# Valuation of Adaro Energy Ltd (ADRO.JK) Stock Price as Blue-Chip Stock in 2021

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## Abstract

Investing on stock asset is one form of financial sector investment that is in great demand by investors. The profit of stock investment can be seen from the return value. The stock price is the main factor that affects the stock return. However, stock prices in the future are often difficult to predict. Geometric Brownian Motion (GBM) is a method that can be used to predict stock prices if the historical stock return are normally distributed. If in the historical stock return that were normally distributed there was a jump, then the Jump Diffusion method was used. After obtaining the predicted stock price, the investment risk can be measured. The results of the prediction for ADRO.JK stock prices at the period 04/01/21 to 31/12/21 using the Jump Diffusion method, obtained a MAPE value of 2.48%. To measure the risk investment of predictive stock prices obtained from the Jump Diffusion model, the VaR-Monte Carlo simulation is used with a 95% confidence level. Within 1 day after 24/12/21, the loss received does not exceed 4.2311%. Based on the backtesting test at 5% probability of violation, the VaR value was accurate, because no violations were found.
*Keywords: Geometric Brownian Motion, Jump Diffusion Model, Value at Risk, Backtesting*

## 1. Introduction

The financial sector is one of the sectors that people are most interested in investing in. In general, investment is divided into two groups, namely real sector investment (real asset investment) and financial sector investment (financial asset investment). Real investment is investment in durable goods, such as buildings, housing and so on. While financial investment is a form of investment in securities. One form of investment in the financial sector which is currently growing rapidly is investment in the capital market. One of its biggest attractions is the potential for huge profits in a short period of time. The most traded investment product in the capital market is stocks.

The profit obtained from stock investment can be seen from the return value, where the return value is influenced by changes in stock prices. Because stock price movements basically cannot be predicted with certainty, a mathematical model of the stock price movement is needed. Basically, even though investment activities have the potential to provide large profits, they are followed by returns with great risks. The risk in this case is the potential loss that arises because the investment returns are not as expected. One method that can be used to measure the magnitude of investment risk is Value at Risk (VaR). VaR can help estimate the maximum loss that will be received in a period at a certain level of confidence.

One of the methods used to predict future stock prices based on past stock prices is the Geometric Brownian Motion (GBM) model. The GBM model assumes that stock returns in the past are normally distributed. If in the past stock returns there was a jump, the Geometric Brownian Motion With Jump model or Jump Diffusion Model is used. The stock price prediction will then be used to estimate the value of VaR. In this study, the VaR calculation method used is the Monte Carlo simulation method. Furthermore, to test the accuracy of the VaR value, a backtesting test was carried out by calculating the violation ratio value.

Several studies on stock price modeling have been carried out. Abidin and Jaffar (2014) researched stock price modeling with Geometric Brownian Motion in several companies in Bursa Malaysia. Trimono, Maruddani, and Ispriyanti (2017) researched the valuation of PT Ciputra Tbk's stock price with Geometric Brownian Motion. Research on Geometric Brownian Motion with Jump has been carried out by Maruddani and Trimono (2017) in the case of PT Astra Argo Lestari Tbk stock data in 2017.

PT Adaro Energy Tbk (ADRO.JK) is a company in Indonesia that is engaged in the mining sector. At the end of 2021, ADRO.JK's shares became one of the companies that won the "Blue Chip 2021" predicate with a percentage change in price of 24.22%. The opening price on January 4, 2021 is Rp. 1455,- and on December 14, 2021 it rose to IDR 1,920 (Indonesian Stock Exchange, 2021). This achievement is influenced by the large number of investors and the growth of shares which are considered to be one of the best of all issuers listed on the IDX. The "Blue Chip" stock predicate is given to issuers whose shares have been the most sought after by investors, show very active transactions, have significant share price growth, and have sound fundamentals.
This study discusses the stock valuation of PT Adaro Energy Tbk, starting with stock price predictions, calculating the predicted stock price VaR value, and evaluating the VaR value using backtesting. The sample that will be used is the closing price of the stock from 04/01/21 – 31/12/21.

### 1.1 Objectives

There are two objectives of this research. The first is to calculate the stock price of ADRK.JK by using Geometric Brownian Motion (GBM) and Jump Diffusion model as an alternative if there is jump in the historical stock return. The second objective is to measure loss risk investment thorugh the VaR method with the Monte Carlo Simulation approach.

