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Comparison of Value at Risk (VaR) in Risk Analysis: Historical, Variance Covariance and Monte Carlo Methods

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Abstract

Value at Risk (VaR) is a method used to measure financial risk in a company. VaR calculations are often used to calculate the level of loss from shares in a company, such as bank shares. The aim of this research is to determine the level of losses in Bank Central Asia shares using the historical method, the Variance-covariance method, and the Monte Carlo method. the results showed that with an initial investment of $50 and using the Historical method at a significant level of 95%, the VaR value was obtained at $16.42 or IDR. 267.301 and at the 90% significant level, the VaR value was obtained at $12.41 or IDR. 202.022. Based on the Variance-covariance method with an initial investment of 50$ at the 95% significant level, the VaR value is obtained at $16.42 or IDR. 267,301 and at the 90% significant level, the VaR value is obtained at $12.79 or IDR. 208.208. Meanwhile, based on the Monte Carlo method with an initial investment of $50, at a significant level of 95%, the VaR value is obtained at $16.46 or IDR. 267,952 and at the 90% significance level, the VaR value is obtained at $12.84 or IDR. 209.022. Based on the three methods used, it was concluded that the Monte Carlo method gave greater results compared to the other two methods.

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Keywords: Historical, Monte Carlo, Stocks, Value at Risk, Variance-covariance

INTRODUCTION

Investors are people who lend capital to a company. Investors must measure the level of risk before making an investment decision to find out the risk of the investment (Maronrong, Hermastuti, & Muntahak, S. (2022). Some investment risks are market risk, credit risk, operational risk, liquidity risk, country risk, systematic risk, behavioral risk, governance risk and inflation risk (Chong Y, 2004) . Value at Risk (VaR) is one of method used to measure a company's financial risk. Financial risk such as the estimated maximum loss that will be incurred during a certain period of time with a certain level of confidence (Elga, Evy, & Hendra, (2018). This study uses daily stock data from Bank Central Asia Tbk PT ADR (PBCRY) to calculate VaR with three methods: historical, variance-covariance, and Monte Carlo. Stock prices are recorded based on the last trade on the stock exchange day so it is often called the closing price. So the stock price is measured from the official price based on the last closing on the stock exchange day (Triani, 2013).

The historical method uses historical data to estimate the probability of an undesirable event. Because it uses historical data directly, this method is the easiest and easiest to use to determine VaR. This method argues that the distribution of past picks provides a good and comprehensive picture of expected returns in the future (Amin et al., 2018). Variance-covariance method is an approach that calculates VaR by assuming that stock returns follow a normal distribution. This method combines information about the mean return and volatility (standard deviation) of stock returns to estimate potential losses. In the variance-covariance method, the initial assumption used is the percentage change in asset prices that are normally distributed, expressed in the form of standard deviation. The first step taken to calculate VaR with variance-covariance is to calculate the value of the asset or portfolio against market risk (Machfiroh, 2016). Monte Carlo method uses random simulation to estimate the probability of undesirable events such as a significant decline in stock value. Because it can calculate a variety of exposure and risk arrangements, including fixed model risk, volatility, and nonlinear price risk, this method is the most powerful method for measuring VaR. In addition, this method is flexible enough to calculate time

variations in fat tails, volatility, and extreme scenarios. Fat tails is a random variable to have exhibits more extreme outcomes than a normally distributed random variable with the same mean and variance, then volatility is standard deviation of the returns on an asset or investment (Danielsson, 2011). Extreme scenarios used Extreme Value Theory (EVT) takes full advantage of extreme observations.

In addition to producing a single amount, simulation can produce an overall probability density function. This can also be used to calculate expected losses that exceed the VaR value (Maruddani & Purbowati, 2009). The benefits of this study for Bank Central Asia Tbk PT ADR are that the bank can understand the risks it faces and make the right decisions in risk management.

