

MA-374 Project

Topic: Option-Greeks and their sensitivity analysis

Name- Dev Sandip Shah

Roll No.- 200123074

Solution-

-> In this assignment, I have done the sensitivity analysis of various option-greeks.

Option Greeks are financial measures of the sensitivity of the option's price to its underlying asset. There are broadly 5 main Greeks-

- I. Delta
- II. Gamma
- III. Vega
- IV. Theta
- V. Rho

Each Greek letter measures a different dimension to the risk in an option position.

-> Call-option prices were computed using the following black scholes formula. Call Option price:

$$C(t, x) = xN(d_+) - Ke^{-r\tau}N(d_-)$$

where $d_{\pm} = \frac{1}{\sigma\sqrt{\tau}} \left[\log(\frac{x}{K}) + (r \pm \frac{\sigma^2}{2})\tau \right]$.

-> Put-option prices were computed using put-call parity as follows:

$$P(t, x) = C(t, x) + Ke^{-r\tau} - x$$

Default parameters used in code:

S0: Initial stock price = 30

σ : Volatility = 0.3

K: Strike Price = 40

T: Time to Maturity = $\frac{240}{365}$

r: Risk-Free Rate = 1%

Delta:

It is defined as the rate of change of the option price with respect to the price of the underlying asset. The slope of the curve relates the option price to the underlying asset price.

$$\Delta = \frac{\delta C}{\delta S}$$

where C is the option's price, and S is the stock price.

$$\Delta(\text{call}) = N(d_+)$$

$$\Delta(\text{put}) = N(d_+) - 1$$

where $N(x)$ is the cumulative distribution function of standard Normal distribution.

Gamma:

It is defined as the rate of change of options delta with respect to the price of the underlying asset.

$$\Gamma = \frac{\delta^2 C}{\delta^2 S}$$

where C is the option price, and S is the stock price.

$$\Gamma = \frac{N(d_+)}{S_0 \sigma \sqrt{T}}$$

Gamma is the same for both call and put options.

Vega:

It is defined as the rate of change of the option price with respect to the volatility of the underlying asset.

$$\mathcal{V} = \frac{\delta C}{\delta \sigma}$$

where C is the option price, and σ is the volatility.

$$\mathcal{V} = S_0 \sqrt{T} N(d_+)$$

Vega is the same for both call and put options.

Theta:

It is defined as the rate of change of the option price with respect to the passage of time, with all else remaining the same.

$$\theta = \frac{\delta C}{\delta t}$$

where C is the option price, and t is the time.

$$\theta(\text{call}) = \frac{-S_0 N'(d_+) \sigma}{2\sqrt{T}} - rKe^{-rT} N(d_-)$$

$$\theta(\text{put}) = \frac{-S_0 N'(d_+) \sigma}{2\sqrt{T}} + rKe^{-rT} N(-d_-)$$

Rho:

It is defined as the rate of change of the option price with respect to the interest rate.

$$\rho = \frac{\delta C}{\delta r}$$

where C is the option price and r is the interest rate.

