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A Comparison of the Valuation of BMRI Stock Call Options for 2025–2026 Using the Black-Scholes and Binomial Methods

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Abstract

This study compares theoretical European call-option values for PT Bank Mandiri (Persero) Tbk (BMRI) using Black–Scholes and a 12-step Cox–Ross–Rubinstein binomial model across three moneyness scenarios. A descriptive comparative quantitative design analyzed 239 daily closing prices from 1 September 2025 to 1 September 2026 using Microsoft Excel. Daily logarithmic returns produced a standard deviation of 0.021169 and annualized historical volatility of 33.60%. Both models used an initial stock price of IDR 4,600, one-year maturity, 4.75% risk-free rate, and zero dividend yield. Strike prices were IDR 4,600 for at-the-money (ATM), IDR 4,370 for in-the-money (ITM), and IDR 4,830 for out-of-the-money (OTM) options. Black–Scholes estimated respective premiums of IDR 712.18, IDR 826.12, and IDR 611.23, compared with binomial estimates of IDR 699.71, IDR 831.84, and IDR 617.05. Absolute differences were IDR 12.47, IDR 5.72, and IDR 5.82, corresponding to relative deviations of 1.75%, 0.69%, and 0.95%. All differences remained below 2%, with the largest deviation occurring under ATM conditions. The results demonstrate close numerical agreement under standardized assumptions but do not establish accuracy against observed option-market premiums. The comparison offers transparent valuation benchmarks for Indonesian banking equities while remaining limited by constant volatility, excluded dividends, fixed interest rates, and twelve binomial steps.

Keywords: *Binomial Model, Black–Scholes Model, BMRI Stock, Call Option, Historical Volatility.*

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INTRODUCTION

Equity option valuation has become an increasingly relevant component of financial risk management as fluctuations in underlying asset prices complicate investment decisions and the assessment of derivative premiums. Within the Indonesian capital market, banking equities provide a particularly relevant setting because their price movements reflect interactions among monetary conditions, investor expectations, and sector-specific financial risks. Darmawan (2025) examined the volatility of leading Indonesian banking stocks, including BBCA, BBNI, and BMRI, highlighting the relevance of market fluctuations to the assessment of banking-sector investments. Empirical research employing the exponential generalized autoregressive conditional heteroskedasticity model has also addressed the volatility characteristics of BMRI alongside other major Indonesian banking equities (Suhendro & Siddi, 2024). The sensitivity of option valuation to underlying price volatility and asset-price dynamics has received further attention in contemporary financial modelling, demonstrating the importance of appropriate assumptions in theoretical pricing procedures (Chavas et al., 2024). Research applying the Black–Scholes model to call and put options on BCA shares illustrates the relevance of derivative valuation methodologies to Indonesian banking equities (Palbeno & Putri, 2024). These developments establish the need for a systematic examination of how alternative option-pricing models generate theoretical call-option values for PT Bank Mandiri (Persero) Tbk (BMRI) during the 2025–2026 observation period.

Contemporary option-pricing research has developed through the refinement of continuous-time analytical models and discrete-time computational approaches, particularly the Black–Scholes and binomial frameworks. The Black–Scholes model derives theoretical European option values under specified stochastic assumptions, whereas the binomial approach represents possible stock-price movements through successive upward and downward branches before determining option values by backward induction. Research incorporating implied volatility into binomial-tree calculations has contributed to the methodological development of stock-option valuation and the examination of

volatility-sensitive pricing mechanisms (Alfajriyah et al., 2024). Alternative specifications of upward and downward price movements have also been investigated through intuitionistic fuzzy-number representations, extending the methodological treatment of uncertainty in binomial valuation (de Andrés-Sánchez, 2024). Comparative research has further evaluated conventional option-pricing formulations alongside alternative approaches, including the Bachelier model and artificial neural networks, demonstrating the continuing relevance of model selection in financial valuation (Gross et al., 2025). Empirical applications comparing Black–Scholes and binomial approaches to Nvidia stock-option contracts provide additional evidence of the use of these methods in individual-equity valuation (Dewi et al., 2023). The existing literature consequently offers an established mathematical foundation for comparative option pricing, although differences in underlying assets, pricing specifications, and empirical settings complicate the direct transfer of findings across financial markets.

Research concerning Indonesian financial instruments has progressively extended option-pricing applications to individual banking equities and broader market indices. Comparative valuation of Asian options on BBCA shares has employed binomial and Black–Scholes approaches, although the path-dependent payoff structure of Asian options differs from that of conventional European call contracts (Antoro & Irsan, 2025). Studies applying Black–Scholes pricing to BCA call and put options have established an individual-bank application without directly providing a corresponding comparative valuation framework for BMRI under identical model inputs (Palbeno & Putri, 2024). Comparative analysis involving Indonesia Composite Index options has similarly addressed binomial and Black–Scholes valuation at the market-index level rather than specifically examining the price behaviour of call options written on an individual state-owned banking equity (Zahrah et al., 2025). Research examining Nvidia stock-option contracts broadens the empirical scope of model comparison but operates within a different underlying asset and market environment (Dewi et al., 2023). These differences reveal a contextual and methodological research gap concerning the comparative theoretical valuation of European-style BMRI call options during 2025–2026 under consistent input assumptions and alternative moneyness conditions. The unresolved issue is not the availability of established option-pricing models, but the extent to which their estimated values differ when applied systematically to the same Indonesian banking stock across at-the-money, in-the-money, and out-of-the-money scenarios.