## 2. Literature Review

### *2.1. Stock Return*

*Return* is the rate of return on the results obtained as a result of investing. The method of calculating returns that is often used in securities analysis is geometric returns, with the following formulation:

$$R(t_i) = \ln\left(\frac{S(t_i)}{S(t_{i-1})}\right) \tag{1}$$

where $R(t_i)$ is the stock return value for period $t_i$, $S(t_i)$ is the stock price for period $t_i$, and $S(t_{i-1})$ represents the stock price for period $t_{i-1}$.

### *2.2. Volatility*

According to Hull (2009), stock price volatility can be defined as the standard deviation value of stock returns. If there are *n* returns, then the expected return value can be determined as follows:

$$\bar{R} = \frac{1}{n}\sum_{i=1}^{n} R(t_i) \tag{2}$$

$$s^2 = \frac{1}{n-1}\sum_{i=1}^{n}(R(t_i) - \bar{R})^2 \tag{3}$$

Based on equation (3), the root value of $s^2$ (variansi) is an estimate of stock price volatility.

### *2.3. Skewness*

*Skewness* is the degree of asymmetry of a distribution. If the frequency curve of a distribution has a tail that extends more to the right (judging by the mean) then it is said to be right skewed (positive) and otherwise it is left skewed (negative). By calculation, skewness is the third moment about the mean. Symmetrical distributions (normal distribution, t distribution, Cauchy distribution, etc.) have a skewness of 0 (zero). The calculation of skewness is as follows (Surya dan Situngkir, 2006):

$$\gamma_1 = \frac{1}{N}\frac{\sum_{i=1}^{N}(x_i-\mu)^3}{\sigma^3} \tag{4}$$

### *2.4. Kurtosis*

Kurtosis is the degree of sharpness of a distribution (usually measured relative to the normal distribution). Curves that are more tapered than the normal distribution are called leptokurtic, those that are flatter are platykurtic and the normal distribution are called mesokurtic. Kurtosis is calculated from the fourth moment to the mean. The normal or mesokurtic distribution has a kurtosis = 3, a leptokurtic distribution usually has a kurtosis > 3, and a platykurtic distribution < 3. Measurement of kurtosis can be measured by the formula (Surya dan Situngkir, 2006):

$$\gamma_2 = \frac{1}{N}\frac{\sum_{i=1}^{N}(x_i-\mu)^4}{\sigma^4} \tag{5}$$

where, is the population mean, whose value can be used with the sample mean x (for large samples). The distribution of excess *kurtosis* (*leptokurtic*) is characterized by a narrow maximum value but very large value, and the tail of the distribution that is fatter than the tail of the Normal distribution and the excess kurtosis can be expressed as:

$$\gamma_2' = \gamma_2 - 3 \quad (6)$$

*2.5. Peak Over Treshold (POT)*

*Peak Over Threshold* is one of the methods in the Extreme Value Theory. In a symmetrical distribution, especially a normal distribution, we will have

*Expected Loss* : $\int_0^{\mu} f(x)dx$ (7)

*Unexpected Loss* : $\int_{\mu}^{x_\alpha} f(x)dx$ (8)

*Worse Case* : $\int_{x_\alpha}^{\infty} f(x)dx$ (9)

So for a symmetrical distribution, in this case a normal distribution, the Worse Case (WC) value is obtained as follow:

$$\text{WC} = 100\% \times (1 - \alpha) \quad (10)$$

*2.6. Stochastic Differential Equation*

The stochastic differential equation for the GBM model is written as follows :

$$dX(t) = f(X(t))\,dt + g(X(t))\,dW(t) \quad (11)$$

Then for the GBM with Jump model the stochastic differential equation is written as follows:

$$dX(t) = f(X(t))\,dt + g(X(t))\,dW(t) + X(t)\,dJ_t \quad (12)$$

where $f(X(t))dt$ is the drift term, $g(X(t))dt$ is the diffusion term, $W(t)$ is Brownian motion, and $J_t$ is the Jump process. (Brigo *et al,* 2008)

*2.7. Geometric Brownian Motion Stock Price Model*

According to Brigo et al 2008, the initial equation for the GBM stock price model is given through the equation below:

$$dS(t) = \mu\, S(t)\, dt + \sigma\, S(t)\, dW(t) \quad (13)$$

if there is a function $G = G(S,t)$, then based on the Ito theorem, the function can be stated as follows:

$$\text{dG} = \left(\frac{\partial G}{\partial S(t)}\mu S(t) + \frac{\partial G}{\partial t} + \frac{1}{2}\frac{\partial^2 G}{\partial S(t)^2}\,\sigma^2 S(t)^2\right)dt + \frac{\partial G}{\partial S(t)}\sigma S(t) dW(t) \quad (14)$$