$$\rho(\text{call}) = KTe^{-rT} N(d_-)$$

$$\rho(\text{put}) = - KTe^{-rT} N(-d_-)$$

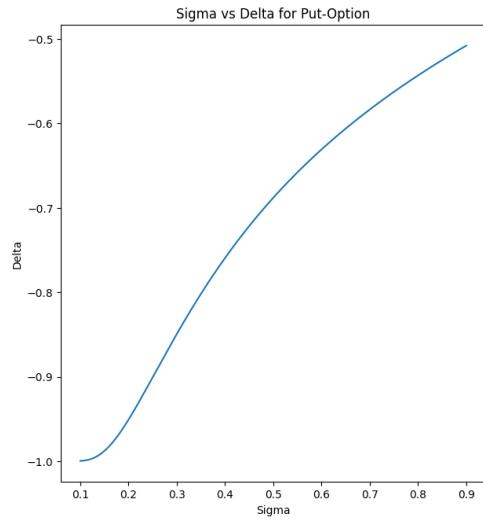
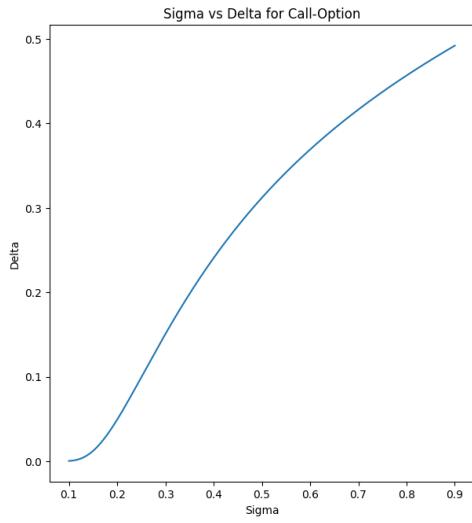
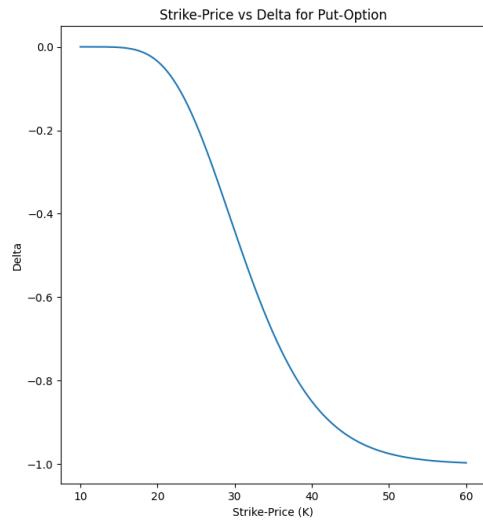
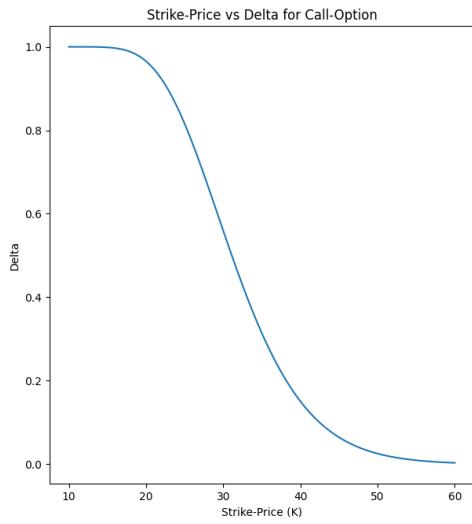
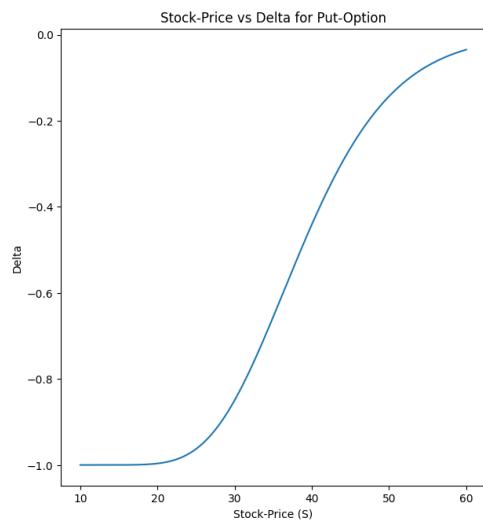
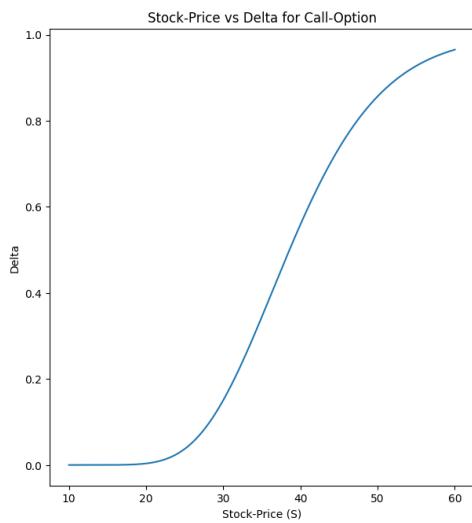
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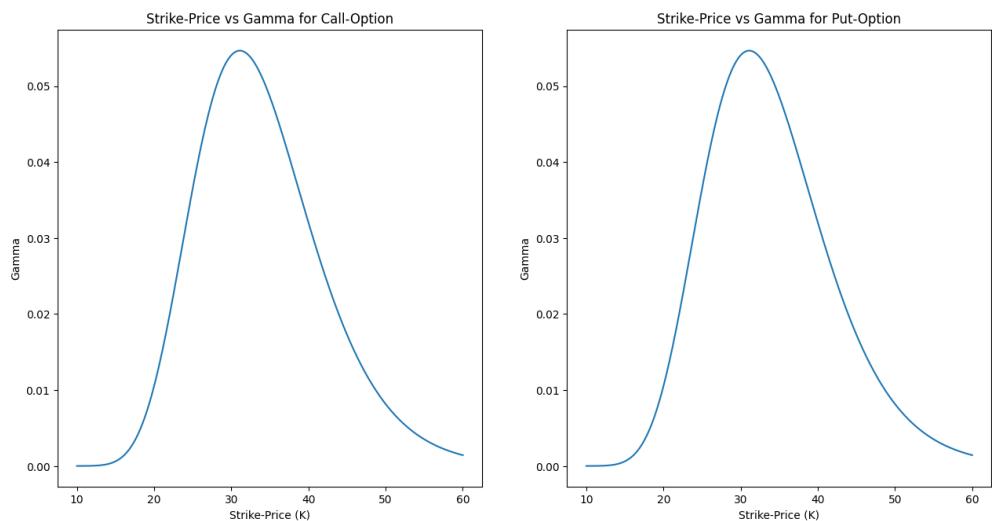
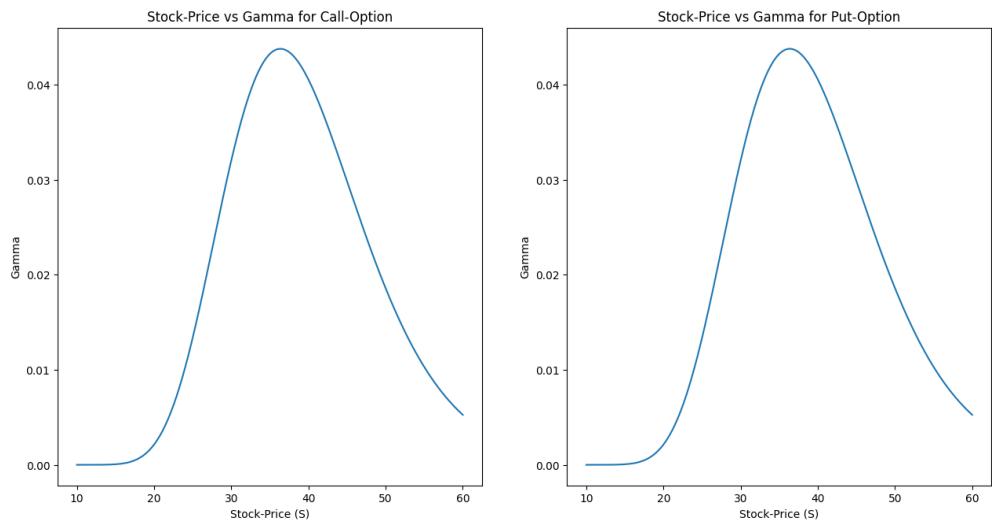
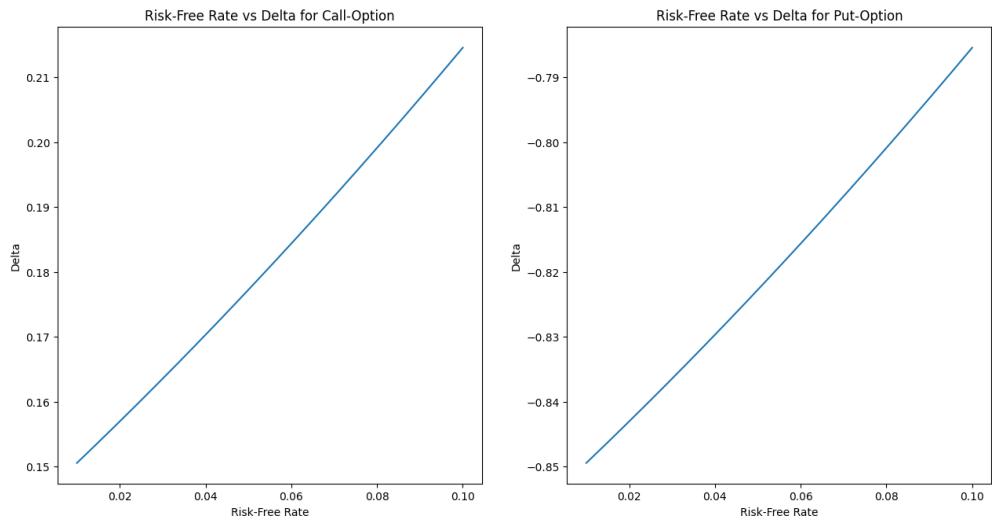
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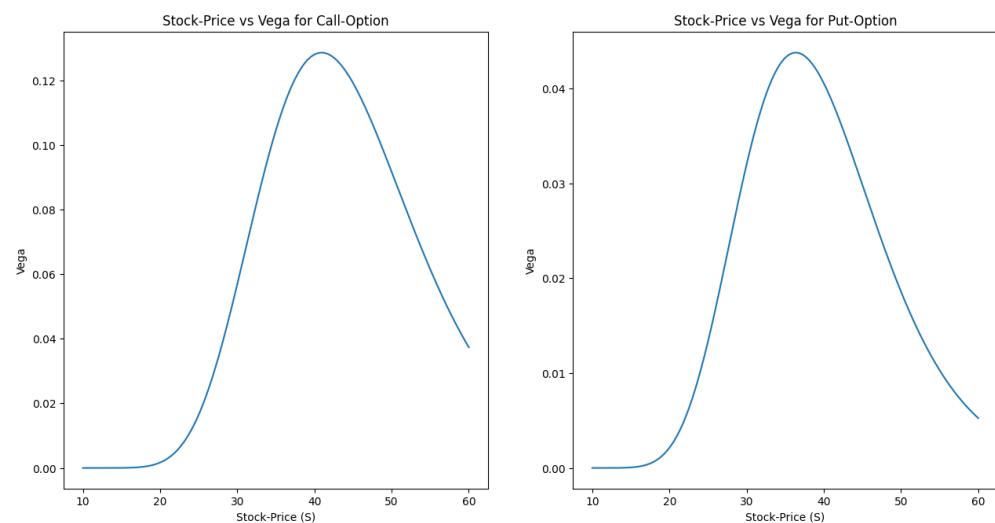
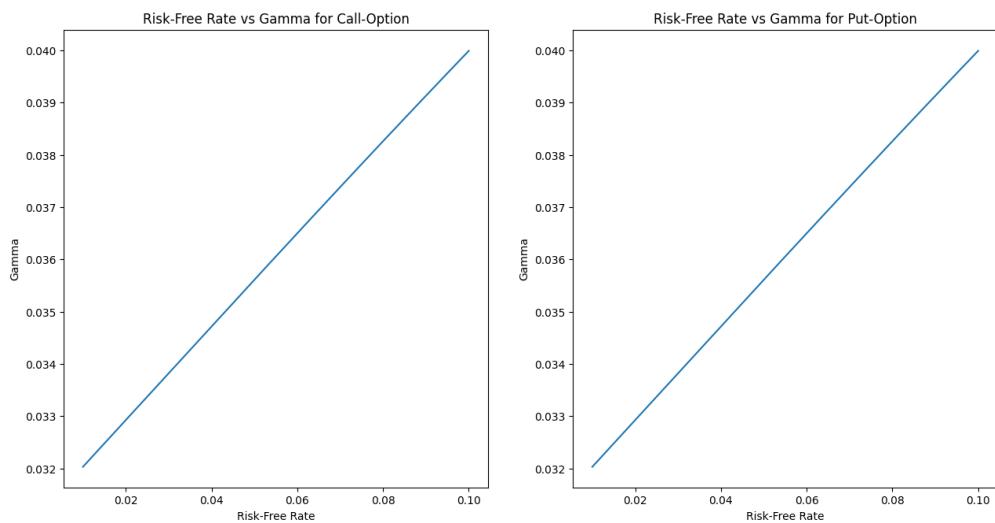
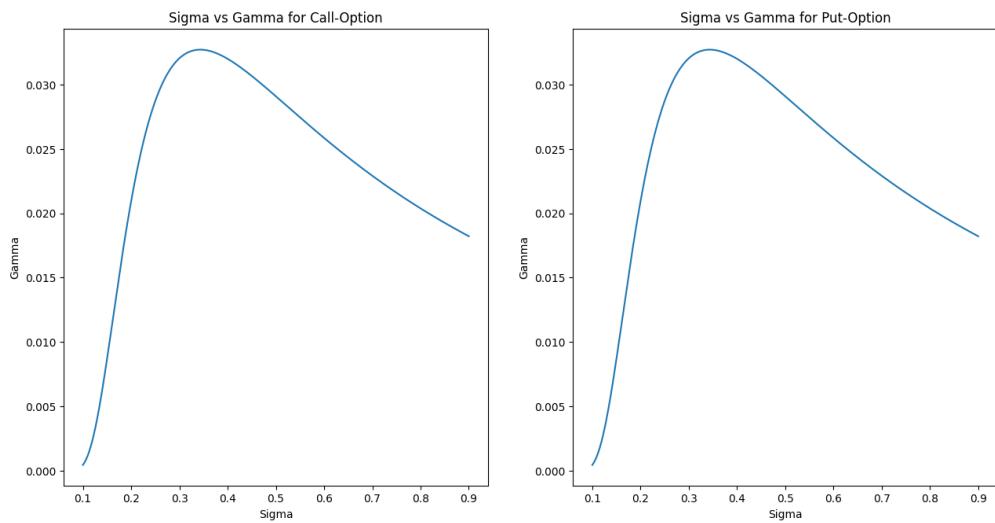
For Call Option-
Option Price: 0.5132843798399405
    Delta: 0.15058613984880015
    Gamma: 0.03203161102008452
    Vega : 0.05686707929045143
    Theta: -0.003663899299916886
    Rho : 0.02632964262328151