The absence of an asset-specific comparison may limit the interpretation of theoretical BMRI call-option premiums, particularly when model outputs are used as analytical benchmarks for financial decision-making. Banking-stock volatility warrants explicit consideration because differences in market conditions can influence the historical price behaviour of BMRI and comparable Indonesian banking equities (Darmawan, 2025). Research examining EGARCH-based volatility patterns in BMRI, BBCA, and BRIS provides an empirical basis for treating the estimation of volatility as a substantive component of banking-stock analysis rather than a purely mechanical parameter-selection exercise (Suhendro & Siddi, 2024). The relationship between price dynamics, volatility assumptions, and derivative valuation further indicates that the interpretation of option premiums requires attention to the stochastic characteristics embedded in pricing models (Chavas et al., 2024). Existing applications of Black–Scholes valuation to Indonesian banking shares demonstrate the practical relevance of theoretical call-option pricing but do not independently establish the magnitude of differences between continuous-time and discrete-time estimates for BMRI (Palbeno & Putri, 2024). A controlled comparison is therefore warranted to clarify whether model-implied pricing differences vary across strike-price conditions and to provide a transparent computational basis for evaluating alternative valuation procedures without assuming that either model necessarily reproduces observable market premiums.

The present study is positioned as an asset-specific and scenario-based comparative investigation rather than an attempt to introduce an alternative theoretical option-pricing formulation. Previous research incorporating implied volatility into binomial-tree pricing provides a methodological reference, whereas the present investigation emphasizes consistent parameterization when comparing binomial and Black–Scholes values for a common underlying equity (Alfajriyah et al., 2024). Unlike methodological extensions that represent binomial upward and downward movements through intuitionistic fuzzy numbers, the proposed analysis employs the conventional Cox–Ross–Rubinstein framework to maintain computational transparency and facilitate replication (de Andrés-Sánchez, 2024). The selection of European-style BMRI call options also distinguishes the investigation from comparative pricing applications involving path-dependent Asian options on BBCA shares (Antoro &

Irsan, 2025). Relative to comparative research examining options on the Indonesia Composite Index, the proposed analysis focuses on a specific banking equity and explicitly differentiates at-the-money, in-the-money, and out-of-the-money strike-price scenarios (Zahrah et al., 2025). The methodological design combines Black–Scholes analytical valuation with a 12-step monthly binomial tree over the specified 2025–2026 analytical period, using corresponding inputs to permit direct examination of differences between theoretical option values. The proposed novelty consists of integrating a BMRI-specific valuation setting, an explicitly defined temporal scope, standardized computational assumptions, and moneyness-based comparisons within a reproducible analytical framework that directly addresses the identified contextual and methodological gap.

This study aims to estimate and compare the theoretical values of European-style call options on BMRI shares during the 2025–2026 analytical period using the Black–Scholes model and the 12-step Cox–Ross–Rubinstein binomial method. The analysis applies consistent underlying stock-price information, exercise-price specifications, risk-free interest-rate assumptions, volatility estimates, and time-to-maturity parameters to establish comparability between the two valuation procedures. Call-option values are calculated separately for at-the-money, in-the-money, and out-of-the-money conditions to determine how differences between theoretical pricing estimates vary across exercise-price scenarios. The comparative evaluation examines absolute and relative valuation differences while presenting the binomial stock-price tree and backward-induction procedure to support computational transparency and reproducibility. Model outputs are interpreted as theoretical valuations rather than direct evidence of empirical pricing accuracy in the absence of independently observed option-market premiums. The scientific contribution lies in extending established option-pricing applications to a systematically defined BMRI valuation setting while clarifying the implications of continuous-time and discrete-time modelling choices for different moneyness conditions. The practical contribution consists of providing a structured analytical reference for investors, financial analysts, and researchers evaluating theoretical derivative prices and the sensitivity of valuation outcomes to alternative computational approaches.

RESEARCH METHODS

This study employed a descriptive, comparative quantitative design to evaluate European-style call options on PT Bank Mandiri (Persero) Tbk (BMRI), a banking equity previously examined in research on Indonesian banking-stock volatility (Darmawan, 2025). The population and sample comprised all trading-day observations recorded in the historical BMRI stock-price dataset from 1 September 2025 to 1 September 2026, including trading dates, opening prices, highest and lowest prices, closing prices, trading volumes, and percentage price changes. Data preparation involved removing title and summary rows, converting Indonesian-formatted numerical values into appropriate formats, arranging observations chronologically, and checking missing values, duplicate records, and inconsistencies among daily price variables. Daily logarithmic returns were calculated from consecutive closing prices, while historical volatility was annualized using 252 trading days, producing a daily sample standard deviation of 0.021169 and an annualized volatility of 0.336043654 (33.60%), consistent with the relevance of banking-stock volatility examined by Suhendro and Siddi (2024). Historical volatility was incorporated as a principal valuation parameter because theoretical option prices are sensitive to underlying asset-price dynamics and fluctuations (Chavas et al., 2024). Microsoft Excel was employed to calculate returns and volatility using the LN and STDEV.S functions, supporting the computational approach applied in binomial-tree valuation research (Alfajriyah et al., 2024). Daily logarithmic returns and annualized historical volatility were calculated as follows:

(1) Historical Return and Volatility

$$R_t = \ln\left(\frac{S_t}{S_{t-1}}\right)$$

$$\sigma = s\sqrt{252}$$

Where R_t denotes the daily logarithmic return, S_t and S_{t-1} represent consecutive BMRI closing prices, s denotes the sample standard deviation of daily returns, and σ represents annualized historical volatility.