Let's say the function G = ln S(t), where $\frac{\partial G}{\partial S(t)} = \frac{1}{S(t)}, \frac{\partial^2 G}{\partial S(t)^2} = \frac{1}{S(t)^2}$, and $\frac{\partial G}{\partial t} = 0$, then suppose that the change in stock prices for the current period with the previous period is one day, then the final model for GBM stock prices is (Trimono, Maruddani, dan Ispriyanti, 2017):

$$\hat{S}(t_i) = \hat{S}(t_{i-1}) \exp\left(\left(\hat{\mu} - \frac{\hat{\sigma}^2}{2}\right)(t_i - t_{i-1}) + \hat{\sigma}\sqrt{t_i - t_{i-1}}Z_{i-1}\right) \quad (15)$$

*2.8. Stock Price Model with Jump Diffusion Model*

Based on Matsuda (2004), the stochastic differential equation with jump is:

$$dS(t) = \mu S(t)dt + \sigma S(t)dW(t) + S(t)\, dJ_t \quad (16)$$

*W(t)* is the Brown Standard motion. J(t) is a standard *jump* process which is defined as:

$$J(t) = \sum_{j=1}^{N_T}(Y_j - 1) \quad (17)$$

$$d\,J(t) = \left(Y_{N(t)} - 1\right)dN(t) \quad (18)$$

N(t) is a Poisson process with intensity λ with *W(t)*, *N(t)*, and *Y(t)* independent of each other. *W(t)* is Brownian motion and the values of $\mu$ and $\sigma$ are parameters of *X* and *t*. According to Cont and Tankov (2004) Ito's theorem for the *jump diffusion model*, if there is a function $G = G(X,t)$, then the G function will follow the following equation:

$$dG = \left(\frac{\partial G}{\partial S(t)}\mu S(t) + \frac{\partial G}{\partial t} + \frac{1}{2}\frac{\partial^2 G}{\partial S(t)^2}\,\sigma^2 S(t)^2\right)dt + \frac{\partial G}{\partial S(t)}\sigma S(t) dW(t) + \left(G\left(S(t + \Delta S_t) - G\left(S(t)\right)\right)\right) \quad (19)$$

Let's say the function G = ln S(t), where $\frac{\partial G}{\partial S(t)} = \frac{1}{S(t)}, \frac{\partial^2 G}{\partial S(t)^2} = \frac{1}{S(t)^2}$, and $\frac{\partial G}{\partial t} = 0$, and the change in stock price of the current period with the previous period is one day with $p_0 < p_1 < p_2 < ... < p_n$, then the final model of stock price with *Jump The Diffusion Model* is (Maruddani dan Trimono, 2017):

$$\hat{S}(t_i) = \hat{S}(t_{i-1}) \exp\left(\left(\hat{\mu} - \frac{\widehat{\sigma^2}}{2}\right)(t_i - t_{i-1}) + \hat{\sigma}\sqrt{t_i - t_{i-1}} Z_{i-1}\right) \prod_{j=1}^{n_j} Y_j \tag{20}$$

*2.9. Mean Absolute Percentage Error* (MAPE)

According to Shcherbakov (2016), MAPE is a method to evaluate the forecast value by considering the effect of the actual value. The MAPE value is determined by the following equation:

$$\text{MAPE} = \frac{1}{n}\sum_{t=1}^{n}|e_t| \times 100\% \tag{21}$$

where

$$|e_t| = \left|\frac{A_t - P_t}{A_t}\right| \tag{22}$$

$A_t$ is the actual value of period *t*. *Pt* is the predicted value at time *t*, and *n* represents the number of observation data.

