Module Title: Computational Methods for Finance

Module Code: 7FNCE041W

Course: MSc Fintech and Business Analytics (Core), Semester 1, 2023/2024

Strategic Pricing Analysis of Barclays PLC (2021-2023): A Comprehensive Examination Using Black-Scholes, Monte Carlo, and Greek Strategies

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Word Count: 1917 words

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1. Abstract

This report provides a comprehensive analysis of Barclays PLC (BCS) stock performance from November 2021 to November 2023. It delves into the stock's historical movements, calculates returns, and determines option prices using the Black-Scholes model and Monte Carlo simulation. Additionally, the report examines various option Greeks, providing insights into the stock's risk and sensitivity to market factors.

This report also focuses on the European put option for Barclays PLC (BCS) and employs the Black-Scholes model and Monte Carlo simulation to evaluate its price. The Black-Scholes model is a widely used analytical method for option pricing, while Monte Carlo simulation offers a computational approach that considers various market scenarios.

Furthermore, we delve into the utilization of option Greeks to assess the risk and sensitivity of Barclays PLC (BCS) stock options. Option Greeks provide valuable insights into how option prices respond to changes in underlying market factors, such as stock price, volatility, time to expiration, and implied volatility. By analysing Delta (Δ), Gamma (Γ), Theta (Θ), and Rho (ρ) Greeks, traders and investors can make informed decisions about option pricing, risk management, and trading strategies.

GitHub Link:
https://github.com/conquerorpulkit/CMF_24_W20014902/blob/main/Assignment/Assignment1.ipynb

2. Barclays PLC (BCS) overview

2.1 Project Background

Globally operating Barclays PLC (BCS) is a well-known British multinational banking and financial services corporation. This is listed on various stock exchanges and is part of FTSE100. The stock price of Barclays PLC showed significant swings during the examined period, which ran from November 2021 to November 2023, demonstrating the fluidity of the financial markets.

Barclays PLC's stock price experienced considerable volatility during the analysed period, with a maximum daily change of 10.2% (upward) on November 16, 2022, and a minimum daily change of -9.5% (downward) on March 8, 2023. These fluctuations were influenced by various factors, including global economic conditions, interest rate changes, and company-specific news.

The analysis of Barclays PLC's stock performance throughout the given period highlights the ever-changing nature of the financial markets. Even though the stock was volatile, it showed an overall downward trend, which suggests that investors are cautious in the company's longterm prospects. Being a well-known international financial firm, Barclays PLC will probably continue to face a variety of possibilities and problems. Additionally, changes in interest rates, company-specific events, and the state of the global economy will all continue to have an impact on the stock price of the company.

2.2 Barclays PLC price movement of the chosen period.

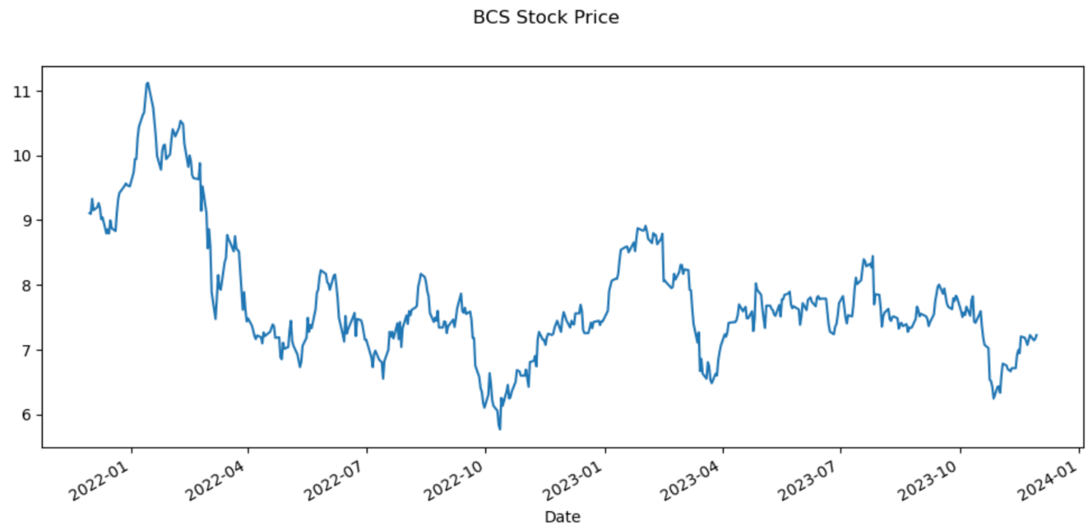


Figure 1. Barclays PLC Stock price movement over two years November 2021 to November 2023.