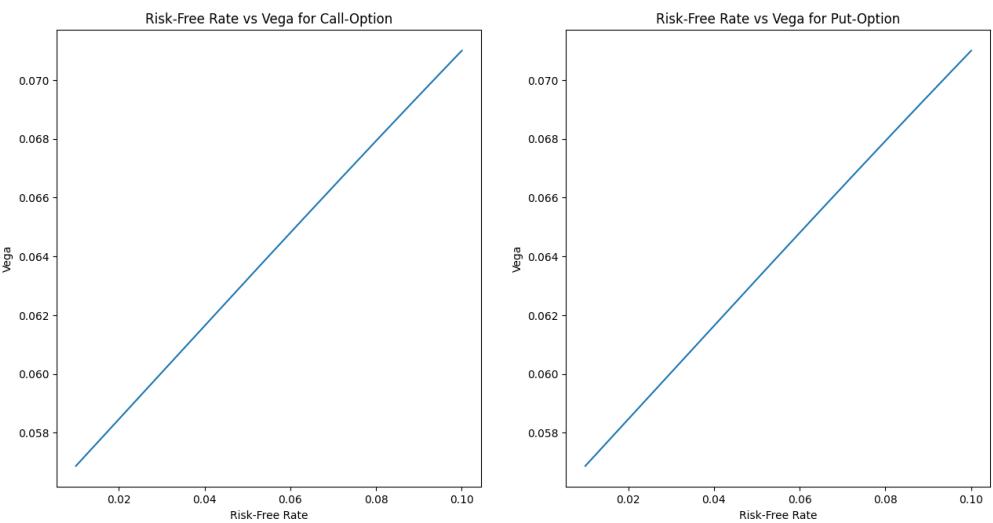
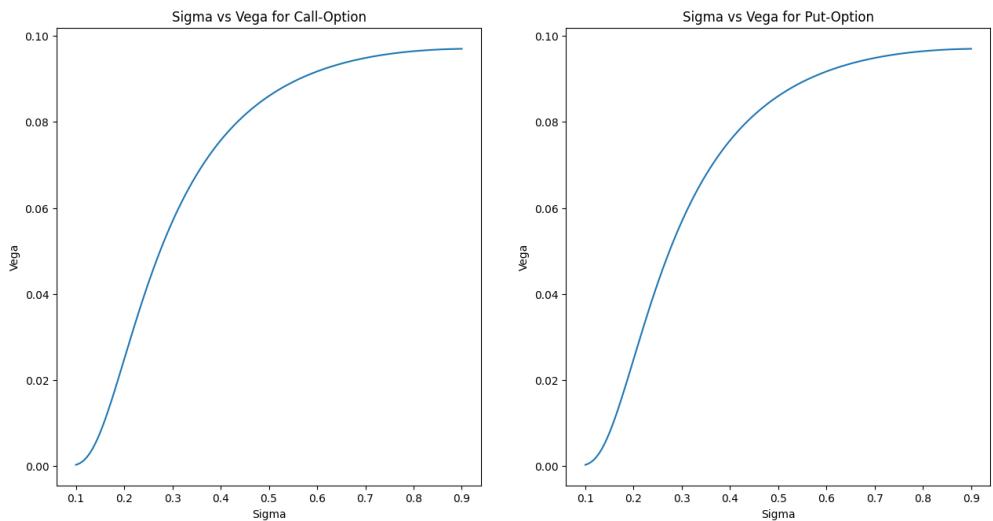
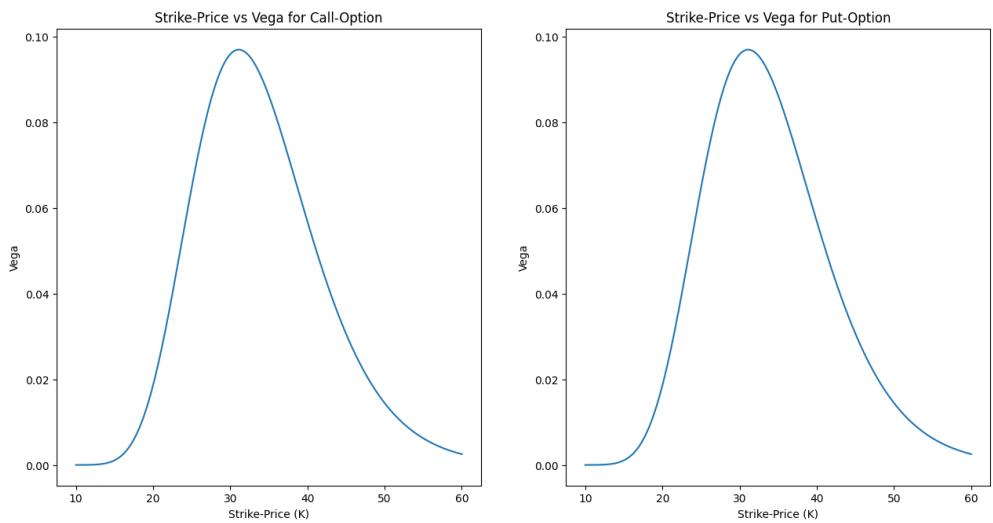
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    Vega : 0.05686707929045143
    Theta: -0.0025751911050726785
    Rho : -0.23496032413932816

