Module Title: Computational Methods for Finance

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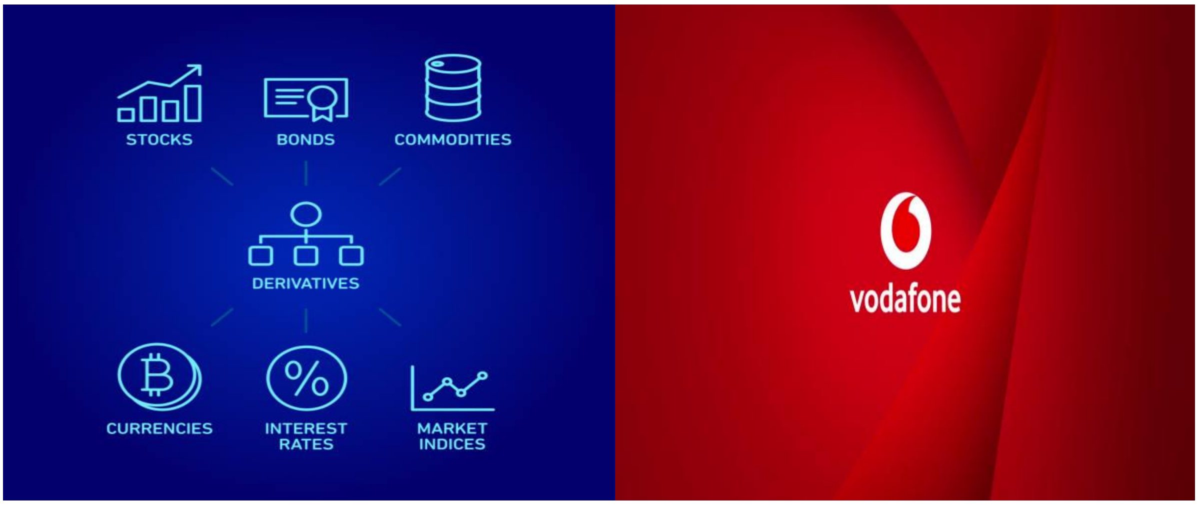
MSc Fintech and Business Analytics (Core), Semester 1, 2023/2024

FINANCIAL DERIVATIVE REPORT

VODAFONE GROUP PLC



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1.EXECUTIVE SUMMARY

This report presents the financial derivative created for the shares of Vodafone, a company included in the FTSE100 index, is examined in this study. Python was used to gather and examine historical daily data over a two-year period, from January 2020 to December 2022(COVID-19 period).

The first step in the research is gathering pertinent data. To achieve this, Python was used to get historical daily data for Vodafone's stock from Yahoo Finance. An analysis of the stock's performance is provided by the computation of the annualized standard deviation and annualized average return, which are shown alongside the movement of the equity price during the specified time-period. And then two model were developed, and Greek analysis is done to analyse the option price and concluded report with findings.

Note: Share price Values are in $.

GitHub Link for Python Jupyter Notebook Codes

https://github.com/xxsarikapatel/CMF-Coursework/blob/main/Sarika%20CWcoursework%203%20month.ipynb

2.INTRODUCTION

This report provides a thorough examination of a financial derivative created for Vodafone, a well-known company that is included in the FTSE100 index. The research uses historical daily data from Yahoo Finance and spans a two-year timeframe, from January 2020 to December 2022.

The report's initial portion is devoted to gathering pertinent data for the study. Utilising the Python programming language, Vodafone's daily historical data is downloaded from Yahoo Finance. Plotting the movement of the stock price throughout the chosen time-period is subsequently done using the gathered data. To further shed light on the performance of the equity, the annualised standard deviation and annualised average return are computed.

