



# Implementing the Variance-Covariance Method for Assessing Market Transaction Risks in Raw Material Sector Stocks

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## Abstract

The capital market plays a crucial role in supporting a country's economic growth. Besides being a funding source, the capital market also serves as an investment avenue for investors, particularly through stocks. Every investor must be willing to bear risks in line with their targeted returns. Risk is defined as the uncertainty of future outcomes due to market condition changes, and VaR (Value at Risk) is used to determine the tolerated loss at a certain confidence level. This study discusses the application of the Value at Risk (VaR) method using the Variance-Covariance approach to mitigate market risks in the portfolio of raw material sector stocks. The study focuses on two raw material sector stocks in Indonesia, assuming a normal distribution of asset price changes. The measurement results indicate that with an investment of IDR. 100,000,000.00, a 95% confidence level, and a 1-day period, the VaR of the portfolio of these five stocks is IDR. 2,769,750.00. This research provides critical insights to assist investors in understanding and managing portfolio risks, making VaR a key indicator to measure potential future risks and laying the foundation for decision-making in risk management.

*Keywords:* Market Risk, Value at Risk (VaR), Variance-Covariance.

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## 1. Introduction

Capital markets have a crucial role in supporting a country's economic growth by providing a platform for various long-term financial instruments traded. The goal is to become an alternative source of funding for companies that need capital for business development through the issuance of securities instruments (Bollerslev, 1988). Apart from being a source of funding, the capital market is also an investment place for investors, especially through securities instruments such as stocks.

Investors in the capital market have the option to adopt active or passive strategies. Active strategies involve active actions in the selection and trading of stocks, while passive strategies involve the more passive actions of investors, following the movements of market indices without seeking information or trading stocks that can generate abnormal returns. Nevertheless, every investor must still be willing to bear the risk under the target return.

Risk in the capital market is defined as uncertainty in future results due to changes in market conditions, especially stock price risk influenced by the global investment climate. Risks faced by financial institutions include market risk, credit risk, and operational risk, with investments in the stock exchange included in the market risk category. Therefore, decision-makers are often interested in knowing how much risk they might bear if market conditions worsen.

Risk management, as a concept that applies the precautionary principle, has an important role in investment activities. The aim is to reduce risk at a low level so that investment activities can provide maximum benefits without harming other parties, following the fatwa of the National Sharia Council which emphasizes risk control for the common good. Risk management aims to ensure business continuity, profitability, and growth with a focus on risk identification and handling. Although in Indonesia risk management in companies can still be improved, especially considering the fluctuating level of stock prices.

The application of standard-compliant risk management, especially through a statistical approach using the Value At Risk (VaR) method, is important to minimize market risk. VaR, which can be applied to a wide range of financial

products, provides an estimate of the probability of losses exceeding predetermined limits. The implementation of VaR is growing rapidly, driven by government regulations such as Bank Indonesia No.5/8/PBI/2003, emphasizing the importance of effective risk management in dealing with financial market dynamics (Buchdadi, 2010).

The advantage of VaR lies in its ability to thoroughly measure risk and provide a significant estimate of the probability of loss (Di Oppong, 2016). The Varian-Covariance method, which is widely used to measure VaR, allows flexible calculations for time variations in volatility. This method also assumes a normal distribution, using expected returns, variance, and covariance to form a portfolio (Sitorus, S. 2018).

(Syariah and Noviana Pratiwi, 2020) who analyzed the comparison of VaR calculations, variance-covariance methods and monte carlo simulation methods, which then both models will be validated backtesting tests with POF-test kupiec on individual and portfolio validity. Based on both the covariance variant method and the monte carlo simulation method, it is obtained that by doing a portfolio, investors can minimize the risk or the risk obtained is smaller than not doing a portfolio. Then in the research (Maria Yus Trinity Irsan, Evelyn Priscilla and Siswanto, 2022) analyze appears to be focused on risk measurement and management in the banking sector, specifically related to the calculation of Value at Risk (VaR) for banking stock portfolios. The research aims to provide insights into risk assessment and management practices in banking stock portfolios, with potential implications for portfolio adjustments and further exploration of VaR calculation methods. This research used the daily stock closing prices for 256 days on PT. Bank Negara Indonesia Tbk (BBNI), PT. Bank Rakyat Indonesia Tbk (BBRI), and PT. Bank Central Asia Tbk (BBCA) concluded obtained that the Variance Covariance method is the best method for the 99% confidence level.

