

Pricing of Chooser Option Based on Black-Scholes Model: Case of AAPL Company

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Abstract. Financial derivatives traded in the markets are becoming more complex and investors' complicated situations also should be responsible for this trend. This study examines the Black-Scholes Model theoretically and practically. By using the information of AAPL company, the simulation of stock price is calculated with related parameter, in the comparison of the straddle, the chooser option has a relatively high potential profit. The paper also gives sensitivity analysis and the conclusion of variables, the result is that the volatility has the largest impact on the stock price, followed by maturity period and date chosen period. Finally, this paper introduces wider application scenarios of our study, it can be used to estimate whether the future is bullish or bearish to obtain higher returns, to predict stock volatility, and to evaluate the value of growing companies, which fill the vacancy in past researches of financial market and gives suggestions for investors.

Keywords: Call option, Put option, Black-Scholes Model, Straddle

1. Introduction

A financial instrument based on the value of underlying securities, such as stocks, is referred to as an option. The buyers of an options contract are given the rights to buy or sell the option hinging on the kinds of underlying asset of the contract they hold. What's different between options and futures is that if the holder decides not to buy or sell the asset, there is no need to buy or sell it. Every option contract must be exercised on the specific maturity date by the holder. The specific price of an option is called the strike price. Options are generally bought and sold through retail brokers or online. In 1973, listed options were first traded on the exchange. After that, the amount of their transaction had boosted strongly all around the world [1]. Specific features of options determined this development. Option contracts provide the buyers with the right to purchase or sell assets according to the type of contracts. Each contract has a specific maturity date for buyers to exercise [2]. Options which are standardized are actively traded. Because of that the option holders are in hoping of creating hedging to make profit for their financial portfolios, new kinds or compounds of options appear. In the past decade, the volume of exotic options has broadened sharply in developed financial markets. Theoretically, in the event that the call option holders decide to exercise their right to purchase the contracts, the writers of call options are granted the right to sell the underlying asset. The obligation to sell a specific quantity of the underlying asset at the strike price on or before the maturity date is a feature of put options [3]. If the holder decides to exercise the put option, the writer of the put option is obliged to purchase the underlying asset at the exercise price.

Chooser option is a kind of the exotic option. The standard option is currently bought, but its investor has the obligation to choose whether the option will finally be a put or a call at a certain time point, but before expiration date [4]. With specific maturity date and exercise price, the chooser option is a type of European option. Particularly, investors are given the right to choose the expected return on the maturity date. If the transaction price of the underlying securities at maturity date is higher than its exercise price, the call option is exercised. The return is the underlying price minus the strike price and then minus the premium [5]. The strike prices of the put and call options may, but need not always, be the same.[6]. The long strategy of owning put and call options with the same exercise price is analogous to the chooser option. They are comparable in that a call or a put will be an option if you don't want to wager on stocks [7]. The investors in the chooser option, however, are exempt from paying for both options. When determining which option to purchase in the future, he is highly

flexible. A straddle's owner is required to pay for both choices at once. As a result, chooser options are generally cheaper than straddles [8].

As the results of that the precise valuation of exotic option is enormously difficult [9], this study simulates the pricing process of the call option and the put option using a simple Black-Scholes model. The assumptions for deriving the Black-Scholes model are as follows: the volatility of stock prices and the risk-free rate of interest are both constant.; the security trading is continuous; there is no transaction costs; there is no riskless arbitrage opportunities.

This study intends to simulate how Apple Inc. (AAPL chooser)'s option is priced at the half and the time to maturity, compared to the straddle which will be later discussed in the article. In sensitivity analysis, this study reveals that the changes in each factor has different effects on option prices. Finally, a wider application scenario is provided based on the BSM model. The results of this research enrich the relevant literature on Option Pricing Based on BSM pricing model theoretically; it also provides support for improving the valuation of the financial market practically, and gives investors some useful advise for the investment based on the research of options.

2. Data and Method

2.1 Data

This paper simulates the price of AAPL's chooser option. This paper gathered all the statistics between Jul15th~Jul29th, 2022's information. Yahoo Finance provided the strike price, the spot price and the sigma. Apple dividend yield provided the delta. Interest rate was collected from treasury.com.