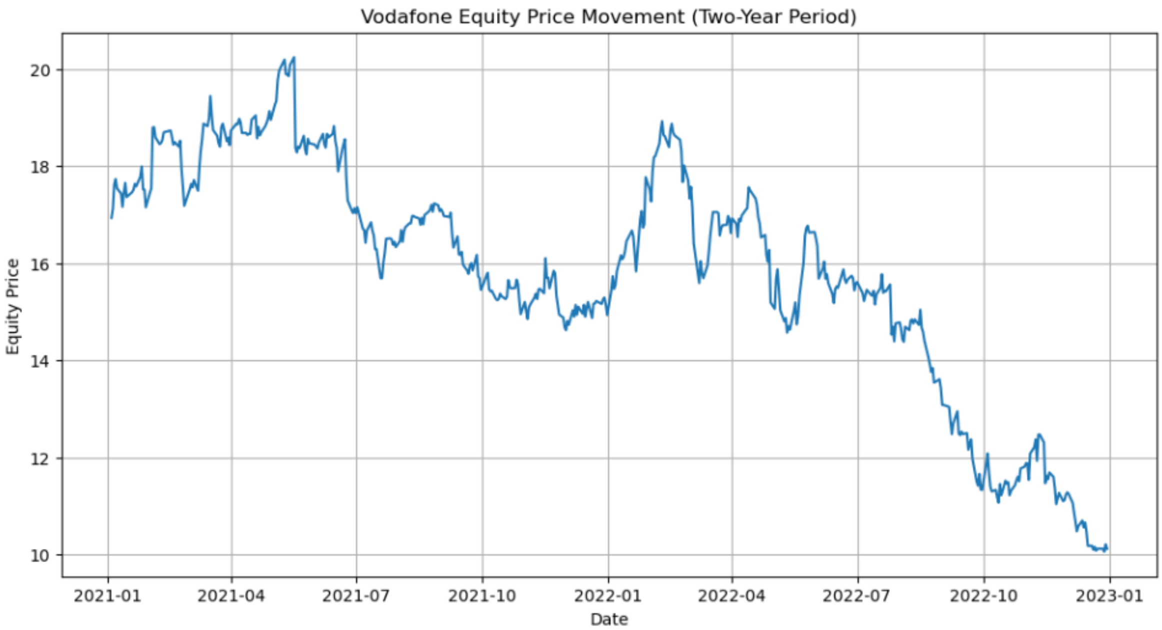
The methodology part then goes on to detail how a non-dividend paying option linked to Vodafone's stock was designed. To ascertain the option's value, two distinct pricing techniques are applied. Among these techniques are Black sholes Merton, and binomial trees. To evaluate each method's efficacy in pricing the option, the outcomes are compared. In addition, the analysis portion explores the Greeks related to the financial derivative.

The purpose of this paper is to illustrate how computational methods may be used in the finance industry by designing and analysing a financial derivative for Vodafone's stock.

3.PRICE MOVEMENT ANALYSIS

Equity Price Movement Analysis of Vodafone for Two year (January 2021 to Dec 2022)

Figure 1. Equity Price Movement Analysis of Vodafone for Two year



Descriptive analysis for Vodafone stock price during selected time period.

Time Period	Mean (%)	Standard Deviation (%)
Jan-2021 to Dec 2022	-19.81	27.33

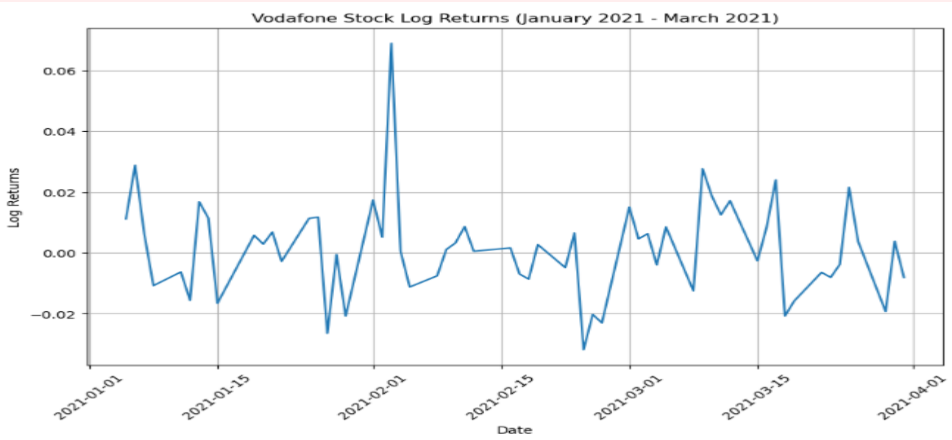
The equity stock of Vodafone has demonstrated an average annualised return of -19.81%, signifying a reduction in the investment's value throughout the designated timeframe. The stock's significant volatility and related risks are further highlighted by its 27.33% standard deviation.

Technical Analysis (Measuring Volatility)

A comprehensive examination of Vodafone's stock performance from January 1, 2021, to March 31, 2021 is provided in this research report.

In financial analysis, log return is a frequently used metric to evaluate an asset's performance over a certain time frame. It computes the percentage change in the asset's price or value's logarithm.

Figure 2 Log-Return for 3 months (Jan-Mar 2021)



Notably, our data shows that, in comparison to other times within the examined span, the volatility recorded on February 3, 2021, was somewhat higher.