Based on previous research, VaR and variance-covariance methods can be applied to minimize investment risk. This research will apply this method to minimize the risk of investment in raw material sector companies, considering that the raw material sector is the sector that has the second highest stock sales volume in Indonesia.

## 2. Materials and Methods

### 2.1. Materials

The data used consists of secondary data in the form of daily stock opening prices from two raw material sector companies listed on the Indonesia Stock Exchange (IDX), namely PT. Vale Indonesia Tbk. (INCO) and PT. Surya Esa Perkasa Tbk. (ESSA). The data was obtained from [www.yahooofinance.com](http://www.yahooofinance.com) from January 2, 2023, to November 29, 2023. The measured variable is the return value, defined as the profit gained by companies, individuals, and institutions from investment policy over the past nine months in both companies. The acquired data is presented in Table 1.

**Table 1:** Daily Opening Stock Price Data for INCO and ESSA from January 2 to November 29, 2023

DATE	INCO	ESSA
1/2/2023	7125	915
1/3/2023	7050	920
1/4/2023	7200	925
⋮	⋮	⋮
11/27/2023	4590	570
11/28/2023	4520	575
11/29/2023	4450	595

### 2.2. Methods

#### 2.2.1. Return Value of Stocks

Return is the profit obtained from the results of investment policies carried out (Adiatmayani, 2021). To calculate the return on a stock can be obtained through the equation (Astuti, 2021):

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$$r_t = \frac{p_{t+1} - p_t}{p_t} \quad (1)$$

where:

$p_t$  = Stock price today

$p_{t+1}$  = Tomorrow's stock price  
 $r_t$  = Return

### 2.2.2. Normality Test

The data normality test aims to test whether the regression model in the study, between the dependent variable and the independent variable both have a normal distribution or not. One method for testing the normality of data distribution is the Kolmogorov-Smirnov test. The concept of the Kolmogorov-Smirnov normality test is to compare the distribution of data with the standard normal distribution (Mahaputra, 2023).

If  $p - value > \alpha$  then  $H_0$  accepted or rejected  $H_1$

If  $p - value < \alpha$  then  $H_0$  rejected or accepted  $H_1$

The hypotheses tested are:

$H_0$  = Data follows a normal distribution

$H_1$  = Data does not follow a normal distribution

### 2.2.3. Value at Risk (VaR)

VaR is a tolerable loss with a certain level of confidence (security) (Bee, 2010). A popular measure of risk is volatility, but the main problem with volatility is that instead of taking into account the direction in which an investment moves, a stock may be highly volatile because its price fluctuates suddenly. For an investor, risk is the odds of losing money and Value at Risk is based on this. By assuming that investors are very concerned about large losses, then by using VaR, investors can determine their investment policies, both passive (VaR as a routine report), definition (VaR is used for risk control tools) and active approach, where VaR reports can be used to control risk and profit maximization such as capital allocation, investment funds, and so on (Mahmud M Hanafi)

The calculation of VaR for assets uses the formula as follows

$$VaR = z_{\alpha} \sigma_p W \quad (2)$$

where:

$z_{\alpha}$  = value of z with confidence level  $\alpha$

$\sigma_p$  = portfolio standard deviation

$W$  = asset proporsion value

VaR *calculation techniques* can use variance-covariance methods, historical methods, and Monte Carlo simulations. The variant-covariance method uses a specific model, namely a matrix, to estimate VaR. The historical method uses historical data (past data) to calculate VaR. Monte Carlo VaR uses simulation for its VaR calculations.

### 2.2.4. Variance-Covariance Method

The Variance-Covariance method starts from the assumption that the percentage change in asset price has a normal distribution so that changes in asset prices can be expressed in the form of standard deviations. Completion in the Variance-Covariance method is in the form of a matrix in which it contains elements such as return, variance, covariance, and mean. Variance-covariance matrix expressed in

$$\Sigma = \begin{bmatrix} \sigma_1^2 & \sigma_{12} & \dots & \sigma_{1p} \\ \sigma_{21} & \sigma_2^2 & \dots & \sigma_{2p} \\ \vdots & \vdots & \ddots & \vdots \\ \sigma_{p1} & \sigma_{p2} & \dots & \sigma_p^2 \end{bmatrix} \quad (3)$$

where  $\sigma_{ij}$  are  $cov(i, j)$ .