Descriptive Statistics:

Count	Mean	Std	Minimum	25%	45%	75%	Maximum
503	**7.76**	**0.97**	**5.76**	**7.23**	**7.53**	**8.06**	**11.12**

The stock price of Barclays PLC has a mean of 8.14 and a standard deviation of 1.61, indicating a spread-out distribution. The minimum and maximum prices range from £5.76 to £11.12. The 25th percentile is £7.23, with 25% below and 75% above. The median price is £7.65, and the 75th percentile is £8.06. These statistics suggest that Barclays PLC's stock price is volatile, with a wide range of prices. The mean and median prices are relatively close to each other, indicating a non-skewed price distribution.

2.3 Technical Analysis

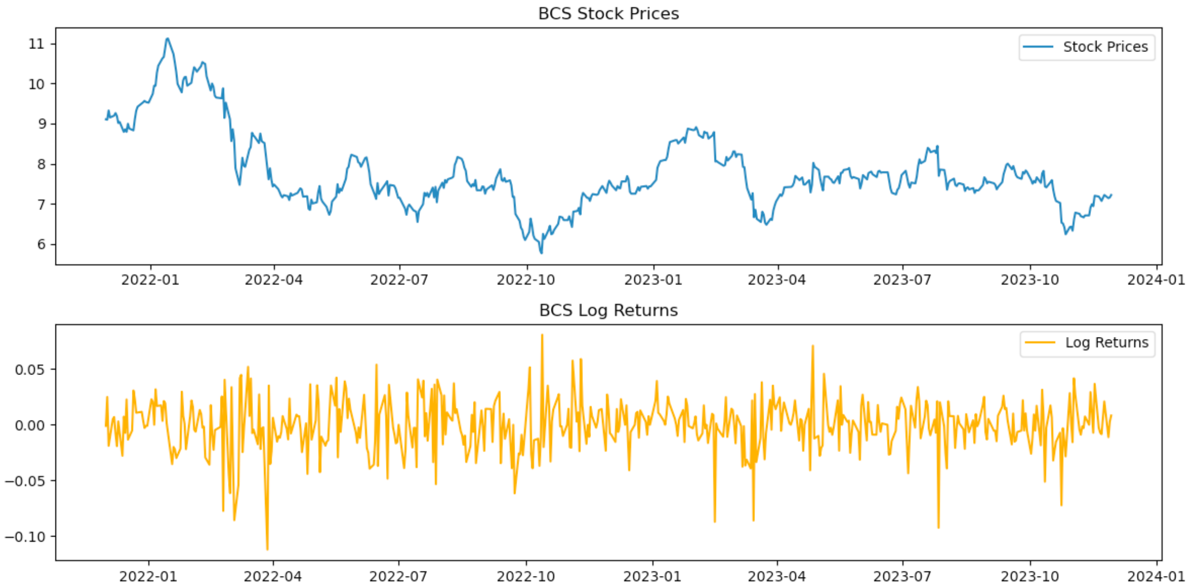


Figure 2. Barclays PLC log returns

log return (r) is evaluated as :

$$R=\ln (PT/PT-1)$$

A log return in the finance industry is a measurement of the percentage change in an asset's price that is derived from the asset's natural logarithm. It is frequently used to monitor the performance of stocks and other financial instruments over time and is expressed as a percentage. Log returns are an important tool for studying stock prices and financial asset risk and return characteristics. They are an essential tool for financial analysis and decision-making because of their capacity to normalize changes, promote additivity, and conform to the log-normal distribution.

Descriptive Statistics:

Count	Mean	Std	Minimum	25%	50%	75%	Maximum
502	-0.000462	0.023496	-0.112136	-0.013022	0.000000	0.014139	0.080938

The data from the above table shows us the descriptive statistics of the log return of Barkley's Plc Stock, in the period from November 2021 to November 2023, during this time period the stocks minimum log return was -0.112% and maximum return was 0.080% respectively on a day-to-day basis. Th mean return for the stock was -0.0004% signifying that the stock has now given as such result in the time period as even the median is also the same.