The valuation parameters comprised an initial stock price (S_0) of IDR 4,600 based on the closing price on 1 September 2026, a one-year maturity (T = 1), a risk-free rate of 4.75%, annualized volatility of 33.60%, and a zero dividend yield, with strike prices of IDR 4,370 (ITM), IDR 4,600 (ATM), and IDR 4,830 (OTM). European call-option values were estimated using the Black–Scholes model under the specified valuation parameters, consistent with comparative option-pricing research involving Indonesian financial instruments (Zahrah et al., 2025). The Cox–Ross–Rubinstein binomial model was implemented using 12 monthly steps, with stock-price movements and risk-neutral probabilities determined using the same volatility and interest-rate assumptions (Subartini et al., 2021). Terminal call-option payoffs were calculated at maturity and discounted through backward induction to obtain initial option values, following discrete-time valuation procedures employed in comparative option-pricing applications (Antoro & Irsan, 2025). Both methods were implemented in Microsoft Excel, and pricing differences were evaluated using absolute deviations and percentages relative to the Black–Scholes estimates. The comparison covered ATM, ITM, and OTM scenarios to examine the influence of alternative computational approaches on theoretical option values, consistent with contemporary comparative option-pricing research (Gross et al., 2025). The Black–Scholes European call-option value was determined using the following formulation:

(2) Black–Scholes Model

$$C = S_0 e^{-qT} N(d_1) - K e^{-rT} N(d_2)$$

$$d_1 = \frac{\ln(S_0/K) + \left(r - q + \frac{\sigma^2}{2}\right) T}{\sigma\sqrt{T}}$$

$$d_2 = d_1 - \sigma\sqrt{T}$$

Where C denotes the theoretical call-option value, S_0 represents the initial stock price, K is the strike price, r is the risk-free rate, q is the continuous dividend yield (set to zero), T represents time to maturity, σ denotes annualized historical volatility, and $N(\cdot)$represents the cumulative standard normal distribution.

(3) Binomial Model Parameters

$$\Delta t = \frac{T}{n}$$

$$u = e^{\sigma\sqrt{\Delta t}}, \qquad d = e^{-\sigma\sqrt{\Delta t}}$$

$$p = \frac{e^{(r-q)\Delta t} - d}{u - d}$$

Where $n = 12$, Δt represents the time interval, u and d denote the upward and downward stock-price factors, respectively, and p represents the risk-neutral probability of an upward movement.

(4) Binomial Option Valuation

Terminal payoff:

$$C_{n,j} = \max\left(S_{n,j} - K, 0\right)$$

Backward induction:

$$C_{i,j} = e^{-r\Delta t}\left[pC_{i+1,j+1} + (1-p)C_{i+1,j}\right]$$

Where $C_{n,j}$ represents the terminal call-option payoff, $S_{n,j}$ denotes the terminal stock price, and $C_{i,j}$ represents the option value at node (i, j), with j indicating the number of upward movements.

(5) Percentage Pricing Difference

$$\text{Percentage Difference} = \frac{|C_{\text{Bin}} - C_{\text{BS}}|}{C_{\text{BS}}} \times 100\%$$

Where C_{Bin} denotes the binomial call-option value and C_{BS} represents the Black–Scholes call-option value. The numerator represents the absolute difference between the two model valuations in IDR per share.

RESULTS AND DISCUSSION

BMRI Stock Returns, Volatility, and Black–Scholes Call-Option Valuation

Historical stock-price movements provide the empirical foundation for evaluating the theoretical value of call options on PT Bank Mandiri (Persero) Tbk (BMRI) during the 2025–2026 observation period. The dataset comprises 239 daily closing-price observations recorded between 1 September 2025 and 1 September 2026, representing the underlying market information used to estimate returns and volatility. BMRI recorded a closing price of IDR 4,320 at the beginning of the observation period and IDR 4,600 at the end, indicating a net price increase of IDR 280 per share despite fluctuations during the intervening trading sessions. The difference between the initial and final prices provides an indication of the direction of price movements but does not adequately represent the variability experienced throughout the observation period. Research examining Indonesian banking equities has identified stock-price volatility as a relevant characteristic of BMRI and other major banking stocks, particularly when assessing market conditions and investment risk (Darmawan, 2025). The importance of examining return fluctuations is reinforced by evidence that Indonesian banking stocks exhibit volatility dynamics requiring systematic quantitative assessment rather than reliance on changes between two observation dates (Suhendro & Siddi, 2024). These characteristics establish the empirical basis for calculating daily returns, estimating annualized volatility, and identifying the principal market parameters required for subsequent call-option valuation.

Daily logarithmic returns were calculated using consecutive BMRI closing prices to measure proportional changes in stock value across trading sessions. The resulting mean daily return was 0.000264, equivalent to approximately 0.0264%, indicating a relatively small average positive movement during the observation period. The sample standard deviation of daily returns reached 0.021169, demonstrating that the dispersion of daily observations was substantially greater than their arithmetic average. This distinction is relevant because option valuation depends on the variability of the underlying asset rather than exclusively on its average historical return, as emphasized in research concerning volatility and option-price dynamics (Chavas et al., 2024). Annualization using the square root of 252 assumed trading days produced a historical volatility estimate of 0.336043, equivalent to approximately 33.60%. The complete descriptive statistics, including the observation period, initial and final closing prices, average daily return, standard deviation, and annualized volatility, are presented in Table 1.

Table 1. BMRI Stock Return and Volatility Statistics

Description	Value
Data period	1 September 2025 to 1 September 2026
Number of daily closing prices	239
Closing price on 1 September 2025	IDR 4,320
Closing price on 1 September 2026	IDR 4,600
Mean daily return	0.000264
Standard deviation of daily returns (s)	0.021169
Annualized volatility ($\sigma = s \times \sqrt{252}$)	0.336043 (33.60%)

Source: Investing.com data processed using Microsoft Excel (2026).

The descriptive results in Table 1 indicate that BMRI experienced substantially greater daily return dispersion than its average daily appreciation throughout the observation period. The mean daily return of 0.000264 was considerably smaller than the standard deviation of 0.021169, suggesting that the magnitude of daily fluctuations cannot be adequately characterized by the average return alone.

Annualized historical volatility of 33.60% represents the estimated standard deviation of returns over a one-year horizon under the conventional square-root-of-time scaling assumption, rather than a forecast of a specific future price movement. The relevance of this parameter is particularly pronounced in call-option valuation because higher assumed volatility generally increases the possibility of substantial positive terminal payoffs while the holder's exercise payoff remains bounded below by zero. Empirical research employing the EGARCH framework for BBCA, BMRI, and BRIS demonstrates the relevance of examining time-varying volatility characteristics in Indonesian banking equities (Suhendro & Siddi, 2024). Methodological developments in binomial-tree pricing have also emphasized the importance of volatility specification, including the use of implied volatility as an alternative to historical estimates (Alfajriyah et al., 2024). The estimated annualized volatility of 0.336043654 was consequently retained as a common input in both valuation models to ensure that subsequent pricing differences reflected the respective computational approaches rather than inconsistent volatility assumptions.

