merton–KMV model, which is based on a structural credit risk framework. This model links default risk to the market value of a firm's assets and liabilities, derived using option pricing theory. By incorporating asset volatility and capital structure, the Merton–KMV model enables a forward-looking estimation of default probability that more accurately reflects a company's financial condition compared to purely accounting-based measures [1]. Nevertheless, this approach relies on assumptions such as lognormal asset value dynamics and market efficiency, which may influence the precision of default probability estimates.

Beyond default risk measurement, insurance companies also face operational challenges related to claim classification and the prediction of future claim payments. The inherent uncertainty in the occurrence, timing, and magnitude of insurance claims creates significant risk exposure, making accurate reserve estimation a critical aspect of insurer solvency. Accordingly, appropriate actuarial methods are required to determine adequate claim reserves. One of the most widely applied techniques in actuarial practice is the Bornhuetter–Ferguson method, which estimates claim reserves by combining prior expectations of ultimate losses with information derived from observed claim development. This method is particularly effective when claims data are incomplete or volatile [2].

Inadequate risk management and reserve estimation can ultimately lead to insurer insolvency, rendering companies unable to meet their obligations to policyholders or beneficiaries [3]. In Indonesia, several insurance companies have experienced insolvency or default events up to 2023. The most prominent case is PT Asuransi Jiwasraya, a state-owned insurer that defaulted on investment-linked insurance products, affecting thousands of policyholders and causing state losses exceeding IDR 16 trillion. Since gaining national attention in 2018, the Jiwasraya case has underscored structural weaknesses within the insurance sector, including underpricing, excessive operational costs, poor investment performance, and insufficient technical reserves. Prior studies identify inadequate reserves, weak asset management, and mispricing as **major** contributors to insurance company defaults [4].

Recurring financial distress, insolvency, and bankruptcy events in the insurance sector have motivated the establishment of Insurance Guarantee Schemes (IGS) in many jurisdictions as a means of protecting policyholders. IGS function as a safety net by ensuring that policyholders receive compensation when insurers fail. In Indonesia, regulatory support for such a mechanism has been formalized through Law No. 4 of 2023 on Financial Sector Development and Strengthening (P2SK), enacted in December 2022. The law mandates the introduction of a Policyholder Protection Program (PPP) for the non-bank financial industry, particularly insurance, to be implemented by the Deposit Insurance Corporation (LPS) within five years, with full implementation expected by 2028.

Despite this regulatory mandate, there is currently a lack of quantitative models tailored to the Indonesian insurance market that can support the design of an ex-ante funding mechanism for insurance guarantee schemes. Existing studies generally treat default probability estimation and claim reserve calculation as separate analytical exercises, without integrating them into a unified framework for determining insurers' expected losses. Addressing this gap, the present study develops an insurance policy guarantee scheme by estimating insurers' loss risk based on default probability using a structural approach and credit risk exposure derived from risk-adjusted claim reserves. The analysis is conducted using financial statements and claims data from Indonesian general insurance companies over the observation period 2013-2022. By integrating the Merton–KMV model with the Bornhuetter–Ferguson reserving method, this study contributes a practical framework for determining ex-ante funding contributions to support the implementation of insurance guarantee schemes in Indonesia.

Method

This study utilizes publicly available financial data from PT Jasaraharja Putera, including balance sheet and income statement information for the period 2013–2022, obtained from the company's official website. Interest rate data are sourced from Bank Indonesia, while data on the composite stock price index (IHSG) are obtained from the Indonesia Stock Exchange. These datasets are employed to estimate the company's probability of default using a structural credit risk approach based on the Merton–KMV model. In addition, insurance claim reserves are estimated using the Bornhuetter–Ferguson method, relying on the company's claims data covering the period 2013–2022. All data used in this study are quantitative in nature. The research procedure is summarized as follows in **Figure 1**.