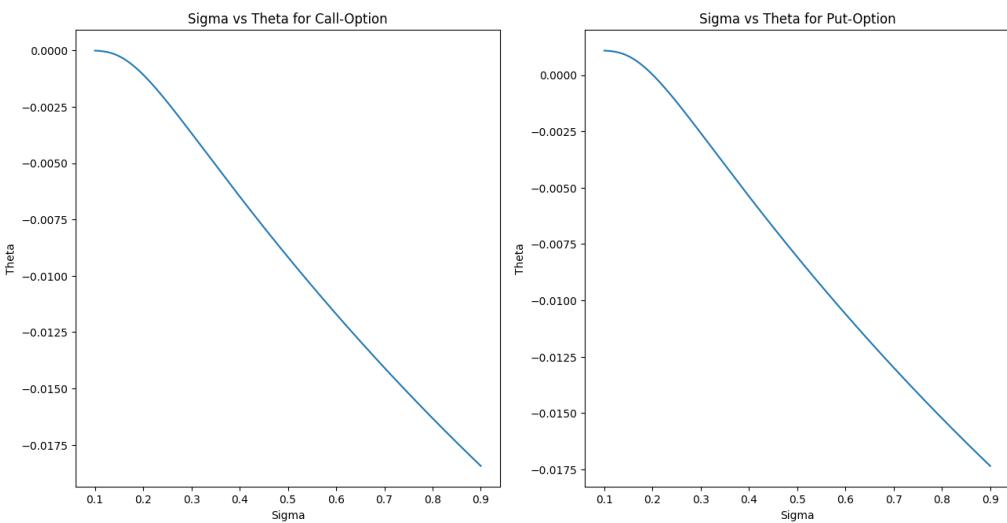
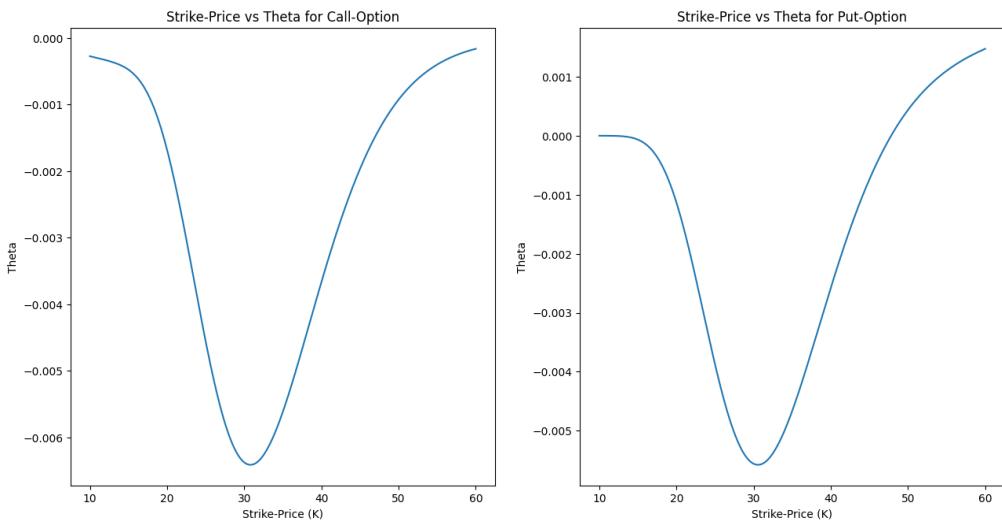
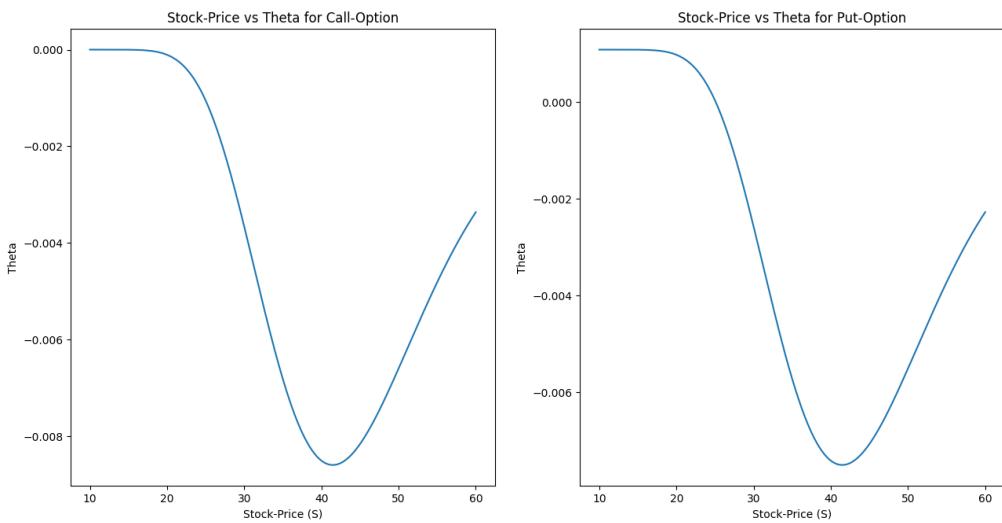
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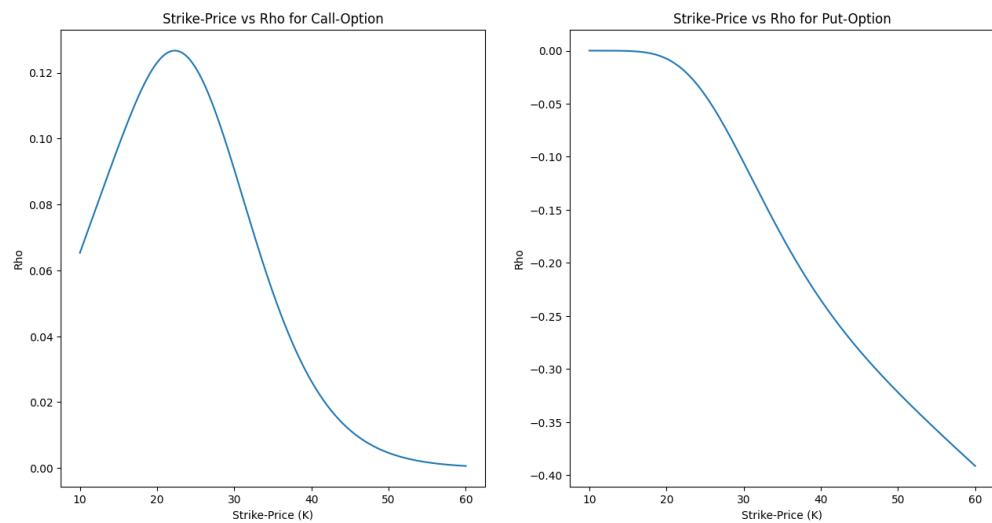
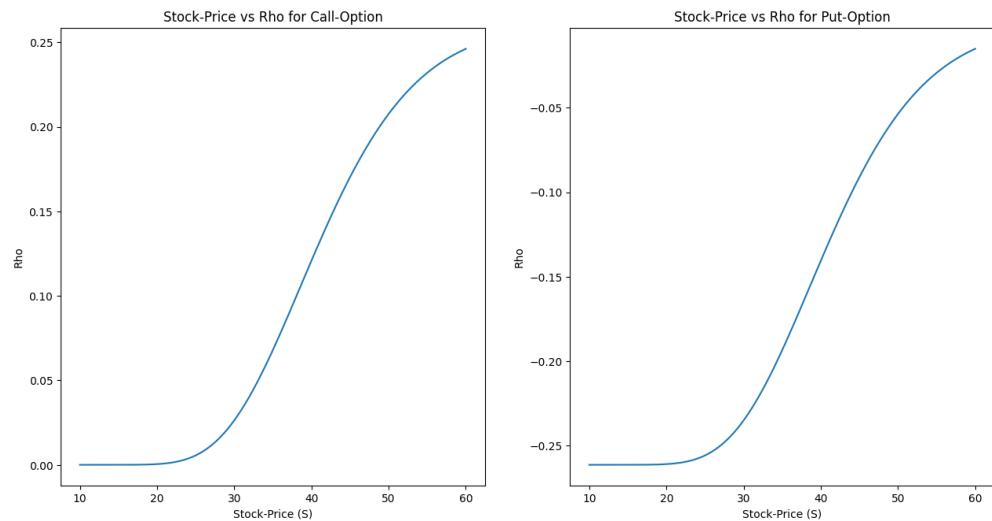
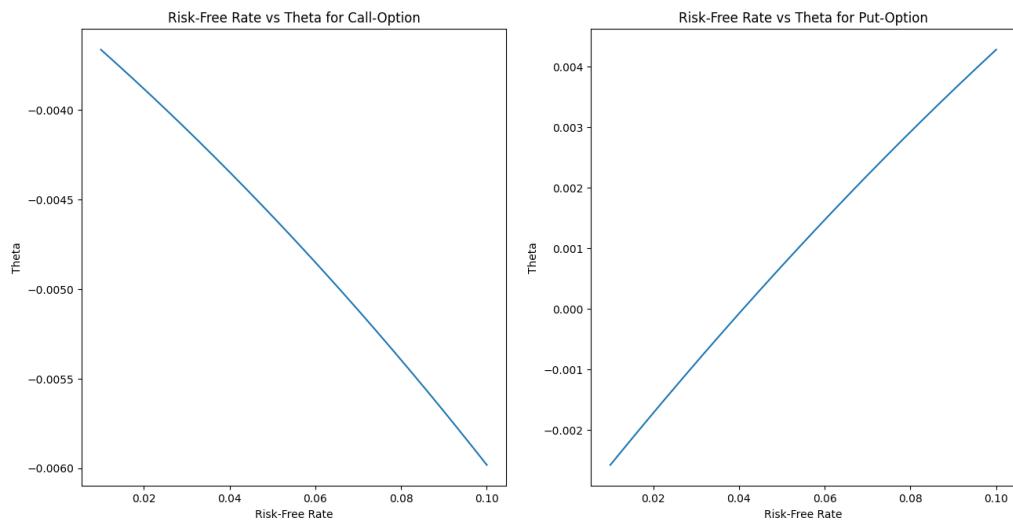


