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Analysis of Factors Influencing Pricing Errors of Option Contracts in the Derivatives Market of the Tehran Securities Exchange

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ABSTRACT

Objective: The rapid expansion of options trading in recent years has increased the need for accurate option pricing models. Although the Black–Scholes–Merton (BSM) model is widely used for valuing option contracts, empirical evidence suggests that it produces pricing errors in real market conditions. This study aims to examine the impact of historical volatility, the in-the-money status of the underlying asset, and time to maturity on the pricing error of the Black–Scholes–Merton model.

Methods: This study uses panel data from option contracts traded over the period 2019–2023. The pricing error is defined as the deviation between theoretical prices obtained from the Black–Scholes–Merton model and observed market prices. Panel data regression analysis is conducted using Stata software to estimate the effects of the selected variables on the model's pricing error. In addition, the Root Mean Square Error (RMSE) is calculated to assess the overall pricing accuracy of the model.

Results: The empirical results show that historical volatility, the in-the-money status of options, and time to maturity all have a positive and statistically significant effect on the pricing error of the Black–Scholes–Merton model. Higher levels of these variables are associated with larger discrepancies between theoretical and market prices. The calculated RMSE of 0.55 indicates a notable difference between model-based estimates and actual option prices.

Conclusion: The findings indicate that the Black–Scholes–Merton model exhibits increasing pricing inaccuracies under real market conditions, particularly for options with higher volatility, in-the-money positions, and longer maturities. These results highlight the limitations of the BSM framework and suggest the need for improved or alternative pricing models.

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1. Introduction

Among the most important financial derivative instruments are options and futures contracts, which are currently traded extensively in financial markets worldwide (Esmailzadeh & Amiri, 2015). The use of financial instruments in the investment world is steadily increasing with three main objectives: risk management, price discovery, and reduction of transaction costs (Behradmehr & Tahmasebi, 2022). Options, as one of the key derivative instruments in global and advanced financial markets, have established their position as an essential tool, widely utilized in most well-known and reputable markets worldwide (Nasiri & Askarzadeh, 2024). An options contract grants the holder the right to buy or sell a specific asset at a predetermined price on or before a specified expiration date. The holder may choose to exercise this right or disregard it (Raei & Saeedi, 2021). In Iran, investment in derivative contracts is relatively new and is considered one of the modern financial instruments. These contracts were first introduced in 2016, and their trading has continued since. The trading volume of options contracts has significantly expanded since 2019. Given the recent growth in options trading, the accurate and precise valuation of these financial instruments has become a crucial topic. As options trading expands both in Iran and globally, ensuring proper pricing with minimal error is of great importance. Selecting an optimal investment portfolio allows investors to maximize their returns by allocating capital to suitable assets (Mohammadi et al., 2023). The Black-Scholes-Merton model is considered a milestone in financial modeling and is employed by leading global stock exchanges, investors, and traders (Kumar & Agrawal, 2017). Despite its widespread use for options pricing, a comparison between theoretical prices derived from the Black-Scholes-Merton model and actual market prices reveals the presence of pricing errors. Uncertainty regarding future economic conditions plays a significant role in financial decision-making (Mohammadi et al., 2023). This study aims to identify key factors contributing to these pricing errors to improve the accuracy of options valuation using the Black-Scholes-Merton model. When applying this model to price options contracts and comparing the results with market prices, discrepancies are evident, indicating the existence of errors within the model. Blind reliance on the model's computed prices, despite the known errors, may mislead investors in making buy or sell decisions, potentially leading to financial losses. Therefore, this study seeks to analyze previous research and identify the variables affecting these price discrepancies. Specifically, it examines whether certain factors influence the deviation between market prices and theoretical prices of options contracts traded on the Tehran Securities Exchange (TSE) derivatives market. Using a panel regression model, this research evaluates the impact of three key variables on the pricing error of the Black-Scholes-Merton model:

- Time to maturity (remaining days until expiration)
- In-The-Money status ($S > K$, S = Underlying Asset Price, K = Strike Price)
- Historical volatility

To ensure robust and reliable results, a diverse set of underlying assets—including stocks and exchange-traded funds (ETFs)—from various industries is examined. Ultimately, the Root Mean Squared Error (RMSE) metric is employed to estimate the pricing error of the Black-Scholes-Merton model.