Analysing its volatility on a yearly basis. According to our research, Vodafone's stock has an annualised volatility of 1.72, which is somewhat greater than other companies in the same market or sector.

Time Period	Volatility Annualised
Jan-2021 to March 2022	1.72

4.METHODOLOGY

NON-DIVIDEND PAYING OPTION PRICING MODELS

The non-dividend paying option pricing model determines an estimated option value. This makes it possible for traders and investors to determine if an option is reasonably valued in the market or is overpriced or underpriced. There are several models to calculate Option pricing. Will discuss two models in this report.

European option pricing will be calculated and analysed using Binomial Tree Model and Black-Scholes model based on following data.

Parametes	Notes	Value
Stock price(S)	Close price as on 1 jan.2021	16.93
Strike price (K)	Price at option expiration	18.74
Risk free Rate of Interest'[r]	10-year USA Treasury rate, April 2021	0.01
Volatility (σ)	calculated using 3-month data jan-mar 2021	1.72
Time to expiration(T)	77 days/365	0.21
No.of time steps (n)	n= (T *365)	77

1.Bionomial Tree Model

The approach enables the computation of option prices and other derivatives by building a tree-like structure with nodes representing various price levels at various times. Based on the anticipated probability of price changes.

Formula

$S(up) = S * e^{(\sigma * \sqrt{\Delta t})}$ $S(down) = S * e^{(-\sigma * \sqrt{\Delta t})}$

Where:

- S is the current price.
- σ is the volatility.
- Δt is the time interval.
- The up and down factors are used to determine the potential future prices of the underlying asset.

Compared to continuous-time models like the Black-Scholes-Merton model, the binomial tree model makes option pricing calculations easier since it assumes a discrete time framework and discrete price fluctuations.

Result: The European put option price is $15.49 and call option price is $15.53.

2.Black -Sholes-Merton Model

The Black-Scholes-Merton model accounts for the likelihood of various price outcomes when estimating the fair value of options. This model offers a framework for option pricing, hedging strategies, and comprehending the link between option prices and market factors.

Formula:

European Call option: $C = S * N(d1) - X * e^{(-r * T)} * N(d2)$

European Put Option: $P = X * e^{(-r * T)} * N(-d2) - S * N(-d1)$

Where:

- $N(d1)$ and $N(d2)$ are cumulative standard normal distribution functions.
- X is the strike price of the option.
- r is the risk-free interest rate.
- T is the time to expiration of the option.
- $d1 = [\ln(S / X) + (r + (\sigma^2 / 2)) * T] / (\sigma * \sqrt{T})$, $d2 = d1 - \sigma * \sqrt{T}$

Result: The European put option price is $6.398 and call option price is $4.627.

3.Comparision of Two model

Model	European option price	
	Call	Put
Binomial Tree	15.53	15.49
Black sholes Merton	4.63	6.4

For both call and put options, the binomial tree model produces option prices that are greater than those of the Black-Scholes-Merton model.

The binomial tree model provides a more thorough analysis of option values by accounting for a variety of potential stock price fluctuations throughout time, it could be the result of taking prospective stock price volatility and variations into more realistic account. With its greater adaptability, the binomial tree model may be used with a wide range of option kinds and intricate payoffs.

The Black-Scholes-Merton model, streamlines the computations by assuming a continuous and regularly distributed change in stock prices, oversimplifying the market or underestimating risk. The Black-Scholes-Merton model might not work well for more complicated choices; it is mainly intended for European options with straightforward payoffs.

It's also advised to take each model's assumptions and limitations into account when choosing an investment.

5.GREEKS ANALYSIS

Greek analysis is a technique used in options trading to assess how sensitive option prices are to changes in a variety of variables. Delta, Gamma, Theta, Vega, and Rho are the important Greek measures. Traders may make well-informed decisions based on shifting market conditions and have a better understanding of and ability to control the risks connected with their options holdings by examining these Greeks.

The Greeks in the Black-Scholes-Merton framework are reviewed in this paper primarily for options with a geometric Brownian motion process, no dividend payments, and only executed at maturity.

Greek Analysis		
Greeks	**Call**	**Put**
Delta	0.606	-0.393
Gamma	0.028	0.028
Theta	-12.25	-12.06
Rho	1.188	-2.758

1.Delta

One of the most important Greeks in options trading is delta, which expresses how sensitive an option's price is to shifts in the price of the underlying asset. It measures how much the option price changes in response to a change in the underlying asset of one unit.