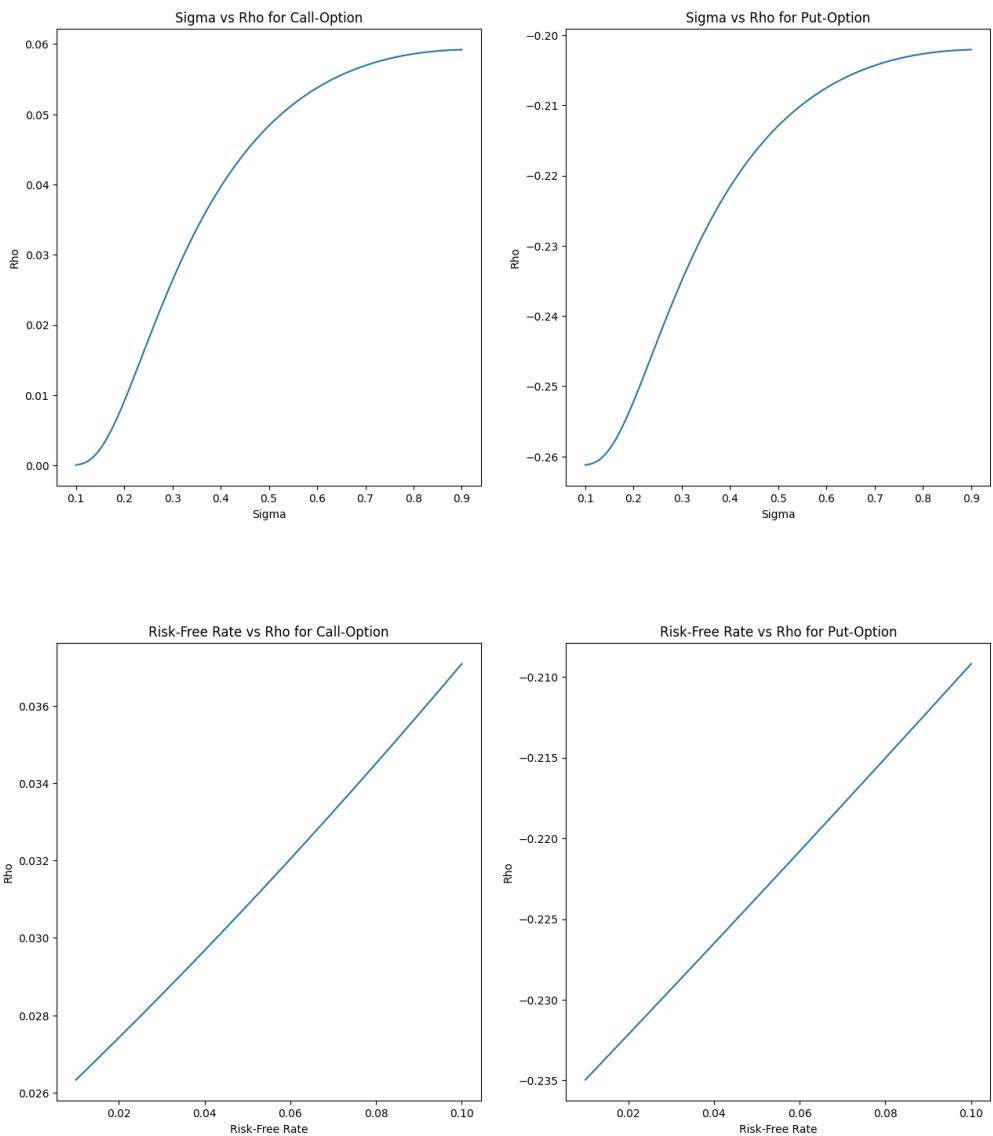








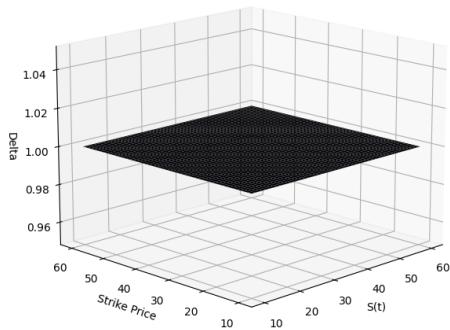




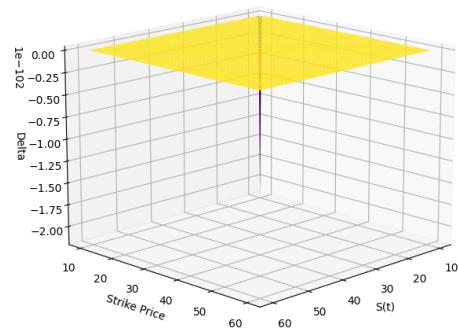
(3-D plots - next page)