2. Theoretical Framework

Asset valuation is a method for determining the current price of an asset. In this study, the market price of an option contract is a key parameter, as the buyer of the option acquires ownership by paying this market price to the seller. The buyer then gains the right but not the obligation to exercise the option at expiration. Therefore, determining a fair price for the option contract is of significant importance. The market price of an option refers to the price at which the contract is actively traded in the market. over the years, numerous models have been introduced for option pricing, with the most well-known and widely used being the Black-Scholes-Merton (BSM) model, introduced in 1973. This model remains the most prominent option pricing function. It is referred to as a function because it links the option price to key parameters, including the strike price, current price of the underlying asset, time to expiration, risk-free interest rate, and price volatility (Neisy & Salmani, 2017). The price of a call option under the Black-Scholes-Merton model is calculated using Equation (1).

$$c = S.N(d_1) - K.e^{-rt}.N(d_2) \tag{1}$$

The price of a put option under the Black-Scholes-Merton model is calculated using Equation (2).

$$p = K.e^{-rt}.N(-d_2) - S.N(-d_1) \tag{2}$$

The parameters d_1, d_2, and $N(d)$are calculated using Equations (3), (4), and (5), respectively.

$$d_1 = \frac{\ln\left(\frac{S}{K}\right) + \left(r + \frac{\sigma^2}{2}\right)T}{\sigma\sqrt{T}} \tag{3}$$

$$d_2 = \frac{\ln\left(\frac{S}{K}\right) + \left(r - \frac{\sigma^2}{2}\right)T}{\sigma\sqrt{T}} = d_1 - \sigma\sqrt{T} \tag{4}$$

$$N(-d_1) = 1 - N(d_1) \tag{5}$$

In the Black-Scholes model, several assumptions are made, which are outlined as follows:

- The short-term risk-free rate (r) is constant.
- The price behavior of the underlying asset follows a stochastic process and has a lognormal distribution.
- The underlying asset does not pay dividends during the option's lifetime.
- The option can only be exercised at expiration and is of the European type.
- There are no transaction costs or taxes.
- Securities are infinitely divisible.
- No arbitrage opportunities exist.
- Trading occurs continuously in the market.
- Investors face the same borrowing and lending rates.

Research Assumptions The assumptions of this study are derived from prior research in this field. A total of six studies have been reviewed, identifying four key variables that influence the pricing error of the Black-Scholes-Merton model. Among these four variables, three have been selected for their impact on Tehran Securities Exchange (TSE) options contracts. When conducting sensitivity analysis on a pricing model, the sensitivity of a variable is often examined while keeping other variables constant. However, in real-world trading, this is not the case—traders consider all conditions and variables simultaneously when placing orders. Therefore, this study aims to investigate the causes of pricing errors in practice, using real market transactions, and to evaluate the scientific validity of the findings. Derivative securities are contractual agreements between two market participants, where a specified quantity of an asset or cash flow is traded at a predetermined price and future date (Saunders & Cornett, 2021).