**Table 1**. MAPE Accuracy Rating Scale

| MAPE Value | Prediction Accuracy |
|---|---|
| < 10% | Very good prediction accuracy |
| 11% - 20% | Good prediction accuracy |
| 21% - 50% | Prediction accuracy is still within reasonable limits |
| >51% | Inaccurate prediction accuracy |

*Source : Shcherbakov, 2016*

*2.10. Value at Risk (VaR) Monte Carlo Simulation*

Danielsson (2011) defines Value at Risk (VaR) as the estimated value of losses in portfolio trading, with the probability that the actual loss value is greater than or equal to VaR is p, and the probability that the actual loss value is lower than the VaR value is (1-*p* ). According to Maruddani and Purbowati (2009), one of the VaR calculation methods is the Monte Carlo simulation method. The Monte Carlo Simulation method assumes that asset returns are normally distributed. The procedure for calculating the VaR of a single asset Monte Carlo simulation is as follows:

1. Determine the parameter value of the return, which includes the mean (μ) and standard deviation (σ).
2. Simulate the return value by generating randomly, with the parameters obtained from step (1) as many as n pieces so that an empirical distribution of the simulated returns is formed.
3. Finding the maximum loss estimate at the confidence level $(1 - \alpha)$ as the value of the $\alpha$ quantile of the empirical distribution of *returns* obtained in step (2), denoted by $R^*$.
4. Calculating the VaR value at the confidence level in a time period of r days, namely:
   $$\text{VaR}_{1-\alpha}(r) = W_0\, R^* \sqrt{r} \tag{23}$$
   where $W_0$ is the initial investment fund of the asset or portfolio, $R^*$ is the value of the α quantile of the return distribution, *r* is the time period. The VaR value obtained is the maximum loss that will be suffered by a single asset.
5. Repeat step (2) to step (4) for m so that it reflects the various possible VaR values of a single asset i.e $VaR_1$, $VaR_2$,..., $VaR_m$.
6. Calculate the average of the results from step (5) to stabilize the value because the VaR values generated by each simulation are different.

*2.11. Backtesting*

*Backtesting* is a VaR accuracy testing procedure that has been calculated. The first step of *bactesting* is to divide the sample by the size *M* menjadi dua bagian, namely the estimation window ($M_E$) and the test window ($M_U$). The estimation window is a group of observations used for calculating the VaR value, the test window is a sample of the period ($M_{E+1}$) up to the period M used to validate the VaR value (Danielsson, 2011)

*Violation Ratio*

According to Danielsson (2011), if the actual return in a certain period is lower than the VaR value in the same period, then a violation is said to have occurred. In the period $\left(M_{E+1}\right)$ up to period *M* (test window length), violation is symbolized by $\eta_m$, which is worth 1 if there is a violation and is worth 0 if there is no violation in the period *m*.

$$\eta_m = \begin{cases} 1 & \text{if } R_m \le -\mathrm{VaR_m} \\ 0 & \text{if } R_m > -\mathrm{VaR_m} \end{cases} \quad (24)$$

Furthermore, the violation ratio equation (VR) is given as follows:

$$VR = \frac{v_1}{p_0 \times M_U} \quad (25)$$

$VR$ is the magnitude of the offense ratio, $v_1$ is the number$\eta_m$ which has a value of 1 (number of days the violation occurred), $p_0$ is the probability of the alleged violation.

## 3. Methods (12 font)

The stages of analysis for predicting stock prices and calculating ADRO.JK VaR are as follows:

1. Collecting data on ADRO.JK saham stock prices.
2. Determine the data in sample and out sample.
3. Calculating the value of stock returns using the geometric return data in sample method.
4. Test the normality of the data in the stock return sample.
5. Peak Over Threshold data in stock return samples.
6. Estimating the parameters of the GBM stock price model and Jump Diffusion.
7. Modeling and predicting stock prices.
8. Calculating stock price prediction errors using the MAPE method.
9. Test the normality of predictive stock return data.
10. Calculate the VaR value of the predicted stock price.
11. Perform backtesting test of VaR value.

## 4. Data Collection (12 font)

The data used is the data of Adaro Energy Ltd stock price for the period 04/01/21 to 31/12/ taken from the website http://finance.yahoo. com/quote/ADRO.JK.

## 5. Results and Discussion (12 font)

*5.1. Determination of Data In Sample and Data Out Sample*

The closing stock price data used as data in the sample is 205 data (04/01/2021 to 02/11/2021), for out sample data is determined as much as 42 data (periode 03/11/2021 to 31/12/2021).

*5.2. Normality Test of Data In Sample Stock Return*

The normality test was carried out using the Kolmogorv-Smirnov test, obtained a D value of 0.160 and a significance value of 0.071. Because the significance value is greater than the error limit (0.05), the data in the stock return sample is normally distributed.

