# Optimizing Investment Strategies: A Case Study on JPMorgan Chase & Co. Stock Options Using the Black-Scholes Model and What-If Analysis in Excel

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**Abstract**

This research focuses on applying the Black-Scholes Model to evaluate European options on JPMorgan Chase & Co. stocks. This model has been a critical foundation in evaluating financial instruments, especially options, since its development in 1973 by Fisher Black, Myron Scholes, and Robert Merton. The study utilizes secondary data from some sources to obtain current information regarding stock prices, strike prices, expiration time, volatility, and relevant risk-free interest rates for option valuation as of December 19, 2023. Through this approach, our aim is to gain a better understanding of how the Black-Scholes Model is used as a framework in determining option prices for these stocks. The research methodology involves What-If analysis, exploring variations in key variables such as current stock price, strike price, expiration time, stock price volatility, and risk-free interest rates to assess how these changes affect the prices of both call and put options. Additionally, the study presents graphs representing stock prices, strike prices, interest rates, time, and volatility to visually support the research findings. The analysis results reveal that the prices of both call and put options are highly responsive to changing market conditions. An increase in the current stock price tends to raise the call option price while reducing the put option price. Conversely, an increase in the strike price has the opposite effect. Moreover, variations in the risk-free interest rates influence the option prices, with rising rates increasing the call option price and decreasing the put option price. Furthermore, as the expiration time approaches or stock price volatility increases, both call and put option prices tend to rise. These findings provide a comprehensive understanding of the dynamics of JPMorgan Chase & Co.'s stock option pricing, offering a foundation for investors to make informed and adaptable investment decisions amid constantly evolving financial markets. Sensitivity to changes in key variables is an essential aspect to consider in designing effective investment strategies in the face of ever-changing financial markets.

*Keywords: Mathematics, Black-Scholes Model, JPMorgan Chase & Co. stock, What-If Analysis*

## 1. Introduction

Investment in stock options has become an intriguing subject within the financial scope, particularly in assessing risks and opportunities within the capital market. The assessment of options is a crucial study in investment decision-making, employing various mathematical models to estimate option prices. One of the most commonly used models in option valuation is the Black-Scholes Model.

This study is focused on applying the Black-Scholes Model to evaluate European options on JPMorgan Chase & Co. stocks. This model has been a critical foundation in evaluating financial instruments, especially options, since its development in 1973 by Fisher Black, Myron Scholes, and Robert Merton.

This approach utilizes secondary data from sources such as Barchart.com to obtain current information regarding stock prices, strike prices, expiration time, volatility, and relevant risk-free interest rates for option valuation as of December 19, 2023. Through this approach, our aim is to gain a better understanding of how the Black-Scholes Model is used as a framework in determining option prices for these stocks.

In this context, the use of What-If analysis becomes a crucial part of exploring variations in key variable values such as current stock price, strike price, expiration time, stock price volatility, and risk-free interest rates. The

objective of this analysis is to comprehend how changes in these variables would affect the prices of both call and put options.

Furthermore, this study will also present graphs representing stock prices, strike prices, interest rates, time, and volatility to provide visualizations supporting the research findings.

Through the results and discussions presented in this study, we hope to contribute to providing a more comprehensive overview of the use of the Black-Scholes Model in evaluating financial options for JPMorgan Chase & Co. stocks. However, it's essential to remember that in investment decision-making, the use of mathematical models is only a part of the considerations, while the continuously changing market conditions also play a crucial role.

## 2. Literature Review

This study applies the Black-Scholes Model to evaluate European options on JPMorgan Chase & Co. stock using secondary data obtained from sources such as Barchart.com and Treasury.com. The data taken includes stock price, strike price, time to maturity, volatility, and risk-free interest rate on December 19, 2023. The Black-Scholes Model is used to determine the call and put option prices on the stock. The study processes and analyzes the data using Microsoft Excel to obtain the call and put option prices. The results of the study are presented through graphs that display stock price, strike price, interest rate, time, and volatility. Through the application of the Black-Scholes Model, a better understanding of option pricing on JPMorgan Chase & Co. stock at the given time can be obtained. The study provides a deeper understanding of financial option valuation using the Black-Scholes Model [1].

## 3. Materials and Methods

### 3.1. Materials

The type of data used is in the form of secondary data. This data consists of information about JPMorgan Chase & Co. stock on December 19, 2023, such as stock prices, deal prices, remaining time until maturity, and volatility. These data are sourced from the website Barchart.com. Additionally, there is data used regarding the risk-free interest rate sourced from the website Treasury.com.