The variance of the variable X is defined as

$$\begin{aligned} var(X) &= E(X - \mu)^2 = E(X^2) - \mu E(X) - \mu E(X) + \mu^2 \\ &= E(X^2) - 2\mu E(X) + \mu^2, \mu = E(X) \\ &= E(X^2) - 2(E(X))(E(X)) + (E(X))^2 \\ &= E(X^2) - 2(E(X))^2 + (E(X))^2 \\ &= E(X^2) - (E(X))^2 \end{aligned}$$

while the covariance of the X and Y variable pairs is defined as follows:

$$cov(X, Y) = E[(X - \mu_X)(Y - \mu_Y)].$$

The expected value of a random variable can be determined using the probability mass function (fmp) for the faric variable or the probability density function (fkp) for the variable malar. In addition, the expectation value can also be determined using the moment generator function which is usually abbreviated to fmp. Some synonymous words of expectation value, including mathematical expectation (mathematical expectation) or the most popular average (mean), MMNV so that it is usually written with the symbol  $\mu$  (read; mu).

#### Definition 2.1

If the random variable  $X$  is faric and is the value of its probability mass function in, the expected value of the random variable  $X$  is

$$p(x)x \mu = E(X) = \sum_x xp(x).$$

If the random variable  $X$  is lazy and is the value of its probability mass function in, the expected value of the random variable  $X$  is

$$f(x)x \mu = E(X) = \int_{-\infty}^{\infty} xf(x)dx \text{ (Ferreira, 2013).}$$

#### 2.2.5 Weight (Portfolio Proportion)

The weighting vector is used so that the portfolio has a minimum variance, meaning that the expected return value of the constituent assets does not differ much from each other among the entire portfolio that can be formed. When the portfolio with minimum variance, with the return following the normal distribution with the mean  $\mu$  and  $\Sigma$  variance can be written  $X \sim N(\mu, \Sigma)$ , the weighting on the portfolio is

$$w = \frac{\Sigma^{-1}1_N}{1_N^T \Sigma^{-1}1_N} \quad (4)$$

by declaring the inverse of the covariance matrix  $N \times N$  and  $1_N$  expressing a vector with as many elements 1 as  $N$  (Aniūnas, 2009).

#### 2.2.6 Standard Deviation and Value at Risk of the Portfolio

The standard deviation value of the portfolio is calculated based on the weight of a single asset and the covariance matrix. In the matrix form, variance of portfolio defined as

$$\sigma_p^2 = [w_1 \quad w_2 \quad \dots \quad w_N] \begin{bmatrix} \sigma_{11} & \sigma_{12} & \dots & \sigma_{1N} \\ \sigma_{21} & \sigma_{22} & \dots & \vdots \\ \vdots & \vdots & \ddots & \vdots \\ \sigma_{N1} & \sigma_{N2} & \dots & \sigma_{NN} \end{bmatrix} \begin{bmatrix} w_1 \\ w_2 \\ \vdots \\ w_N \end{bmatrix} = w_t \Sigma w \quad (5)$$

where  $w_i$  = weight of stock  $i$ .

the Portfolio VaR Value defined as a measure of risk that may be obtained by investors with following equation

$$VaR = z_{0,95} \sigma_p W \quad (6)$$

### 3. Results and Discussion

First, the calculation of daily stock returns for both stocks will be performed using the equation (1). The calculation results are presented in Table 2.

