Modern Approaches to the Valuation and Application of Options in the Stock Market: Tools, Models, and Behavioral Aspects

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Abstract

The article examines modern approaches to the valuation and application of options as derivative financial instruments. It analyzes key pricing models, including the Black–Scholes model, the binomial model, and the Monte Carlo method. The role of market makers in maintaining liquidity and the impact of informational events on volatility are discussed. The study also explores retail investor behavior and typical options strategies, with an emphasis on risk profiles and the use of sensitivity parameters (the Greeks).

Keywords: options, derivative financial instruments, Black–Scholes model, binomial model, Monte Carlo method, volatility, market makers, retail investors, option strategies, risk management, Greeks

JEL Classification: G12, G13, G41

Introduction

Options are standardized derivative financial instruments that are actively used for hedging market risks as well as in speculative strategies. In recent decades, there has been a significant expansion of their application scope, driven by increased liquidity, the development of exchange infrastructure, and improvements in pricing models. The growing share of retail participants in the total volume of options trading has become one of the structural changes in

the derivatives market dynamics, which necessitates a comprehensive analysis of the mechanisms of operation and valuation of this instrument.

Modern options trading practice is based on the use of quantitative models that factor in the probabilistic nature of the underlying asset movement, the volatility level, the contract's term, and several other parameters. The most common models are the Black–Scholes model, the binomial model, and the Monte Carlo method, each with specific theoretical assumptions and practical limitations. Additionally, sensitivity parameters, known as the "Greeks" (delta, gamma, theta, vega), which reflect the option value's reaction to key market variables, play an important role in assessing risks and potential returns.

This research aims to systematize the theoretical foundations and practical aspects of options valuation, as well as to analyze the factors determining their value and applicability within various investment strategies.

Theoretical Foundations of an Option as a Derivative Financial Instrument

An option is a derivative financial instrument that gives its holder the right, but not the obligation, to buy or sell a certain amount of an underlying asset at a pre-agreed price within a specified period. Historically, options were traded over-the-counter, which was accompanied by limited liquidity, a high level of counterparty risk, and the need to negotiate the terms of each contract individually [6].

The transition to standardized option contracts became an important stage in the development of financial infrastructure. The unification of parameters for such contracts, including the strike price, expiration date, and delivery volume of the underlying asset, contributed to increased market transparency, reduced transaction costs, and enhanced liquidity. Centralized trading platforms and clearing organizations ensured higher reliability of contract execution and accelerated settlement processes. An additional factor in the growth of options trading was the introduction of automated trading systems and the development of risk assessment technologies [7].

At the current stage, options are widely used by various categories of financial market participants. Professional investors use them for hedging market positions, implementing arbitrage strategies, and optimizing portfolio structures. Retail investors are increasingly utilizing options as a tool to implement directional trading ideas and increase potential returns. The expansion of the circle of participants and strategies necessitates a deeper classification and analysis of the characteristics of option contracts.

The key classification parameter is the option's orientation. Options are divided into two main types: call, which grants the right to buy the underlying asset, and put, which grants the right

to sell it. Another important feature is the exercise style. American-style options allow the right to be exercised at any time during the contract's term, while European-style options are exercised exclusively on the expiration date. These differences directly affect the choice of valuation models and the development of trading strategies.

Options can also differ in the form of execution: delivery contracts imply the physical delivery of the underlying asset, while cash settlement contracts are finalized by a monetary settlement of the difference between the market price and the strike price. The choice of form depends on the characteristics of the underlying asset, regulatory requirements, and the trading platform specifics.

Option Valuation Methods

In financial theory, option valuation is a central task with significant practical implications for developing investment and hedging strategies. Modern methods are based on probabilistic models of the underlying asset price movement and formalized assumptions about the market environment, including the level of interest rates, volatility, and the absence of arbitrage and transaction costs. The most common are the Black–Scholes model, the binomial model, and the Monte Carlo method. Each of these models has certain advantages and limitations that define its scope of applicability.