2.2 Method: BSM model

This paper adopts BSM model to simulates the AAPL's chooser option. The options pricing models contain six factors (volatility, interest rate, dividend rate, decision date, time to maturity, spot price, and strike price) which are used to determine a theoretical value of options, that must be considered when pricing an option contract. This paper used Microsoft office Excel to build a BSM model simulation, BSM model is shown as follows,

$$S_T = S_0 e^{(\alpha - \frac{1}{2}\sigma^2)T + z\sigma\sqrt{T}} \quad (1)$$

Where σ is the implied volatility of the underlying asset where the strike price is closest to the market price; delta is the implied dividend rate from apple dividend yield, so $\alpha = r - \text{delta}$; T is the implied maturity time Jul15th~Jul29th, about 15 days and we assume that the decision date was after half the period; the implied current market price of the underlying asset is known as the spot price; strike price is the implied maturity time price, yahoo finance provided the information of the strike price.

The maturity price of the chooser option will be influenced by six BSM parameters. This study extends the Black-Scholes model to deal with dividend-paying stocks as compared to just using it to price non-dividend-paying stocks.

3. Pricing Simulation

3.1 Simulation parameter setting

Compared with other options, maturity period and date chosen period are two period in the chooser option. So, this study conducts two sets of simulations, they are price on ST1 and ST2. The first set of simulations ST1 price was up to the decision time, which conducts the simulation of the pricing process of the chooser option to the chosen date. The second set of simulation ST2 price, which simulates the pricing of the chooser option to the maturity time, was conducted at that time.

The simulation is up to the decision time, after half the period you need to make decision whether to choose a call or a put. In accordance with the price on the chosen date, investors will decide whether to be bullish or bearish. The person would pick call options if the price on the chosen date was much higher than the strike price. They could also decide to choose the put options in this way.

BSM states that the maximum value between the strike price minus the expiration time price and 0 determines the call option price. Additionally, the maximum value of the strike price minus the expiration time price and 0 define the price of the put option. Finally, the return is the highest value between the call option and the put option. And then take the value of 1000 simulation times.

3.2 Results of the option pricing

The value of 1000 simulated dot plots can illustrate this evaluation more clearly. We can draw the dot graph of call option price and put option price as figure 1 and figure 2. By using the data of the simulation price at the maturity time and the payoff, we can draw the chooser option price-scatter plot simulation as figure 3. However, "straddle" is a term that chooser options is similar to, which refers to buying both call and put options at the same time. As a result, the graph of straddle has a "V" structure without the 0 line. In contrast, the difference between straddle and the chooser option is that there are some values at the 0 line. This is because that in some cases investors made mistakes and did an incorrect choice result in getting payoff of 0. For example, we choose a call, but the price dropped, or we choose a put, but the price increased. The fact that the dots equaling to zero indicates that market behavior has been inconsistent with investor expectations.

The difference between straddle and the chooser option also show that due to the chosen date the chooser options have a potentially higher profit. Investors can generate a significant amount of revenue as long as there are sharp fluctuations.