The risk-free interest rate constitutes another essential valuation parameter because it determines the discounting of future contractual cash flows under risk-neutral pricing assumptions. The study employed the BI Rate as a proxy for the risk-free rate, using monthly observations covering September 2025 through September 2026. The compiled data indicate that the BI Rate remained at 4.75% from September 2025 through April 2026 before increasing to 5.25% in May 2026. Subsequent observations show a further increase to 5.50% in June 2026, followed by a rate of 5.75% from July through September 2026. Interest-rate assumptions are integral to the application of option-pricing models to Indonesian banking shares because they influence the discounting component of theoretical option premiums (Palbeno & Putri, 2024). Table 2 presents the monthly BI Rate observations used to establish the interest-rate assumption for the valuation calculations.

Table 2. BI Rate from September 2025 to September 2026

Month	BI Rate (%)	Month	BI Rate (%)
September 2025	4.75	March 2026	4.75
October 2025	4.75	April 2026	4.75
November 2025	4.75	May 2026	5.25
December 2025	4.75	June 2026	5.50
January 2026	4.75	July 2026	5.75
February 2026	4.75	August 2026	5.75
		September 2026	5.75

Source: Bank Indonesia data compiled by the authors (2026).

The interest-rate observations in Table 2 demonstrate that the compiled BI Rate series remained unchanged for eight consecutive months before increasing during the final portion of the observation period. The valuation procedure adopted an annual risk-free rate of 4.75%, representing the level observed for the longest interval within the historical dataset rather than the final recorded rate of 5.75%. This specification establishes a constant interest-rate assumption for the comparative calculations, although the observed monetary conditions varied over time. Within the Black–Scholes framework, the risk-free rate affects the present value of the exercise price and consequently influences the theoretical premium associated with a European call option (Salami, 2024). Applying an identical rate across the ATM, ITM, and OTM scenarios prevents differences in interest-rate inputs from obscuring the effects associated with the exercise-price structure. The selection nevertheless introduces a methodological limitation because the valuation rate does not incorporate the subsequent increases observed between May and September 2026. Comparative research on option-pricing methodologies emphasizes the importance of consistent model specifications when evaluating differences between theoretical valuation approaches, supporting the standardized parameterization adopted in this study (Gross et al., 2025).

The Black–Scholes valuation was conducted using an initial BMRI stock price of IDR 4,600, an annualized volatility of 0.336043654, a one-year maturity, and a continuously compounded risk-free rate of 0.0475. Three exercise-price conditions were specified to represent different relationships between the prevailing stock price and the contractual purchase price, namely ATM at IDR 4,600, ITM at IDR 4,370, and OTM at IDR 4,830. The ITM and OTM exercise prices were positioned 5% below

and 5% above the initial stock price, respectively, while the ATM exercise price was equal to the initial market value. Dividend payments were excluded from the analysis, resulting in a continuous dividend yield of zero and allowing the conventional non-dividend-adjusted Black–Scholes formulation to be applied. Previous comparative research on Indonesian financial instruments has employed the Black–Scholes model to estimate theoretical option values under predetermined pricing parameters, providing a methodological reference for the present calculations (Zahrah et al., 2025). Table 3 reports the complete valuation parameters, intermediate normal-distribution calculations, and resulting call-option premiums for each moneyness scenario.

Table 3. Parameters and Call-Option Valuation Results Using Black–Scholes

Component	Symbol	ATM	ITM	OTM
Initial stock price	S_0	4,600	4,600	4,600
Strike price	K	4,600	4,370	4,830
Time to maturity (years)	T	1	1	1
Risk-free interest rate	r	0.0475	0.0475	0.0475
Annualized volatility	σ	0.336043654	0.336043654	0.336043654
Value of d_1	d_1	0.309372510	0.462011293	0.164182552
Value of d_2	d_2	−0.026671144	0.125967639	−0.171861103
Probability $N(d_1)$	$N(d_1)$	0.621480910	0.677963389	0.565206282
Probability $N(d_2)$	$N(d_2)$	0.489361014	0.550121230	0.431773364
Call-option value (IDR)	C	712.18	826.12	611.23

Source: Authors' calculations using Microsoft Excel (2026).

The Black–Scholes calculations presented in Table 3 show that the ITM scenario generated the highest theoretical call-option premium of IDR 826.12, followed by the ATM scenario at IDR 712.18 and the OTM scenario at IDR 611.23. These results indicate an inverse relationship between the exercise price and the theoretical call premium when the underlying stock price, volatility, interest rate, and maturity remain constant. The ITM exercise price of IDR 4,370 provides an immediate intrinsic value of IDR 230 per share, whereas the ATM and OTM scenarios have zero intrinsic value at the valuation date. The corresponding premium differences reflect the combined effects of intrinsic value and the time value associated with the probability distribution of future stock prices. The ITM scenario also produced the highest $N(d_1)$ value of 0.677963389, indicating greater sensitivity of the theoretical call premium to changes in the underlying stock price under the zero-dividend Black–Scholes specification. The ATM and OTM scenarios recorded $N(d_1)$ values of 0.6214809104 and 0.5652062817, respectively, consistent with the declining call-price sensitivity as the exercise price increases. Empirical applications of Black–Scholes valuation to Indonesian banking equities similarly demonstrate the analytical significance of exercise-price conditions in determining theoretical call-option premiums (Palbeno & Putri, 2024).

