Journal of Actuarial, Finance and Risk Management (JAFRM)
e-ISSN:28303938
Vol. 4(1), Juni, 2025.
http://e-journal.president.ac.id/presunivojs/index.php/JAFRM/index

Pricing Asian Options on BBCA Stocks: A Binomial and Black-Scholes Approach

Srava Chrisdes Antoro[1], Maria Yus Trinity Irsan[2*]

[1]*Universitas Bunda Mulia, Serpong, Tangerang, Indonesia*
[2] *Universitas Presiden, Cikarang, Bekasi, Indonesia*
[*]*Corresponding author: maria.irsan@president.ac.id*

Receive: June 24, 2025, Revised: July 24, 2025, Accepted: July 2029

Abstract—This paper aims to evaluate the pricing of Asian options using two widely recognized methods: the Binomial Option Pricing Model and the Black-Scholes Model. Asian options are a form of exotic options where the payoff depends on the average price of the underlying asset over a specified period, reducing the impact of market volatility compared to standard European or American options. The research focuses on BBCA (Bank Central Asia) stock data over a two-month period from September to November 2024. The study uses the arithmetic average for the binomial model and the geometric average for the Black-Scholes model. Essential financial parameters such as risk-free interest rate, volatility, and strike prices are determined based on real market data and standard assumptions. The binomial model offers a numerical approach through discrete time intervals, while the Black-Scholes model provides a closed-form analytical solution. Results show that the call option prices from the binomial and Black-Scholes models are 1,228.79 and 1,272.02 respectively, with a Mean Absolute Percentage Error (MAPE) of 3.52%. For the put options, the binomial and Black-Scholes prices are 1,754.46 and 1,711.21, respectively, with a MAPE of 2.46%. These low error rates suggest that both models can accurately estimate Asian option values. The study concludes that both the binomial and Black-Scholes models are effective tools for pricing Asian options on BBCA stock, offering comparable results with minimal deviation. This finding supports the use of these models in financial decision-making for exotic options in the Indonesian market.

Keywords—Asian Option, Black Scholes, Binomial, BBCA, Option Pricing

I. INTRODUCTION

An option is a financial contract that gives the holder the right, but not the obligation, to buy or sell an underlying asset at a predetermined price (known as the strike or exercise price) within a specified period (referred to as the maturity or expiry date). The underlying assets can include stocks, bonds, or exchange-traded funds (ETFs) [1]. Options are generally divided into two types based on the rights they offer: **call options**, which give the right to buy, and **put options**, which give the right to sell.

Based on the time of execution, options can be categorized as **European options**, which can only be exercised at maturity, and **American options**, which can be exercised at any time before expiry. In terms of complexity, options are further classified as **vanilla options**, which have standard features, and **exotic options**, which possess more complex structures and payoffs [2][3].

Exotic options derive their value not only from the underlying asset's price at maturity but also from its performance over the life of the option. Two common types include **barrier options**, which activate or deactivate depending on the asset price hitting a certain level, and **Asian options**, where the payoff is based on the average price of the underlying asset during a specific period [4][5].

Various models are available to estimate option prices, including the **Binomial Option Pricing Model**, **Trinomial Option Pricing Model**, **Black-Scholes Model**, and **Monte Carlo Simulation**. The **binomial model** is a flexible numerical method ideal for discrete time steps [6][7][10]. The **Black-Scholes model** offers a closed-form analytical solution under assumptions like constant volatility and lognormal stock price distribution [8]. The **Monte Carlo method** uses simulations to estimate expected payoffs and is well-suited for complex derivatives [9].This study applies both the Binomial Option Pricing Model and the Black-Scholes Model to price Asian options on BBCA stocks data from September to November 2024 and compares their results to assess consistency and accuracy.

The selection of BBCA (Bank Central Asia) as the underlying asset is motivated not only by its liquidity and relevance in the Indonesian financial market, but also by its consistent financial performance and governance practices, as noted in recent ESG and risk-based studies. According to the IDX ESG Star listing evaluated by Sustainalytics, BBCA is among the companies recognized for its strong commitment to environmental, social, and governance (ESG) performance, which contributes to investor confidence and stock stability. This aspect is crucial, considering that volatility—one of the primary variables in option pricing models—is often influenced not only by market dynamics but also by fundamental company factors, including governance, sustainability, and operational risk.