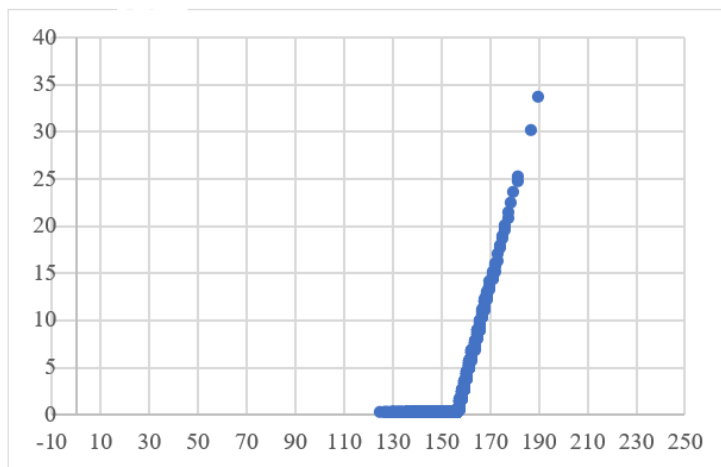


Fig 1. call option price scatters plot simulation

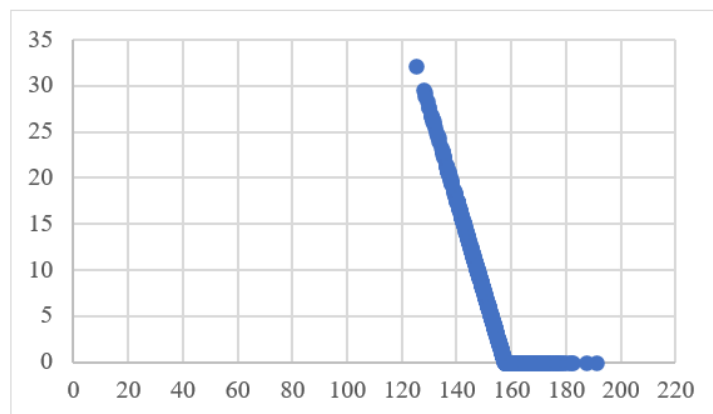


Fig 2. put option price scatters plot simulation

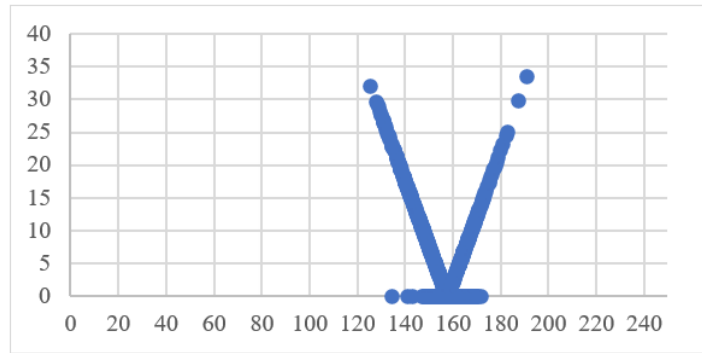


Fig 3. Chooser option price-simulation

3.3 Analysis of sensitivity

We repeat the pricing model process in sensitivity analysis, changing the dependent variables one at a time while holding the other variables constant. To finish the process, this study uses what-if analysis in Excel. The variables in our simulation include time to maturity, time to choose the date, and volatility.

3.3.1 Analysis of time to maturity sensitivity

The independent variable from 2 to 13 with the step of 1 and the fluctuation is between 140 and 175 as figure 4 in the analysis of the time to maturity's sensitivity.

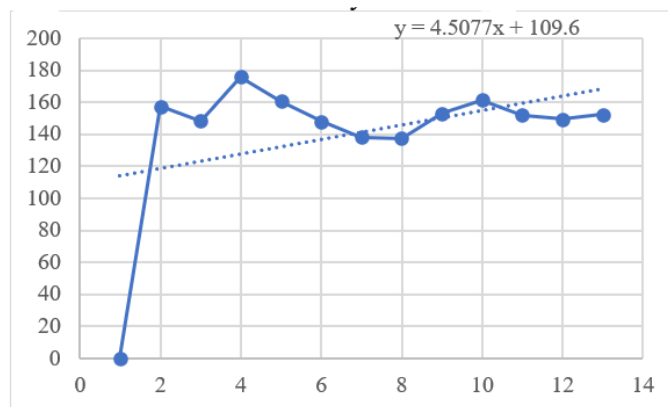


Fig 4. Time to maturity sensitivity analysis

3.3.2 Analysis of time to choose date sensitivity

The independent variable from 2 to 9 with the step of 1 and the fluctuation is between 139 and 160 as figure 5 in the analysis of the time to choose date's sensitivity.

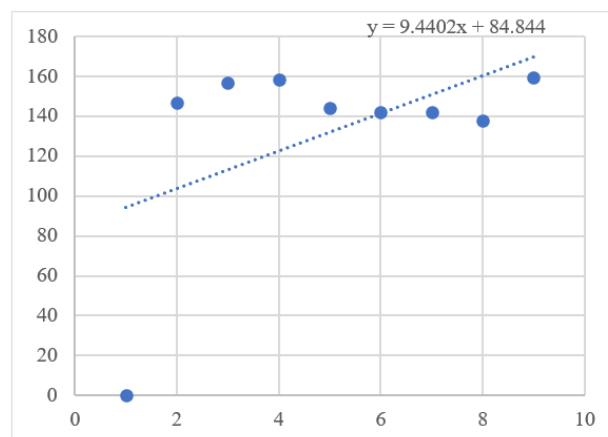


Fig 5. Time to choose date sensitivity analysis

3.3.3 Analysis of volatility sensitivity

In the analysis of the time to maturity's sensitivity, the independent variable from 2 to 13 with the step of 1 and the fluctuation is between 32 and 93 as figure 6.