Formula:

Call option: N(d1)

Put Option: N(d1) - 1

Where:

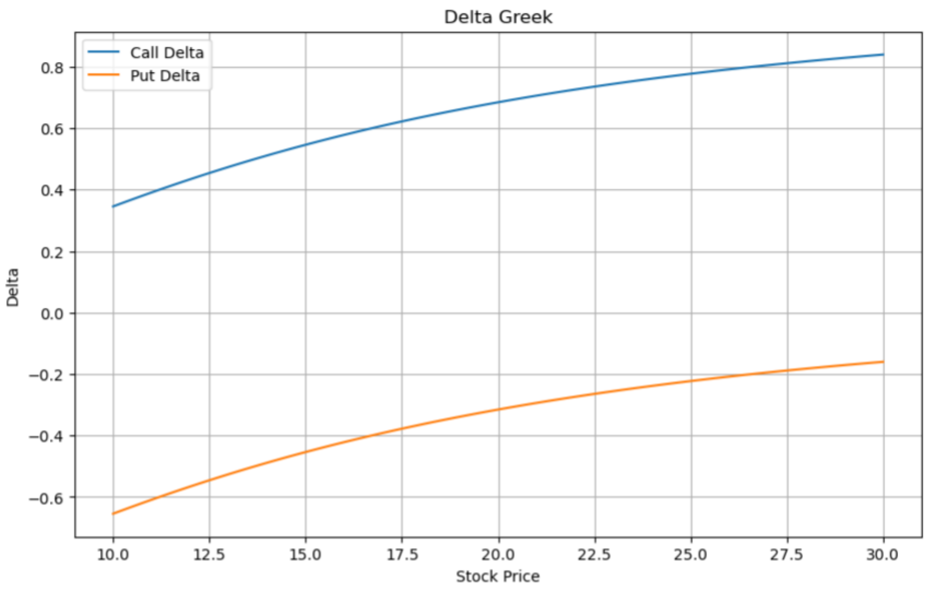
- N(d1) represents the cumulative standard normal distribution function evaluated at d1.
- d1 = [ln(S / X) + (r + (σ^2 / 2)) * T] / (σ * √T)

Result:

Delta for Vodafone's Call option is 0.61 and For Put option is -0.39.

If Vodafone's price increase by $1 ,the European put option's premium will be decreased by $0.39.

Figure 3 Delta 2D Movement



2.Gamma

It calculates the rate at which the delta of an option varies in response to price movements of the underlying asset. It measures the price sensitivity of the option's curve. A greater gamma means that when the price of the underlying asset changes, the option's delta will move more quickly. It is especially important for traders who want to take advantage of short-term market fluctuations or who want to dynamically hedge their bets.

Formula

Gamma = N'(d1) / (S * σ * √T)

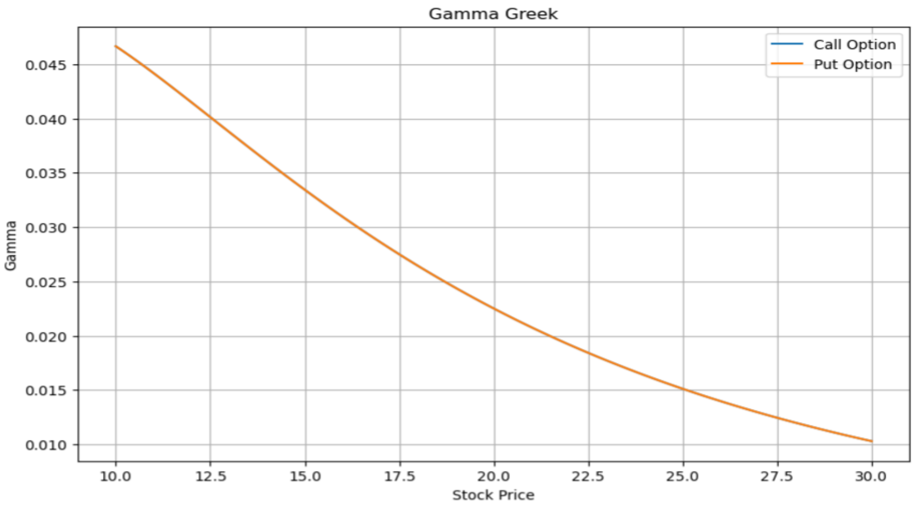
Where,

- N'(d1) represents the probability density function of a standard normal distribution evaluated at d1.
- d1 = [ln(S / X) + (r + (σ^2 / 2)) * T] / (σ * √T)

Result: Gamma for Vodafone's Call &Put option is 0.028.