The Black–Scholes model is an analytical framework for estimating the fair value of European options. The model is based on the assumption that the price of the underlying asset changes continuously and follows a geometric Brownian motion, i.e., a random process with constant expected return and volatility. In this model, the option value is determined using parameters that include the current price of the underlying asset, the option's strike price, the risk-free interest rate, expected volatility, and the remaining time to maturity. The result is the premium, the fair market value of the option, under the assumption that no dividends are paid on the underlying asset over the contract term. A distinguishing feature of the Black–Scholes model is its analytical nature, which yields a closed-form solution without the need for numerical iteration [2]. This ensures high computational efficiency and convenience for large-scale option valuation under stable market conditions. The limitations of the Black–Scholes model include its inapplicability to options with early exercise features (e.g., American-style options), the assumption of constant volatility and interest rates, and the exclusion of transaction costs and taxes. Despite these simplifications, the model is widely used in theoretical and applied problems and also serves as the foundation for more advanced and flexible valuation techniques.

Unlike the Black–Scholes analytical model, the binomial model is a numerical method based on a discrete simulation of possible price paths of the underlying asset. The time interval until option expiration is divided into a specified number of steps, at each of which the asset price may move up or down by a fixed amount. This representation forms the so-called "price tree," at whose nodes the option values are calculated. The valuation process is performed using backward induction: starting from the terminal option values at expiration, values are successively calculated at preceding nodes of the tree until the current time is reached. This allows for the early exercise of options, making the model suitable for valuing American-style options and other contracts with early exercise rights. An additional advantage is the ability to accurately account for various market conditions, including time-varying interest rates, volatility, dividend payments, and other parameters. Increasing the number of tree steps improves valuation accuracy, bringing the result closer to the analytical solution, while the model remains robust to small fluctuations in input data and is highly adaptable to the characteristics of the specific instrument [4].

The Monte Carlo method is a stochastic approach that simulates a multitude of random price scenarios for the underlying asset. For each scenario, the present value of the cash flow corresponding to the option's terms is calculated. These values are then averaged to obtain an estimate of the option's value. This method is used primarily in cases where the option payoff structure is complex and analytical or recursive approaches prove difficult. Such instruments include barrier, Asian, and basket options, as well as options with multiple underlying assets or nonlinear exercise conditions. The advantage of the method is its high versatility: variable interest rates, stochastic volatility, market restrictions, and other features characteristic of real-world trading can be incorporated into the calculation. A significant disadvantage is the high computational load: achieving acceptable accuracy requires a significant number of simulations [3]. Furthermore, the results are subject to statistical noise, which necessitates repeated runs and the use of statistical techniques to construct confidence intervals.

In all these approaches, the key parameter exerting a decisive influence on the option's value is the underlying asset volatility. In financial practice, there is a distinction between realized volatility (ex post), calculated based on historical data, and implied volatility (IV), which reflects market expectations regarding future price dynamics. Implied volatility is not directly observable but is determined by the reverse calculation method: by substituting the market price of the option into a model (most often Black–Scholes) and subsequently numerically finding the volatility value at which the model price matches the market price. Thus, IV serves as an indicator of current market sentiment and an important component of strategic analysis.

The choice of a specific valuation method depends on the type of option, its exercise conditions, and requirements for accuracy and computational resources. In typical situations,

analytical models may be preferred, while for complex contracts, the use of binomial or stochastic methods is justified as they provide greater flexibility and adaptability to the market environment.

The Role of Market Makers and the Liquidity Mechanism

The options market cannot function without stable liquidity mechanisms that enable trades to be executed at low cost and with minimal delay. One of the key elements of this infrastructure is market makers, professional participants who undertake to constantly display buy and sell quotes for option contracts within a specified spread. Their activity is aimed at maintaining liquidity, reducing the volatility of price gaps, and ensuring the continuity of trading.

Market makers set prices based on models that include the current parameters of the underlying asset, expected volatility, time decay, the risk-free interest rate, dividend payments, and other market factors. Central to the pricing algorithms is the estimation of the probability that an option will expire in the money [1]. In practice, market makers rely on adapted versions of the Black–Scholes model that account for real market conditions, as well as implied volatility estimation methods that allow for the integration of behavioral and fundamental signals into the model.

Informational events, such as the publication of corporate reports, changes in macroeconomic indicators, or regulatory statements, play a significant role in price formation. In anticipation of such events, market makers incorporate elevated levels of implied volatility into option prices, reflecting uncertainty and the potential reaction of market participants. Behavioral activity during these periods is characterized by increased demand for hedging strategies and speculative positions, which leads to a temporary widening of spreads and an increase in trading volume.