Delta vs $S(t)$ vs Strike Price

Delta for Call-Option

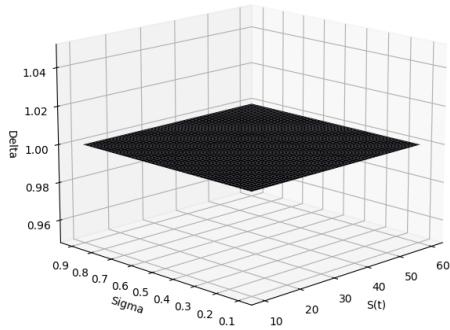


Delta for Put-Option

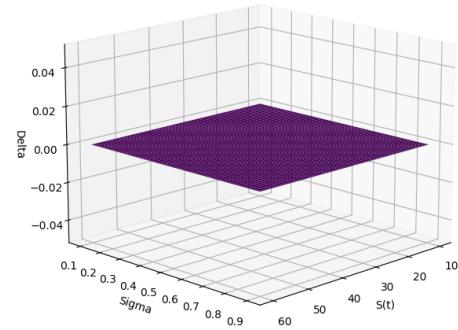


Delta vs $S(t)$ vs Sigma

Delta for Call-Option

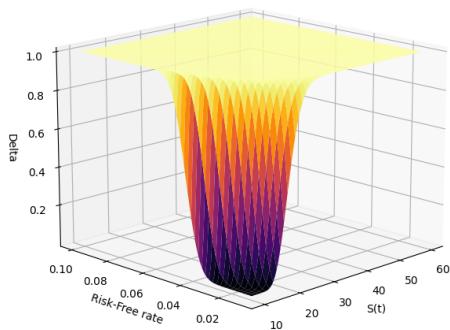


Delta for Put-Option

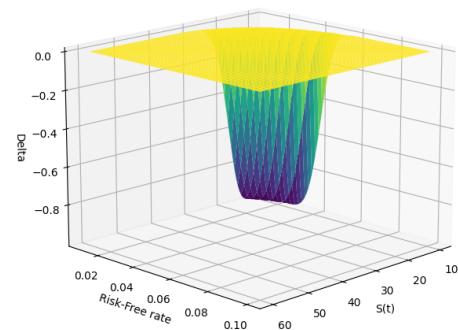


Delta vs $S(t)$ vs Risk-Free rate

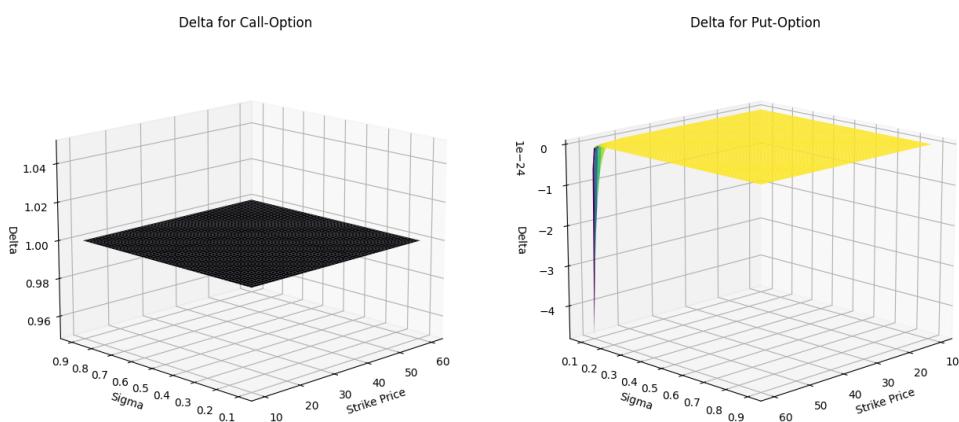
Delta for Call-Option



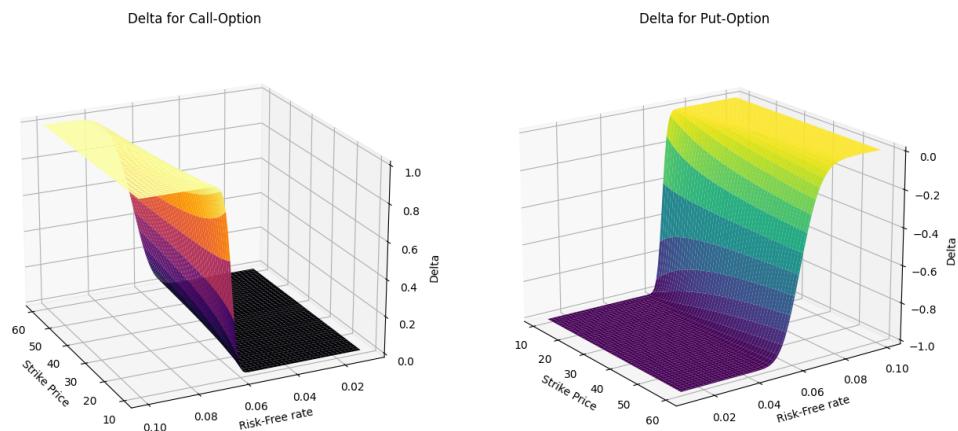
Delta for Put-Option



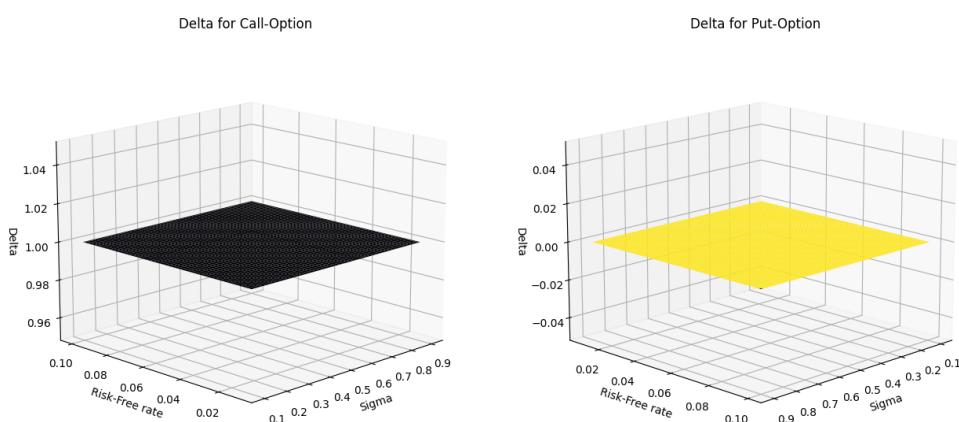
Delta vs Strike Price vs Sigma



Delta vs Strike Price vs Risk-Free rate



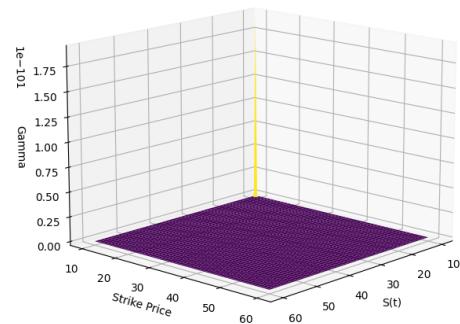
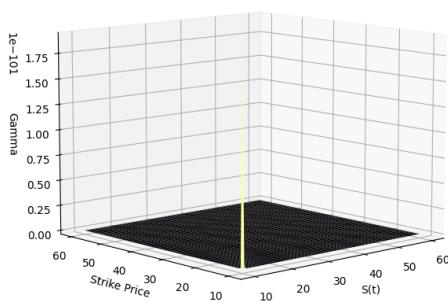
Delta vs Sigma vs Risk-Free rate



Gamma vs S(t) vs Strike Price

Gamma for Call-Option

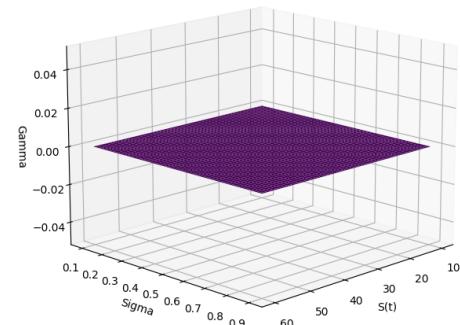
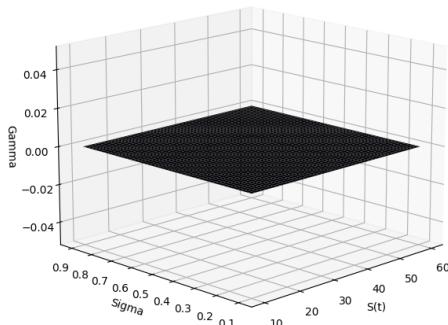
Gamma for Put-Option



Gamma vs S(t) vs Sigma

Gamma for Call-Option

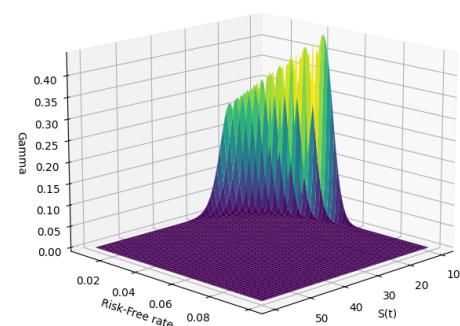
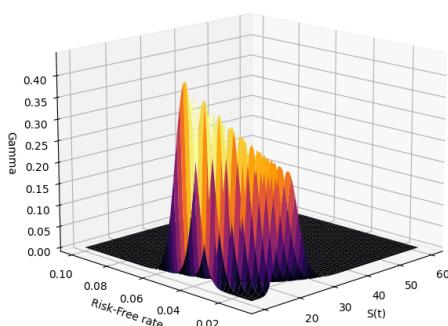
Gamma for Put-Option



