Value at Risk Calculation of Digital Bank Stocks Portfolio in Indonesia

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Abstract— Nowadays, stock investment has been increasingly growing in society. In investing activities, there are risks that may be experienced by investors. However, sometimes many investors do not realize how much risk that they might suffer in the future. One way that can be done to measure this risk is to calculate the Value at Risk (VaR). This study aims to calculate the VaR value of digital bank stock portfolio in Indonesia. The calculation of VaR will be done using two methods, include the Historical Simulation and Monte Carlo Simulation method. From the calculation, VaR with Historical Simulation and Monte Carlo sequentially generate results of IDR 6,006,718 and IDR 10,797,904 for 99% confidence level, IDR 4,135,857 and IDR 5,376,949 for 95% confidence level, and IDR 3,219,885 and IDR 3,417,553 for 90% confidence level. Based on the results, it is found that VaR result is directly proportional to the confidence level used. Through the calculation results, it also found that VaR value with the Monte Carlo Simulation method are greater than those with the Historical Simulation method.

Keywords— Value at Risk; Historical Simulation; Monte Carlo Simulation, Digital Bank Stock Portfolio

I. INTRODUCTION

Investment can be interpreted as an activity of investing or allocating money or valuable resources that are currently owned and hold until specified time with aim to make profit [1]. Stocks are a type of investment that is popular and favored by the public considering the price offered is quite affordable, easy to do, and flexible. The ease and efficiency that offered on conducting stock transaction makes it be the one of investment typed that favored by the society [2] . Stocks have always been known as an aggressive investment. However, it cannot be denied that stocks are one of investment type that can provide greatest return. In general, making profit from invested funds be the motive for someone to invest. However, there is a fundamental thing that investors must remember that risk always follows return. In common, risk can be classified into two types, systematic risk and unsystematic risk. There is a unidirectional or linear relationship between return and risk. The greater the risk incurred, the greater expected return will be generated [3]. Risk certainly cannot be avoided, but it can be minimized and estimated. One of the ways to estimate risk is by calculating the Value at Risk (VaR).

VaR can be interpreted as the estimated maximum loss that will be obtained during a certain time period at a certain confidence level. The VaR concept was popularized by J.P. Morgan In 1900s. There are three primary methods to calculate VaR, namely Historical Simulation method, Monte Carlo Simulation method, and Variance Covariance method. Each method has its own characteristics. Variance Covariance method has an assumption that the portfolio return is linear to the single asset return and return is assumed to be normally distributed. As for Variance Covariance method, Monte Carlo Simulation also assumed that return is following normal distribution but it is not linear to the single asset return. As for the Historical Simulation method, all assumptions both for assumption that the return is following normal distribution and linear nature between return of portfolio and single asset return are ruled out of the calculation [4].

Research conducted by Bukit and Hendratno [5]unveil that VaR result using Historical Simulation for BBRI is bigger than BNGA with the confidence level of 95% and if the initial fund invested is 100 million Rupiah. Furthermore, research in cigarette sub sector stocks conducted by Adrianto, Azhari, and Khairunnisa concluded that VaR value using Monte Carlo simulation provides greater results than Historical Simulation, since Monte Carlo simulations carry out repeated iterations involving random number generation and a lot of data synthesis so that there are more data samples which makes the calculations bigger [6]. Thariq also conducted research for VaR calculation on BJTM stock using Monte Carlo Simulation method that gives a conclusion that confidence level used is commensurate to the risk. As the increase of confidence level used, the possibility of maximum loss that will be suffered by investor will also increase and vice versa [7].

Digital bank stock prices have experienced a significant decline during 2022. Market conditions that have changed drastically be one of the main factors that caused digital bank stock prices drop sharply. For this reason, digital banks have received special attention from public due to the significant price decline from time to time [8]. In this study, VaR calculation will be carried out

for digital bank stock portfolio that consist of 4 privately owned digital bank, including PT. Bank Jago Tbk (ARTO), PT. Bank Neo Commerce Tbk (BBYB), PT. Allo Bank Indonesia (BBHI), and PT. Bank Aladin Syariah Tbk (BANK) on period of April 1st, 2021 to March 30th, 2023. Weight of each stock consist on the portfolio assumed to be the same. The calculation will be performed using two methods. First is the Historical Simulation since this method uses actual historical data to calculate VaR so it can reflect actual changes in asset or portfolio prices over time and its flexibility allows it to capture a variety of market conditions, including extreme behavior, without certain assumptions about distribution. and Monte Carlo Simulation method. Second is Monte Carlo Simulation which is the most powerful method for measuring VaR since it can calculate various exposure and risk structures including nonlinear price risk, volatility risk and fixed model risk.