Research by Breliastiti et al. (2025) shows that companies with strong ESG ratings demonstrate better resilience, lower perceived risk, and greater stakeholder trust, which can lead to lower volatility in stock prices—an important consideration in options modeling, particularly for Asian options whose payoff depends on price averaging [11]. Similarly, Pratiwi & Kurniawan (2025) highlight that financial indicators like CAR (Capital Adequacy Ratio) and NIM (Net Interest Margin) significantly affect the performance of banking firms, and therefore may also influence their stock price behavior over time [12]. Furthermore, Panjaitan et al. (2025) demonstrate that positive organizational factors such as Leader-Member Exchange (LMX) and Perceived Organizational Support (POS) reduce turnover intention, contributing to internal stability, which is indirectly linked to long-term business performance and investor sentiment [13]. Thus, this study not only aims to evaluate the computational consistency between two widely used pricing models—binomial and Black-Scholes—but also to position such modeling in the broader context of corporate sustainability and risk management, which underlie price dynamics in the capital market. By understanding the pricing behavior of Asian options in relation to a company like BBCA—an issuer with robust ESG and financial profiles—this research bridges the gap between quantitative modeling and qualitative business fundamentals, offering a more comprehensive view of derivative valuation in emerging markets.

II. LITERATURE REVIEW

A. Stock

Stock can also be referred to as a share, and it is a share in the ownership of the organizations. Owning stock does not make you responsible for the day to day running of the company. We can, however, benefit when the company becomes profitable. This is possible because owning stocks allows you to make a claim on the overall earnings of a company, as well as any assets that they may own. By owning shares, an individual or business entity has a claim on the assets and income of the company as well as the right to participate in decision-making, such as attending the General Meeting of Shareholders (GMS) and receiving dividends. The benefit we can earn can increase with the more stock we purchase and own from the company [14]. Shares can be traded on the stock exchange, and their prices fluctuate based on the company's performance and general market conditions [4].

B. Option

In the world of finance, an option is a contract that gives its holder the right, but not the obligation, to buy or sell an underlying asset or instrument at a predetermined strike price within a specified timeframe, depending on the type of option. Historically, contracts resembling options have been used since ancient times. In London, during the reign of William and Mary in the 1690s, puts and "refusals," which functioned similarly to call options, emerged as popular trading tools. In 19th-century America, over-the-counter options known as "privileges" were traded, with specialized dealers offering both puts and calls on stocks [15].

C. Exotic Option

An exotic option is a type of financial option with non-standard features, designed to meet specific investment needs that cannot be fulfilled by conventional options. These options have unique characteristics such as complex payoff structures, customized terms, and valuation methods different from standard options. Examples of exotic options include barrier options, binary options, lookback options, and Asian options. While most exotic options are traded over-the-counter (OTC), their growing popularity has led some exchanges to list them as publicly traded investment instruments [16].

D. Asian Option

Asian options are a sort of exotic option in which the payment is decided by the average price of the underlying asset over a specified time period rather than the price upon expiry. This averaging characteristic

Journal of Actuarial, Finance and Risk Management (JAFRM)
e-ISSN:28303938
Vol. 4(1), Juni, 2025.
http://e-journal.president.ac.id/presunivojs/index.php/JAFRM/index

reduces the volatility of the option's payment, making Asian options less susceptible to underlying asset fluctuations than regular options [5]. Asian options are a hybrid of American and European options, where Asian options can be exercised like European or American options. What distinguishes Asian options from American options is the price at the time of exercise. The stock price used as a reference in Asian options is the average stock price at time T. Asian options are more likely to be European because of the exercise of these options at time T [6]. Based on the determination of the payoff for Asian options, two types of averages can be used: the arithmetic average and the geometric average to calculate the payoff. Let G represent the geometric mean of the underlying asset over the option's lifespan [9] and A represent the arithmetic mean of the underlying asset over the option's lifespan.