If Vodafone's price increase by $1, the European Call and put option's Delta will be increased by 0.028.

Figure 4 Gamma 2D Movement



3.Theta

It evaluates how quickly the price of an option is declining as it gets closer to expiration. A negative theta signifies a declining option's value over time as a result of the extrinsic value eroding.

Formula

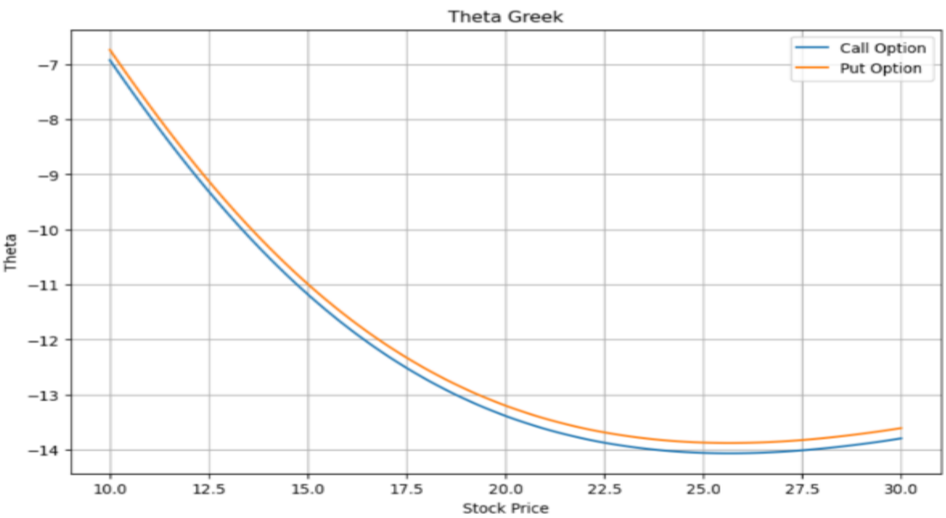
Call option:(Call) = (-S * N'(d1) * σ) / (2 * √T) - r * X * e^(-r * T) * N(d2)

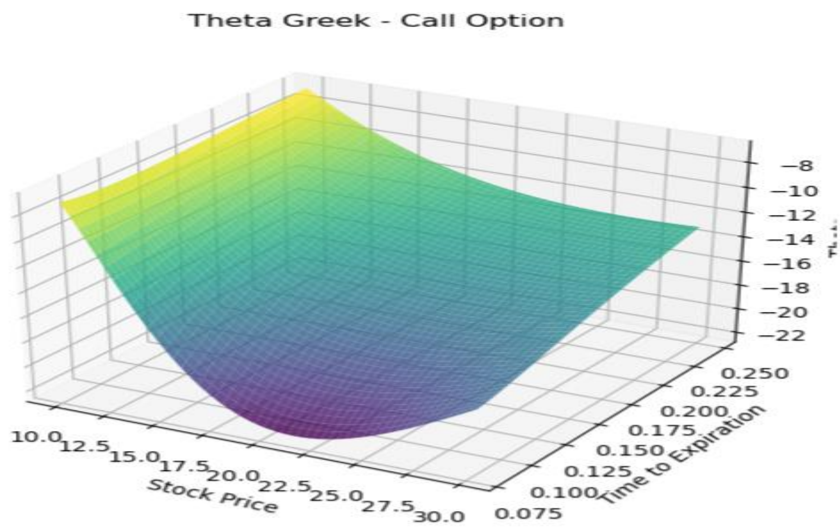
Put Option: (Put) = (-S * N'(d1) * σ) / (2 * √T) + r * X * e^(-r * T) * N(-d2)

Result: Theta for Vodafone's Call option is -12.25 and For Put option is -12.06.

If the time to maturity decrease by 1 year, the put option value decrease by $12.06 and call option value decrease by $12.25 respectively if all other factor remain constant.

Figure 5 Theta 2D Movement, 3D (Call option)





3.Rho

It determines how sensitive the price of an option is to variations in the risk-free interest rate. It measures how interest rate changes affect the value of the option. Higher option prices are predicted by a positive rho, whereas lower option prices are suggested by a negative rho.