II. LITERATURE REVIEW

A. Stock Portfolio

Stock portfolio is a collection of fixed assets in the form of stocks owned by both companies and individuals [9]. In forming a portfolio, investors try to maximize the expected return with a certain acceptable risk level. A portfolio is said to be efficient if the portfolio formed compared to other portfolios fulfills several conditions, including provide greatest expected return with same risk provide smallest risk with same expected return. To construct an efficient portfolio, assumptions about investor behavior must be considered when making investment decisions, whether the investor is risk-averse or risk-seekers. Investors with risk-averse behavior will choose investments with lower risk. In contrast to risk-averse investors, risk-seekers offer a higher level of risk tolerance that an investor is willing to accept.

B. Return

Return can be interpreted as the total expected return from an investment in a certain period [7]. Stocks returns are the benefits obtained from investors' share ownership for their investment activities consisting of dividend and capital gains/losses. When it comes to investing, there is a trade-off between risk and return. The greater the risk, the greater the return [4]. The calculation of stock return can be done using the formula:

$$R_t = \frac{P_t - P_{t-1}}{P_{t-1}}$$

(1)

where R_t is the return in period t, P_t is the stock price in period t, and P_{t-1} is the stock price in period t-1. As for the return of a portfolio, it can be calculated by the formula:

$$R_{p,t} = \sum_{i=1}^{n} w_i R_{i,t}$$

(2)

where t denotes the period (1,2, 3,…,m), n is the number of data observed, and w_i is the proportion or weight of each stocks.

C. Risk

Risk can be interpreted as a form of uncertainty about a situation that will occur in the future *[10]*. Risk in investment management is the degree of divergence between the expected return and the actual return. Risks can be divided into two categories, including systemic risk and unsystematic risk. Systematic risk is the risk created by market price fluctuations and cannot be eliminated or mitigated by diversification. Meanwhile, unsystematic risk is a risk that is not related to changes in market prices that can be eliminated or reduced by diversification since this risk only occurs in a particular industry or agency *[7]*. Statistically, the risk level is represented by a measure of deviation or a measure of data spread. It is commonly denoted by variance and standard deviation values [4]. Given n returns, the expected return value can be estimated using equation:

$$E(R_i) = \frac{\sum_{t=1}^{n} R_t}{n}$$

(3)

where n is the amount of data used. Then, this value can be used to estimate the variance of each period which is formulated as:

$$\sigma^2 = \frac{\sum_{t=1}^{n}[R_t - E(R_i)]^2}{n-1}$$

(4)

If the variance value is rooted, the resulting standard deviation is an estimate of the risk of the stock price which can be calculated using the formula:

$$\sigma = \sqrt{\sigma^2} = \sqrt{\frac{\sum_{t=1}^{n}[R_t - E(R_i)]^2}{n-1}}$$

(5)

For Portfolio risk, it can be expressed by taking the root of the variance of portfolio returns. The portfolio variance value can be formulated mathematically by *[11]*:

$$Var(p) = \sigma_p{}^2 = \sum_{i=1}^{n} w_i{}^2 \sigma_i{}^2 + \sum_{j=1}^{n} w_j{}^2 \sigma_j{}^2 + 2\sum_{i=1}^{n}\sum_{j=1}^{n} w_i w_j \sigma_{ij} \tag{6}$$

where $i \neq j$, and

$\sigma_p{}^2$ = variance of the portfolio returns

$\sigma_i{}^2$ = variance of the asset-i returns

σ_{ij} = covariance between asset-i and asset-j returns

w_i = investment weight on asset-i

w_j = investment weight on asset-j

D. Value at Risk (VaR)

Value at Risk, commonly abbreviated as VaR, is a risk measurement method that is often used to calculate the maximum value of financial risk that may be faced by investors under normal conditions at a certain period of time. The VaR concept was popularized by J.P. Morgan in the 1900s. This was based on the dissatisfaction of J.P. Morgan executives with the long risk reports issued by the company's risk managers. The executives wanted a statistical figure that would summarize the risk of the company's entire portfolio reported daily after the close of trading. From this problem, the concept of VaR emerged. Since then, the concept of VaR calculation has been used by banks to measure risk [4].