The variation in theoretical premiums across the three moneyness scenarios illustrates the importance of distinguishing contractual exercise-price conditions when evaluating call options on individual banking equities. The difference between the ITM premium of IDR 826.12 and the OTM premium of IDR 611.23 reflects the effect of changing the exercise price while maintaining all other valuation inputs at identical levels. The ATM estimate of IDR 712.18 provides an intermediate benchmark because its exercise price corresponds exactly to the initial BMRI stock price of IDR 4,600. Research examining the interaction between volatility and asset-price dynamics indicates that the interpretation of option premiums requires attention to the assumptions governing the possible distribution of underlying asset prices (Chavas et al., 2024). Comparative valuation research involving Indonesia Composite Index options further supports the application of established analytical pricing models to Indonesian financial-market instruments, although index-based results are not directly interchangeable with individual-equity valuations (Zahrah et al., 2025). The reported estimates should be interpreted as theoretical prices derived from the specified historical volatility, constant interest rate, one-year maturity, and zero-dividend assumptions rather than as observed transaction prices or independently validated market premiums.

BMRI Call-Option Valuation Using the 12-Step Binomial Model

The Cox–Ross–Rubinstein (CRR) binomial model was applied to estimate the theoretical value of European-style call options on BMRI shares through a discrete-time representation of possible stock-price movements. Unlike the Black–Scholes model, which derives option values analytically under continuous-time assumptions, the binomial approach constructs successive price movements and determines the present option value through backward induction. The valuation employed an initial BMRI stock price of IDR 4,600, an annualized volatility of 0.336043654, a one-year maturity, and a constant risk-free interest rate of 4.75%, maintaining consistency with the Black–Scholes calculations. Three exercise-price scenarios were retained, comprising IDR 4,370 for in-the-money (ITM), IDR 4,600 for at-the-money (ATM), and IDR 4,830 for out-of-the-money (OTM) call options. Previous research has demonstrated the applicability of binomial-tree methods to stock-option valuation, particularly when volatility is incorporated into the construction of upward and downward price movements (Alfajriyah et al., 2024). The application of identical valuation parameters across the three scenarios allows the resulting differences in option premiums to be interpreted in relation to the exercise-price structure rather than changes in the underlying modelling assumptions.

The binomial valuation divided the one-year maturity into 12 equal intervals, with each interval representing approximately one month or 0.083333 years. The upward stock-price factor was estimated at 1.101869, indicating that the simulated stock price increases by approximately 10.19% following an upward movement. The corresponding downward factor was 0.907549, representing a price reduction of approximately 9.25% following a downward movement. Risk-neutral probabilities were calculated at 0.496178 for upward movements and 0.503822 for downward movements, with the two probabilities summing to one. These probabilities represent mathematical weights used to determine discounted expected option payoffs rather than empirical forecasts of actual stock-price movements. The use of risk-neutral probabilities and backward-induction procedures is consistent with established binomial option-pricing applications, including comparative evaluations of binomial and Black–Scholes valuation methods (Subartini et al., 2021). Table 4 presents the complete parameters used to construct the 12-step binomial valuation model.

Table 4. Parameters of the 12-Step Binomial Model

Parameter	Symbol	Value
Initial stock price	S_0	4,600
Time to maturity (years)	T	1
Number of steps	n	12
Risk-free interest rate	r	0.0475
Annualized volatility	σ	0.336043654
Time interval	Δt	0.083333
Upward factor	u	1.101869
Downward factor	d	0.907549
Risk-neutral upward probability	p	0.496178
Risk-neutral downward probability	1 − p	0.503822

Source: Authors' calculations using Microsoft Excel (2026).

The parameters presented in Table 4 provide the mathematical foundation for constructing possible BMRI stock-price movements over the twelve-month valuation horizon. Each price movement is generated by multiplying the preceding stock price by either the upward factor of 1.101869 or the downward factor of 0.907549, producing a recombining binomial tree. The reciprocal relationship between these factors allows a sequence containing equal numbers of upward and downward movements to return to the initial stock-price level. This characteristic reduces the number of distinct price nodes required at successive periods and supports the computational efficiency of the binomial valuation procedure. Research on alternative representations of upward and downward movements demonstrates that the specification of these factors constitutes an important methodological component of binomial option-pricing models (de Andrés-Sánchez, 2024). The resulting stock-price tree provides a structured representation of potential price outcomes under the model assumptions without implying that the simulated values constitute observed or independently forecast market prices.

The initial stock-price tree begins with a single valuation node of IDR 4,600 at t = 0, corresponding to the BMRI closing price used as the underlying asset value. Following the first monthly interval, the simulated price increases to IDR 5,068.60 under the upward scenario or decreases to IDR 4,174.73 under the downward scenario. At t = 2, the recombining structure produces three distinct stock-price nodes, including the original IDR 4,600 level generated by one upward and one downward movement. The number of possible price nodes subsequently increases by one at each time step, creating seven distinct stock-price outcomes at t = 6. The uppermost price at the sixth interval reaches IDR 8,232.59, whereas the lowest price declines to IDR 2,570.27, illustrating the widening range of simulated outcomes over longer horizons. Research examining binomial and trinomial option-pricing methods has established the importance of discrete stock-price structures in representing alternative valuation paths and their relationship to continuous-time pricing formulations (Josheski & Apostolov, 2020). The detailed sequence of BMRI stock-price movements from the initial valuation date through the sixth monthly interval is presented in Table 5.

Table 5. BMRI Stock-Price Tree for Steps t = 0 to t = 6 (IDR)

Nodes	t = 0	t = 1	t = 2	t = 3	t = 4	t = 5	t = 6
Node 1	4600.00	5068.60	5584.93	6153.85	6780.74	7471.48	8232.59
Node 2		4174.73	4600.00	5068.60	5584.93	6153.85	6780.74
Node 3			3788.77	4174.73	4600.00	5068.60	5584.93
Node 4				3438.50	3788.77	4174.73	4600.00
Node 5					3120.60	3438.50	3788.77
Node 6						2832.10	3120.60
Node 7							2570.27

Source: Authors' calculations using Microsoft Excel (2026).