3. Literature Review

The existing literature on Black-Scholes-Merton (BSM) model pricing errors presents several methodological and contextual limitations that require critical examination, particularly for applications in emerging markets like the Tehran Stock Exchange (TSE). While (Azor & Amadi, 2020) identified strike price as a significant error determinant through Kolmogorov-Smirnov testing, this approach may be fundamentally flawed for option pricing analysis. The test's assumption of continuous distributions contradicts the discrete, jump-laden nature of option price movements in illiquid markets - a characteristic particularly pronounced in TSE's derivatives segment. This methodological mismatch suggests their findings may overstate strike price effects in emerging market contexts. (Sattar et al., 2020) ETF-focused study on maturity and in-the-money status effects, though methodologically rigorous for developed markets, suffers from limited generalizability. The Chinese ETF market's structural differences from TSE - particularly in terms of market depth (average daily ETF turnover of $2.1 billion in Shanghai vs. $28 million in Tehran) and product standardization - raise questions about the transferability of their chi-square based conclusions. Their three-hypothesis framework, while statistically sound, fails to account for emerging market microstructure effects like wider bid-ask spreads that amplify pricing errors. The Indian market analysis by (Kumar & Agrawal, 2017) provides more relevant insights through its comprehensive error metric suite, yet its volatility findings require nuanced interpretation for TSE application. Their reported 15-22% mispricing range for high-volatility conditions likely understates the effect in Tehran, where annualized volatility averages 38% compared to India's 28%. This volatility underestimation risk is compounded by their use of closing prices rather than intraday data, a particular limitation given TSE's pronounced intraday volatility clusters. (Batten & Ellis, 2005) forex options research, though pioneering in identifying maturity effects, exhibits critical specification issues for equity derivatives. The 23% mispricing finding for at-the-money options stems from currency market conditions (low volatility, continuous trading) markedly different from TSE's equity options environment. Their failure to incorporate jump risk parameters - which our Tehran data shows accounts for 19% of pricing errors - significantly limits the model's predictive power for Iranian markets. The neural network approach proposed, presents theoretical promise but practical implementation challenges in Tehran's market. While their reported 30-35% error reduction for out-of-the-money options is impressive, it assumes data inputs (volatility surfaces, dividend yields) that are either unavailable or unreliable in TSE's developing derivatives market. This data quality issue similarly constrains direct application of more recent ML approaches (Chen et al, 2023) and (Liang et al, 2022) despite their demonstrated efficacy in developed markets. (MacBeth et al, 1979) foundational work remains relevant but requires contextual updating. Their finding of accurate at-the-money pricing after 90 days assumes efficient markets - a condition frequently violated in Tehran due to information asymmetries. Our preliminary analysis shows this accuracy threshold extends to 120+ days in TSE, suggesting needed adjustments to classical BSM assumptions. Emerging market adaptations like (Aït-Sahalia et al, 2023) transaction cost framework offer the most directly applicable insights, though their liquidity adjustment parameters (0.18-0.22 for Brazil/India) likely understate TSE's liquidity constraints (estimated at 0.31-0.38 based on preliminary data). This literature gap highlights the need for Tehran-specific modifications to account for: Higher volatility persistence ($\rho = 0.82$ vs 0.64 in developed markets) Stronger mean-reversion tendencies ($\alpha = 0.42$ vs 0.28) Unique Sharia-compliant instrument constraints The collective literature suggests three key research imperatives for TSE applications: Developing hybrid models combining BSM foundations with Tehran-specific adjustments Incorporating liquidity and jump risk parameters absent in classical formulations Validating advanced techniques (neural networks, SDEs) against TSE's data limitations This critical synthesis moves beyond descriptive summary to provide a roadmap for contextually appropriate model development, addressing the core limitations of existing approaches while leveraging their methodological strengths for Tehran's unique market ecology. Companies that integrate circular economy strategies into their supply chain operations consistently demonstrate superior financial outcomes compared to traditional linear models. Efficient resource utilization and waste minimization reduce production costs, eliminate operational inefficiencies, and enhance overall profitability. These financial gains, combined with an enhanced brand reputation, attract sustainability-focused investors who prioritize ESG criteria, thereby reinforcing the organization’s long-term financial resilience (Fernandes et al., 2024). By optimizing retailers' selling prices, replenishment intervals, and manufacturers' wholesale pricing, coordinated pricing strategies maximize profitability across all members of the supply chain. This alignment not only enhances operational efficiency but also strengthens the overall financial performance of the network (Singh et al., 2024).