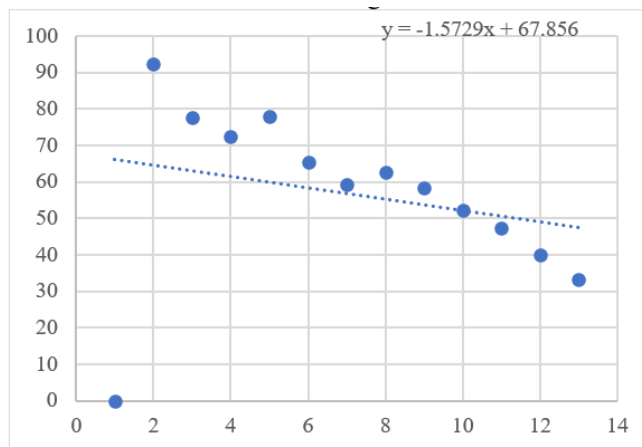


Fig 6. volatility sensitivity analysis

3.3.4 Discussion on the results of sensitivity analysis

The results of the sensitivity analysis lead us to the conclusion that volatility has the greatest influence on the price of the chooser option. This conclusion shows that traders of options can like fluctuation the most. This is because the straddle and the chooser option are comparable. This means that no matter whether the price have a upward trend or a downward trend, investors can gain a decent profit as long as the change was anticipated correctly. Additionally, the second and third highest sensitivities, respectively, are maturity period and date chosen period. This is due to the fact that the likelihood of an investor making a false prediction increases with the length of the time scale.

4. Discussion

The BSM model can be used to give investment advice for investors. After obtaining the transaction data and calculating the relevant parameters, then we can simulate the call and put option price under different conditions based on the BSM pricing model. We can also calculate the corresponding option return within a certain range of stock price change, and judge whether the call or put will obtain higher profits.

The BSM model can be applied not only on option pricing, but also to predicting the volatility of stocks, which means the process of reverse repeated pricing. Because the option pricing model provides a mathematical relationship between the option price and the five fundamental parameters—interest rate, price of the underlying stock, strike price, expiration date, and volatility to calculate the option price. The pricing formula can be used to determine the implied volatility as long as the four fundamental factors and the actual market price of options are entered as known values.. By analyzing the implied volatility of the stock, we can predict the future market volatility of the stock. Compared with the historical volatility, the implied volatility shows a better estimation value, provides more accurate information for investors, and helps make effective judgments.

BSM model can be used to evaluate the value of growing companies [10]. Compared with the binary tree model of the evaluation of put options, if the growth company is regarded as a call expansion option, the results of the evaluation using BSM model are more convincing. Secondly, the information provided by market stocks is based on BSM model, which is the mainstream option pricing model in financial market nowadays. It has a wide range of applications and its results are horizontally comparable.

5. Discussion

Based on the in-depth study of BSM option pricing model for chooser option, this paper takes AAPL company as an example to conduct data analysis and simulation pricing, draws the scatter plot of call and put options, and get to know the difference between the chooser option and the straddle, from which we can see that comparing the chooser option to the straddle, it has a pretty high potential profit. Through sensitivity analysis, the factors affecting the chooser option price are ranked, and the influence intensity of each factor change on the chooser option price is revealed: volatility has the largest impact on the stock price, followed by maturity period and date chosen period. In the discussion section, we discuss the wider application scenarios of BSM model. BSM model can be used to estimate whether the future is bullish or bearish to obtain higher returns; this model can also predict stock volatility; this model can also be used to evaluate the value of growing companies. However, the BSM model adopted in this paper implies that investors are risk-neutral. The market in the real world is usually risk-averse, so the expectation of return on investment and the discount rate of cash flow will change, which needs further discussion in the future.

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