### 3.2. Methods

#### 3.2.1. What-If Analysis

What-If Analysis is the process of changing the values in cells to see how those changes will affect the outcome of formulas on the worksheet. Three kinds of What-If Analysis tools come with Excel: Scenarios, Goal Seek, and Data Tables [2]. In this paper, the What-If analysis used is Data Tables, one of the What-If Analysis tools provided by Excel. This What-If analysis process involves changing the values of variables, such as current stock prices, strike prices, maturity dates, stock price volatility, and risk-free interest rates, to understand how these changes will affect the prices of put and call options.

#### 3.2.2. Black-Scholes Model

This paper utilizes the Black-Scholes Model as a foundation for determining the pricing of option selection with a case study on JPMorgan Chase & Co.'s stocks. The Black-Scholes Model, developed by Fisher Black, Myron Scholes, and Robert Merton in 1973, has become a critical analytical tool in the valuation of financial options.

This model provides a mathematical formula for valuing European options on stocks, considering factors such as the current stock price, strike price, time to expiration, stock price volatility, and risk-free interest rate. Here's how to determine the option price using the Black-Scholes model [3].

$$C(s,t) = N(\omega d_1)\omega S - N(\omega d_2)\omega K e^{-r(T-t)} \tag{1}$$

Where $C(s,t)$ is the option price with $\omega = 1$ for buy options and $\omega = -1$ for put options. Then $S$ represents the stock price; $K$ is the strike price; $r$ is the risk-free interest rate; $T$ is the time left until maturity (in years) which is December 19 – December 22, about 3 days, so $T = 3/252 \approx 0.011905$; $\sigma$ is the volatility of stock price returns. With:

$$d_1 = \frac{\ln\left(\frac{S}{K}\right) + \left(r + \frac{1}{2}\sigma^2\right)(T-t)}{\sigma\sqrt{T-t}} \tag{2}$$

$$d_2 = d_1 - \sigma\sqrt{T-t} \tag{3}$$

In this paper, the aim is to gather JPMorgan Chase & Co stock data regarding the current stock price, strike price, expiration time, stock price volatility, and risk-free interest rate. Subsequently, determining the call and put option prices using the Black-Scholes model through Microsoft Excel will be carried out. Furthermore, a What-If analysis involving variations in the values of variables such as current stock price, exercise price, time to expiration, stock price volatility, and risk-free interest rate will be conducted. This analysis aims to comprehend the impact of these changes on the call and put option prices.

## 4. Results and Discussion

### 4.1. Calculations with the Black-Scholes Model

On December 19, 2023, the closing stock price of JPMorgan Chase & Co was $168.45. There are 3 days remaining until the expiration date, while the risk-free interest rate stands at 5.12%. The exercise/strike price agreed upon between the option seller and buyer is $167.5, with a volatility value ($\sigma$) of 20.75%. Here are the calculations for the call and put options using the Black-Scholes method:

Determine the value of $d_1$ by using Equation (2):

$$d_1 = \frac{\ln\left(\frac{S}{K}\right) + \left(r + \frac{1}{2}\sigma^2\right)T}{\sigma\sqrt{T}}$$

$$= \frac{\ln\left(\frac{168.45}{167.5}\right) + \left(0.0512 + \frac{1}{2}(0.2075)^2\right)0.011905}{0.2075\sqrt{0.011905}}$$

$$= 0.2880476605$$

Determine the value of $d_2$ by using Equation (2):

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

$$= 0.2880476605 - 0.2075\sqrt{0.011905}$$

$$= 0.2654075544$$

Determine the forecast price of a buy option by using Equation (1):

$$C(s,t) = N(d_1)S - N(d_2)Ke^{-rT}$$

$$= N(0.2880476605)168.45 - N(0.2654075544)167.5e^{-0.0512(0.011905)}$$

$$= \$2.100406547$$

Then using Equation (1) can also be calculated the forecast price of buy options, namely:

$$P(s,t) = N(-d_2)Ke^{-rT} - N(-d_1)S$$

$$= N(-0.2654075544)167.5e^{-0.0512(0.011905)} - N(-0.2880476605)168.45$$

$$= \$0.1028342417$$

### 4.2. What-If Analysis

We conduct a What-If analysis, where we explore the impact of changes in key variables on option prices. Variables such as the current stock price, exercise price, risk-free interest rates, expiration time, and stock price volatility will be variable to assess how these changes affect the value of buy and put options.