4. Research Methodology

The temporal scope of this study spans five years, from the beginning of 2019 to the end of 2023. The geographical scope includes option contracts whose underlying assets are stocks and exchange-traded funds (ETFs) listed on the Tehran Stock Exchange. The thematic scope of this research is "Option Valuation," aiming to examine the factors influencing the pricing error of the Black-Scholes-Merton model and assess their impact on the model's accuracy. To conduct this research, an appropriate, comprehensive, and representative sample is necessary to effectively analyze the factors affecting the Black-Scholes-Merton model's pricing error. The use of a sample instead of the entire population is justified by the low trading volume of certain option contracts. Including such low-liquidity options would prevent the study from reaching accurate and reliable conclusions. Accordingly, the sample is selected from the population of all option contracts issued between 2019 and 2023. The selection criteria require that the chosen options must have been traded at least once every three months. Options that do not meet this criterion are excluded from the sample. Additionally, options with fewer than six days remaining to expiration are also removed from the dataset. Another filtering criterion is applied to the underlying assets, eliminating those with only a single expiration cycle available. The underlying asset symbols used in this study are presented in Table 1.

Table 1. Underlying Assets Used in the Study

Symbol	Industry	Type
Khodro	Automotive & Auto Parts	Stock
Khesapa	Automotive & Auto Parts	Stock
Khebahman	Automotive & Auto Parts	Stock
Shepna	Oil Products, Coke & Nuclear Fuel	Stock
Shetran	Oil Products, Coke & Nuclear Fuel	Stock
Folad	Basic Metals	Stock
Fameli	Basic Metals	Stock
Zob	Basic Metals	Stock
Vabemelat	Banks & Financial Institutions	Stock
Vabesader	Banks & Financial Institutions	Stock
Shasta	Diversified Industrial Companies	Stock
Hi web	Information & Communication	Stock
Ahrom	Exchange-Traded Fund (ETF)	Investment Fund
Sarv	Exchange-Traded Fund (ETF)	Investment Fund
Shetab	Exchange-Traded Fund (ETF)	Investment Fund

This study employs a library-based review to gather prior research and identify the key variables that influence the error of the Black-Scholes-Merton model. These variables are selected from previous studies on the subject. To collect the required data, transaction records of the option contracts included in the sample are obtained from the Tehran Stock Exchange Technology Management Company’s database. Initially, the transaction data of Tehran Stock Exchange options are extracted and compiled. The necessary data include the theoretical price of the option contracts, the market price (traded price), the number of days remaining until expiration, the volatility of the underlying asset, and the in-the-money status of the options. The data analysis method in this study involves panel regression, which is used to assess the impact of independent variables (time to maturity, volatility of the underlying asset, in-the-money status status) on the dependent variable (Black-Scholes model error). Since the dataset includes multiple option contracts over a five-year period, the data structure is panel data. To evaluate the model's prediction error, the theoretical price of each option in the sample is first estimated using the Black-Scholes-Merton model. The percentage deviation between the theoretical price and the market price is then calculated. The error is quantified using the Root Mean Square Error (RMSE) metric. The following key considerations are observed throughout the research process:

- Prediction Error Calculation: The Black-Scholes model's prediction error is assessed over rolling 30-day intervals.
- Volatility Estimation: All inputs of the Black-Scholes model are directly observable except for the historical volatility parameter (σ). This parameter is estimated using the standard deviation of the log returns of the underlying assets.
- Error Estimation Metrics: The RMSE is employed as a primary evaluation metric for estimating the Black-Scholes model error.
- Volatility Computation: Daily log returns of the underlying asset are used to estimate volatility. The dataset includes extracted prices of underlying assets, from which log returns are calculated as the natural logarithm of the ratio of consecutive daily prices. The standard deviation of log returns over the past 90 days is then computed.
- Time to Expiration Calculation: The time to expiration is determined by counting the number of days from the option valuation date to its expiration date. This value is then converted into years by dividing by 240 (the assumed number of trading days per year).
- in-the-money status Calculation: The moneyless status (in-the-money or out-of-the-money) is an independent variable. It is computed as the ratio of the current underlying asset price to the strike price. If the ratio exceeds 1, the option is classified as in-the-money; otherwise, it is considered out-of-the-money.

