J-KOMA Journal of Computer Science and Applications

Universitas Negeri Jakarta
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Open Access

E-ISSN: *2620 - 4872*
Vol.*08*, ***No***.*01*
Doi: *https://doi.org/10.21009/j-koma.v8i1.01*

Recivied: *28 Mei 2025*
Accepted: *4 Juni 2025*
Published: *22 Juni 2025*

Keywords:
Monte Carlo Simulation;
Stock Price Prediction;
BRIS;

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Application of Monte Carlo Simulation in Predicting Stock Prices at PT Bank Syariah Indonesia Tbk.

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Abstract

Stock investment has become a popular choice for individuals seeking financial returns, although it comes with high risks due to market price volatility. This study aims to apply the Monte Carlo Simulation method to predict the stock price of PT Bank Syariah Indonesia Tbk (BRIS) and assess the accuracy of its predictions. BRIS was selected as it represents the largest Islamic bank in Indonesia and is attractive to investors focused on sharia-compliant finance. The research uses historical daily closing prices from January 2023 to December 2024, which are processed into daily returns and volatility as inputs for the simulation model based on Geometric Brownian Motion (GBM). The simulation was run three times to generate a variety of potential price paths. The predicted results were then compared with actual stock prices, and the Mean Absolute Percentage Error (MAPE) was used to evaluate prediction accuracy. The MAPE result of 39.75% indicates a moderate level of forecasting error. Although not perfectly precise, the model provides a valuable insight into possible price movements. The Monte Carlo method proves useful in capturing the uncertainty of the stock market and serves as a supportive tool for better investment decisions, especially in the Islamic banking sector. This research is expected to offer useful guidance for investors and stakeholders in managing portfolios using a quantitative approach.

INTRODUCTION

Investment is a commitment for someone to place a certain amount of funds in the hope of making a profit. we chose PT Bank Syariah Indonesia Tbk (BSI) shares because the growth of stock investment in the Islamic banking sector in Indonesia has increased significantly, along with the growing public awareness of the importance of implementing Islamic financial principles. PT Bank Syariah Indonesia Tbk (BSI), which is the result of the merger of three state-owned Islamic banks PT Bank BRI Syariah Tbk, PT Bank Syariah Mandiri, and PT Bank BNI Syariah has officially operated since February 1, 2021 and is now the largest Islamic banking institution in Indonesia [1]. As a public company with the stock code BRIS, BSI has become one of the most attractive investment instruments for investors who prioritize sharia compliance, especially as the valuation and performance of its stock have shown significant growth post-merger [2].

However, stock investment is not free from risks, especially market risks caused by stock price fluctuations. Therefore, a strategy is needed in predicting stocks so that investors do not make mistakes and can manage stocks optimally. Stock Management Strategy Stock prices often experience decreases or increases at any time so that they are difficult to predict. Therefore, investors need risk management and estimation to avoid higher risks [3], [4]. In the world of Islamic banking, risk management plays an important

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role in ensuring that investment activities remain in line with sharia principles while being able to generate maximum profits.

Monte Carlo simulation is a statistical technique that uses random numbers to simulate various possible outcomes in a complex and uncertain process. It is widely recognized as one of the statistical methods for modeling uncertainty and calculating the probability of different events that may occur within a system, and it has been extensively applied in stock price prediction. This method enables the calculation of a large number of possible outcomes derived from a random process, providing a more realistic and comprehensive overview. In this study, we adopt the Monte Carlo simulation approach to predict the stock price of PT Bank Syariah Indonesia Tbk, considering the high level of market uncertainty and the need to support investors in making better-informed decisions. Several recent studies have shown that Monte Carlo simulation can be used to analyze stock prices more accurately, even though financial markets are often influenced by unpredictable factors. For instance, Naufal and Jamilah demonstrated that this method is effective in estimating the financial risk of banking stocks, including BSI, using the Value at Risk (VaR) approach [5]. Additionally, another study found that applying the Monte Carlo method with a Geometric Brownian Motion model yielded highly accurate predictions of Islamic stock indices in Indonesia, achieving a MAPE value of just 2.03% [6]. Based on these findings, this paper aims to further explore the application of Monte Carlo simulation in predicting the stock price of PT Bank Syariah Indonesia Tbk and assess its effectiveness in the context of the Indonesian stock market.