*5.3. Peak Over Treshold data in sample Stock Return*

*Peak Over Treshold* is used to see the jump that occurs in the data in the sample return of ADRO.JK shares. Indications of a jump can be seen from the kurtosis value. If the kurtosis value is greater than 3 (fat tail/leptocustosis), it indicates a jump. Based on table 2, the data in the sample return for ADRO.JK shares has a kurtosis value greater than 3, indicating a jump.

**Table 2. Descriptive Statistical Value**

| Descriptive statistics | Value |
|---|---|
| *Skewness* | 2.6971 |
| *Kurtosis* | 10.8827 |

Because the ADRO.JK stock return data indicated a jump, a *Peak Over Threshold* was carried out by calculating the lower threshold value of 10%, and the upper threshold value of 10%.

**Table 3.** Threshold Value of Data Return Using Peak Over Threshold

| Quantile | Value |
|---|---|
| Lower threshold quantile | -0.0243 |
| Upper threshold quantile | 0.0323 |

From table 3, the lower threshold quantile is the lower limit of extreme data values or jumps determined from the return value of ADRO.JK shares with a threshold of 10% having a value of -0.0243. This means that the return value lower than -0.0243 is a jump that occurs in the return data of ADRO.JK. A total of 7 negative data is a jump. Then the upper threshold quantile is the upper limit of extreme data values or jumps determined from the return value of ADRO.JK shares with a threshold of 10% having a value of 0.0323. This means that the return value higher than -0.0243 is a jump that occurs in ADRO.JK return data. A total of 7 positive data is a jump.

*5.4. Estimated Parameter Value of GBM Model and Jump Diffusion*

*a. GBM Model Parameter Value Estimation*

The GBM model has 2 parameters, namely $\alpha$ and $\sigma$. Stock return used is stock return data in sample. Based on Table 2, the estimated value of $\alpha$ is 0.00290 and is 0.03122.

**Table 4.** GBM Model Parameter Value Estimation

| Parameter | Value |
|---|---|
| Average *return* (α) | 0.00398 |
| *Return volatility* (σ) | 0.03674 |

*b. Estimation of Jump Diffusion Model Parameter Values*

The Jump Diffusion model has 5 parameters, namely α, σ, λ, μ, δ. The stock return used is the stock return of in sample data. Based on Table 3, the estimated value of α is 0,00290, σ is 0,03122, λ is 0,01376, μ is 0,01477, and δ is 0,02848.

**Table 5.** Estimated value of Jump Diffusion model parameters

| Parameter | Value |
|---|---|
| Return average (α) | 0.00398 |
| Return volatility (σ) | 0.03674 |
| Jump intensity (λ) | 0.01366 |
| Jump average (μ) | 0.01687 |
| Jump standard deviation (δ) | 0.03108 |

*c. GBM stock price model*

$$\hat{S}(t_i) = \hat{S}(t_{i-1}) \exp\left(\left(\hat{\mu} - \frac{\hat{\sigma}^2}{2}\right)(t_i - t_{i-1}) + \hat{\sigma}\sqrt{t_i - t_{i-1}}Z_{i-1}\right)$$

$$\hat{S}(t_i) = \hat{S}(t_{i-1}) \exp\left(\left(0.00398 - \frac{0.03674^2}{2}\right)(t_i - t_{i-1}) + 0.03674\sqrt{t_i - t_{i-1}}Z_{i-1}\right)$$

d. *Jump Diffusion stock price model*

$$\hat{S}(t_{i+1}) = \hat{S}(t_i) \exp\left(\left(\hat{\alpha} - \frac{\widehat{\sigma^2}}{2} - \lambda\right)(t_i - t_{i-1}) + \hat{\sigma}\sqrt{t_i - t_{i-1}}Z_{i-1}\right) + N_i$$

$$\hat{S}(t_{i+1}) = \hat{S}(t_i) \exp\left(\left(0.00398 - \frac{0.03674^2}{2} - 0.01366\right)(t_i - t_{i-1}) + 0.03674\sqrt{t_i - t_{i-1}}Z_{i-1}\right) + N_i$$

*5.5. ADRO.JK Stock Price Prediction*

Stock price predictions are carried out to find out the estimated ADRO.JK stock price for the period 03/11/2021 to 31/12/2021, the prediction results are presented in Table 6.