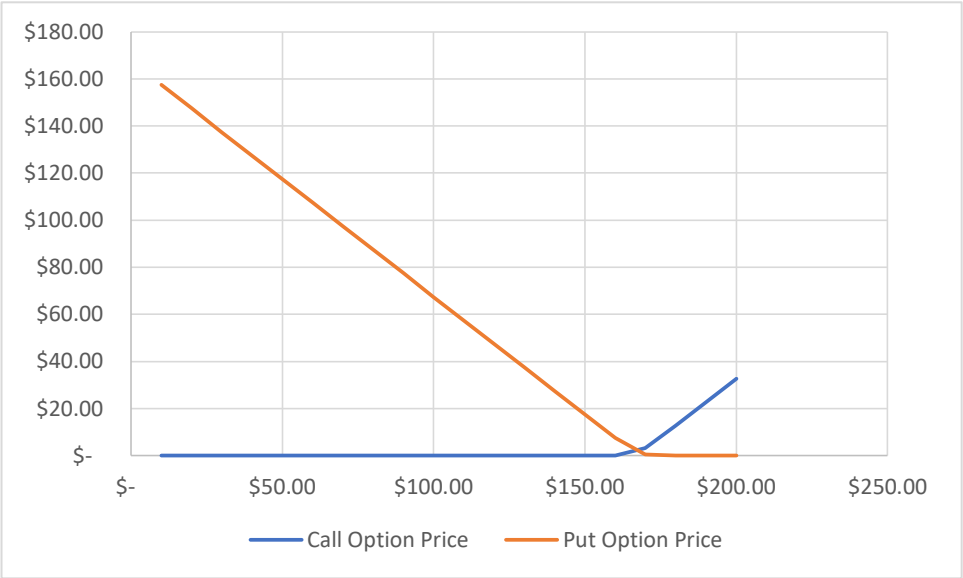### 4.2.1. What-If Analysis of Current Stock Prices



**Figure 1**: What-If Analysis of Current Stock Prices

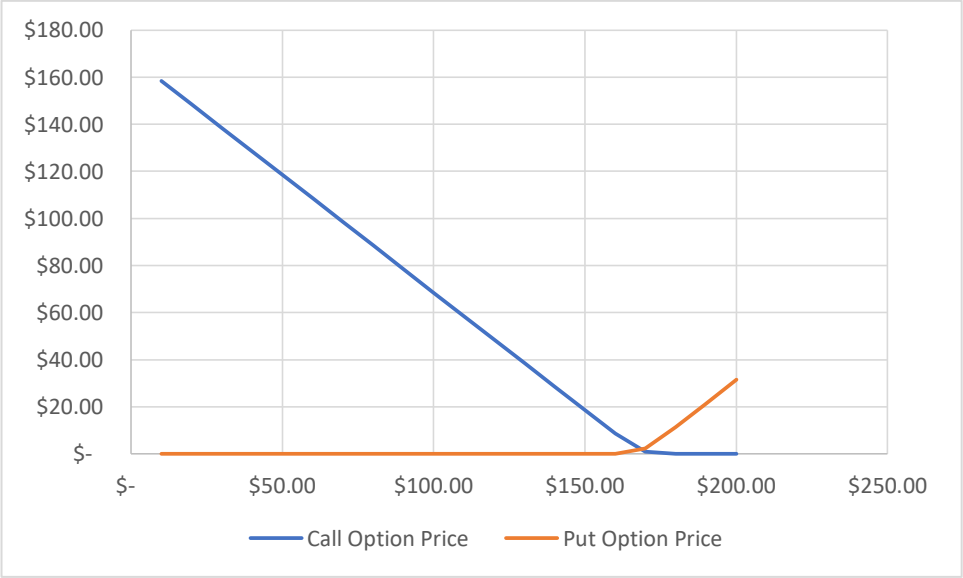### 4.2.2. What-If Analysis of Exercise Prices