$$G = \left(\prod_{i=1}^{n} S(t_i)\right)^{\frac{1}{n}} = \sqrt[n]{S(t_1)S(t_2)\dots S(t_n)} \quad (1)$$

$$A = \frac{1}{n}\sum_{i=1}^{n} S_i \quad (2)$$

Later, either geometric average or arithmetic average can be called as S(t) depend on which average will be used in the calculation. Then, for the call option payoff and put option payoff can be calculated by following this equation:

$$Call = \max(Average\ Price - K, 0) \quad (3)$$

$$Put = \max(K - Average\ Price, 0) \quad (4)$$

with

$S(t)$ = Geometric or Arithmetic average

Call= Asian call option payoff

Put = Asian put option payoff

n = number of averaged asset prices

K = Execution price

To calculate arithmetic and geometric volatility for Asian Option, we use this formula as follows:

$$\sigma_{arith} = \frac{\sigma\sqrt{T}}{\sqrt{3}} \quad (5)$$

where, by mathematical approximation, the arithmetic mean-variance for an Asian option will be about $\frac{1}{3}$ of the total variance calculated based on a single price

$$\sigma_{geo} == \frac{\sigma\sqrt{T}}{\sqrt{6}} \quad (6)$$

where, mathematically, the geometric mean variance is $\frac{1}{6}$ of the total variance calculated based on a single price.

E. Black-Scholes Model

The Black-Scholes model is one of the most significant contributions to modern financial theory, introduced by Fischer Black and Myron Scholes. This model offers a closed-form solution for pricing European call-and-put options. The key assumptions underlying the Black-Scholes model include a constant risk-free interest rate, constant volatility, and the lognormal distribution of stock prices [8]. However, before that, daily stock price data for two months and risk-free price data for one year must be available to calculate stock price volatility (V) and risk-free rate (r).

$$\sigma = \sqrt{\frac{1}{n-1}\sum_{t=1}^{n}(R_t - \bar{R})} \tag{7}$$

where:
R_t:The return of stocks
$\bar{R}$: The average return of all R_t
n:Amount of Data
where the return we can get from the formula below:

$$R_t = ln\left(\frac{P_t}{P_{t-1}}\right) \tag{8}$$

where:
P_t: Price of stock at time t
P_{t-1}: Price of Stock before time$t$

Then, we can determine the return and sigma. The risk-free rate can be determined based on the risk-free rate of each country. Since the company we used is PT. Bank Central Asia Tbk. (BCA) and it is located in Central Jakarta, Indonesia, so the researchers used the Indonesia Government Bond rate which is 0.07. The researchers assume the time to maturity is 1 year. Then calculate the average since Asian options depend on the average share price over a period of time, not just on the final price as with European options. The researchers used the Geometric average in formula (1) for the Black-Scholes Model. Then, calculate $\hat{\sigma}^2$(Average Volatility) to estimate the geometric mean variance of the stock price in Asian options. With the corrections provided by (n+1), (2n+1), and $6n^2$, this formula reflects the reduced risk due to the average stock price in the Asian option model compared to the ordinary option, using the formula by:

$$\hat{\sigma}^2 = \frac{(\sigma\times 2)(n+1)(2n+1)}{6n^2} \tag{9}$$

$$\hat{\mu} = \frac{1}{2}\hat{\sigma}^2 + \left(r - \frac{\sigma^2}{2}\right)\frac{n+1}{2n} \tag{10}$$

where:
σ = volatility of the stock's return (annualized)
n = number of steps
$\hat{\sigma}$ = Average Volatility

Then, we can find the d_1 and d_2 which are already adjusted with the geometric average using the formula below:

$$\hat{d}_1 = \frac{\ln\left(\frac{S_0}{K}\right) + \left(\hat{\mu} + \frac{1}{2}\hat{\sigma}^2\right)T}{\hat{\sigma}\sqrt{T}} \tag{11}$$

$$\hat{d}_2 = \frac{\ln\left(\frac{S_0}{K}\right) + \left(\hat{\mu} - \frac{1}{2}\hat{\sigma}^2\right)T}{\hat{\sigma}\sqrt{T}} \tag{12}$$