**Table 6**. Actual and Prediction of ADRO.JK Stock Price

| Period | Actual | Prediction | | Period | Actual | Prediction | |
|---|---|---|---|---|---|---|---|
| | | GBM | Jump Diffusion | | | GBM | Jump Diffusion |
| 11/3/2021 | 1675 | 2177.50 | 1671.65 | 12/2/2021 | 1810 | 2389.20 | 1806.38 |
| 11/4/2021 | 1675 | 2177.50 | 1671.65 | 12/3/2021 | 1815 | 2395.80 | 1811.37 |
| 11/5/2021 | 1645 | 2138.50 | 1641.71 | 12/6/2021 | 1910 | 2521.20 | 1906.18 |
| 11/8/2021 | 1695 | 2203.50 | 1691.61 | 12/7/2021 | 1905 | 2514.60 | 1901.19 |
| 11/9/2021 | 1705 | 2216.50 | 1701.59 | 12/8/2021 | 1925 | 2541.00 | 1921.15 |
| 11/10/2021 | 1690 | 2197.00 | 1686.62 | 12/9/2021 | 1935 | 2554.20 | 1931.13 |
| 11/11/2021 | 1685 | 2190.50 | 1681.63 | 12/10/2021 | 1920 | 2534.40 | 1916.16 |
| 11/12/2021 | 1685 | 2190.50 | 1681.63 | 12/13/2021 | 1920 | 2534.40 | 1916.16 |
| 11/15/2021 | 1610 | 2093.00 | 1606.78 | 12/14/2021 | 1920 | 2534.40 | 1916.16 |
| 11/16/2021 | 1615 | 2099.50 | 1611.77 | 12/15/2021 | 2020 | 2666.40 | 2015.96 |
| 11/17/2021 | 1640 | 2132.00 | 1636.72 | 12/16/2021 | 2040 | 2692.80 | 2035.92 |
| 11/18/2021 | 1625 | 2112.50 | 1621.75 | 12/17/2021 | 2050 | 2706.00 | 2045.90 |
| 11/19/2021 | 1645 | 2138.50 | 1641.71 | 12/20/2021 | 2050 | 2706.00 | 2045.90 |
| 11/22/2021 | 1640 | 2132.00 | 1636.72 | 12/21/2021 | 2120 | 2798.40 | 2115.76 |
| 11/23/2021 | 1705 | 2216.50 | 1701.59 | 12/22/2021 | 2150 | 2838.00 | 2145.70 |
| 11/24/2021 | 1695 | 2203.50 | 1691.61 | 12/23/2021 | 2150 | 2838.00 | 2145.70 |
| 11/25/2021 | 1745 | 2268.50 | 1741.51 | 12/24/2021 | 2220 | 2930.40 | 2215.56 |
| 11/26/2021 | 1655 | 2151.50 | 1651.69 | 12/27/2021 | 2180 | 2877.60 | 2175.64 |
| 11/29/2021 | 1690 | 2197.00 | 1686.62 | 12/28/2021 | 2300 | 3036.00 | 2295.40 |
| 11/30/2021 | 1700 | 2210.00 | 1696.60 | 12/29/2021 | 2310 | 3049.20 | 2305.38 |
| 12/1/2021 | 1755 | 2281.50 | 1751.49 | 12/30/2021 | 2250 | 2970.00 | 2245.50 |

*5.6. MAPE value calculation*

Through the help of software *R 3.3.2*, The MAPE value of ADRO.JK stock price prediction is 12.55% (forecasting accuracy is in the good category) and the MAPE value for the Jump Diffusion method is 2.48% (forecasting accuracy is in the very good category). Based on the MAPE value, it can be concluded that the best model for predicting the ADRO.JK stock price is the Jump Diffusion model. Next, the stock price prediction of the Jump Diffusion model will be used to calculate the estimated VaR value.

*5.7. Stock Return Normality Test Prediction Jump Diffusion Model*

The normality test was carried out using the Kolmogorv-Smirnov test, obtained a D value of 0.1225 and a significance value of 0.7642. Because the significance value is greater than the error limit (0.05), the data in stock return predictions are normally distributed.

*5.8. VaR Monte Carlo Simulation*

Before performing VaR calculations, stock return data is divided into two parts, namely the estimation window ($M_E$) and test window ($M_U$). The estimation window is determined by 37 data and the test window is 5 data. In this study, the level of confidence used is 95%.