VaR calculations can produce positive or negative values. VaR can provide a number that summarizes the overall risk in a portfolio of financial assets. In portfolios, VaR can be interpreted as an estimate of the maximum possible loss that a portfolio could incur over a specified time period and a specified confidence level. There are two parameters in VaR, which are:

1. The Time Horizon
   VaR can be calculated based on daily, weekly, and even monthly time horizons if there is sufficient data. When calculating VaR, the time horizon is chosen based on the application. In risky markets, risk analysts will calculate VaR using a short time horizon such as one day. On the other hand, if the instrument being traded is less active, VaR will be calculated using a longer time horizon such as 1 month or even 1 year. The assumptions commonly used are:

$$\text{T-day } VaR = \text{1-day } VaR \times \sqrt{T} \tag{7}$$

   where T is a notation that represent the time horizon.

2. Confidence Level
   Confidence Level is the measure of confidence owned by investors expressed in percentage that investors will experience losses in their investment activities. The confidence level $(1 - \alpha)$ that can be denoted by X which is written in percentage form. Commonly used confidence levels are 95%, 97.5%, and 99% [12].

In simple terms, it can be concluded that the VaR concept states that with a confidence level of X%, a person or an institution will not experience losses exceeding the calculated VaR value within a certain time (T). Despite being one of the most popular ways to calculate total risk, VaR has the disadvantage of only measuring the percentile of profit or loss sharing without considering losses that exceed the VaR level. In addition, VaR has an incoherent nature. Calculation of VaR with confidence level X after t period can be formulated as follows:

$$VaR_X(t) = S_0 R^* \sqrt{t} \tag{8}$$

where:

$VaR_X(t)$ = VaR value with X confidence level after t period.

S_0 = initial investment fund.

R^* = α^{th} quantile of the return distribution.

A. Normality Test

Normality test can be done through several methods. To test the normality of a data, Kolmogorov-Smirnov test can be an alternative that can be used. The Normality test on stock data is intended to determine whether the stock return data is normally distributed or not. The Kolmogorov-Smirnov test focuses on the largest deviation D (maximum deviation) which is the maximum difference between the cumulative frequency of the normal distribution and the cumulative frequency of observations. The Kolmogorov-Smirnov normality test can be calculated using the formula:

$$D = {}^{sup}_{x}|S(x) - F(x)| \tag{9}$$

where:

D = supremum (smallest upper limit) value for all x from the absolute value of the difference $S(x) - F(x)$

S(x) = cumulative probability distribution of observational data

F(x) = cumulative distribution of the normal distribution probability

The Kolmogorov-Smirnov test will have the following hypothesis:

 H_0: return is following normal distribution

 H_1: return is not following normal distribution

H_0 is rejected if $p - value < \alpha$, where α is the level of significance and the value of $p - value$ is the critical value obtained from the Kolmogorov-Smirnov test *[13]*.

E. Skewness

In a symmetrical distribution, the tail sizes on both sides on the center of the distribution are same. However, in an asymmetrical distribution, the size of the tail on the curve will have a difference. Skewness is a statistical value that is used to indicate the slope or symmetry of the curve shape obtained from the distribution data. When a curve has one tail that is longer than the other tail, the skewness value will measure the extent to which the difference has from the tail of a data distribution. The difference in curve tail length means that the mean and median will not be at the same point. Mathematically, the skewness value can be calculated using the equation:

$$S = \frac{\frac{1}{N}\sum_{t=1}^{N}(r_t - \mu)^3}{\sigma^3} \tag{10}$$

where:

 N = total data

 r_t = return

 μ = sample average of return

 σ = sample standard deviation of return

The skewness value for each distribution will be different. Skewness can be positive, negative, or zero. Skewness in data that has perfectly symmetrical distribution curve, for example a normal distribution, is equal to zero. If Skewness is positive, then it can be said that a distribution has a curve that is skewed to the right or the tail size on the right side of the curve is longer than the other side. Conversely, if the value is negative, the curve is said to be skewed to the left, which means the tail on the left side is longer than the other side *[14]*.