where:
S_0 = Current Stock Price
K = Strike Price of the Option
T = time to maturity of the option
$\hat{\sigma}$ = Average Volatility
Thus, the formula for the call and put option price using the Black-Scholes geometric average is:

$$Call = e^{-rT}(S_0 e^{\hat{\mu}T} N[\hat{d}_1] - KN[\hat{d}_2]) \tag{13}$$

$$Put = e^{-rT}(KN[-\hat{d}_2] - S_0 e^{-\hat{\mu}T} N[-\hat{d}_1]) \tag{14}$$

F. Binomial Option Pricing Model

The binomial model, developed by Cox, Ross, and Rubinstein in 1979, is a simple and flexible method for calculating option prices compared to analytical approaches such as Black-Scholes. Originally used for European options, the model was later extended to American options that can be exercised at any time before maturity. The advantage of this model lies in its ability to value American options as well as its flexibility in handling options with more complex payoffs such as Asian or Barrier options [7]. Using Daily Stock Price data and assumptions for (S_0, K, T, r, n) we determine the parameters for the Binomial Model. Then, to determine the time length of each step in the binomial model, we can use the equation below:

$$\Delta T = \frac{T}{n} \quad (15)$$

where:
T: Time of maturity (in a year)
n: Number of Steps
ΔT: Indicates the time length of each step in the binomial model

The basic principle is to divide the time to maturity into small steps, where the stock price may increase by a factor of u or decrease by a factor of d at each step, with a risk-neutral probability p used to calculate the expected option price. The formula for the up factor, down factor, the probability can be followed as below:

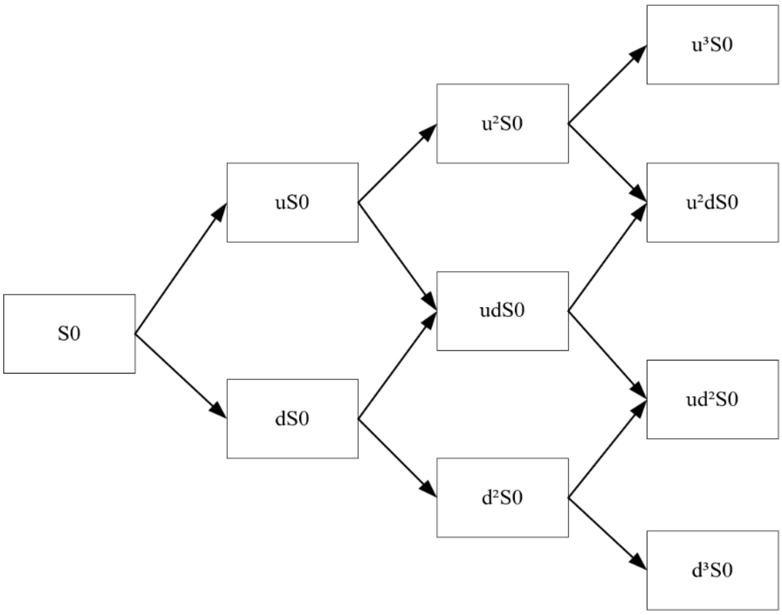
$$\text{Up factor } (u) \text{ and Down factor } (d)\text{: } u = e^{\sigma\sqrt{\Delta T}}, \quad d = \frac{1}{u} \quad (16)$$

$$\text{Neutral Risk Probability } (p)\text{: } p = \frac{e^{r\Delta T} - d}{u - d} \quad (17)$$

$$\text{Stock Option Tree:} S_{i,j} = S_0 u^{i-j} d^j by\ i \geq j \geq 0 \quad (18)$$

where:
u: Up factor
d: Down factor
r: Risk free-rate
i: time steps to i
j: Number of descending movements at step-i

The movement of the up factor and down factor can be followed as below:



After calculating the stock option tree, we need to calculate the backward induction to determine the present value of the option price by following this equation:

$$V_i = e^{-r\Delta T}[pV_{i+1}^u + (1-p)V_{i+1}^d] \quad (19)$$

where:
V_i: Option Value at step i

Journal of Actuarial, Finance and Risk Management (JAFRM)
e-ISSN:28303938
Vol. 4(1), Juni, 2025.
http://e-journal.president.ac.id/presunivojs/index.php/JAFRM/index

V_{i+1}^{u} and V_{i+1}^{d}: option value at step i+1 for upward and downward price movements, respectively.
Lastly, the process is repeated until reaching the start node ($i = 0$), where $V_{0,0}$ is option price.