Formula

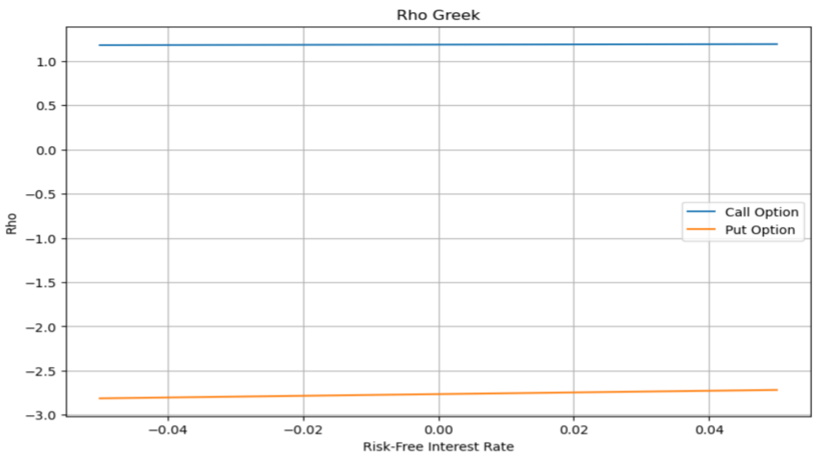
Call option:(Call) = X * T * e^(-r * T) * N(d2)

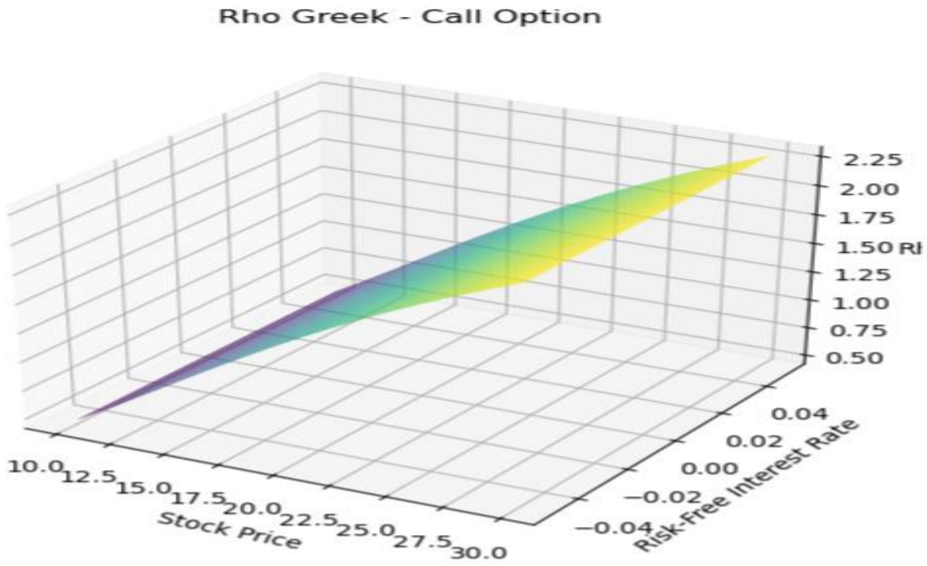
Put Option: (Put) = -X * T * e^(-r * T) * N(-d2)

Result: Rho for Vodafone's Call option is 1.188 and For Put option is -2.756.

If the Risk-free rate increased by 1% the put option will be decreased by $2.76 and call option will increase by $1.19 respectively if all other factors remain constant.

Figure 6 Rho 2D Movement ,3D (Call Option)





6.CONCLUSION

The call option has a delta of 0.606, which indicates a favourable association with the underlying stock price based on the Greek study of Vodafone stock. Given that the gamma is 0.028.Theta is -12.25, meaning that time decay causes the call option's value to drop by $12.25 per day. The call option is positively sensitive to changes in interest rates, as indicated by the rho of 1.188.

However, the put option has an inverse correlation, as seen by its negative delta of -0.393. The delta is changing at a same pace, as indicated by the gamma, which stays constant at 0.028. The put option's value is decreasing by $12.06 every day due to time decay, as indicated by the theta . The put option's negative sensitivity to changes in interest rates is indicated by the rho of -2.758.

All things considered, these figures indicate that the call option is more sensitive to fluctuations in interest rates and stock prices than the put option. Additionally, as seen by their negative theta values, both choices suffer from significant in time decay.

7.LIMITATIONS

- Mathematical models are based on various assumptions which do not hold real world market condition.
- Market dynamics cannot remain constant at each point of time.
- Quite complex instruments
- Estimation of future volatility can lead to mispricing of options.
- Non constant parameters can play vital role.
- Liquidity and market depth will affect real world where model does not take that into account.

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