**Figure 2**: What-If Analysis of Exercise Prices

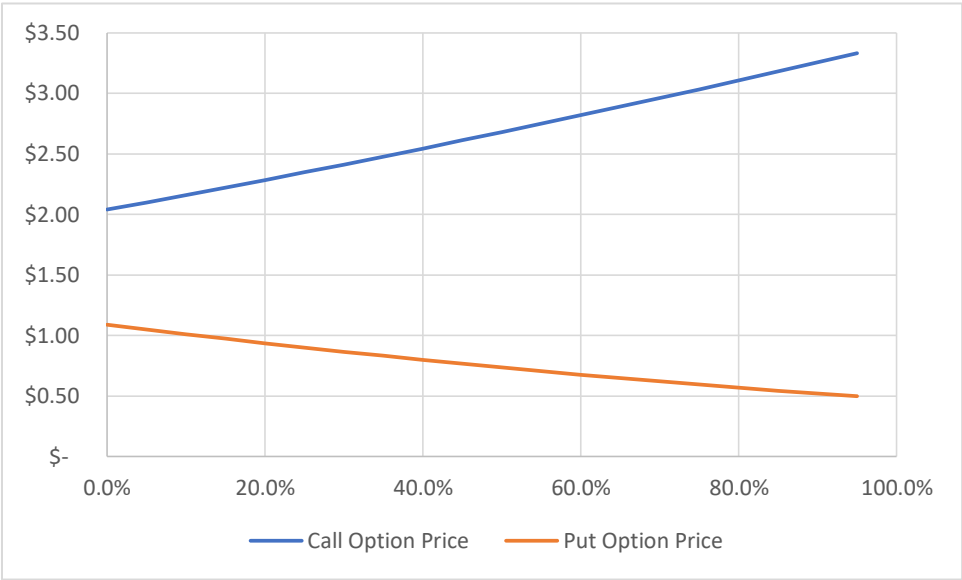### 4.2.3. What-If Analysis of Risk-Free Interest Rates



**Figure 3**: What-If Analysis of Risk-Free Interest Rates
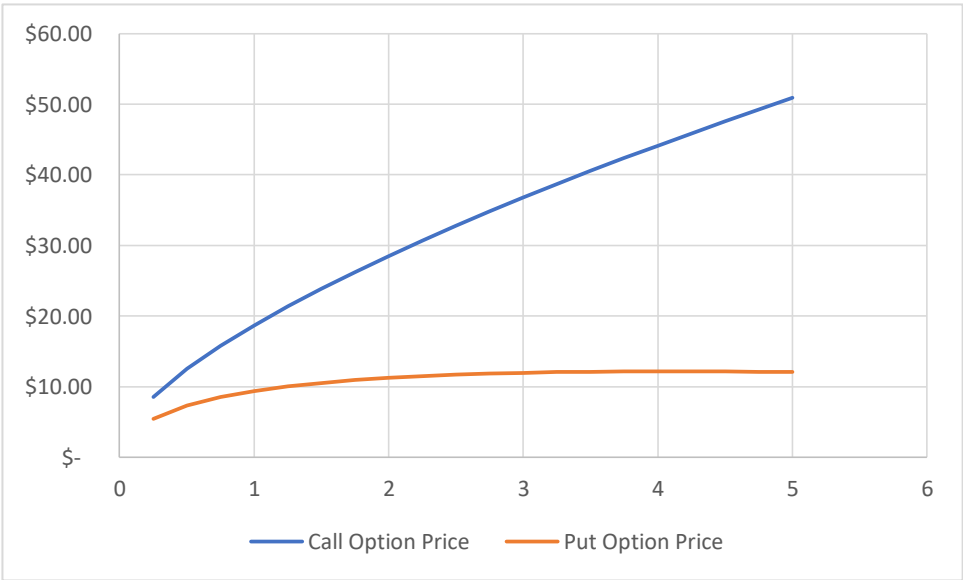
### 4.2.4. What-If Analysis of Expiry Time Prices



**Figure 4:** What-If Analysis of Expiry Time Prices

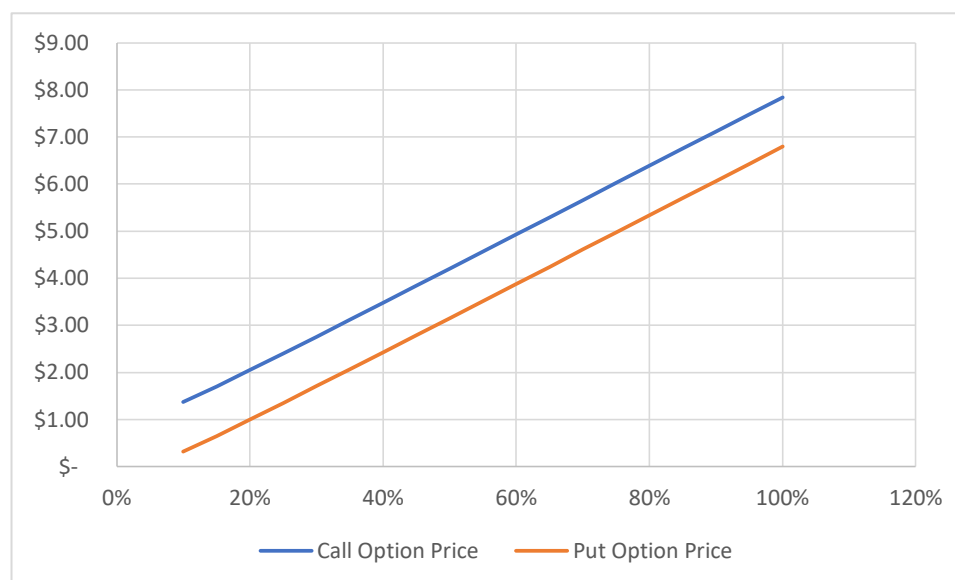**4.2.5. What-If Analysis of Stock Price Volatility**