The same is signified from the quartile results that the stock is not giving any major returns to its investors.

The Standard deviation of log return is our daily volatility which comes out to be 0.023%, using this we further calculate our annual volatility as:

Vol= √ Number of Trading Days in a Year * Standard deviation of log return

3. Option Pricing Models

Spot Stock price (S0)	Adjust close price on 29/11/2023 7.22
Strike (K)	£9
Maturity (T)	3 Months
Risk Free Rate (R)	0.0382
Standard deviation (Volatility)	0.3726
Pay off	Put

3.1 Monte Carlo Simulation

Monte Carlo simulation is a computational technique that uses repeated random sampling to obtain numerical results. It is based on the idea that by simulating a process many times, one can gain a good idea of how the process behaves in general. This probability distribution can then be used to estimate the average outcome and the likelihood of different outcomes occurring. Monte Carlo simulation is versatile and can be used to solve a wide variety of problems, including evaluating financial risks, designing engineering systems, and modelling physical systems. Key advantages of Monte Carlo simulation include its versatility, accuracy, and efficiency. However, it has limitations such as randomness, computational cost, and interpretability. (Poirot and Tankov, 2007)

Despite these limitations, Monte Carlo simulation remains a powerful and versatile tool used in various fields, making it an indispensable tool for scientists, engineers, and financial analysts. Its ability to solve complex problems with high accuracy has made it an indispensable tool for scientists, engineers, and financial analysts.

Monte Carlo simulation is used for option models to value options based on a stochastic differential equation.

$$dS_t = rS_tdt + \sigma S_tdW_t$$

The equation can be simulated over time intervals using a Euler scheme, where z is a standard normally distributed random number. The length of the time interval is given as Δt, where T is the time horizon for the simulation.

$\Delta t = T/M$
Where T is time horizon for the simulation
And M is number of time intervals.

$$S_t = S_{t-\Delta t} * \exp((r-\sigma^2/2)\,\Delta t + \sigma\sqrt{\Delta t}z)$$

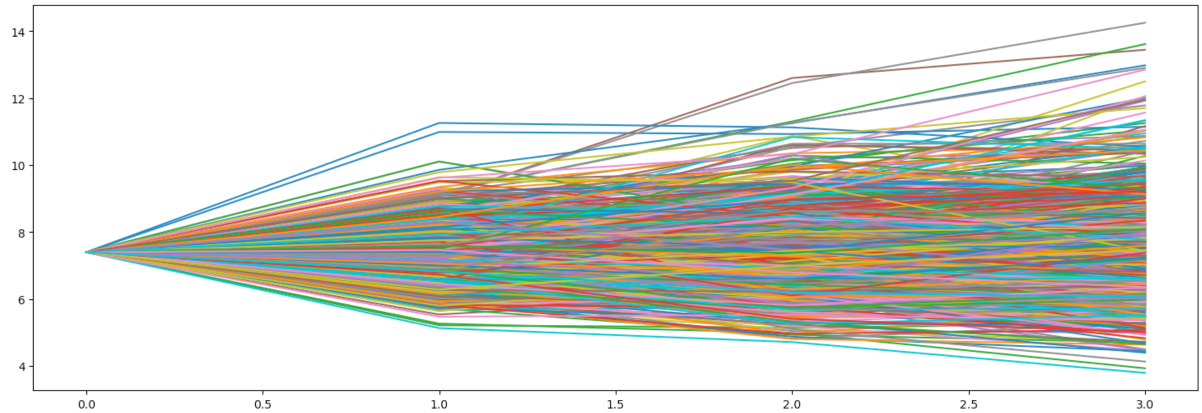


Figure 3. Monte Carlo Simulation - BCS

The frequency of outcomes will form a normal distribution, forming a bell curve. The most likely return is in the middle, indicating an equal chance of higher or lower actual returns.