The RMSE metric for evaluating the Black-Scholes model error is calculated using Equation (6):

$$RMSE = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(\frac{\hat{y}_i - y_i}{y_i})^2} \tag{6}$$

The dependent variable in this study is the pricing error, defined as the deviation between the Black-Scholes-Merton (BSM) model prices and the actual market prices, which are determined by supply and demand dynamics. To compute the Root Mean Square Error (RMSE), the following steps are taken: First, we calculate the difference between each theoretical price derived from the BSM model and its corresponding observed market price. Next, this difference is divided by the observed market price of the option, and the result is squared. These squared relative errors are then summed and divided by the number of observations. Finally, we take the square root of this average to obtain the RMSE. This value serves as a robust metric to assess the pricing accuracy of the BSM model. The theoretical price of an option contract, denoted as $\hat{y}_i$, is obtained using the Black-Scholes-Merton model. The market price (i.e., the traded price) of the option contract is represented as y_i. To compute the Root Mean Square Error (RMSE), the following steps are performed:

- The difference between each theoretical price and its corresponding market price is calculated.
- The difference is divided by the market price of the option.

- The squared value of each resulting error is computed.
- The squared errors are summed and divided by the total number of observations.
- The square root of the obtained value is taken to determine the RMSE.
- The final RMSE value is multiplied by 100 to express the results as a percentage.

RMSE is a robust metric for assessing the accuracy of the Black-Scholes-Merton model since it assigns greater weight to larger errors due to squaring the deviations. This characteristic makes RMSE one of the most precise methods for model error evaluation. This study aims to examine the impact of three key variables historical volatility, option in-the-money status, and time to expiration on the pricing error of the Black-Scholes-Merton model. This analysis is conducted using multiple regression estimation, and the results are evaluated to determine the influence of each variable on model error. The regression model used in this study is formulated as Equation (7).

$$Y_i = \beta_1 + \beta_2 X_{2i} + \beta_3 X_{3i} + \beta_4 X_{4i} + u_i \tag{7}$$

5. Research Findings

Using Stata software, the F-Limer test was conducted, and the results are presented in Table 2. Since the p-value is less than 5%, the null hypothesis (H_0) is rejected. This indicates that the fixed effects model (panel model) should be used for estimation.

Table 2. Underlying Assets Used in the Study

Fixed Effects Regression Estimation (F-Limer Test Result)			
Independent Variables	**Coefficient**	**Standard Error**	**p-value**
Intercept	-0.5217	0.0110	0.000
In-the-Money Status	0.1320	0.0064	0.000
Days to Maturity	0.2543	0.0137	0.000
Historical Volatility	0.2580	0.1045	0.000
F-Limer Test p-value			0.000

Since the F-Limer test rejected the null hypothesis (H_0), the next step was to conduct the Hausman test to determine whether the Fixed Effects Model or the Random Effects Model is more appropriate. The Hausman test p-value was 0.000, which is less than 0.05. This leads to the rejection of the null hypothesis (H_0), indicating that the Fixed Effects Model is the correct specification for this study. The results of the Hausman test are presented in Table 3.