G. Mean Absolute Percentage Error (MAPE)

MAPE is an error measure to calculate the predicted price and actual price. In this paper, the actual price is the Binomial Model and the predicted price is Black-Scholes Model. To find the MAPE we can follow the equation below:

$$MAPE = \left|\frac{Binomial\ Price - Black{-}Scholes\ Price}{Binomial\ Price}\right| \text{X } 100\% \tag{20}$$

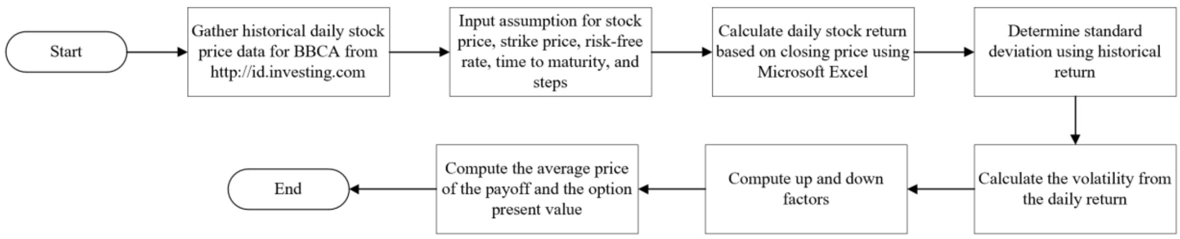
III. METHODOLOGY

This study aims to calculate Asian option prices using the Binomial Option Pricing Model and the Black-Scholes Model. The process begins with collecting BBCA stock data from September to November 2024 to calculate returns and estimate volatility. Key parameters such as stock price, strike price, time to maturity, and risk-free rate are then determined.

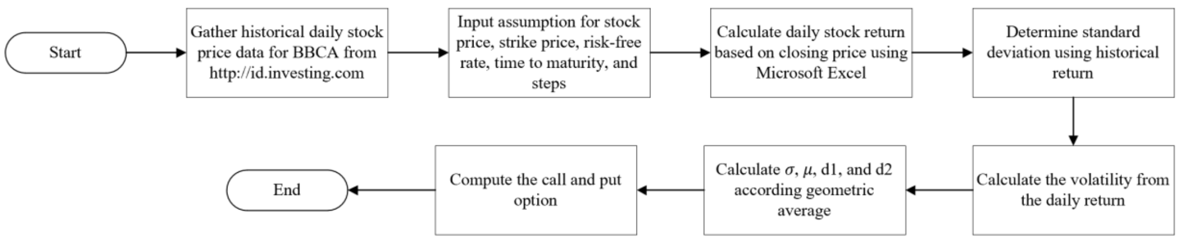
The binomial model constructs a price tree based on possible price movements and calculates the option's value using the arithmetic average of stock prices. The option price is derived through backward induction. In contrast, the Black-Scholes model uses the geometric average and adjusted volatility to estimate option prices through a closed-form formula.

Finally, results from both models are compared using Mean Absolute Percentage Error (MAPE) to assess the accuracy of the Black-Scholes model against the binomial approach.

Binomial Option Pricing Model



Black-Scholes Model



IV. RESULT AND DISCUSSION

BBCA Historical Data

The BBCA's historical data stock is starting from September 2024 to November 2024. The data is downloaded from the website id.investing.com [17].