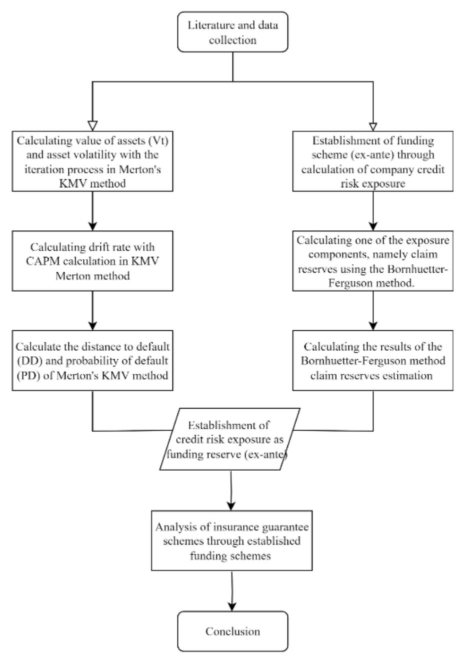

Figure 1. Research Flowchart

The research procedure is conducted through the following steps:

- Literature review and data collection. Relevant literature is reviewed, and financial statement data, claims data, interest rates, and stock market indices are collected from official and publicly available sources.
- Estimation of asset value and asset volatility. The market value of the insurer's assets and the corresponding asset volatility are estimated using an iterative procedure within the Merton–KMV structural framework.
- Estimation of the expected return on assets (drift rate). The expected return on assets is calculated using the Capital Asset Pricing Model (CAPM) and incorporated as the drift parameter in the KMV model.
- Computation of distance to default and probability of default. The distance to default and the associated probability of default are calculated to quantify the insurer's default risk.
- Assessment of credit risk exposure. The insurer's credit risk exposure is preliminarily determined based on the estimated probability of default.
- Estimation of claim reserves using the Bornhuetter–Ferguson method. Insurance claim reserves are estimated using the Bornhuetter–Ferguson method to account for uncertainty in claims development.
- Quantification of claim reserve exposure. The estimated claim reserves are quantified as a key component of the insurer's overall risk exposure.
- Establishment of ex-ante funding reserves. Default probability and claim reserve estimates are integrated to determine the ex-ante funding reserves required for the insurance guarantee scheme.
- Analysis of the insurance guarantee scheme. The proposed insurance guarantee scheme is evaluated based on the established ex-ante funding reserves and risk exposure.
- Conclusions are drawn regarding the adequacy and effectiveness of the proposed framework in supporting policyholder protection.

Material and Research Tools

Insurance Guarantee Schemes

Insurance Guarantee Schemes protect customers when insurance companies default. In many countries, policy guarantee programs in insurance companies are known as Insurance Guarantee Schemes (IGS). In general, insurance guarantee schemes are established to support a healthy and sustainable insurance business, as well as providing protection to customers through policy guarantee programs. Several general insurance products do not receive guarantees, such as maritime, aviation, credit, and surety insurance products, insurance products that have financial guarantees, and reinsurance. Meanwhile, almost all products that provide life and health protection in life insurance are fully guaranteed, but life insurance products related to investment are not mentioned [5].

Ex-Ante Funding Schemes

In forming an effective insurance guarantee scheme, the funding mechanism is a crucial component. One of the funding method schemes in the insurance guarantee scheme, which includes ex-ante (pre-event) funding, is the formation of funding reserves to anticipate future defaults, the formation of these reserves is carried out before the problem occurs. The main advantage of the ex-ante funding scheme is that funds are already available in reserves to compensate when a failure occurs. However, the drawback is that it can provide problems related to fund management. [6]. The establishment of an ex-ante funding scheme is done by taking into account the technical reserves of an insurance company that have been adjusted for the risk of loss or probability of default, and in other words, through the establishment of credit risk exposure.

Credit Risk

Credit risk is the risk of loss associated with the possibility of a counterparty failing to fulfill its obligations when due. In other words, credit risk is the risk that a borrower will not pay its debts. The amount of credit risk consists of the quantity of credit exposure and the quality of credit exposure. The size of the loan reflects the quantity of credit exposure. The larger the loan, the greater the level of credit exposure. The quality of the exposure is reflected by the probability of default of the debtor or credit buyer and the quality of the collateral provided by the debtor or credit buyer. The lower the quality of collateral and credit quality, the higher the credit risk [7].

Probability of Default

Probability of Default is a financial term used to measure the likelihood of a borrower failing to meet its debt obligations within a specified period. It is a critical component of credit risk assessment and is essential in credit risk modeling, loan pricing, and portfolio management. The probability of default is usually estimated using statistical models and

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historical data considering financial health, credit history, and economic conditions. This analysis does not predict the likelihood of future defaults, but provides estimates based on historical data. Probability of default is used along with loss given default (LGD) and exposure at default (EAD) in various risk management models to estimate the possible losses faced by lenders. [8].