**Table 2:** Results of Stock Return Calculation

DATE	INCO		ESSA	
	OPEN	RETURN	OPEN	RETURN
1/2/2023	7125		915	
1/3/2023	7050	-0.01064	920	0.005435
1/4/2023	7200	0.020833	925	0.005405
⋮	⋮	⋮	⋮	⋮
11/27/2023	4590	-0.00218	570	0
11/28/2023	4520	-0.01549	575	0.008696
11/29/2023	4450	-0.01573	595	0.033613

Before calculating VaR (value at risk), it is assumed that stock returns follow a normal distribution. As a preparatory step, a test for the normality assumption of data on INCO and ESSA stocks separately is conducted. This

test utilizes the Kolmogorov-Smirnov test to determine whether the returns on these five stocks follow a normal distribution. The results of the normality test using the Kolmogorov-Smirnov test are presented in Table 3.

**Table 3:** Results of the Normality Test Using Kolmogorov-Smirnov

	INCO	ESSA
Number of Data Returns	218	218
Mean	-0.002318	-0.002676
Standard Deviation	0.0177816	0.0375585
Asymp.Sig.(2-tailed)	0.088	0.51

The test employs the hypotheses:

$H_0$  : stock return data follows a normal distribution.

$H_1$  : Stock return data does not follow a normal distribution.

The significance level used in this study is  $\alpha = 5\%$ , and the test statistic  $p - value$  obtained from the Kolmogorov-Smirnov normality test. For the INCO stock code, the  $p - value$  is 0.088, hence  $p - value > \alpha$ , indicating acceptance of  $H_0$ . Therefore, it can be concluded that the return data for INCO stock follows a normal distribution. Similarly, for the ESSA stock code, the  $p - value$  is 0.51, again showing  $p - value > \alpha$ , and thus  $H_0$  is accepted. Consequently, it can be inferred that the return data for ESSA stock follows a normal distribution.

Then, we will calculate the Value at Risk (VaR) for a single asset for the next day with a 95% confidence level. VaR can be computed using the equation (2) with the standard deviation values provided in Table 3. For INCO stock:

$$VaR = z_{\alpha}\sigma_p W\sqrt{t} = (1.65)(0.0178)(100,000,000)(\sqrt{1}) = 2,937,000$$

while for ESSA stock:

$$VaR = z_{\alpha}\sigma_p W\sqrt{t} = (1.65)(0.0376)(100,000,000)\sqrt{1} = 6,055,500.$$

From the obtained values, covariance matrices are created following equation (3). The covariance matrices obtained are as follows:

$$\Sigma = \begin{bmatrix} 0.000315 & 0.000111 \\ 0.000111 & 0.001404 \end{bmatrix}.$$

The inverse of the covariance matrix is

$$\Sigma^{-1} = \begin{bmatrix} 3265.181 & -257.046 \\ -257.046 & 729.455 \end{bmatrix}.$$

The asset weights for each stock are found using the equation (4), resulting

$$w = \begin{bmatrix} 0.863 \\ 0.136 \end{bmatrix}.$$

From these values, the weight for INCO stock is obtained as 0.864 or 86.4%, and the weight for ESSA stock is 0.136 or 13.6%.

By utilizing equation (5), the calculation of the portfolio's standard deviation is performed based on the weights of individual assets and the covariance matrix as follows:

$$\sigma_p^2 = [0.864 \quad 0.136] \begin{bmatrix} 0.000315 & 0.000111 \\ 0.000111 & 0.001404 \end{bmatrix} \begin{bmatrix} 0.864 \\ 0.136 \end{bmatrix} = 0.00028.$$

Thus, the portfolio's standard deviation value is obtained as  $\sqrt{0.000287} = 0.016950$ .

Next, assuming an investment of IDR 100,000,000, the calculation of the portfolio's VaR value is computed using equation (6) as follows:

$$VaR = z_{\alpha}\sigma_p P = (1.65)(0.0178)(100,000,000) = 2,796,750.$$

This indicates that at a 95% confidence level or a significance level of 5%, the potential risk faced by an investor when investing IDR 100,000,000 in the specified portfolio is IDR 2,796,750.

#### 4. Conclusion

Based on the research, the variance-covariance method can be applied to calculate the portfolio risk of investing in PT. Vale Indonesia Tbk. (INCO) and PT. Surya Esa Perkasa Tbk. (ESSA) stocks. The resulting portfolio involves investing 86.4% in INCO stocks and 13.6% in ESSA stocks. If using a significance level of 5% and considering an investment amount of IDR100,000,00, the potential risk that an investor might face with this portfolio is IDR2,796,750.

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