METHODS

2.1 Data used

This study uses historical data on daily closing prices of PT Bank Syariah Indonesia Tbk (BRIS) shares from the financial platform investing.com, the company's official website, the Indonesia Stock Exchange (IDX), and other relevant financial publications for the period 2023 to 2024. The data is processed to calculate daily returns using the logarithmic formula, according to the concept in financial mathematics. The average return and standard deviation obtained are used as parameters of the log-normal distribution in the Monte Carlo simulation. This simulation generates thousands of possible future stock prices, and allows for the measurement of investment risk through the Value at Risk (VaR) value, as part of financial risk management. This data is used as the basis for applying the Monte Carlo method to predict stock price movements stochastically and measure investment risk. This method generates thousands of stock price simulations based on probability distributions derived from historical data. This approach allows for a more accurate analysis of market uncertainty and helps estimate Value at Risk (VaR) as an indicator of financial risk. Thus, Monte Carlo provides an overview of potential profits and losses, while supporting more measurable decision making. The data used includes:

1. Secondary Data

This study utilizes secondary data obtained from open sources, such as Yahoo Finance, investing.com, the company's official website, the Indonesia Stock Exchange (IDX), and other relevant financial publications that provide historical data on PT Bank Syariah Indonesia Tbk (BRIS) shares. The use of secondary data makes it easier for researchers to obtain complete and reliable information without having to collect data directly from the field. A similar approach was also applied by Azis et al. (2021) in a study on the capital market in Indonesia, where they utilized secondary data from Yahoo Finance as a basis for applying Monte Carlo Simulation in estimating asset value movements during the COVID-19 pandemic.

2. Historical Stock Price Data (Time Series)

The main type of data used is the daily closing price of BRIS shares in the period January 2021 to December 2023. Because it is a time series, this data reflects the dynamics of stock prices over time, allowing the identification of trends, seasonal patterns, and volatility as a basis for predictive analysis and risk management.

3. Numeric Data (Quantitative)

All data analyzed are in the form of numbers or quantitative data, such as closing prices, daily returns, average return values, and standard deviations. These numerical data allow the application of mathematical and statistical approaches, especially in calculating logarithmic returns and estimating volatility, which are important in Monte Carlo simulations.

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2.2 Research procedure

This study uses a quantitative approach because the Monte Carlo method is used to predict bank stock prices. The research procedure is carried out through several stages as follows:

1. Literature Study

The initial stage of this research involved a comprehensive literature review to understand the fundamental theories relevant to the topic. Reviewed materials include key concepts in financial mathematics, such as Monte Carlo simulation, volatility, and stock return theory. Additionally, prior studies employing similar methodologies were examined to support the chosen approach. Previous research applied Monte Carlo simulation using daily closing price data of LQ-45 stocks to predict future price movements, demonstrating its effectiveness in generating probabilistic estimates for asset prices [7],[8],[9].

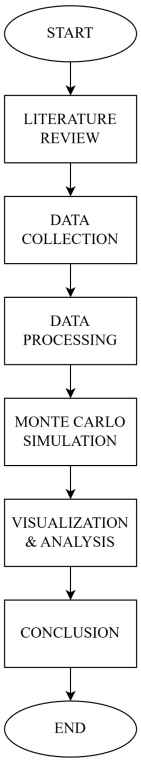

Figure 1. Flowchart

2. Data collection

The data used is secondary data from daily bank stock prices obtained from the investing.com site. The shares to be studied as the object of research are Bank Syariah Indonesia (BSI) shares. the data period taken for 2 years, starting from January 2023 to December 2024. This data will be used as the basis for calculating daily returns and calculations using the Monte Carlo method.

3. Data processing

After the data is collected, the researcher processes the stock price into a daily return using the logarithmic return formula

$$R_t = In(\frac{P_t}{P_{t-1}}) \qquad (4)$$

Keterangan :

R_t : profit rate
P_t : investment price at time t
P_{t-1} : investment price at time t-1

From the daily return data, the average return and standard deviation (volatility) are calculated as the main parameters in the simulation.

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4. Monte Carlo Simulation

Monte Carlo Simulation was conducted using the Geometric Brownian Motion (GBM) model, which is formulated as

$$S_t = S_{0.} e^{(\mu - \frac{1}{2}\sigma^2)t + \sigma\sqrt{t}Z} \quad (5)$$

where z is a random number that follows a standard normal distribution [10].

5. Visualization and Analysis

The simulation results will be visualized in the form of a simulation path graph, a histogram of stock price distribution, and a calculation of Value at Risk (VaR) to measure investment risk. Analysis is carried out on the visualization results to determine the possibility of stock price movements and to evaluate the probabilistic distribution formed.