Probability of default models are categorized as structural or empirical. Structural models look at the borrower's ability to pay based on market data such as equity prices, market value, book assets, and liabilities. Hence, these models are used mainly to predict the probability of default of companies and countries, especially in commercial and industrial banking. In contrast, empirical models or credit scoring models are used to quantitatively determine the likelihood that a loan or loan holder will default if the loan holder is an individual. This model looks at the portfolio of loans that have been paid by the individual and considers variables such as age, education level, debt-to-income ratio, etc. This second approach is more applicable to the retail banking sector.

KMV Merton Model

Merton's 1974 model is one of the structural models that models the evolution of a firm's structural variables (assets) and determines the probability of default. The model assumes that the value of a firm's assets evolves through a simple diffusion process. Bankruptcy is triggered when the value of a firm's assets falls below the value of its debts. In Merton's model, a firm must know its assets and liabilities before it can determine the probability of default [9]. Merton's KMV model uses asset volatility along with equity market price information to calculate the market value of a company's equity. Asset volatility is determined by determining the standard deviation of the asset value return. $\boldsymbol{R_{A_t}}$ and then multiplying the result by the square root of the number of time points to convert it into volatility per period. The asset value return is obtained by:

$$R_{A_t} = \ln\left(\frac{A_{t+1}}{A_t}\right) \tag{1}$$

$\boldsymbol{A_t}$ is the value of the company's assets at the time $\boldsymbol{t}$ and $\boldsymbol{R_A}$ is the Return assets. Asset volatility is estimated using the equation:

$$\sigma_A = \sqrt{\frac{1}{n-1}\sum_{t=1}^{n}\left(R_{A_t} - \overline{R_A}\right)^2 \times n} \tag{2}$$

To calculate the equity value, it is obtained from the standard Black-Scholes call option formula:

$$E_t = A_t\phi(d_1) - L_t e^{-r_t(T-t)}\phi(d_2) \tag{3}$$

$$d_1 = \frac{\ln A_t + \left(r_t + \frac{1}{2}{\sigma_A}^2\right)(T-t) - \ln L_t}{\sigma_A\sqrt{T-t}} \tag{4}$$

$$d_2 = d_1 - \sigma_A\sqrt{T-t} \tag{5}$$

Assuming that the company's liabilities have a maturity of 1 year, the value of the company's assets every month over the past n periods can be expressed in a system of equations as follows:

$$A_t = \frac{E_t + L_t e^{-r_t}\phi(d_2)}{\phi(d_1)} \tag{6}$$

$$A_{t-1} = \frac{E_{t-1} + L_{t-1}e^{-r_{t-1}}\phi(d_2)}{\phi(d_1)} \tag{7}$$

Description:
E_t : Equity value of the company at time t
A_t : Asset value of the company at a time t
ϕ : Cumulative standard normal distribution
σ_A : Asset volatility
L_t The company's liabilities at time t
r_t : interest rate at time t
T : Maturity time of the company
t : Current time
d_1 : Parameter count price
d_2 : Parameter count to reflect further adjustment of d_1

Through the estimation of the expected return of the asset, the drift rate μ) can be determined through the equation:

$$\mu_t = \ln(1 + E[R_t]) \tag{8}$$

which $\boldsymbol{E[R_t]}$ is the expected asset return at the period $\boldsymbol{t}$. Merton's KMV model emphasizes this and uses Black-Scholes and Merton to calculate the distance to default (DD) before calculating the probability of default. Default occurs when the value of the company's assets is below the default point. Thus, the formula of DD under risk neutral probability is as follows:

$$DD_t = \frac{\ln A_t + (\mu_t - \frac{1}{2}{\sigma_A}^2)(T-t) - \ln L_t}{\sigma_A\sqrt{T-t}} \tag{9}$$

Meanwhile, the formula for finding the probability of default value can be written as follows:

$$PD_t = \phi\left(\frac{\ln\frac{L_t}{A_t} - (\mu_t - \frac{1}{2}{\sigma_A}^2)(T-t)}{\sigma_A\sqrt{T-t}}\right) \quad (10)$$

PD_t is the probability of default at period t while DD_t is distance to default at period t and μ_t is the drift rate at a period t.