In highly liquid markets characterized by competition among market makers and high participant activity, the spread between the purchase and sale price of an option contract is minimal, ensuring high pricing efficiency. Under such conditions, deviations from the fair value are quickly eliminated through arbitrage operations. By contrast, in illiquid markets, especially in the segment of options on low-capitalization assets, spreads can be significantly wider, and quotes less stable. This increases the costs of entering and exiting a position and requires a more thorough assessment of the risks associated with implementing the strategy.

Practical Application and Risks

Today, options are widely used in both professional and retail investment strategies. Thanks to their standardized structure, the ability to create asymmetric risk profiles, and a predetermined

level of potential losses when purchasing contracts, options are becoming an instrument accessible to various categories of investors.

In recent years, there has been a significant increase in the activity of retail participants in the options market, evidenced by the growth of their share in total trading volume. The main factors driving this trend are the development of platforms with low transaction costs, the wide availability of educational resources, and investors' pursuit of short-term speculative profits. The behavior of this category of participants is marked by high sensitivity to news, a focus on short-term movements of the underlying asset, a tendency to use options with near-expiration dates, and aggressive risk-reward ratios.

In practice, the following options strategies are most commonly used:

1. Buying a call option in anticipation of an increase in the price of the underlying asset, with limited losses in the form of a premium paid and unlimited profit potential.
2. Purchasing a put option to insure against the decline in the value of an already owned asset (protective put).
3. Selling a put option to receive a premium and potentially acquiring the asset at a reduced price (cash-secured put).
4. Combined structures that include both the purchase and sale of options on the same asset with different strikes and maturities (spreads, straddles, strangles, etc.).

When using options, special attention should be paid to risk profile analysis. There is a fundamental difference between covered and uncovered positions. Covered positions imply the presence of the underlying asset in the investor's portfolio or sufficient collateral, which limits potential losses. An example is selling a call option while simultaneously holding the underlying asset. Uncovered (naked) positions are not secured by assets or funds required to meet obligations. Selling uncovered call options is considered the riskiest, as potential losses are unlimited if the price of the underlying asset increases. When selling an uncovered put option, the loss is limited only by the zero value of the asset, but it can constitute a significant portion of the investor's capital.

Options analysis must consider their sensitivity to key market parameters. In practical application, the so-called "Greeks", derivatives of the pricing model [5], are used to evaluate how the option's value responds to changes in the corresponding factors:

- **Delta (Δ)** reflects the change in an option's value resulting from a change in the value of the underlying asset. The value of delta also indicates the probability that the option will be in the money by the time of expiration.

- **Gamma (Γ)** measures the sensitivity of delta to changes in the underlying asset's value. It is highest for at-the-money options and indicates how quickly delta changes as the underlying asset's value approaches the strike price.
- **Vega (ν)** shows how the option's value changes in response to changes in implied volatility. It is especially important when trading during news releases and periods of increased market uncertainty.
- **Theta (Θ)** characterizes time decay, that is, the change in an option's value as the expiration date approaches, all else being equal. Short-term options, especially those that are out of the money, are most sensitive to theta.

An understanding and quantitative interpretation of these parameters allows the investor to determine the fair value of an option and effectively manage portfolio risk. Regularly updating calculations during the holding period, especially near the expiration date or during high volatility, enables more accurate forecasting of the instrument's behavior and supports informed trading decisions.

Conclusion

The analysis has shown that options are a universal stock market instrument combining a high degree of flexibility with the ability to manage risks accurately. Thanks to contract standardization and the development of exchange infrastructure, they have become widely used by both institutional and retail investors. At the same time, the higher level of involvement of non-professional participants requires increased attention to issues of risk assessment and market liquidity.

At the theoretical level, the key models remain the Black–Scholes model, the binomial model, and the Monte Carlo method, each of which has a specific area of applicability depending on the complexity of the contract and the required accuracy. The choice of model affects the accuracy of the fair value estimate and, consequently, the correctness of investment decision-making.

The issue of liquidity and the behavior of market makers becomes particularly important in conditions of information uncertainty. Pricing mechanisms that factor in implied volatility enable the statistical characteristics of an asset and the market's reaction to external events to be considered. In contrast, in low-liquidity segments, the role of spreads and transaction costs increases, which must be taken into account when implementing strategies.

The practical application of options involves the use of both simple directional and combined strategies. The fundamental difference between covered and uncovered positions necessitates careful assessment of potential losses, especially when dealing with naked selling. The use of

sensitivity parameters (the "Greeks") allows for a quantitative assessment of the impact of key factors on contract value and enables strategies to be adapted to changing conditions.

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