F. Kurtosis

Kurtosis or often called as peak of curve is a statistical value that measures the spiciness or flatness of a distribution. Generally, kurtosis is used to measure the flatness or spiciness of the data distribution peaks compared to the normal distribution. Kurtosis will compare the sensitivity level of the tail and the peak of the data distribution curve with the normal distribution. Skewness and kurtosis are often used together in statistical analysis since both of them can provide useful information related to the shape of the distribution data. Mathematically, the kurtosis value can be calculated using the equation:

$$K = \frac{\frac{1}{N}\sum_{t=1}^{N}(r_t - \mu)^4}{\sigma^4} \tag{11}$$

The kurtosis value for a data that follows a normal distribution is equal to 3. With this, it can be interpreted that if a data has a kurtosis value greater than 3, then the data sample tends to be outside the normal distribution. Conversely, if the kurtosis value is less than 3, the data sample will tend to be within the normal distribution range. In other word, if the kurtosis value is equal to 3, it can be said that the distribution curve is normal. Meanwhile, for a kurtosis value of more than 3, the curve will be spiky (leptokurtic). The curve will be obtuse (platykurtic) when the resulting kurtosis value is less than 3 from a sample data *[14]*.

G. Cornish-Fisher Expansion

In the world of the economy, especially financial industry, Cornish-Fisher expansion is often used in financial risk analysis. Generally, conventional risk calculations assume that the observed data follows the assumption of normality or it is normally distributed. However, in reality, data related to finance often shows irregularities or it can be said that financial data is often not following normal distribution since these data tend to fluctuate. The Cornish-Fisher expansion is a method that calculates and estimates the statistics of a probability distribution that has skewness and kurtosis values that are different from the normal distribution. The Cornish-Fisher expansion approach is an approach that overrides the assumption of normality. This approach

provides an extension of the quantile calculation by taking into account the skewness and kurtosis values in the data distribution. Mathematically, the Cornish-Fisher expansion approach for calculating Value at Risk can be formulated as follows *[15]*:

$$Z' = Z + \frac{S}{6}(Z^2 - 1) + \frac{K}{24}(Z^3 - 3Z) - \frac{S^2}{36}(2Z^3 - 5Z) \tag{12}$$

where:

Z' = new standard normal distribution value

Z = standard normal distribution value

S = Skewness of return data

K = Kurtosis of return data

H. Historical Simulation

Historical simulation is one of the most popular ways to calculate VaR. The historical simulation method directly involves using past data as a guide to calculate what will happen in the future *[16]*. It also assumes that the returns of a single asset or portfolio are not normally distributed. In other words, the historical simulation method does not require the use of normal distribution statistical assumptions and estimates volatility and correlation. This method only require portfolio return data in the form of time series. Furthermore, the calculation of Value at Risk (VaR) using historical simulation methods unaffected by the fat tails of the distribution of portfolio returns. The ease of understanding and the modifications provided make this method be the one of most popular methods among financial and non-financial entities. The calculation of VaR with historical simulation can be done by using formula on equation (8).

I. Monte Carlo Simulation

A mathematical technique that utilized to estimate possible outcomes of an uncertain events is the definition of Monte Carlo Simulation or regularly known as multiple probability simulation [17]. This method was introduced by John Von Neumann and Stanislaw Ulam during World War II with the aim of improving decision-making under uncertain conditions. The name Monte Carlo itself comes from the famous casino located in Monaco considering its random characteristics such as roulette. Monte Carlo simulation can be used to assess risk and make accurate long-term predictions that can be applied in various fields such as business, finance, and even online gaming.

A fundamental principle of Monte Carlo simulation lies in the ergodicity that describes the behavior of moving statistics in closed systems. This method uses a random number generator to create inherent uncertainty in the input parameters. The level of accuracy in this method is directly proportional to the number of simulations performed. In other words, running 1,000 simulations will give more accurate results compared to 100 simulations. Regardless of the tool or software used, the Monte Carlo simulation method has three basic steps:

1. Prepare the predictive model by identifying the dependent variable to be predict and the independent variable that will drives the prediction.
2. Determine the probability distributions of the independent variables using historical data or the subjective judgment of the analyst, determine the range of possible values, and assign probability weights to them.
3. Run the simulation iteratively until enough values are generated to create a representative sample of the nearly infinite possible combinations.

III. METHODOLOGY

A. Research Design

A quantitative approach used in this research. In the quantitative approach, research is pre-determined and statistical data analysis and interpretation are performed. In this research process, a large number of data and formulas will be involved, starting from the data collection process to the appearance of the results at the end of the process as answers to questions and hypotheses formed in this research. This research also involves a literature study method in which the author collects, studies, and explores various journals and books as references for conducting research. From those description, it can be concluded that this research is according to the positivist philosophy used to study a specific population or sample. Based on the background and formulation of the problem that has been mentioned, this study uses a quantitative approach to calculate Value at Risk and Expected Shortfall in Bank Digital's stock portfolio.