The stock-price movements presented in Table 5 demonstrate the progressive expansion of possible BMRI price outcomes as additional monthly intervals are incorporated into the binomial structure. The subsequent six intervals extend the simulation from t = 7 to t = 12, completing the one-year maturity specified in the valuation procedure. At expiration, the uppermost terminal stock price reaches IDR 14,733.82, whereas the lowest terminal stock price declines to IDR 1,436.15, producing a substantial range of hypothetical outcomes under the assumed volatility. The seventh terminal node records a stock price of IDR 4,600 because its corresponding paths contain equal numbers of upward and downward movements, resulting in an unchanged price relative to the initial valuation date. This distribution of terminal stock-price nodes is directly relevant to option valuation because the relationship between each terminal price and the contractual exercise price determines whether the call option produces a positive payoff. The importance of modelling upward and downward price movements is also reflected in recent methodological research examining extensions of binomial option-pricing frameworks under uncertainty (de Andrés-Sánchez, 2024). Table 6 presents the continuation of the stock-price tree from the seventh through the twelfth monthly interval.

Table 6. BMRI Stock-Price Tree for Steps t = 7 to t = 12 (IDR)

Nodes	t = 7	t = 8	t = 9	t = 10	t = 11	t = 12
Node 1	9071.24	9995.31	11013.52	12135.45	13371.67	14733.82
Node 2	7471.48	8232.59	9071.24	9995.31	11013.52	12135.45
Node 3	6153.85	6780.74	7471.48	8232.59	9071.24	9995.31
Node 4	5068.60	5584.93	6153.85	6780.74	7471.48	8232.59
Node 5	4174.73	4600.00	5068.60	5584.93	6153.85	6780.74
Node 6	3438.50	3788.77	4174.73	4600.00	5068.60	5584.93
Node 7	2832.10	3120.60	3438.50	3788.77	4174.73	4600.00
Node 8	2332.65	2570.27	2832.10	3120.60	3438.50	3788.77
Node 9		2116.99	2332.65	2570.27	2832.10	3120.60
Node 10			1921.28	2116.99	2332.65	2570.27

Node 11	1743.65	1921.28	2116.99
Node 12		1582.45	1743.65
Node 13			1436.15

Source: Authors' calculations using Microsoft Excel (2026).

The terminal stock prices reported in Table 6 were subsequently used to calculate the expiration payoffs of BMRI call options under the ATM, ITM, and OTM exercise-price conditions. Each terminal payoff was determined as the greater of zero and the difference between the simulated terminal stock price and the corresponding exercise price. This payoff structure ensures that the option holder receives a positive exercise payoff only when the underlying stock price exceeds the contractual strike price at maturity. The highest terminal stock price of IDR 14,733.82 generates payoffs of IDR 10,133.82 for ATM, IDR 10,363.82 for ITM, and IDR 9,903.82 for OTM options. Discounted backward induction produces initial theoretical call-option values of IDR 699.71 for ATM, IDR 831.84 for ITM, and IDR 617.05 for OTM. The relationship between strike prices, terminal stock values, and option payoffs is consistent with the mathematical principles underlying binomial-based option valuation, including applications involving alternative stock-option contract structures (Silalahi et al., 2026). Table 7 reports the complete terminal payoff calculations and the corresponding binomial option values at the initial valuation date.

Table 7. Terminal Call-Option Payoffs and Option Values at t = 0 (IDR)

Nodes (t = 12)	Stock price	ATM (K = 4,600)	ITM (K = 4,370)	OTM (K = 4,830)
Node 1	14733.82	10133.82	10363.82	9903.82
Node 2	12135.45	7535.45	7765.45	7305.45
Node 3	9995.31	5395.31	5625.31	5165.31
Node 4	8232.59	3632.59	3862.59	3402.59
Node 5	6780.74	2180.74	2410.74	1950.74
Node 6	5584.93	984.93	1214.93	754.93
Node 7	4600.00	0.00	230.00	0.00
Node 8	3788.77	0.00	0.00	0.00
Node 9	3120.60	0.00	0.00	0.00
Node 10	2570.27	0.00	0.00	0.00
Node 11	2116.99	0.00	0.00	0.00
Node 12	1743.65	0.00	0.00	0.00
Node 13	1436.15	0.00	0.00	0.00
Option value at t = 0		699.71	831.84	617.05

Source: Authors' calculations using Microsoft Excel (2026).

The terminal payoff distribution in Table 7 indicates that Nodes 1 through 6 generate positive call-option payoffs under all three exercise-price scenarios because their simulated stock prices exceed the corresponding strike prices. Nodes 8 through 13 produce zero payoffs across all scenarios because their terminal prices remain below the lowest exercise price of IDR 4,370. The seventh terminal node represents a distinctive valuation condition because its stock price of IDR 4,600 produces zero payoffs for ATM and OTM options but generates an ITM payoff of IDR 230. Consequently, the ITM scenario contains seven positive terminal payoff nodes, whereas the ATM and OTM scenarios each contain six positive nodes. The differences demonstrate that the positioning of the strike price relative to discrete terminal stock-price nodes determines the number of positive payoff outcomes within the binomial tree. Previous research on European-style option valuation using binomial methods similarly identifies the underlying stock price, exercise price, volatility, and discrete price-movement parameters as fundamental determinants of theoretical option premiums (Maulida et al., 2019).

The final binomial option values were obtained by applying backward induction from the thirteen terminal payoff nodes at t = 12 to the single valuation node at t = 0. At each preceding interval, the option value was calculated as the discounted probability-weighted average of the two possible subsequent option values, using an upward probability of 0.496178 and a downward probability of

0.503822. For the ATM scenario, the calculated option values at t = 1 were IDR 981.28 for the upward branch and IDR 427.93 for the downward branch, which yielded an initial theoretical premium of IDR 699.71 after discounting. Applying the same procedure to the ITM and OTM scenarios generated respective initial values of IDR 831.84 and IDR 617.05, maintaining the expected ordering of option premiums according to exercise-price conditions. The highest premium occurred in the ITM scenario because its lower exercise price produces a larger payoff at each terminal node where the call option is exercised. Research examining binomial-tree valuation has established backward induction as a central computational procedure for determining present option values from terminal payoff distributions (Subartini et al., 2021). These findings provide three directly comparable binomial estimates at the initial valuation date, establishing the numerical basis for evaluating differences against the Black–Scholes results under identical stock-price, volatility, maturity, and risk-free interest-rate assumptions.