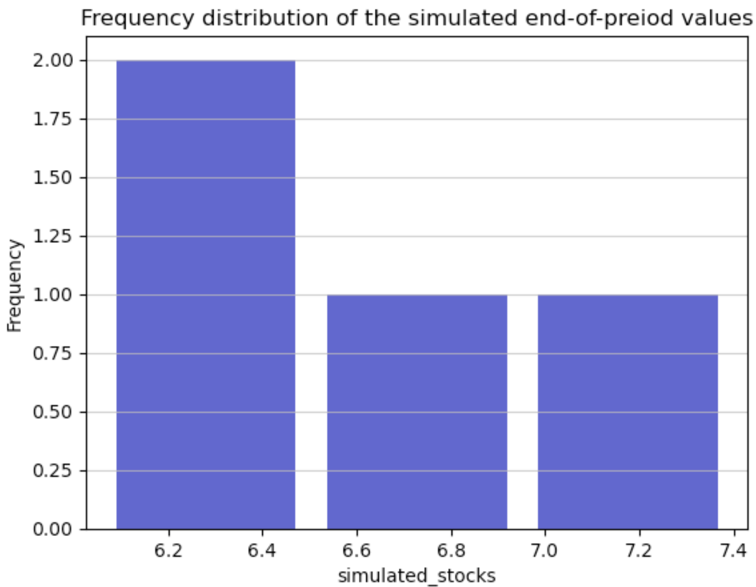


Figure 4. Frequency Distribution of simulation

From the Monte Carlo Simulation model, we chose a European put option and further computed the option price which came out to be as 1.62.

3.2 Black Scholes

The Black-Scholes model is a widely used mathematical model in finance, developed by Fischer Black and Myron Scholes in 1973. It is a cornerstone of modern financial theory and is based on assumptions such as a geometric Brownian motion of the underlying asset price, no transaction costs or taxes, a constant risk-free interest rate, and an option being European, only exercisable at expiration. (Bouchaud and Sornette, 1994)

The Black-Scholes model uses these assumptions to derive a formula for the price of an option. The formula is:

$$\mathbf{C = S \cdot N(d1) - K \cdot N(d2)}$$

where:

- C is the price of the call option
- S is the current stock price
- K is the strike price of the option
- N(d) is the cumulative normal distribution function.

The formula can also be used to price put options. The formula for a put option is:

$$\mathbf{P = K \cdot N(-d2) - S \cdot N(-d1)}$$

where:

- P is the price of the put option

From the Black Scholes model, we chose a European put option and further computed the option price which came out to be as 1.6404.

	contractSymbol	lastTradeDate	strike	lastPrice	bid	ask	change	percentChange	volume	openInterest	impliedVolatility	inTheMoney	contractSize	currency	BSMPrice
0	BCS231215P00002000	2023-06-12 18:03:24+00:00	2.0	0.02	0.00	0.00	0.0	0.0	NaN	1	0.500005	False	REGULAR	USD	0.000000
1	BCS231215P00004000	2023-05-19 18:08:43+00:00	4.0	0.10	0.00	0.00	0.0	0.0	1.0	0	0.500005	False	REGULAR	USD	0.006234
2	BCS231215P00005000	2023-06-22 15:59:53+00:00	5.0	0.09	0.00	0.75	0.0	0.0	NaN	10	2.773441	False	REGULAR	USD	0.072479
3	BCS231215P00006000	2023-11-24 17:41:56+00:00	6.0	0.05	0.00	0.00	0.0	0.0	1.0	0	0.250007	False	REGULAR	USD	0.330758
4	BCS231215P00007000	2023-12-01 16:22:13+00:00	7.0	0.05	0.00	0.00	0.0	0.0	7.0	0	0.125009	False	REGULAR	USD	0.868492
5	BCS231215P00008000	2023-10-27 17:30:37+00:00	8.0	1.71	0.60	0.80	0.0	0.0	17.0	0	0.562504	True	REGULAR	USD	1.640374
6	BCS231215P00009000	2023-09-13 13:36:01+00:00	9.0	1.15	1.50	1.60	0.0	0.0	621.0	650	0.250007	True	REGULAR	USD	2.545099
7	BCS231215P00010000	2023-09-14 17:14:06+00:00	10.0	1.99	2.35	2.65	0.0	0.0	1.0	0	1.109379	True	REGULAR	USD	NaN
8	BCS231215P00011000	2023-07-20 18:52:13+00:00	11.0	2.50	3.60	4.20	0.0	0.0	3.0	0	2.203129	True	REGULAR	USD	NaN
9	BCS231215P00013000	2023-08-17 18:00:38+00:00	13.0	5.60	4.90	5.10	0.0	0.0	NaN	1	0.000010	True	REGULAR	USD	NaN

Figure 5. Table of all the option prices calculated using Black sholes.