Bornhuetter-Ferguson Method

The Bornhuetter-Ferguson method is a claim reserve estimation method that combines the features of the Chain-Ladder method and the Expected Loss Ratio method, and assigns a percentage weight to each loss incurred and paid by the insurance company to the policyholder or insured. [10]. This method predicts claim reserves by multiplying the final claim estimate by the percentage of future claim development in the year of the event based on the delay pattern.

Let $Z_{i,k}$ With i, k ∈ {0,1,...,n} be the incremental loss of accident year i and development year k. $Z_{i,k}$ is the claim in accident year i that is settled with a delay of k years so that it is within development year k and calendar year $i + k$.

$$Z_{i,k} = \begin{cases} S_{i,0}, & if\ k=0 \\ S_{i,k} - S_{i,k-1}, & others \end{cases} \quad (11)$$

$\boldsymbol{S_{i,k}}$ is the cumulative claims observed during the calendar year $\boldsymbol{i + k \leq n}$.

$$S_{i,k} = \sum_{l=0}^{k} Z_{i,l}\ , 1 \leq i \leq n, 0 \leq k \leq n-1 \quad (12)$$

The determination of estimated future claims reserves is based on the development factor and is determined using the formulation defined as follows

$$\hat{\varphi}_k^{CL} = \frac{\sum_{i=1}^{n-k} S_{i,k}}{\sum_{i=1}^{n-k} S_{i,k-1}}, 0 \leq k \leq n-1 \quad (13)$$

Cumulative quotas estimator for all development years k ∈ {0,1,...,n}, $\hat{\gamma}^{BF} = (\hat{\gamma}_0^{BF}, \hat{\gamma}_1^{BF}, \ldots, \hat{\gamma}_n^{BF})$ is the cumulative quotas estimator for the Bornhuetter-Ferguson method with $\hat{\gamma}_n^{BF} = 1$ can be obtained using the equation:

$$\hat{\gamma}_k^{BF} = \prod_{l=k+1}^{n} \frac{1}{\hat{\varphi}_l^{CL}} \quad (14)$$

The expected ultimate losses for each development year k ∈ {0,1,...,n} and accident year i ∈ {0,1,...,n}, $\hat{\alpha}^{BF} = (\hat{\alpha}_0^{BF}, \hat{\alpha}_1^{BF}, \ldots, \hat{\alpha}_n^{BF})$ is the expected ultimate losses estimator for the Bornhuetter-Ferguson method can be obtained using the equation:

$$\hat{\alpha}_i^{BF} = \frac{S_{i,n-i}}{\hat{\gamma}_{n-i}^{BF}} \quad (15)$$

For each development year k ∈ {0,1, ... ,n} and event year i ∈ {0,1, ... ,n}, the cumulative claims estimator $\hat{S}_{i,k}$ with $i + k \geq n + 1$ for the Bornhuetter-Ferguson method, namely $\hat{S}_{i,k}^{BF}$ is defined by Equation:

$$\hat{S}_{i,k}^{BF} = S_{i,n-i} + (\hat{\gamma}_k^{BF} - \hat{\gamma}_{n-i}^{BF})\hat{\alpha}_i^{BF} \quad (9)$$

The incremental claim estimator for the Bornhuetter-Ferguson method, namely $\hat{Z}_{i,k}^{BF}$ can be defined using Equation:

$$\hat{Z}_{i,k}^{BF} = \begin{cases} \hat{S}_{i,k-i+1}^{BF} - S_{i,n-i}, & if\ i+k = n+1 \\ \hat{S}_{i,k}^{BF} - \hat{S}_{i,k-1}^{BF}, & if\ i+k > n+1 \end{cases} \quad (17)$$

In the Bornhuetter-Ferguson method, the aggregate loss reserve R can be defined using the equation:

$$R^{BF} = \sum_{l=1}^{n} \sum_{j=n-l+1}^{n} \hat{Z}_{j,l}^{BF} \quad (18)$$

Exposure Credit Risk

Insurance company exposure is an evaluation of the risk of loss that may be caused by the insurance policy issued. One way to reduce the possibility of an insurance company experiencing default or insolvency is to assess the risk of loss through exposure. The risk exposure formed is the result of adjusting the technical reserves to the estimated risk of loss experienced by the company considering the possibility of the company's default. The following equation shows how this adjustment occurs:

$$Exposure\ Credit\ Risk = R^{BF} \times PD^t \quad (19)$$

Which R^{BF} is Estimation of aggregate loss reserve, Bornhuetter-Ferguson method, and PD^t is the Probability of default at the period t.