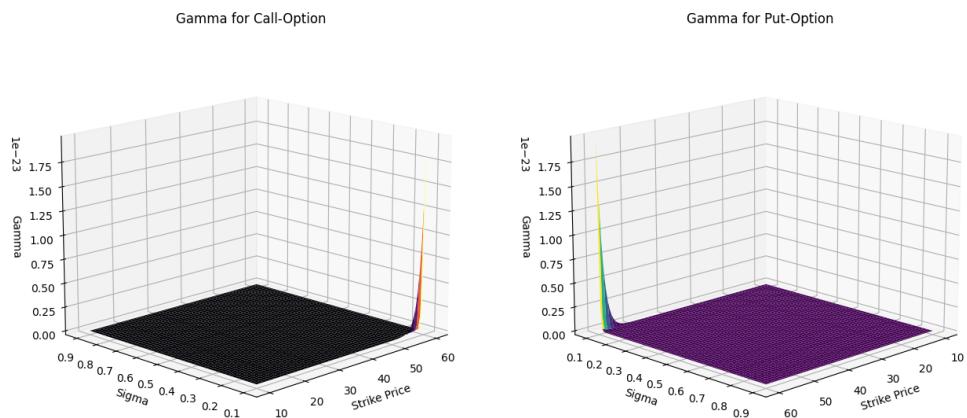
Gamma vs S(t) vs Risk-Free rate

Gamma for Call-Option

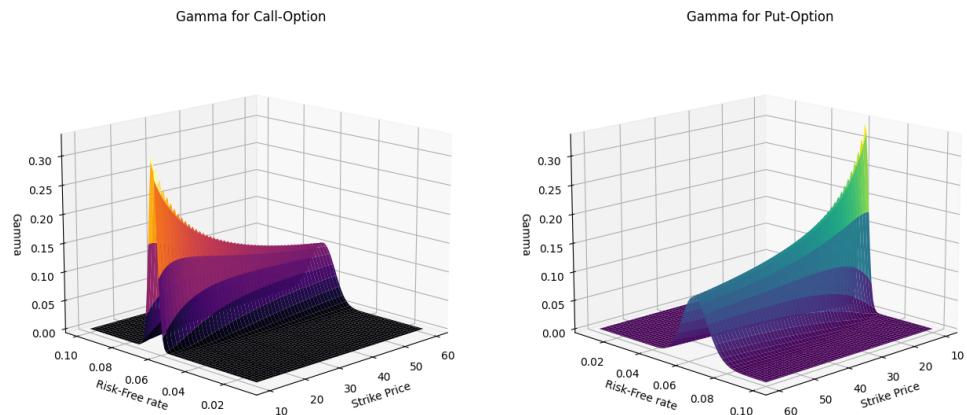
Gamma for Put-Option



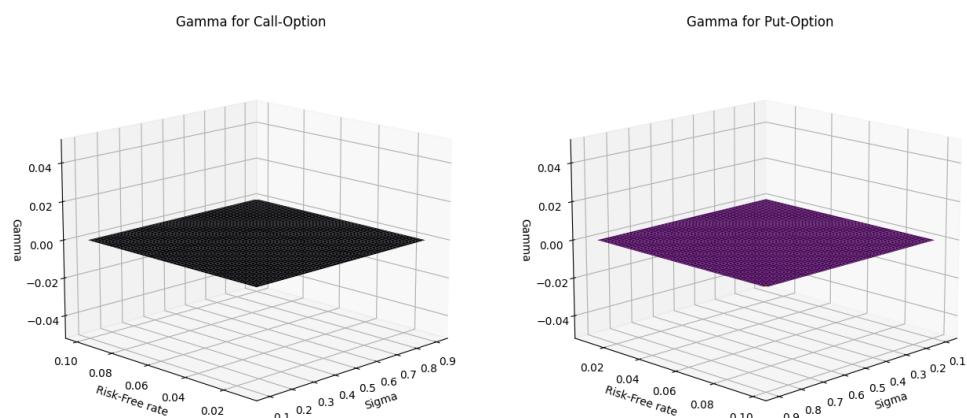
Gamma vs Strike Price vs Sigma



Gamma vs Strike Price vs Risk-Free rate



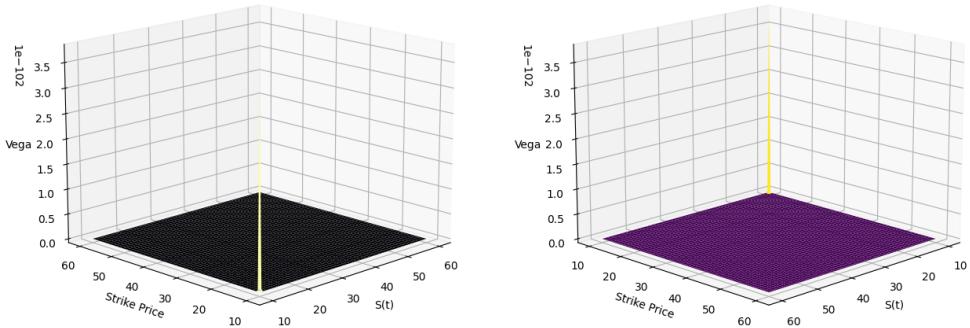
Gamma vs Sigma vs Risk-Free rate



Vega vs $S(t)$ vs Strike Price

Vega for Call-Option

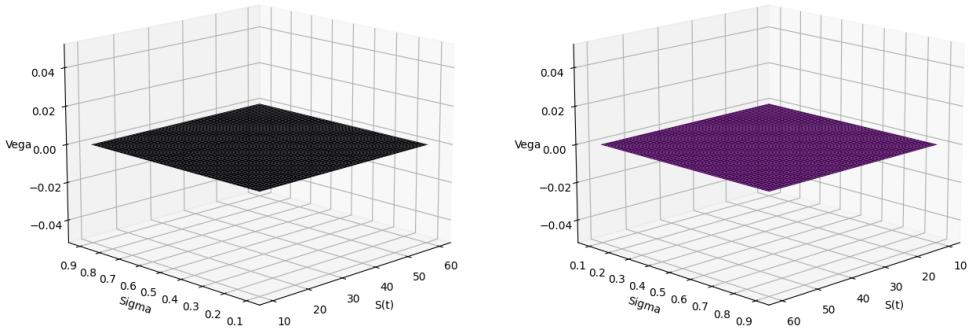
Vega for Put-Option



Vega vs $S(t)$ vs Sigma

Vega for Call-Option

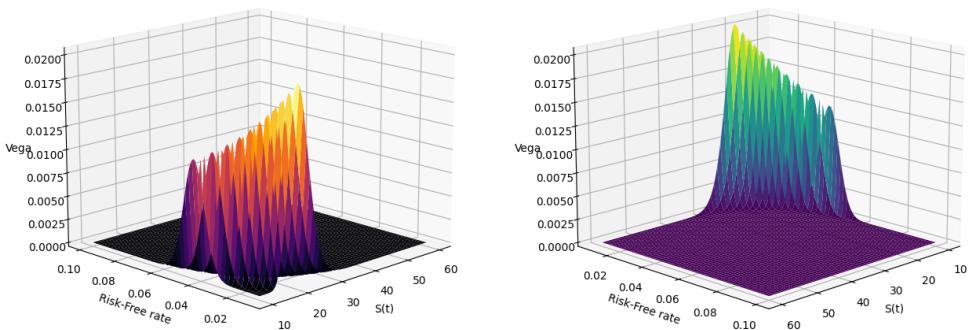
Vega for Put-Option