B. Data Collection Design

This research uses secondary data types, where data is obtained indirectly through the study of research-related data and documents. The data used is the closing stock price of 4 privately owned digital bank companies, including PT. Bank Jago Tbk, PT. Allo Bank Indonesia Tbk, PT. Bank Neo Commerce Tbk, and PT. Bank Aladin Syariah on the period of April 1st, 2021 to March 30th, 2023. These data were obtained from the Yahoo finance website which provides historical data of closing stock prices. This research uses the help of Microsoft Excel and SPSS software.

C. Data Analysis Design

To perform VaR and ES calculations using the Historical Simulation and Monte Carlo Simulation methods, there are several steps or procedures that must be carried out. The following is an explanation of what must be done in calculating VaR and ES values using both the Historical Simulation and Monte Carlo Simulation method.

The Historical Simulation Method assumes the stock price patterns that occurred in the past will be the same as future price patterns, so the calculation can be done by:
1. Collecting closing stock price data within a predetermined period
2. Calculate the portfolio return using equation (2). The investment weight in this research is assumed to be the same.
3. Sort data returns starting from the biggest loss to the biggest profit.
4. Find the value of αth percentile of the sorted data returns. Percentile itself is a statistical measure in data analysis that measures the location of data in a distribution or population. If there is an initial investment fund, the formula in the equation can be used (8).

As for the Monte Carlo Simulation method, the steps that must be taken to obtain VaR and ES values are as follows:
1. Collecting closing stock price data within a predetermined period.
2. Calculate the portfolio return using equation (2). The investment weight in this research is assumed to be the same.
3. Performing the Kolmogorov-Smirnov normality test for portfolio return data. However, if data are not following normal distribution, the Cornish-Fisher Expansion approach can be used according to the equation on (12) and (13)
4. Determine parameter values for variables.
5. Stimulating the return value by generating random numbers from each asset return that has been normally distributed with the risk measures that have been obtained.
6. Calculate VaR value using the formula on equation (8).
7. Repeat step 4 and 5 until m times. The more iterations, the better the results will be.
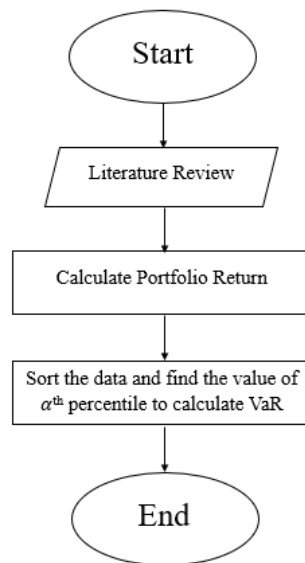
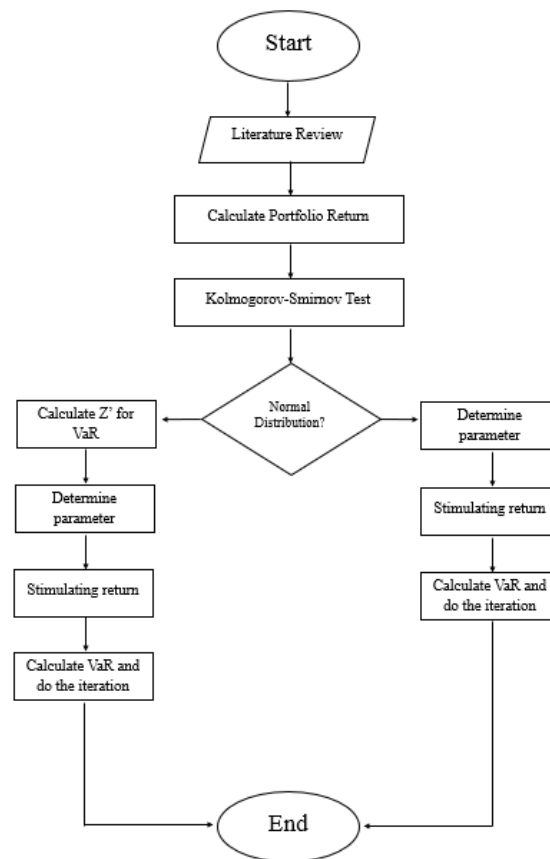## D. Research Flowchart