METHODS

The data used in this study is secondary data in the form of daily stock data of Bank Central Asia Tbk PT ADR (PBCRY) from the official website https://id.investing.com/markets for the period from June 6, 2023 to June 4, 2024 with a total of 251 data. The calculation used in this study is VaR. VaR is a risk measurement method that has become a standard for measuring risk by calculating market risk and determining the greatest risk of loss that can occur in a portfolio (Gunay, 2017). VaR calculates the maximum amount of risk that investors can accept and can determine how much loss may occur with a probability of X% in a certain period of time. Three common approaches to assessing VaR as in this study with the historical simulation method, variance-covariance and Monte Carlo methods.

Historical Method

Analysis technique for calculating VAR on a single asset using historical simulation methods.

1. Calculating stock returns

$$R_{t(i)} = \frac{P_t - P_{t-1}}{P_{t-1}} \quad (1)$$

2. Calculating expected returns by averaging daily return values

$$E\left(R_i\right) = \frac{\sum_{t=1}^{n} R_{t(i)}}{n} \quad (2)$$

3. Calculating stock risk using standard deviation

$$\sigma = \sqrt{\frac{1}{n-1}\sum_{t=1}^{n}\left[R_{t(i)} - E\left(R_i\right)\right]^2} \quad (3)$$

4. Sorting return values from the smallest to the largest

5. Determining the percentile value for the basis of VaR calculation

6. Calculating the VaR value of stocks

$$VaR = E\left(R_i\right) - R_\alpha \quad (4)$$

Variance-Covariance Method

Analysis techniques for calculating VAR using the variance-covariance method.

1. Collecting historical data which is used to calculate variance covariance

2. Calculating Z-score

$$D = \sup_x \left|S(x) - F(x)\right| \quad (5)$$

3. Calculating the VaR value of Stocks

$$VaR = P \times Z_\alpha \times \sigma \quad (6)$$

Monte Carlo Method

Analysis techniques for calculating VAR using the monte carlo method.

1. Determining stock weights

2. Calculating research returns. In equation 1

3. Sorting stock return values from the smallest return value to the largest return value

4. Determining the percentile for the basis of VaR calculation

5. Calculating the VaR value of stocks

$$VaR = E\left(R_i\right) - \left(Z_\alpha \times \sigma\right) \quad (7)$$

RESULTS

In this section, return data is continuous time series data so that to find out the daily return results calculated based on the price ratio. Descriptive statistics analysis of PBCRY are presented in Table 1.

Table 1. Descriptive statistics analysis

Mean Return	Minimum Return	Maximum Return	Standar Deviation Return	Data Observation Return
-0,001	-0,450	0,590	0,199	143

Based on Table 1, the return data with the minimum return -0,450 and the maximum return 0,590. While the mean return -0,001 with standard deviation 0,199. Then, the next step is calculate VaR.

VaR with Historical Methods

Table 2. VaR with Historical Method of PBCRY Stock

	PBCRY	PBCRY
$\boldsymbol{\mu(R)}$	-0,001	-0,001
Standar Deviation Return	0,199	0,199
Percentile	5%	10%
$\boldsymbol{R_\alpha}$	-0,300	-0,248
Significant Level	95%	90%
P (Initial funds)	$50	$50
VaR value (USD)	%15,00	%12,41
VaR value (IDR)	IDR 244.185	IDR 202.022

Based on table 2, VaR value of PBCRY assets IDR 244.185, that means 95% certainty that the loss experienced by investors will not exceed IDR 244.185 within one day after the historical data period or it can be said there is a 5% possibility that the investment loss in PBCRY shares will be IDR 244.185 or more. At 90% certainty, VaR value of PBCRY assets is IDR 202.022, that means the loss experienced by investors will not exceed IDR

202.022 within one day after the historical data period or it can be said there is a 10% possibility that the investment loss in PBCRY shares will be IDR 202.022 or more.

VaR with Variance-Covariance Method

The first step in this section is perform a normality test on the return data. This step have to done for the ensure whether the return data is normally distributed. The normality test used is the Kolomogorov Smirnov test, based on the result obtained a p-value 0.069 with a significance level of 95%, so that it can be concluded that the return data is normally distributed. After the return data is normally distributed, the VaR value is calculated using the variance-covariance method are presented in Table 4.