Journal of Actuarial, Finance and Risk Management (JAFRM)
e-ISSN:28303938
Vol. 4(1), Juni, 2025.
http://e-journal.president.ac.id/presunivojs/index.php/JAFRM/index

Table 1

BBCA Daily Data Stock

Date	Close	Date	Close
01/11/2024	10,425	02/10/2024	10,500
31/10/2024	10,250	01/10/2024	10,550
30/10/2024	10,350	30/09/2024	10,325
29/10/2024	10,500	27/09/2024	10,650
28/10/2024	10,600	26/09/2024	10,700
25/10/2024	10,750	25/09/2024	10,850
24/10/2024	10,700	24/09/2024	10,800
23/10/2024	10,650	23/09/2024	10,950
22/10/2024	10,500	20/09/2024	10,775
21/10/2024	10,675	19/09/2024	10,900
18/10/2024	10,750	18/09/2024	10,625
17/10/2024	10,725	17/09/2024	10,500
16/10/2024	10,475	13/09/2024	10,425
15/10/2024	10,625	12/09/2024	10,475
14/10/2024	10,500	11/09/2024	10,425
11/10/2024	10,375	10/09/2024	10,350
10/10/2024	10,500	09/09/2024	10,275
09/10/2024	10,425	06/09/2024	10,300
08/10/2024	10,400	05/09/2024	10,250
07/10/2024	10,300	04/09/2024	10,300
04/10/2024	10,475	03/09/2024	10,175
03/10/2024	10,450	02/09/2024	10,275

Determine the parameter

The stock price in this research is based on BBCA's stock price on 5th December 2024, the strike prices are based on the researcher's assumption and are different between the call option and put option because of the characteristics of these two types. For the risk-free rate, the researchers used the Indonesia Government Bond rate which is 0.07. And last, the time of maturity and the steps are based on the researcher's assumption as well. Thus, the parameters are shown in the table below:

Table 2

Parameters	
Stock Price	10250
Call Strike Price	9000
Put Strike Price	12000
Risk-Free Rate	0.07
Time to Maturity (T)	1 month
Steps (n)	1000
Volatility Arithmetic	0.00207
Volatility Geometric	0.0014655
Time length (T/n)	0.00008

Daily Return and Volatility of BBCA Stock

By using formula (6), we can get the daily return of BBCA data stock as shown below:

Table 3

BBCA Daily Return

Date	Return	Date	Return
01/11/2024	-	02/10/2024	-0.004762
31/10/2024	-0.016929	01/10/2024	-0.004739
30/10/2024	-0.009662	30/09/2024	0.0217918
29/10/2024	-0.014286	27/09/2024	-0.030516
28/10/2024	-0.009434	26/09/2024	-0.004673
25/10/2024	-0.013953	25/09/2024	-0.013825
24/10/2024	0.0046729	24/09/2024	0.0046296
23/10/2024	0.0046948	23/09/2024	-0.013699
22/10/2024	0.0142857	20/09/2024	0.0162413
21/10/2024	-0.016393	19/09/2024	-0.011468
18/10/2024	-0.006977	18/09/2024	0.0258824
17/10/2024	0.002331	17/09/2024	0.0119048
16/10/2024	0.0238663	13/09/2024	0.0071942
15/10/2024	-0.014118	12/09/2024	-0.004773
14/10/2024	0.0119048	11/09/2024	0.0047962
11/10/2024	0.0120482	10/09/2024	0.0072464
10/10/2024	-0.011905	09/09/2024	0.0072993
09/10/2024	0.0071942	06/09/2024	-0.002427
08/10/2024	0.0024038	05/09/2024	0.004878
07/10/2024	0.0097087	04/09/2024	-0.004854
04/10/2024	-0.016706	03/09/2024	0.012285
03/10/2024	0.0023923	02/09/2024	-0.009732

From Table 3, we can calculate the volatility using formula 5 which shows that the volatility is 0.012437736261173. Then, we calculate the volatility of Asian option using formula (5) and (6) which results 0.00207249849355439 for arithmetic average and 0.001465478 for geometric average.