Figure 1. Historical Simulation Flowchart

Figure 2. Monte Carlo Simulation Flowchart

IV. RESULT AND DISCUSSION

A. *Portfolio Return Calculation*

The first step that must be carried out in this study is find and collect daily closing prices of 4 privately owned digital bank on the period of April 1st, 2021 to March 30th,2023. This data was obtained by citing historical data for each stock on Yahoo Finance website. Portfolio return calculation can be done using formula that already stated on previous chapter. In this case, the weight of each stock is assumed to be the same or equal to 25%. The portfolio return graph can be seen in the figure below.
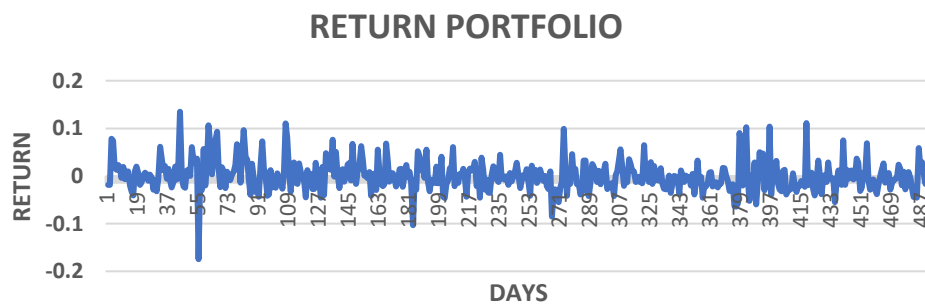

Figure 3. Graph of Portfolio Return

From the graph of portfolio returns which can be seen in figure 3, it can be stated that the portfolio return is shifting between -0.2 to 0.15 followed by 0.00059 as the average return value and 0.29008 as the total return value. The graph also shows that the portfolio returns obtained vary greatly, where there are very high returns and some are very low. After obtaining and processing all the required data, the portfolio return calculation results can be sorted from the biggest loss to the biggest profit. This step is needed to calculate Value at Risk using Historical Simulation.

B. Normality Test

Since Monte Carlo Simulation method assumes that returns follow a normal distribution, data normality assumption tests for portfolio returns using the Kolmogorov-Smirnov test are performed before calculating the Value at Risk. This process is aimed to see whether digital bank portfolio returns follow the normal distribution assumption or not. If the test results state that the data is normally distributed, then calculations can be directly carried out using the ordinary normal distribution equation to determine the Z value, which is one of the factors for calculating VaR. However, if the test results state that the data does not follow normal distribution, then the Cornish-Fisher Expansion approach can be used to determine the value of Z apostrophe (Z'). The Kolmogorov-Smirnov test was carried out with the help of SPSS software. The figure below shows the result of normality test for digital bank stock portfolios.

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Portofolio_Return	.090	492	<.001	.938	492	<.001

a. Lilliefors Significance Correction

Figure 4. Graph of Portfolio Return

From the results of the Kolmogorov-Smirnov test calculations which can be seen in figure 4, it can be seen that digital bank portfolio returns have a $p - value < 0.001$, which means H_0 is rejected for all α. Therefore, it can be concluded that digital bank portfolio return doesn't follow normal distribution. Since data used doesn't follow normal distribution, then the Cornish-Fisher Expansion approach must be carried out. The following table is the result of Cornish-Fisher Expansion calculation.

TABLE 1
CORNISH-FISHER EXPANSION

Confidence Level	Skewness	Kurtosis	Z	Z' for VaR	Z' for ES
99%	0.539568	3.520463	2.326348	3.436577	1.776921
95%	0.539568	3.520463	1.644854	1.721716	1.362425
90%	0.539568	3.520463	1.281551	1.101882	1.190998

C. Value at Risk Using Historical Simulation Method

Calculation of VaR using the Historical Simulation method can be carried out by following the steps presented in the previous chapter. The help of Microsoft Excel is needed to perform this calculation. The percentile *(=PERCENTILE())* formula is used to obtain the VaR value, The VaR calculation results for an initial portfolio investment of IDR 100,000,000 are shown in the table below:

TABLE 2
VALUE AT RISK USING HISTORICAL SIMULATION

Confidence Level	VaR (%)	VaR (IDR)
99%	6.01%	IDR 6,006,718
95%	4.14%	IDR 4,135,857
90%	3.22%	IDR 3,219,885

From table 2, it can be stated that for 99% confidence level, the maximum loss that may experience by the investor for one trading day period is IDR 6,006,718 or in other words, it can be said that with a significance level of 1%, the investment risk in the digital bank stock portfolio is amounted to IDR 6,006,718. While for 95% confidence level the maximum loss is IDR 4,135,857 or in other words, it can be said that with a significance level of 5%, the investment risk in the digital bank stock portfolio is amounted to IDR 4,135,857. For 90% confidence level, the maximum loss that may be experienced by the investor is IDR 3,219,885 or in the other words, it can be said that with a significance level of 10%, the investment risk in the digital bank stock portfolio is amounted to IDR 3,219,885.