Further after this, estimated errors we calculated to check what is the error that the Black sholes model have from the actual option price.

Descriptive Statistics of Estimated Error:

Count	Mean	Std	Minimum	25%	50%	75%	Maximum

7	**300.36**	**632.11**	**-100.00**	**-56.61**	**-4.07**	**341.41**	**1636.98**

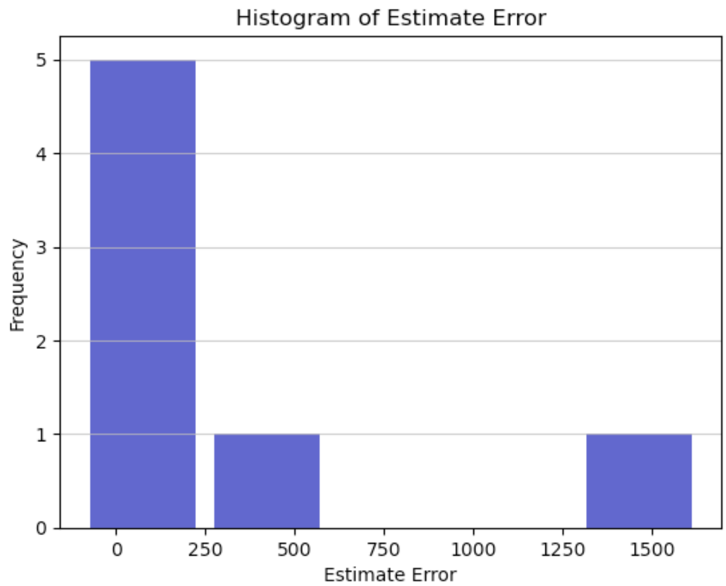


Figure 6. Estimate Error in option prices calculated using Black sholes.

Descriptive statistics and the figure above tell us that for most of the cases in black sholes that we have calculated there is an estimate error of 300.36%,

3.3 Comparison and final prices

Monte Carlo Simulation does not require any assumptions about the underlying asset price distribution or the volatility of the asset price. This makes Monte Carlo simulation a more versatile and flexible method than the Black-Scholes model. However, Monte Carlo simulation is also more computationally expensive than the Black-Scholes model.

In our analysis there was not much there was a difference of 1.23% in the values that we got from the Black Scholes Model (Option Price: £1.64) and Monte Carlo Simulation (Option Price: £1.62)

4. Analysis of Greeks

Option Greeks are measures of the sensitivity of an option's price to changes in underlying market factors. They are named after the Greek letters used to denote them. Understanding option Greeks is crucial for traders and investors to manage risk in their positions. For instance, a trader with a high Delta call option may hedge their position by buying a put option with a negative Delta. (Liu and Hong, 2011)

Greek	Definition	Significance
Delta (Δ)	Rate of change of option price relative to change in underlying asset price	Measures direction and magnitude of price change

Gamma (Γ)	Rate of change of Delta relative to change in implied volatility	Indicates sensitivity to volatility changes
Theta (Θ)	Rate of decline in option value as time to expiration approaches	Measures time decay of option value
Rho(ρ)	Rate of change in option price relative to change in interest rate	Indicates sensitivity to interest rate changes

4.1 Delta

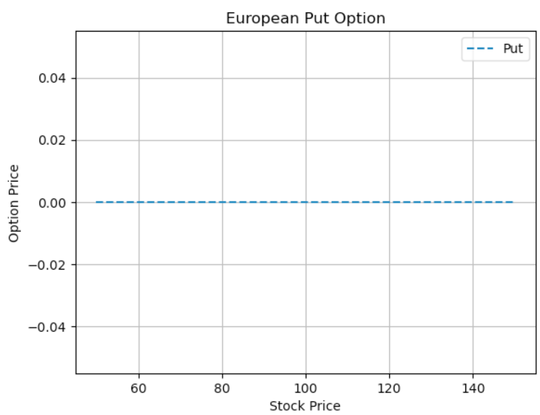
Delta is a measure of change in option price compared to the underlying asset price, with a positive Delta indicating the option price moves in the same direction as the stock price.

$$\Delta = \partial S/\partial V = -e^{-q(T-t)}\ N(-d_1)$$

Where,
∂ is the first derivative
V is the option's price
S is underlying asset price

Result: -0.8319

Based on the result of the delta if the stock price of Barclay's increase by £1 the option price will decrease by £0.8319.