Results And Discussion

To obtain the probability of default value using the Merton method, the asset volatility must first be calculated. The result of asset volatility is 31.75%, which means that the company's asset value has an annual fluctuation rate of 31.75% and indicates that the company's asset value can change by ± 31.75% from the average value in a year. The higher the volatility, the higher the risk of the asset. Asset volatility of 31.75% for insurance companies in the context of Merton's KMV Model can be considered high, but this assessment remains relative and depends on several specific factors.

The estimation of the calculation of the value of assets A_{t-a} at iteration $k + 1$ uses data on the company's structural

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variables (assets, equity and liabilities) from the financial statements of general insurance companies for an annual period of 10 years from 2013 to 2022 (n = 10) with adjustment for asset volatility (σ_A = 31.75%), market data in the form of interest rates from the Bank Indonesia benchmark interest rate (BI-rate) during the estimation period (r_{t-n}), and uses a standard assumption of one year as the time horizon for the maturity of the company's liabilities $T - t$).

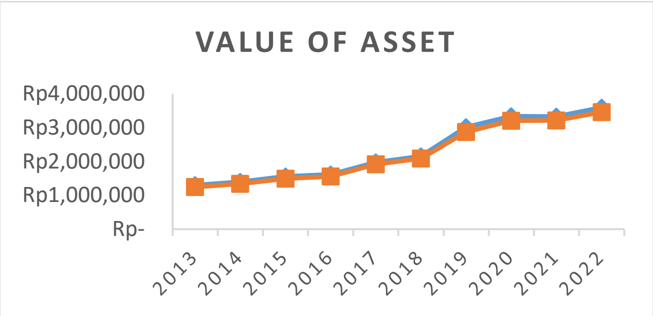


Figure *2*. Comparison of Asset Value Calculation Results

Based on the asset value generated by the iteration procedure from the original asset value at iteration k (blue line) and the asset value at iteration $k + 1$ (orange line) which has undergone market data adjustment, it is found that it tends to stabilize and fluctuate equally between iterations. As in **Figure 2**, it can be seen that the asset value at iteration $k + 1$ has decreased from the original asset value at iteration k, this is because in the iteration process several variables related to market dynamics and the characteristics of the KMV Merton model itself are used, such as asset volatility and macroeconomic conditions. Adjustment of asset volatility used in each iteration, if the estimated volatility increases, the risk associated with the asset also increases, so it can cause a decrease in asset value.

The drift rate is the expected return value of the asset's market value compared to the market index value. With the asset value obtained from the previous calculation, a standard procedure can be applied to estimate the expected return with the Capital Asset Pricing Model (CAPM). The asset value estimated in the CAPM calculation with the market uses the composite stock index (IHSG) because there is no insurance company index on the Indonesia Stock Exchange (IDX) and the assumption of a risk premium of 4%, and the risk-free interest rate return R using the Bank Indonesia interest rate (BI-rate). Then the drift rate (μ) is the logarithmic return of the expected asset return. The results of the expected asset return and drift rate estimation for each estimation period are shown in **Table 1**.

Table 1. Expected Asset Return and Drift Rate

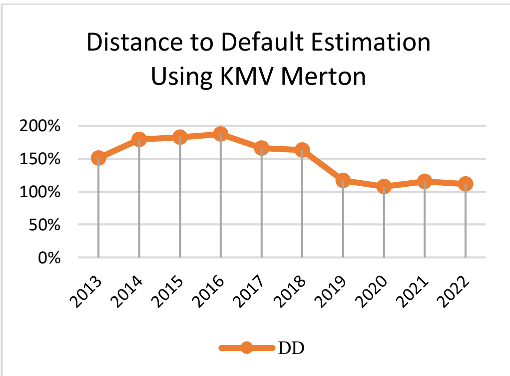
Period	$(E[R_i])$	(μ)
2013	0.063186	0.061270
2014	0.073911	0.071307
2015	0.073911	0.071307
2016	0.057863	0.056251
2017	0.042055	0.041194
2018	0.047298	0.046213
2019	0.053889	0.052487
2020	0.039443	0.038685
2021	0.031646	0.031156
2022	0.036837	0.036175