Comparative Analysis of Black–Scholes and Binomial Valuation Results

The comparative valuation of BMRI call options was conducted to identify differences between the theoretical premiums generated by the Black–Scholes and Cox–Ross–Rubinstein (CRR) binomial models under identical financial assumptions. Both approaches employed an initial stock price of IDR 4,600, annualized historical volatility of 33.60%, a one-year maturity, a risk-free interest rate of 4.75%, and a zero dividend yield. The comparison incorporated three exercise-price conditions, comprising at-the-money (ATM), in-the-money (ITM), and out-of-the-money (OTM) scenarios, to determine whether differences between model estimates varied according to moneyness. The Black–Scholes model produced theoretical prices through a continuous-time analytical formulation, whereas the 12-step binomial model calculated discounted expected option payoffs through a discrete stock-price tree. Standardizing the valuation parameters ensured that the observed pricing deviations could be examined in relation to the computational characteristics of the two models rather than differences in underlying financial inputs. Comparative investigations of option-pricing models have emphasized the importance of examining differences among analytical and computational approaches when evaluating theoretical derivative values (Gross et al., 2025). Empirical applications involving individual equity-option contracts also demonstrate the relevance of comparing Black–Scholes and binomial estimates under specified market conditions and contractual characteristics (Dewi et al., 2023).

The Black–Scholes model generated an ATM call-option value of IDR 712.18, whereas the 12-step binomial model produced a corresponding estimate of IDR 699.71. Under the ITM condition, the theoretical premium reached IDR 826.12 using Black–Scholes and IDR 831.84 using the binomial method. The OTM scenario produced values of IDR 611.23 and IDR 617.05 under the respective valuation procedures. These estimates indicate that the ordering of option premiums remained consistent across both models, with ITM producing the highest value, ATM occupying the intermediate position, and OTM generating the lowest premium. The differences between the estimates demonstrate that identical financial assumptions do not necessarily generate identical option values when the models employ distinct mathematical representations of possible stock-price movements. Previous comparative research involving Asian options on BBCA shares also illustrates the relevance of evaluating differences between binomial and Black–Scholes valuation procedures, although the contractual payoff structure differs from the European-style call options examined here (Antoro & Irsan, 2025).

The magnitude of pricing differences was evaluated using absolute deviations expressed in Indonesian rupiah and percentage deviations calculated relative to the corresponding Black–Scholes estimates. The ATM scenario generated the largest absolute difference of IDR 12.47, equivalent to 1.75% of its Black–Scholes value. The ITM scenario recorded the smallest absolute difference of IDR 5.72, representing a percentage deviation of 0.69%. The OTM scenario produced an absolute difference of IDR 5.82 and a corresponding percentage deviation of 0.95%. These results indicate that the magnitude of disagreement between the two models differed across exercise-price conditions despite the use of consistent volatility, maturity, interest-rate, and underlying stock-price assumptions. Comparative valuation research involving options on the Indonesia Composite Index provides a relevant methodological reference for examining differences between binomial and Black–Scholes pricing estimates within Indonesian financial-market applications (Zahrah et al., 2025). Table 8 presents the complete comparison of theoretical call-option values, absolute pricing deviations, and percentage differences across the three moneyness scenarios.

Table 8. Comparison of Black–Scholes and Binomial Call-Option Prices

Scenario	Strike Price (IDR)	Black–Scholes (IDR)	12-Step Binomial (IDR)	Absolute Difference (IDR)	Difference (%)
ATM	4,600	712.18	699.71	12.47	1.75
ITM	4,370	826.12	831.84	5.72	0.69
OTM	4,830	611.23	617.05	5.82	0.95

Source: Authors' calculations using Microsoft Excel (2026).

The results presented in Table 8 demonstrate that the largest relative pricing deviation occurred in the ATM scenario, where the binomial estimate was 1.75% lower than the Black–Scholes value. The ITM scenario exhibited the smallest relative deviation of 0.69%, with the binomial premium exceeding the corresponding Black–Scholes estimate by IDR 5.72. A similar direction was observed in the OTM scenario, where the binomial model generated a premium IDR 5.82 higher than the Black–Scholes estimate, corresponding to a difference of 0.95%. The direction of pricing deviations therefore differed across moneyness conditions, indicating that the discrete-time model did not systematically overestimate or underestimate the continuous-time valuation results within the three examined scenarios. All percentage differences remained below 2%, indicating relatively close numerical agreement between the two valuation procedures under the specified model assumptions and twelve-step configuration. Research examining binomial-tree pricing with volatility-based parameterization provides a methodological basis for interpreting such differences as part of the numerical relationship between discrete-time and continuous-time option-pricing formulations (Alfajriyah et al., 2024).

The variation in pricing deviations across moneyness conditions can be examined through the relationship between contractual exercise prices and the terminal stock-price nodes generated by the binomial model. In the ATM scenario, the exercise price of IDR 4,600 coincided exactly with the seventh terminal node, producing a zero payoff because the terminal stock price equalled the contractual purchase price. The next higher terminal node recorded a stock price of IDR 5,584.93, leaving intermediate terminal prices between IDR 4,600 and IDR 5,584.93 unrepresented within the discrete twelve-step structure. The ITM exercise price of IDR 4,370 was positioned between terminal stock prices of IDR 3,788.77 and IDR 4,600, allowing the seventh terminal node to generate a positive payoff of IDR 230. The OTM exercise price of IDR 4,830 was located between the seventh and sixth terminal nodes, generating a zero payoff at IDR 4,600 and a positive payoff of IDR 754.93 at IDR 5,584.93. These differences in terminal-node positioning provide a plausible explanation for the observed variation in pricing deviations, although the results do not independently establish that node alignment is the sole determinant of differences between the two models. Research examining the convergence of binomial and trinomial pricing formulations toward Black–Scholes values demonstrates that discrete time-step specifications influence numerical valuation outcomes and should be considered when interpreting model differences (Josheski & Apostolov, 2020).