D. Value at Risk Using Monte Carlo Simulation Method

Calculation of VaR using Monte Carlo Simulation method can be carried out by following the steps listed in the previous chapter. In this study, digital bank stock portfolio returns are not normally distributed. Therefore, the Cornish-Fisher Expansion approach is necessary. The parameter value of the return asset will be determined after generating the new standard normal distribution quantile value. Mean and standard deviation of the portfolio return are the parameter that will be used in this calculation. The following table shows the results of the parameter calculation.

TABLE 3
DIGITAL BANK STOCK PORTFOLIO PARAMETER CALCULATION

Parameter	Digital Bank stock Portfolio
Mean	0.000589591
Standard Deviation	0.031628124

Afterwards, the $=RAND()$ function is used to generate a random number between 0 and 1 and the $=NORMINV()$ function which aims to simulate returns by generating return asset values that are normally distributed randomly using parameter values that already obtained. Furthermore, the mean and standard deviation values of the return stimulation results are calculated since these two parameters will be used in the calculation of VaR and ES. The following table shows the calculation results of the new parameters values.

TABLE 3
DIGITAL BANK STOCK PORTFOLIO PARAMETER CALCULATION AFTER RETURN STIMULATION

Parameter	Digital Bank Stock Portfolio
Mean	0.003144147
Standard Deviation	0.031069413

In this study, 1,000 times iteration was carried out. Then proceed with calculating the average VaR value of the iteration results to stabilize the VaR value since the results obtained from each simulation will be different. After obtaining the average VaR value for each confidence level, ES value can be calculated using the formula stated in previous chapter. The calculation results for VaR and ES values using the Monte Carlo Simulation method can be seen in the table below.

TABLE 3
VALUE AT RISK USING MONTE CARLO SIMULATION METHOD

Confidence Level	VaR (%)	VaR (IDR)
99%	10.80%	IDR 10,797,904
95%	5.38%	IDR 5,376,949
90%	3.42%	IDR 3,417,553

From table 3, it can be stated that for 99% confidence level, the maximum loss that may experience by the investor for one trading day period is IDR 10,797,904 or in other words, it can be said that with a significance level of 1%, the investment risk in the digital bank stock portfolio is amounted to IDR 10,797,904. While for 95% confidence level the maximum loss is IDR 5,376,949 or in other words, it can be said that with a significance level of 5%, the investment risk in the digital bank stock portfolio is amounted to IDR 5,376,949. For 90% confidence level, the maximum loss that may be experienced by the investor is IDR 3,417,553 or in the other words, it can be said that with a significance level of 10%, the investment risk in the digital bank stock portfolio is amounted to IDR 3,417,553.

E. Result Comparison

After carrying out all the necessary calculations, the results obtained by each calculation can then be compared using both the Historical Simulation method and the Monte Carlo Simulation method. Comparison of these results can be seen in the table below.

TABLE 4
RESULT COMPARISON

	Historical Simulation			Monte Carlo Simulation		
CL	99%	95%	90%	99%	95%	90%
S_0	100,000,000	100,000,000	100,000,000	100,000,000	100,000,000	100,000,000
VaR	6,006,718	4,135,857	3,219,885	10,797,904	5,376,949	3,417,553

From the table above it can be seen that the calculation results using the Monte Carlo Simulation are greater than the values generated by the Historical Simulation method because the iterative process carried out in the Monte Carlo method includes the generation of random numbers which results in a larger number of data samples which ultimately impacts the more calculations that occur.

V. CONCLUSION

1. VaR values using Historical Simulation with a 99% confidence level generate value of 6.01% or IDR 6,006,718. While 95% confidence level, VaR value of 4.14% or IDR 4,135,857 is generated. For the 90% confidence level, VaR of 3.22% or IDR 3,219,885 is obtained. From these results it can be concluded that the maximum loss that may be experienced by an investor with a 99% confidence level will not exceed IDR 6,006,718, 95% will not exceed IDR 4,135,857, and 90% will not exceed IDR 3,219,885 for one day period after March 30th, 2023.