6. Drawing conclusions

The final step is to draw conclusions from the results of the simulation and analysis that have been carried out, including evaluating the effectiveness of the Monte Carlo method in providing predictions of BRIS stock prices in the future and providing recommendations for investors and related parties.

RESULT AND DISCUSSION

3.1 Data Description

This study utilizes historical data on daily closing prices of PT Bank Syariah Indonesia Tbk (BRIS) shares from January 2023 to December 2024. Data was obtained from a trusted source, namely Investing.com. The closing price is processed into daily returns using a logarithmic formula. This daily return value is then used to calculate the average return and standard deviation (volatility) as the basis for Monte Carlo simulations. The use of historical data as the basis for Monte Carlo simulations has been widely studied in various studies.

3.2 Results of Parameter Calculation and Monte Carlo Calculation

After the historical data of daily closing prices of PT Bank Syariah Indonesia Tbk (BRIS) shares for the period January 2023 to December 2024 has been collected and processed, the next step is to calculate the daily return using the logarithmic formula as stated in Formula (4). From the results of the return, the Expected Return value or average return and its volatility level are then calculated.

Expected Return	0.0015830733
Volatilitas	0.02515385894

Figure 2. Expected Return Value Results And volatility levels.

Based on the calculation results in the Spreadsheet application shown in Figure 4.2.1, the Expected Return value is obtained as 0.0015830733 which is then rounded to 0.0016. This value is calculated by adding up all daily returns and dividing it by the number of observation days. Meanwhile, the volatility level is obtained as 0.02515385894 and rounded to 0.025. This volatility value is calculated using Formula (4). After obtaining the return value and volatility level, then look for random numbers to generate the Monte Carlo method.

Table 1. Results of Return Value calculation and Comparison of Original Price and Predicted Price.

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Date	Parameter		
	Return	Price	Prediction price
01/02/2023	0	1,285	2726,471409
01/03/2023	0,0000222575870 6	1,395	2720,9518
01/04/2023	0,0000222570916 7	1,385	2722,672207
01/05/2023	0,0000222565963	1,335	2712,061941
01/06/2023	0,0000222561009 5	1,390	2712,703151
:	:	:	:
12/20/2024	0,0000219079646 4	2,750	2734,137473
12/23/2024	0,0000657210143 2	2,800	2737,225537
12/24/2024	0,0000219060449 7	2,750	2739,466033
12/27/2024	0,0000657152558 2	2,770	2743,47927
12/30/2024	0,0000657109376 1	2,730	2743,21833

Table 1 shows actual stocks and predicted prices obtained through the Monte Carlo method. In this simulation, three iterations are carried out to obtain more accurate prediction values. From the results of 3 iterations, the accuracy value is then sought in the Monte Carlo method using the following forecasting formula.

Mean Absolute Percentage Error (MAPE) is one of the evaluation methods commonly used to measure the accuracy of forecasting results. MAPE calculates the average of the absolute difference between the actual value and the predicted value expressed as a percentage. Mape value is 39.74775202 In the Financial Mathematics course, the MAPE (Mean Absolute Percentage Error) value of 39.75% means that the average error in predicting stock prices reaches almost 40% of the actual price. This figure shows that the model used to predict stock prices is quite accurate. This is because the predicted value obtained is consistently two times the value of the actual price. Prediction models such as Monte Carlo simulations are suitable for predicting future values.

3.3 Graphic Visualization

The graph produced from the Monte Carlo simulation in this study offers a clear visual representation of the projected stock price trajectory of PT Bank Syariah Indonesia Tbk (BRIS), where each of the three iterations depicts a potential future path. This illustration underscores the range of outcomes and inherent uncertainty based on historical volatility and return parameters drawn from daily closing prices. A similar visualization approach was employed by Anastasia (2022) in a study on LQ-45 stocks, showing multiple simulated paths (100 to 10,000 runs) over a 10-day period to assess probable price movements and risk exposure Likewise, Ramadhan & Hilmy [11] used Monte Carlo simulation to predict long-term

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trajectories of Apple Inc. stock, demonstrating that plotted simulation paths effectively communicate stochastic variability and potential price ranges