**Figure 5**: What-If Analysis of Stock Price Volatility

**4.3. Discussion**

    What-If analysis is performed to explore how changes in key variables affect option prices. What-If charts show an option's sensitivity to changes in the current stock price, exercise price, expiration time, risk-free interest rate, and stock price volatility. What-If Analysis of Current Stock Prices (Figure 1) shows the impact of changes in current stock prices on the prices of buy options and put options. It can be seen that the current increase in stock price increases the price of the buy option and decreases the price of the put option. What-If Analysis of Exercise Prices (Figure 2) shows how changes in exercise prices affect the prices of buy options and put options. It can be seen that an increase in the exercise price decreases the price of the buy option and increases the price of the put option. What-If Analysis of Risk-Free Interest Rates (Figure 3) shows the sensitivity of options to changes in risk-free interest rates. Rising interest rates tend to increase the price of buy options and reduce the price of put options. What-If Analysis of Expiry Time Prices (Figure 4) presents the impact of changes in expiry time on the prices of buy options and put options. It is seen that the closer the expiration date, the price of buy and sell options tends to increase. What-If Analysis of Stock Price Volatility (Figure 5) shows how stock price volatility affects option prices. Higher volatility tends to increase the price of buy and sell options. The results of this analysis provide an in-depth look at the sensitivity of options to changes in key variables, assisting investors in making more informed investment decisions in the face of dynamic market conditions.

**5. Conclusion**

    The What-If Analysis chart reveals that the prices of buy and sell options are very responsive to changing market conditions. Increases in stock price currently increase the price of the buy option and reduce the price of the put option, while an increase in the exercise price tends to have the opposite effect. The risk-free interest rate also tends to have an effect, where rising interest rates increase the price of the buy option and reduce the price of the put option. The expiration time and volatility of the stock price also have a significant effect, where the increase in the expiration time or volatility of the stock price increases the price of the buy option and the price of the put option. As such, the results of this study provide an in-depth understanding of JPMorgan Chase & Co.'s stock option pricing dynamics and provide a foundation for investors to make more informed and adaptive investment decisions. Sensitivity to changes in key variables is an important element to consider in designing an effective investment strategy in the face of ever-changing financial markets.

**References**

Barchart.com. (n.d.). *JP Morgan Chase & Company (JPM)*. Retrieved December 20, 2023, from https://www.barchart.com/stocks/quotes/JPM/volatility-greeks?expiration=2023-12-22-w

Black, F. and Scholes, M. (1973). The Pricing of Options and Corporate Liabilities. *The Journal of Political Economy*. 81(3), 637-654.

Corporatefinanceinstitute.com. (n.d.). *Black-Scholes-Merton Model.* Retrieved December 21, 2023, from https://corporatefinanceinstitute.com/resources/derivatives/black-scholes-merton-model/

Dalsem, S.V. (2020, April 23). Black Scholes Model. [Video]. https://youtu.be/p4g-GnnkqFo?si=PWh7Z8vyz3FE5rAL

Hayes, Adam. (2023, October 31). Black-Scholes Model: What It Is, How It Works, Options Formula. *Investopedia.* https://www.investopedia.com/terms/b/blackscholes.asp

Microsoft.com. (n.d.). *Introduction to What-If Analysis.* Retrieved December 21, 2023, from https://support.microsoft.com/en-au/office/introduction-to-what-if-analysis-22bffa5f-e891-4acc-bf7a-e4645c446fb4#:~:text=What%2DIf%20Analysis%20is%20the,values%20and%20determine%20possible%20results.

Peng, Like. (2022). Pricing of Chooser Option Based on Black-Scholes Model: Case of AAPL Compan. *BCP Business & Management.* 32, 473-478.

Perdue, R. K., McAllister, W. J., King, P. V., & Berkey, B. G. (1999). Valuation of R and D projects using options pricing and decision analysis models. *Interfaces*, *29*(6), 57-74

Treasury.gov. (n.d.). *Daily Treasury Bill Rates.* Retrieved December 20, 2023, from https://home.treasury.gov/resource-center/data-chart-center/interest-rates/TextView?type=daily_treasury_bill_rates&field_tdr_date_value_month=202312