**Table 7.** Estimation Window and Tes Window

| Estimation Window | | Tes Window |
|---|---|---|
| ***T*** | ***t + $M_E$ - 1*** | ***VaR (t + $M_E$)*** |
| 1 (03/11/2021) | 37 (23/12/2021) | VaR(38) (24/12/21) |
| 2 (04/12/2021) | 38 (24/12/2021) | VaR(39) (27/12/21) |
| 3 (05/12/2021) | 39 (27/12/2021) | VaR(40) (28/12/21) |
| 4 (06/12/2021) | 40 (28/12/2021) | VaR(41) (29/12/21) |
| 5 (08/11/2021) | 41 (29/12/2021) | VaR(42) (30/12/21) |

with the help of software R 3.3.2, at the 95% confidence level with 5000 repetitions, the VaR value is obtained in Table 8.

**Table 8.** *VaR* Monte Carlo Simulation on Test Window

| Tes Window | *t* | Date | VaR |
|---|---|---|---|
| 1 | 38 | 24/12/21 | -0.04231 |
| 2 | 39 | 27/12/21 | -0.04332 |
| 3 | 40 | 28/12/21 | -0.04512 |
| 4 | 41 | 29/12/21 | -0.04411 |
| 5 | 42 | 30/12/21 | -0.04241 |

Based on table (8), if the sample is taken for the 1st test window, it can be concluded that there is 95% confidence that within 1 day after 24/12/21 the losses received do not exceed 4.2311% of the total invested funds.

*5.9. Backtesting*

The backtesting test in this study was simulated on several values of alleged violation probability ($p_0$), namely 1%, 2%, 3%, 4%, dan 5%.

1. Counting the number of violations

**Table 9**. Determination value of the violation

| No | Estimation Window | | Test Window | | Violation |
|---|---|---|---|---|---|
| | ***t* (time)** | **VaR** | **t (time)** | ***Return*** | |
| 1 | 1 - 37 | -0.04231 | 38 | -0.02241 | 0 |
| 2 | 2 - 38 | -0.04332 | 39 | -0.02238 | 0 |
| 3 | 3 - 39 | -0.04512 | 40 | 0.00088 | 0 |
| 4 | 4 - 40 | -0.04411 | 41 | -0.02171 | 0 |
| 5 | 5 - 41 | -0.04241 | 42 | -0.02287 | 0 |

Based on Table 9, it is concluded that in the test window no violations were found, meaning that all stock return values have a value that is smaller than the corresponding VaR value.

2. Violation Ratio

   Through the help of R 3.3.2 software, the violation ratio values for several violation probability values are obtained, which are presented in Table 10.

**Table 10.** Violation Ratio of VaR with Monte Carlo Simulation

| VaR Monte Carlo Simulation | |
|---|---|
| **($p_0$)** | **Violation Ratio (VR)** |
| 1% | 0 |
| 2% | 0 |
| 3% | 0 |
| 4% | 0 |
| 5% | 0 |

Based on Table 10, a proper violation ratio of 0 shows that the VaR calculation using the Monte Carlo simulation method can be used on all violations probability values ranging from 1% to 5%.

## 6. Conclusion

The conclusions that can be obtained based on the problems discussed in this study are:

1. The ADRO.JK share price model formed through the GBM Method is as follows:
$$\hat{S}(t_i) = \hat{S}(t_{i-1}) \exp\left(\left(0.00398 - \frac{0.03674^2}{2}\right)(t_i - t_{i-1}) + 0.03674\sqrt{t_i - t_{i-1}}Z_{i-1}\right)$$
with a prediction error value of 12.55%.
The stock price model of ADRO.JK formed through the Jump Diffusion Method is as follows:
$$\hat{S}(t_{i+1}) = \hat{S}(t_i) \exp\left(\left(0.00398 - \frac{0.03674^2}{2} - 0.01366\right)(t_i - t_{i-1}) + 0.03674\sqrt{t_i - t_{i-1}}Z_{i-1}\right) + N_i$$
with a prediction error value of 2.48%.
2. The Jump Diffusion method is more appropriate for predicting the stock price of ADRO.JK because it produces a smaller modeling error than the GBM method.
3. Through the Monte Carlo simulation method with a 95% confidence level, the VaR value for the period 24/12/21 was 4.2311%.
4. The backtesting test represents that at the 95% confidence level, the VaR calculation of the Monte Carlo simulation method can be used on all violation probability values ranging from 1% to 5%.

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## Biography

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