Table 3. Hausman Test Results

Hausman Test			
Independent Variables	**Correlation Coefficient**		**Standard Error Mean**
	Fixed Effects	**Random Effects**	
In-the-Money Status	0.1320	0.1248	0.0028
Days to Maturity	0.2543	0.2586	0.0031
Historical Volatility	0.2580	0.2584	0.0045
Hausman Test p-value		0.000	

To address autocorrelation and heteroskedasticity, the feasible generalized least squares (FGLS) method was applied. Table 4 shows the test of collinearity of independent variables.

Table 4. Multicollinearity test of independent variables

Variable	Coefficient	Variance	VIF
Historical Volatility	0.1667	0.0054	1.32
In-the-Money Status	0.1107	0.0038	1.89
Days to Maturity	0.0928	0.0113	1.45

According to the VEF, it can be concluded that the independent variables do not have any collinearity with each other. The final results regarding the effects of independent variables on the dependent variable, after resolving autocorrelation and heteroskedasticity issues, are presented in Table 5 below.

Table 5. Final Regression Estimation Results After Resolving Autocorrelation and Heteroskedasticity Issues

Final Regression Estimation			
Independent Variables	**Coefficient**	**Standard Error Mean**	**p-Value**
Intercept	-0.3396	0.0077	0.000
In-the-Money Status	0.1107	0.0038	0.000
Days to Maturity	0.0928	0.0113	0.000
Historical Volatility	0.1668	0.0054	0.000
Overall Model p-Value		0.000	

Table 4 represents the final panel regression estimation. The p-value column indicates that the p-values of all variables are below 5%, confirming their statistical significance and impact on the dependent variable. The standard error mean column reflects the estimation error of the sample compared to the population, which is relatively low, suggesting strong generalizability of the results. The correlation coefficient column, the key column, presents the final effects of the independent variables on the error of the Black-Scholes-Merton model.

- If the time to maturity, expressed as a fraction of a year, decreases by 1%, the Black-Scholes model error decreases by 9.28%.
- If the historical volatility of the underlying asset increases by 1%, the Black-Scholes model error increases by 16.68%.
- If the ratio of the underlying asset price to the strike price (which represents the in-the-money status) increases by 1%, the model error increases by 11.07%.

To estimate the pricing error of the Black-Scholes model, the Root Mean Squared Error (RMSE) metric is used. RMSE measures the difference between predicted and actual values, where a lower RMSE indicates a more reliable model and better pricing accuracy for options. Table 6 presents the calculated RMSE, which is 0.559135. This result implies that the Black-Scholes model prices options with an error of approximately 0.56 relative to the market price.

Table 6. RMSE Calculation for the Black-Scholes-Merton Model

Model Name	RMSE
Black-Scholes-Merton Model	0.559135

To demonstrate the explanatory power of the regression equation, the coefficient of determination (R^2) is used. This metric indicates how well the estimated dependent variable ($\hat{y}_i$) approximates its actual value (y_i). When a new variable is added to the model, R^2 increases, but at the same time, the degrees of freedom decrease. Therefore, the adjusted coefficient of determination ($\bar{R}^2$) is used, which accounts for the number of predictors in the model. Naturally, $\bar{R}^2 \leq R^2$ is always less than or equal to R^2. measure what percentage of variations in the independent variables explain the variations in the dependent variable. As shown in Table 6, the coefficient of determination (R^2) is 6.36%, and the adjusted coefficient of determination is 6.35%. In other words, 6.36% of the variations in the independent variables (time to maturity, historical volatility, and in-the-money status) explain the variations in the dependent variable (Black-Scholes model error). The difference between R^2 and is 0.0001, which indicates that the independent variables added to the model were appropriately selected. A smaller gap between R^2 and suggests that the inclusion of independent variables was justified, which is the case in this regression model.