After the expected asset return and drift rate obtained, the probability of default calculation will be carried out with $\alpha = 0, 1, 2, \ldots, n$, is the estimation period. The distance to default (DD) calculation of KMV Merton method will be estimated from the estimated asset value of iteration $k + 1$ with asset volatility adjustment (σ_A= 31.75%), as well as the average rate of change of the asset value (drift rate) μ_t during the 10-year estimation period from 2013 to 2022 (n = 10). Then estimate the probability of default value by substituting the estimated value of the distance to default (DD_t) obtained into the cumulative distribution function for the standard normal. The distance to default and probability of default estimation results for each estimation period are shown in **Table 2**.

Table 2. Distance to Default and Probability of Default

Period	DD	PD
2013	1.506912	0.065917
2014	1.789469	0.036770
2015	1.822583	0.034183
2016	1.871714	0.030623
2017	1.657120	0.048748
2018	1.631079	0.051437
2019	1.166682	0.121669

Period	DD	PD
2020	1.076160	0.140928
2021	1.155475	0.123948
2022	1.116198	0.132169



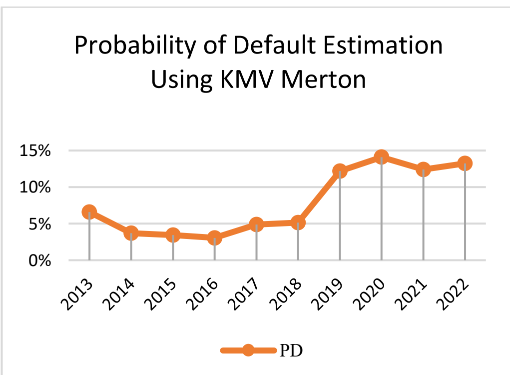


Figure 3. Distance to Default (DD) and Probability of Default (PD) Values

Based on the distance to default (DD) and probability of default (PD) estimates reported in **Table 2**, the highest DD value is observed in 2016, amounting to 1.871714, which corresponds to the lowest PD of 0.030623. In contrast, the lowest DD value occurs in 2020 at 1.076160, accompanied by the highest PD of 0.140928. These results are consistent with the patterns illustrated in **Figure 3** and confirm the inverse relationship between DD and PD implied by the Merton–KMV framework. A higher distance to default indicates that the market value of the insurer's assets is substantially above its liability threshold, thereby implying a lower likelihood of default.

Overall, the estimated PD values across the observation period range from approximately 3% to 14%, indicating that the insurer faces a relatively low probability of default. This low default risk is largely driven by the insurer's financial condition, particularly the market value of its assets, which remains sufficient to cover outstanding obligations in most periods. When asset values are high relative to liabilities, the buffer against default increases, resulting in lower PD estimates.

While these PD results suggest that the insurer is generally solvent, default probability alone does not fully reflect the insurer's potential loss exposure to policyholders. Even in periods of low PD, substantial claim obligations may arise due to the uncertainty in claim frequency and severity. Therefore, to obtain a more comprehensive assessment of potential losses, the analysis is extended to incorporate claim reserve estimation using the Bornhuetter–Ferguson method. This method captures the expected magnitude of future claim payments by combining prior loss expectations with observed claims development patterns.

By linking PD estimates with Bornhuetter–Ferguson claim reserves, the study establishes a coherent risk-based framework in which default likelihood is evaluated jointly with the size of potential claim obligations. In periods such as 2020, where PD increases while claim reserves are also elevated, the insurer's overall credit risk exposure becomes significantly higher. Consequently, the integration of PD and claim reserve estimates provides a more realistic basis for determining the required ex-ante funding reserves under an insurance guarantee scheme, ensuring that funding levels adequately reflect both the probability and the severity of potential losses.