Table 3. VaR with Variance-Covariance Method of PBCRY Stock

	PBCRY	**PBCRY**
Standar Deviation Return	0,199	0,199
Significant Level	95%	90%
Z_α	-1,644	-1,281
Initial funds	$50	$50
VaR value (USD)	$16,42	$12,79
VaR value (IDR)	IDR 267.301	IDR 208.208

Based on table 3, VaR of PBCRY assets IDR 267.301, that means 95% certainty the loss that investors will experience will not exceed IDR 267.301, at 90% certainty the VaR of PBCRY assets IDR 208.208, that means the loss that investors will experience will not exceed IDR 208.208.

VaR with Monte Carlo Method

Table 4. VaR with Monte Carlo Method of PBCRY Stock

	PBCRY	**PBCRY**
Mean Return	-0,001	-0,001
Standar Deviation Return	0,199	0,199
Significant Level	95%	90%
Z_α	1,644	1,281
Initial funds	$50	$50
VaR value (USD)	$16,46	$12,84
VaR value (IDR)	IDR 267.952	IDR 209.022

Based on table 4, VaR of PBCRY assets IDR 267.952, that means 95% certainty the loss that investors will experience will not exceed IDR 267.952, at 90% certainty the VaR of PBCRY assets IDR 209.022, that means the loss that investors will experience will not exceed IDR 209.022.

After VaR calculation results are obtained using the historical, variance-covariance and Monte Carlo methods, the next step is compare VaR results from the three methods are presented in Table 5.

Table 5. The result of VaR

		PBCRY	**PBCRY**
	Initial funds	$50	$50
Historical Methods	**VaR value (USD)**	$15,00	$12,41
	VaR value (IDR)	IDR 244.185	IDR 202.022
Variance-Covariance Method	**VaR value (USD)**	$16,42	$12,79
	VaR value (IDR)	IDR 267.301	IDR 208.208
Monte Carlo Method	**VaR value (USD)**	$16,46	$12,84
	VaR value (IDR)	IDR 267.952	IDR 209.022

Based on Table 5, the results of VaR calculations using the historical, variance-covariance and Monte Carlo methods can be concluded, the one with the highest risk value is the Monte Carlo method.

DISCUSSION

Based on the result VaR using the historical method with data totaling 144 days (June 6 - December 29, 2023) show that at 95% significant level the VaR value for PBCRY $15 or IDR 244.185. This indicates that if investors invest their funds of $50 with a 95% significant level, the investment loss in PBCRY shares will not exceed IDR 244.185. While at 90% significant the VaR value for PBCRY $12.41 or IDR 202.022. This indicates that if investors invest their funds of $50 with a 90% significant level, the investment loss in PBCRY will not exceed IDR 202.022. The results of the VaR calculation using the variance-covariance method with data totaling 144 days (June 6 - December 29, 2023) show that at 95% significant level the VaR value for PBCRY $16.42 or IDR 267.301. This indicates that if investors invest their funds of $50 with a 95% significant level, the investment loss in PBCRY shares will not exceed IDR 267.301. While at 90% confidence

the VaR value for PBCRY $12.79 or IDR.208.208. This indicates that if investors invest their funds of $50 with a 90% significant level, the investment loss in PBCRY shares will not exceed IDR 208.208. The results of the VaR calculation using the Monte Carlo method with data totaling 144 days (June 6 - December 29, 2023) show that at 95% significant level the VaR value for PBCRY $16.46 or IDR 267.952. This indicates that if investors invest their funds of $50 with a 95% significant level, the investment loss in PBCRY shares will not exceed IDR 267.952. While at 90% significant level the VaR value for PBCRY shares is $12.84 or IDR 209.022. This indicates that if investors invest their funds of $50 with a 90% significant level, the investment loss in PBCRY shares will not exceed IDR 209.022.

CONCLUSION

The conclusion from this study is in the VaR calculation using historical, variance-covariance and Monte Carlo methods concluded that the Monte Carlo method gives greater results compared to the other two methods. That things because the Monte Carlo method has a repetition by generating random numbers, so the value obtained in the calculation is greater.

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