Call and Put Option Price

After have all the parameters we can compute the option price using the formulas shown above both for the binomial and black-scholes model. Then, we need to calculate the MAPE to check the accuracy of the calculation using formula 16. Thus, the results are shown below:

Table 4

Call Option Price	
Binomial Arithmetic Call Option Price	: 1228.785
Black-Scholes Geometric Call Option Price	: 1272.02
MAPE	: 3.52%

Table 5

Put Option Price	
Binomial Arithmetic Put Option Price	: 1754.46
Black-Scholes Geometric Put Option Price	: 1711.21
MAPE	: 2.46%

V. CONCLUSION

Asian options are a type of exotic option where the payoff is determined by the average price of the underlying asset over a specific period. This averaging feature helps reduce price volatility and makes Asian options less sensitive to short-term market fluctuations compared to standard options. There are two commonly used approaches to pricing Asian options: the Binomial Option Pricing Model and the Black-Scholes Model

In this study, both models were applied to BBCA stock data over a two-month period, with a time to maturity of one month. The risk-free rate was based on the Indonesian government bond rate (7%), and different strike prices were used for call and put options due to their differing characteristics. The binomial model used arithmetic averaging, while the Black-Scholes model employed geometric averaging.

The results show that the call option price calculated using the binomial model was 1,228.79, while the Black-Scholes model produced a value of 1,272.02, with a MAPE of 3.52%. For put options, the binomial model produced a price of 1,754.46, and the Black-Scholes model gave a price of 1,711.21, with a MAPE of 2.46%. Since both error rates are below 10%, the two models are considered to have a high level of accuracy and produce comparable results.

Future research may incorporate Monte Carlo simulation for comparison or extend the analysis to other stocks and maturities.

VI. References

[1] Hull, J.C. (2018). Options, Futures, and Other Derivatives. 10th ed. Pearson.
[2] Chance, D.M. & Brooks, R. (2015). An Introduction to Derivatives and Risk Management. South-Western Cengage Learning.
[3] Bouzoubaa, M. & Osseiran, S. (2010). Exotic Options and Hybrids: A Guide to Structuring, Pricing and Trading. Wiley.
[4] Soraya, S. (2016). Penentuan Nilai Hedge Ratio untuk Call Option dan Put Option Tipe Eropa dalam Model Black–Scholes. Fakultas Sains dan Teknologi.
[5] Lakhlani, V.B. (2013). Pricing and Hedging Asian Options. Utah State University.
[6] Syam, R., Zaki, A., & Basri, M.H. (2019). Prediksi Harga Kontrak Opsi Asia dalam Perdagangan Pasar Saham dengan Metode Monte Carlo. Journal of Mathematics, Computations, and Statistics, 1(1), 31–37.
[7] Cox, J.C., Ross, S.A., & Rubinstein, M. (1979). Option Pricing: A Simplified Approach. Journal of Financial Economics, 7(3), 229–263.
[8] Black, F. & Scholes, M. (1973). The Pricing of Options and Corporate Liabilities. Journal of Political Economy, 81(3), 637–654.
[9] Boyle, P. (1997). Options: A Monte Carlo Approach. Journal of Financial Economics, 4, 323–338.
[10] Geman, H. & Yor, M. (1993). Bessel Processes, Asian Options, and Perpetuities. Mathematical Finance, 3(4), 349–375.
[11] Breliastiti, R., *et al.* (2025). Best Sustainability Practices with Sustainalytics: Insights from IDX ESG Star Companies. Jurnal Akuntansi Bisnis, 18(1), 22–41.
[12] Pratiwi, D. & Kurniawan, B. (2017). Pengaruh Penerapan Manajemen Risiko terhadap Kinerja Keuangan Industri Perbankan. Jurnal Akuntansi Bisnis, 10(1), 73–93.
[13] Panjaitan, C.A.S., *et al.* (2025). Leader-Member Exchange dan Perceived Organizational Support sebagai Penentu Turnover Intention pada Perusahaan Surveyor di Indonesia. Jurnal Ilmiah Ilmu Pendidikan, 8(2), 2174–2180.
[14] Duncan, Winston J. (2016). Stocks. Lulu Press
[15] Chen, R. (2020). The Black-Scholes Option Pricing Model.
[16] Deshpande, M., Mallick, D., & Bhatia, R. (2008). An Introduction to Listed Binary Options [internet]. New York: Lehman Brother (cited December 2024). Available from: http://www.cboe.com/institutional/pdf/listedbinaryoptions.pdf
[17] id.investing.com. BBCA Historical Data [internet] (cited December 2024). Available from: https://id.investing.com/equities/bank-central-asia-historical-data