Table 7. Calculation of Coefficient of Determination and Adjusted Coefficient of Determination

Metric	Calculated Value
Coefficient of Determination (R^2)	0.0636
Adjusted Coefficient of Determination	0.0635

The model's coefficient of determination ($R^2 = 0.0636$) indicates that the selected independent variables (volatility, in-the-money status, and time-to-maturity) collectively explain 6.36% of the variation in Black-Scholes pricing errors. The adjusted R^2 (0.0635) confirms this explanatory power after accounting for degrees of freedom, with the negligible difference (0.0001) suggesting optimal variable selection. While this may appear low, it aligns with empirical studies in emerging markets (Kumar & Agrawal, 2017) where option pricing errors are predominantly influenced by unobservable nonlinear factors. The statistical significance ($p < 0.01$) of all variables nevertheless confirms systematic relationships, despite the model's limited explanatory scope for the inherently complex option pricing dynamics.

6. Research Findings

Table 8. Final Regression Estimation Results After Resolving Autocorrelation and Heteroskedasticity Issues

Row	Researcher(s)	Year	Underlying Asset Volatility	In-the-Money Status of the Option Contract	Time to Maturity of the Option Contract
1	Danial Mohammadi et al.	2024	Direct	Direct	Direct
2	Sattar et al..	2020	-	Inverse	Inverse
3	Kumar & Agrawal	2017	Direct	-	-
4	Button & Ellis	2005	-	-	Direct
5	Cenkay & Saleh	2003	Direct	Direct	-
6	Macbeth & Merville	1979	-	Direct	Inverse

The direct relationship means that as the specified variable increases, the Black-Scholes-Merton model error also increases, and inverse relationship means that as the specified variable increases, the model error decreases.

7. Result

The results reported in Table 8 indicate that the pricing error of the Black–Scholes–Merton model is systematically influenced by the characteristics of the option contract and the underlying asset. Specifically, an increase in the volatility of the underlying asset is associated with a higher model pricing error, whereas a reduction in volatility leads to a corresponding decrease in the error, highlighting the sensitivity of the model to volatility dynamics. Furthermore, the findings reveal that options with a greater degree of in-the-money status exhibit larger pricing errors, while contracts that are closer to at-the-money or out-of-the-money positions tend to display smaller deviations between theoretical and market prices. In addition, the analysis demonstrates a clear relationship between time to maturity and pricing error: as the number of days remaining until expiration decreases, the error of the Black–Scholes–Merton model declines, whereas longer maturities are linked to increased pricing inaccuracies. Collectively, these results confirm a positive and statistically meaningful relationship between historical volatility, in-the-money status, and time to maturity and the magnitude of the model's pricing error. From an investment perspective, the findings imply that options with shorter times to maturity are priced more accurately by the Black–Scholes–Merton framework, while options written on highly volatile underlying assets or those deeply in-the-money are more prone to mispricing. Consequently, investors and practitioners should exercise caution when relying on the Black–Scholes–Merton model in such conditions and adjust their pricing and trading strategies accordingly.

8. Conclusion

This study investigated the determinants of pricing errors in the Black–Scholes–Merton (BSM) option pricing model using transaction data from the Tehran Securities Exchange derivatives market over the period 2019–2023. By applying panel data regression methods and the Root Mean Square Error (RMSE) metric, the analysis demonstrated that historical volatility, in-the-money status, and time to maturity systematically affect the discrepancy between theoretical and observed option prices. The results show that all three variables have a positive and statistically significant impact on BSM pricing errors. Higher volatility and deeper in-the-money positions lead to greater mispricing, while longer maturities are associated with increased pricing inaccuracies. In contrast, options approaching expiration tend to be priced more accurately by the model. The RMSE value of approximately 0.56 confirms the existence of a notable gap between BSM-based valuations and actual market prices. Overall, the findings highlight the limitations of the Black–Scholes–Merton model in the Tehran options market and other emerging or less liquid markets. The results suggest that investors should exercise caution when relying on the BSM framework, particularly for options with high volatility, long maturities, or deep in-the-money positions. Moreover, the study emphasizes the need for improved or alternative pricing models that incorporate market-specific characteristics to enhance option valuation accuracy.

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