Table 3. Run-Off Triangle Incremental Claims

Accident Year i	*Development Year* (k Year)				
	0	1	...	9	10
0	Rp0	Rp29,830,644,950	...	Rp42,921,968	Rp31,796,216
1	Rp15,509,398,197	Rp114,511,538,856	...	Rp15,093,415	
2	Rp38,396,003,778	Rp147,725,196,611	...		
3	Rp24,447,524,636	Rp161,983,857,448	...		
4	Rp17,993,698,196	Rp69,321,557,195	...		
5	Rp34,715,377,400	Rp100,180,214,236	...		
6	Rp35,923,465,096	Rp293,733,169,272	...		
7	Rp55,772,810,429	Rp324,699,173,623	...		
8	Rp147,841,272,992	Rp433,646,005,946	...		
9	Rp33,237,476,192	Rp103,196,419,287	...		
10	Rp910,155,603				

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Table 4. Run-Off Triangle Cumulative Claims

Accident Year i	Development Year (k Years)				
	0	1	...	9	10
0	Rp0	Rp29,830,644,950	...	Rp93,796,215,921	Rp93,828,012,136
1	Rp15,509,398,197	Rp130,020,937,052	...	Rp264,088,296,065	
2	Rp38,396,003,778	Rp186,121,200,389	...		
3	Rp24,447,524,636	Rp186,431,382,083	...		
4	Rp17,993,698,196	Rp87,315,255,391	...		
5	Rp34,715,377,400	Rp134,895,591,636	...		
6	Rp35,923,465,096	Rp329,656,634,368	...		
7	Rp55,772,810,429	Rp380,471,984,052	...		
8	Rp147,841,272,992	Rp581,487,278,938	...		
9	Rp33,237,476,192	Rp136,433,895,479	...		
10	Rp910,155,603				

Using Bornhuetter-Ferguson method, the aggregate loss reserve can be calculated by utilizing the results of the incremental claim estimator, so that the Bornhuetter-Ferguson claim reserve value for claims occurring in 2013, 2014, 2015 to 2022 is obtained.

Table 5. Aggregate Claims Reserve

Year	Claim Reserves
2013	Rp89,523,957
2014	Rp169,245,164
2015	Rp264,001,863
2016	Rp552,077,619
2017	Rp1,842,360,362
2018	Rp13,082,104,682
2019	Rp46,732,854,304
2020	Rp169,744,262,894
2021	Rp116,340,464,851
2022	Rp8,203,808,155

Based on **Table 5**, claim reserves estimation from 2013 to 2022 can be seen in **Figure 4**.

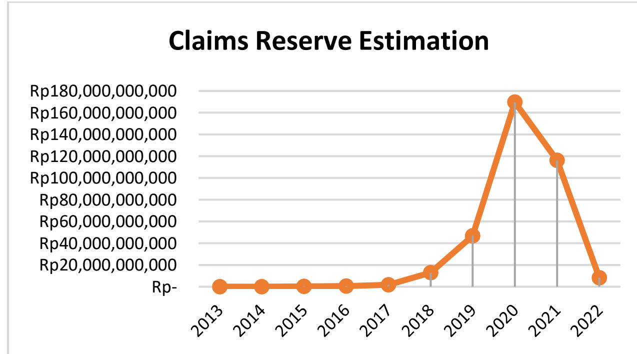

Figure 4. Claim Reserve Estimation

Based on the results of the estimated claim reserves generated in **Table 5**, the largest claim reserves occurred in the 2020 period and the lowest estimated claim reserves occurred in the 2013 period. The claims reserves generated through Figure 4 fluctuate significantly. This is because the resulting claim reserves are influenced by the amount of claims and the frequency of claims that occur. When there are many claims, the claim reserves will increase. The amount of claims that occurred in 2020 was the highest claim that occurred at the estimation time, causing the resulting claim reserves for 2020 to produce large claim reserves compared to other years.

In forming an effective insurance guarantee scheme, the funding mechanism is a crucial component. One of the funding method schemes in the insurance guarantee scheme, which includes ex-ante (pre-event) funding, is the formation of funding reserves to anticipate future defaults, the formation of these reserves is carried out before the problem occurs.