The annualized historical volatility of 33.60% constitutes a central parameter underlying the theoretical premiums generated by both valuation approaches. Within the binomial model, this volatility estimate produced an upward factor of 1.101869 and a downward factor of 0.907549, generating terminal stock prices ranging from IDR 1,436.15 to IDR 14,733.82. Research examining the relationship between volatility, price dynamics, and option valuation demonstrates that the specification of underlying asset-price uncertainty remains fundamental to the interpretation of theoretical derivative prices (Chavas et al., 2024). The assumed risk-free rate of 4.75% also influenced both valuation models, although the historical BI Rate observations increased to 5.75% toward the end of the observation period. Maintaining constant volatility and interest-rate assumptions enabled a controlled comparison but limited the ability of the calculations to represent changes in market conditions throughout the valuation horizon. Empirical analysis of BBCA, BMRI, and BRIS using the EGARCH approach illustrates the relevance of volatility dynamics in Indonesian banking equities and supports consideration of alternative volatility specifications in subsequent valuation research (Suhendro & Siddi, 2024).

The comparative findings provide a theoretical pricing reference for investors and financial analysts assessing European-style call options on BMRI shares under the specified contractual and market assumptions. For the ATM scenario, the estimated premiums ranged from IDR 699.71 under

the binomial model to IDR 712.18 under Black–Scholes, indicating a relatively narrow numerical difference between the two procedures. The Black–Scholes approach offers a direct analytical calculation, while the binomial method provides additional computational transparency by illustrating possible stock-price movements, terminal payoffs, and backward-induction values. These characteristics allow the two models to serve as complementary analytical benchmarks rather than necessarily competing representations of a single observable market premium. Comparative research examining Black–Scholes and binomial valuation for stock-option contracts has highlighted the relevance of contractual characteristics and maturity conditions when interpreting differences between model estimates (Hanifa et al., 2025). Empirical examination of the Black–Scholes framework further emphasizes the distinction between theoretical option-pricing outputs and assessments of pricing performance based on actual financial-market observations (Salami, 2024). The present findings should consequently be interpreted as evidence of numerical agreement between theoretical models under controlled assumptions, rather than confirmation of their empirical accuracy or the profitability of particular investment strategies.

Several methodological limitations constrain the interpretation and generalizability of the comparative valuation results. Historical volatility was estimated using observations from a single annual period and treated as constant throughout the one-year option maturity, preventing the model from explicitly incorporating changes in volatility conditions over time. Dividend payments were excluded, the risk-free rate was fixed at 4.75% despite subsequent movements in the BI Rate, and the binomial implementation employed only twelve monthly steps. Subsequent research could examine alternative volatility specifications, including GARCH-based modelling approaches previously applied to option-pricing comparisons involving Indonesian capital-market instruments (Hendrawan et al., 2020). Further methodological extensions could incorporate dividend-sensitive valuation assumptions, investigate a larger number of binomial steps, and assess the implications of alternative option-pricing formulations for the estimated premiums (Cherubini & Mulinacci, 2026). The absence of observed BMRI option-market premiums also prevented direct empirical validation of pricing accuracy, indicating that the principal contribution of the present investigation lies in its reproducible comparison of Black–Scholes and binomial theoretical values across ATM, ITM, and OTM conditions.

CONCLUSION

This study establishes that BMRI stock exhibited annualized historical volatility of 33.60% during 1 September 2025–1 September 2026, based on 239 daily closing-price observations. Using an initial stock price of IDR 4,600, a one-year maturity, a risk-free rate of 4.75%, and a zero dividend yield, the Black–Scholes model produced theoretical European call-option values of IDR 712.18 for ATM, IDR 826.12 for ITM, and IDR 611.23 for OTM. Under identical assumptions, the 12-step Cox–Ross–Rubinstein binomial model yielded IDR 699.71, IDR 831.84, and IDR 617.05 for the respective scenarios. Absolute pricing deviations amounted to IDR 12.47 for ATM, IDR 5.72 for ITM, and IDR 5.82 for OTM. Their corresponding relative differences were 1.75%, 0.69%, and 0.95%, indicating numerical agreement below 2% across all three scenarios. Both models assigned the highest call premium to the ITM scenario and the lowest to the OTM scenario, confirming consistent moneyness-related pricing patterns under standardized valuation parameters. The relatively larger ATM deviation is plausibly associated with the exercise price coinciding with a zero-payoff terminal node in the twelve-step binomial tree, although this explanation was not independently tested using alternative numbers of steps.

The findings contribute a reproducible, asset-specific comparison of continuous-time and discrete-time call-option valuation for BMRI using consistent financial parameters and three moneyness conditions. The Black–Scholes model provides a computationally direct valuation benchmark, whereas the binomial approach enables transparent examination of simulated stock-price movements, terminal payoffs, and backward-induction calculations. The resulting theoretical premium ranges are IDR 699.71–712.18 for ATM, IDR 826.12–831.84 for ITM, and IDR 611.23–617.05 for OTM. These relatively small pricing differences demonstrate agreement between theoretical model estimates but do not establish empirical accuracy against traded option prices or guarantee investment profitability. The findings remain constrained by the assumption of constant historical volatility, the exclusion of dividend payments, the fixed 4.75% risk-free rate despite subsequent BI Rate increases, and the twelve-step binomial specification. The absence of observed BMRI option-market premiums further prevents direct

evaluation of valuation errors against actual market transactions. Future research should examine additional binomial steps, alternative volatility specifications, updated interest-rate assumptions, dividend adjustments, and observable option prices to evaluate pricing sensitivity and empirical accuracy more comprehensively.

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