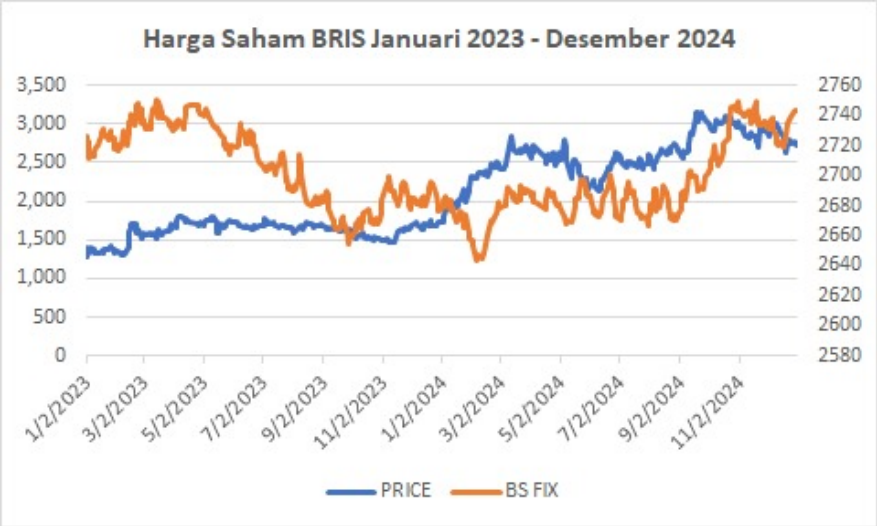

Figure3. Comparison of Actual Price and Predicted Price

Figure 3 shows two lines comparing the actual stock price and the simulated results of PT Bank Syariah Indonesia Tbk (BRIS) from January 2023 to December 2024. The blue line marked price shows the actual stock price in the market, which fluctuates due to the influence of economic conditions, investor sentiment, and fundamental and technical factors. Meanwhile, the orange line marked Black-Scholes fix is the result of a simulation of the Black-Scholes model with fixed parameters. This line is formed from one stochastic process path that takes into account expected returns, volatility, and normally distributed random numbers. The Price line represents the actual data on the stock price of PT Bank Syariah Indonesia Tbk (BRIS) during the period from January 2023 to December 2024. The movement of this line reflects the real market dynamics, which are greatly influenced by various external factors such as macroeconomic conditions, fluctuations in global financial markets, company performance, and investor sentiment and behavior. The ups and downs that appear on the graph reflect the unstable and uncertain nature of the market. Meanwhile, the orange line labeled Black Scholes shows the results of stock price simulations using the Black-Scholes model with parameters assumed to be constant throughout the observation period. This model works based on a stochastic approach, where stock prices are predicted through a probabilistic distribution with the assumption of normality in random variables. Because parameters such as expected returns, volatility, and risk-free interest rates are considered constant, the simulation result line tends to show a more stable and regular pattern than actual data. These two lines show a comparison between market reality and the results of the mathematical approach. The Black-Scholes model, although theoretical and based on ideal assumptions, provides an initial framework that can be used in the development of stochastic simulations, such as Monte Carlo. By comparing the simulation results with actual data, it can be seen that the model provides useful estimates, but still has limitations in capturing the complexity of the real market. Therefore, this graph is very important as a basis for evaluating the accuracy of the model and developing investment strategies based on mathematical predictions.

CONCLUSION

Based on the results of the research and discussion on the use of Monte Carlo Simulation in predicting the stock price of PT Bank Syariah Indonesia Tbk (BRIS), it can be concluded that this method is capable of estimating stock prices by utilizing historical daily closing price data. Logarithmic daily returns are used to

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determine the expected return and volatility, which serve as parameters in the Geometric Brownian Motion (GBM) model. The simulation, conducted in three iterations, aims to more accurately estimate the distribution of future stock prices. The model's accuracy was tested using the Mean Absolute Percentage Error (MAPE), resulting in a value of 39.75%, indicating an average deviation of nearly 40% between predicted and actual prices. Although the predictions tended to overestimate, the Monte Carlo Simulation still offers a reasonably good estimate of stock price direction and can be considered a useful tool for investment decision-making, despite its limitations in fully capturing complex market dynamics. For future research, it is recommended to use a longer span of historical data that includes various market conditions to enhance accuracy, and to increase the number of simulation iterations for more stable results. Moreover, combining Monte Carlo with models such as GARCH, ARIMA, or AI-based approaches could improve predictive performance. Evaluation of accuracy should also include additional metrics like RMSE and MAE. Lastly, incorporating company fundamentals and macroeconomic indicators is essential to complement the analysis, making the findings more practical and beneficial for investors and market analysts in projecting stock prices and assessing associated risks.

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