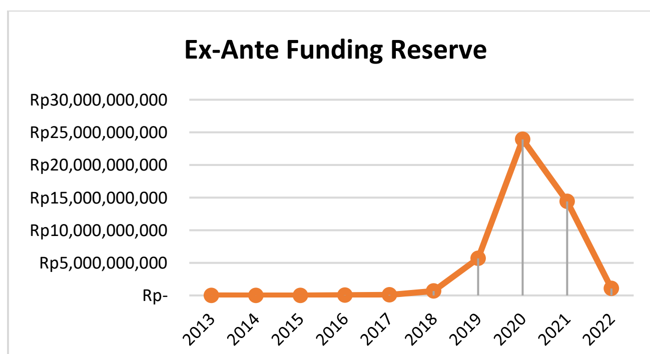

Figure 5. Estimated Ex-Ante Funding Reserves

Based on the results of the ex-ante funding reserve estimation, the highest funding reserve is in the 2020 period and the lowest in the 2013 period. In **Figure 5**, it can be seen that the ex-ante funding reserve fluctuates very significantly and the graph has more or less the same pattern as the claim reserve graph in **Figure 4**. The resulting funding reserve is influenced by the company's probability of default. If the probability of default is low, the company can raise less funds because the anticipated risk of loss is smaller. The probability of default affects the ex-ante funding scheme by determining how much funds should be raised to cover the risk of future losses.

Although the empirical analysis in this study is based on data covering the period 2013–2022, the results remain relevant for current and future assessments of insurance default risk and the design of insurance guarantee schemes. The proposed framework—integrating the KMV Merton structural model with the Bornhuetter–Ferguson reserving approach—is grounded in forward-looking market-based and actuarial principles. In particular, the KMV Merton model captures variations in asset values, asset volatility, and liability structures, enabling the probability of default (PD) to respond dynamically to changing market conditions [1,9]. The use of a ten-year observation period further strengthens the analysis by encompassing multiple economic phases, including periods of heightened stress such as the economic disruption observed in 2020, thereby enhancing the robustness of default risk assessment.

From a practical perspective, the framework explicitly embeds PD estimation within the insurance guarantee scheme by linking default probabilities to risk-adjusted claim reserves and ex-ante funding requirements. This risk-based integration allows insurer contributions to reflect both the likelihood and the potential severity of default events, rather than relying on static or rule-based mechanisms [5,10]. As the methodology can be readily updated using more recent financial and claims data, the analytical framework and policy implications of this study remain valid and adaptable, providing a reliable reference for the ongoing implementation of insurance guarantee schemes in Indonesia.

Conclusions

Based on the estimation results obtained using the KMV Merton model, the probability of default (PD) of the insurance company ranges between approximately 3% and 14% over the period 2013–2022. The highest PD value of 14.09% is observed in 2020, while the lowest PD of 3.06% occurs in 2016. Within the context of structural credit risk models, PD values below 20% are generally interpreted as indicating a low to moderate level of default risk, particularly for non-life insurance companies with relatively stable asset structures. These findings suggest that the insurer remains broadly solvent, supported by sufficient asset values to meet its liabilities, although periods of heightened vulnerability are evident and warrant continuous monitoring.

The sharp increase in PD observed in 2020 highlights the sensitivity of the KMV Merton model to adverse macroeconomic conditions and heightened asset volatility. This period coincides with the economic disruption caused by the COVID-19 pandemic, which adversely affected financial markets, investment returns, and overall economic activity. The resulting decline in asset values and increased uncertainty led to a reduced distance to default and a higher PD. Importantly, this behavior demonstrates the model's ability to capture market-based signals of financial stress, reinforcing its relevance for current and future risk assessments, particularly in an environment characterized by global economic uncertainty, financial market volatility, and evolving systemic risks.

From a policy and managerial perspective, the integration of PD estimates with claim reserve calculations using the Bornhuetter–Ferguson method provides a comprehensive measure of insurers' loss exposure for the purpose of designing an insurance guarantee scheme. The substantial variation in claim reserves and ex-ante funding requirements over time underscores the importance of adopting a risk-based funding mechanism in which insurer contributions are dynamically adjusted based on both default probability and claim exposure. As the proposed framework can be readily updated using more recent financial and claims data, the analytical insights and policy implications of this study remain relevant for current regulatory implementation. The findings offer a practical and forward-looking reference for strengthening policyholder protection programs and enhancing the sustainability of insurance guarantee schemes in Indonesia.

Conflicts of interest

There are no conflicts to declare.

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