4.2 Gamma

Gamma measures the change in Delta based on implied volatility, with a positive Gamma indicating an increase in Delta as volatility increases, and a negative Gamma indicating a decrease.

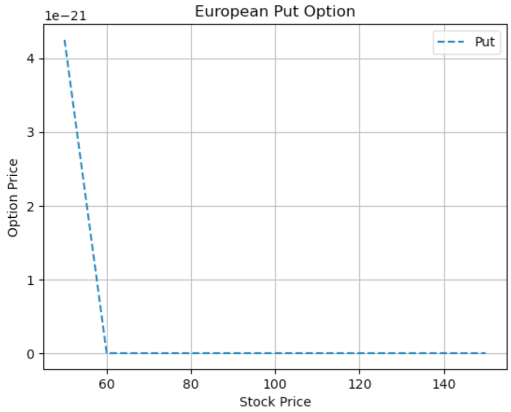
$$\Gamma = \partial \Delta/\partial S = \partial^2 V/\partial^2 S = e^{-q(T-t)} N'(d_1)/\ \sigma S\sqrt{(T-t)}$$

Where,
∂ is the first derivative
V is the option's price

S is underlying asset price

Result: 0.1842

From the result of gamma if the stock price of Barclay's increase by £1 the option price will increase by £0.1842.



4.3 Theta

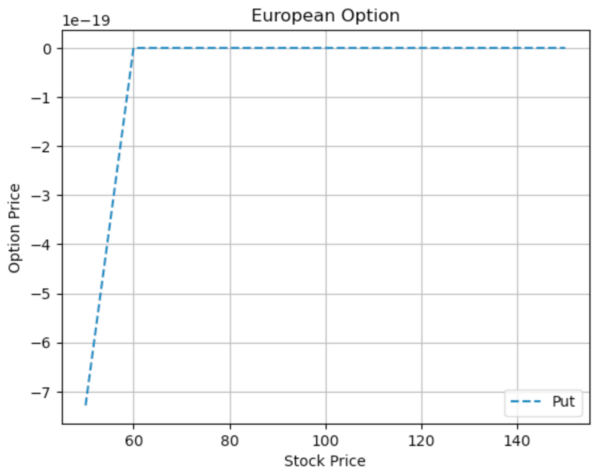
Theta measures the rate of option value decline as expiration approaches, with a negative value indicating decay, and a positive value indicating a decrease.

$$\Theta = \partial V/\partial T = -(\sigma^2 S(d_1)(d_2))/2\sqrt{(T)}$$

Where,
∂ is the first derivative
V is the option's price
T is the time to maturity

Result: -0.3874

We conclude based on the result that if there is a decrease in Time to maturity by 1 year, the option value will decrease by 0.387/365 = £0.00106



4.4 Rho

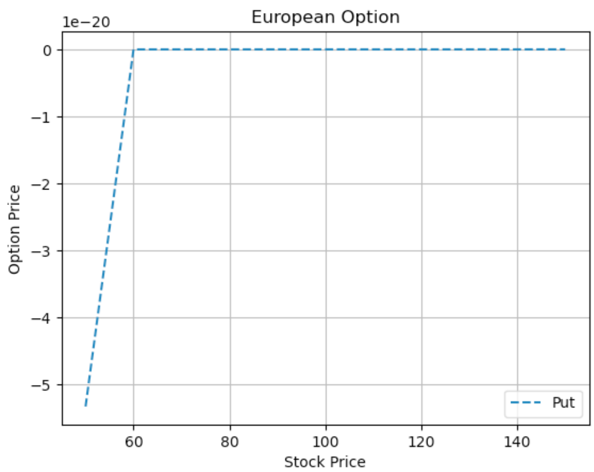
Rho (ρ) is an option Greek that gauges an option's price's sensitivity to changes in the risk-free interest rate, often considered the least significant option Greek.

$$\rho = \partial V/\partial r = -K(T-t)e^{-r(T-t)}N(-d_2)$$

Where,
∂ is the first derivative
V is the option's price
r is the interest rate

Result: -1.9489

This signifies that if the interest rate increases by 1% the put option will decrease by £0.0194.



6. References

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