2. VaR values using Monte Carlo Simulation with a 99% confidence level generate value of 10.8% or IDR 10,797,904. While 95% confidence level, VaR value of 5.38% or IDR 5,376,949 is generated. For the 90% confidence level, VaR of 3.42% or IDR 3,417,553 is obtained. From these results it can be concluded that the maximum loss that may be experienced by an investor with a 99% confidence level will not exceed IDR 10,797,904, 95% will not exceed IDR 5,376,949, and 90% will not exceed IDR 3,417,553 for one day period after March 30th, 2023.

3. Based on VaR results using the two methods, Historical Simulation and Monte Carlo Simulation, it can be concluded that the confidence level is directly proportional to the probability of risk occurrence. The higher confidence level used, the greater maximum potential loss that an investor may suffer. This also applies to the reverse. In addition, the VaR using Monte Carlo Simulation yield larger values compared to the Historical Simulation due to iterative process which includes a random number generator factor so that the number of observational data samples becomes larger which results in larger calculation results.

REFERENCES

[1] A. Hayes, "Investment Basics Explained With Types to Invest in," 2023. [Online]. Available: https://www.investopedia.com/terms/i/investment.asp.

[2] D. Safitri, "Kemudahan Investasi Saham di Era Digital yang Serba Online," 2019. [Online]. Available: https://duniafintech.com/kemudahan-investasi-saham-digital/.

[3] I. M. Adnyana, Manajemen Investasi dan Portofolio, Jakarta : LPU-UNAS, 2020.

[4] J. C. Hull, Options, Futures, and Other Derivatives, New Jersey: Pearson Education, Inc., 2022.

[5] G. C. Bukit and Hendratno, "Analisis Backtesting dan Value at Risk (VaR) Dengan Metode Simulasi Historis Dalam Sub Sektor Bank (Studi Kasus Pada Saham PT Bank Rakyat Indonesia Tbk dan PT Bank CIMB Niaga Tbk)," *e-Proceesing of Management,* pp. 772-778, 2021.

[6] A. D. Adrianto, M. Azhari and Khairunnisa, "Perhitungan Value at Risk (VaR) Dengan Metode Historis dan Monte Carlo Pada Saham Sub Sektor Rokok," *Jurnal Riset Bisnis dan Management,* pp. 1-8, 2018.

[7] M. N. A. Thariq, Pengukuran RIsiko Value at Risk (Var) Pada Investasi Saham Menggunakan Metode Simulasi Monte Carlo (Studi Kasus: PT Bank Pembangunan Daerah jawa Timur Tbk), Islam Indonesia University: Unpublished Thesis, 2020.

[8] I. Fadilah, "Ternyata ini Penyebab Saham Bank Digital Kompak Nyungsep di 2022," 2022. [Online]. Available: https://finance.detik.com/bursa-dan-valas/d-6486070/ternyata-ini-penyebab-saham-bank-digital-kompak-nyungsep-di-2022.

[9] N. Sofiana, Pengukuran Value at Risk Pada Portofolio dengan Simulasi Monte Carlo (Studi Kasus: Harga Penutupan Saham Harian PT Telekomunikasi Indonesia Tbk dan PT Unilever Indonesia Tbk Bulan Januari - Desember 2010), Yogyakarta State Universitu: Thesis, 2011.

[10] W. W. Hidayat, Konsep Dasar Investasi dan Pasae Modal, Ponorogo: Uwais Inspirasi Indonesia, 2019.

[11] P. Jorion, Value at Risk The New Benchmark For Managing Financial Risk 3rd edition, United States: McGraw-Hill Companies, Inc., 2007.

[12] Š. Čorkalo, "Comparison of Value at Risk Approaches on A Stock Portfolio," *Croatian Operational Research Review (CRORR), Vol. 2,* pp. 81-90, 2011.

[13] W. J. Conover, Practical Nonparametric Statistics 3rd edition, New York: John Wiley & Sons, Inc., 1999.

[14] E. T. Kusumawati, Pengukuran Risiko Untuk Aset Tunggal Menggunakan Modified Value at Risk, Sebelas Maret University: Unpublished Thesis, 2012.

[15] D. Maillard, "A User's Guide to the Cornish Fisher Expansion," *HAL Open Science,* 2020.

[16] J. C. Hull, Risk Management and Financial Institution 5th edition, New Jersey: John Wiley & Sons, Inc., 2018.

[17] D. Vaidya, "Wall Street Mojo," 2023. [Online]. Available: https://www.wallstreetmojo.com/monte-carlo-simulation/. [Accessed 15 April 2023].