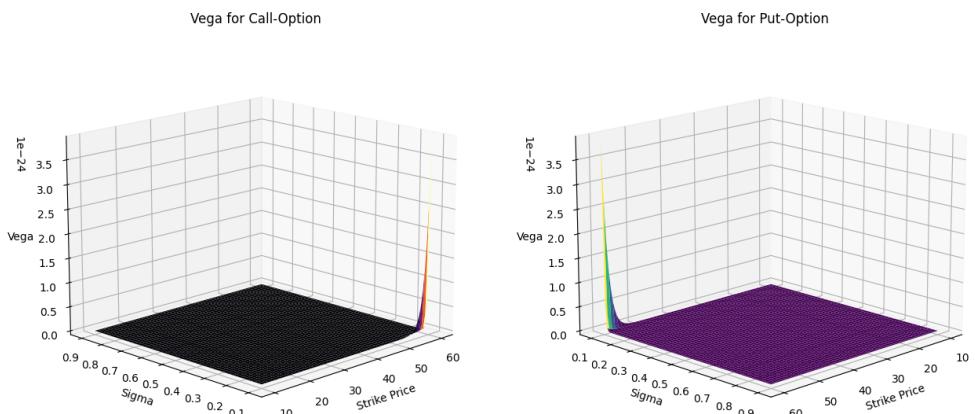
Vega vs $S(t)$ vs Risk-Free rate

Vega for Call-Option

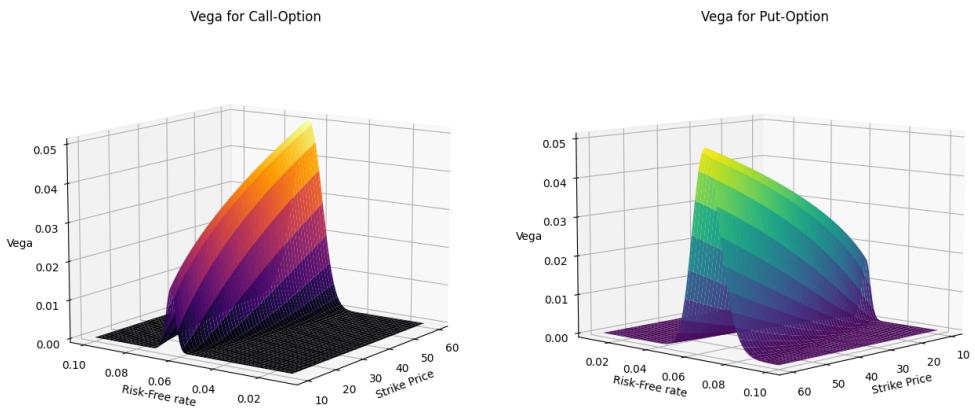
Vega for Put-Option



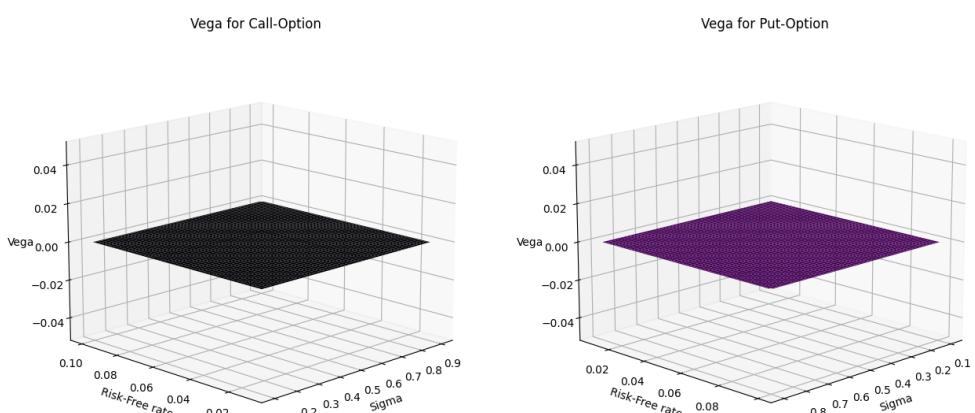
Vega vs Strike Price vs Sigma



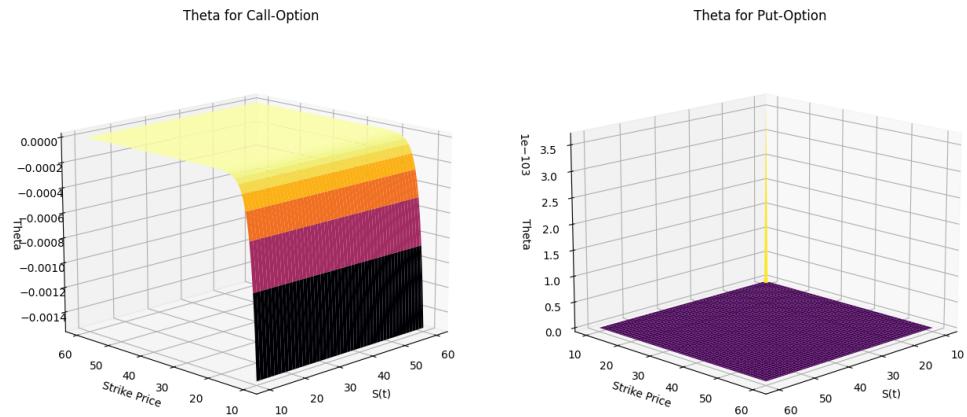
Vega vs Strike Price vs Risk-Free rate



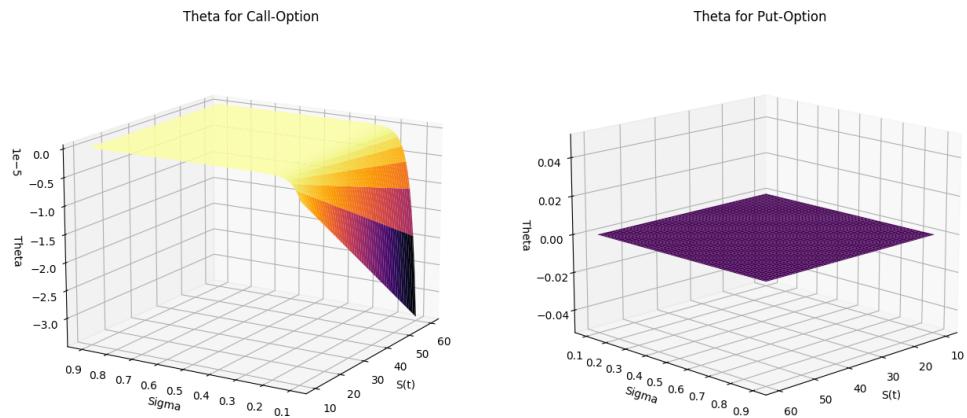
Vega vs Sigma vs Risk-Free rate



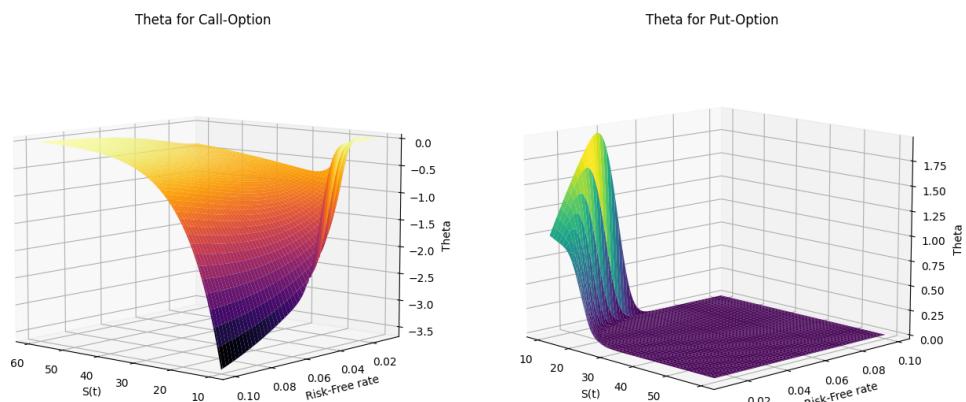
Theta vs $S(t)$ vs Strike Price



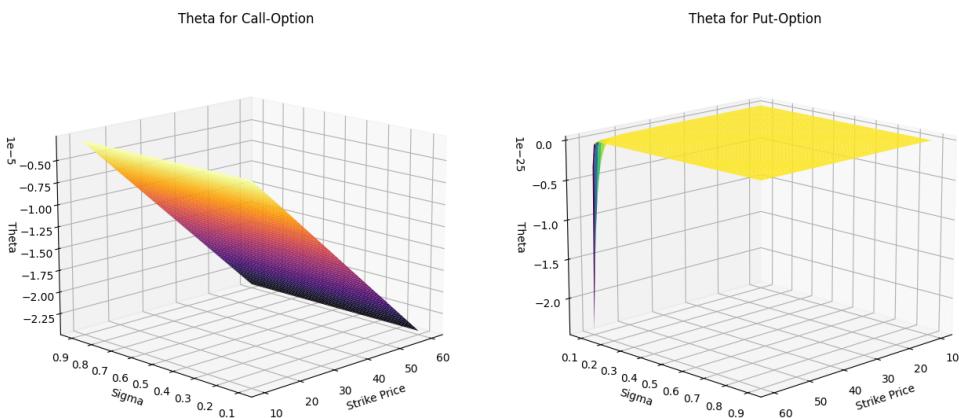
Theta vs $S(t)$ vs Sigma



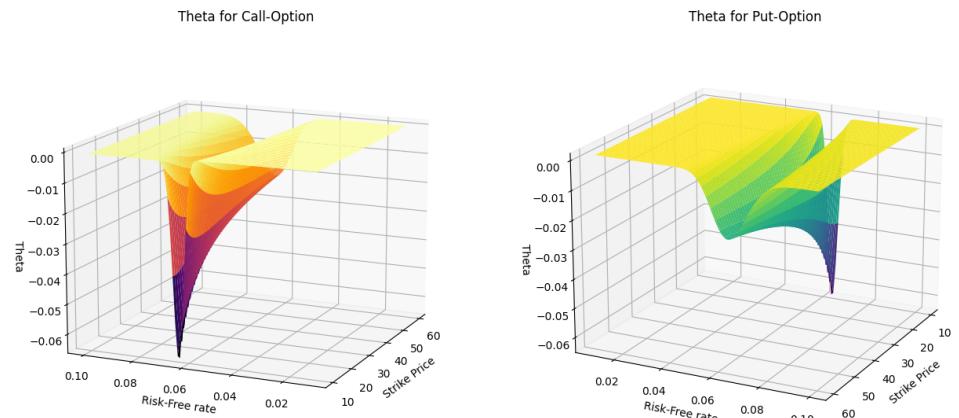
Theta vs $S(t)$ vs Risk-Free rate



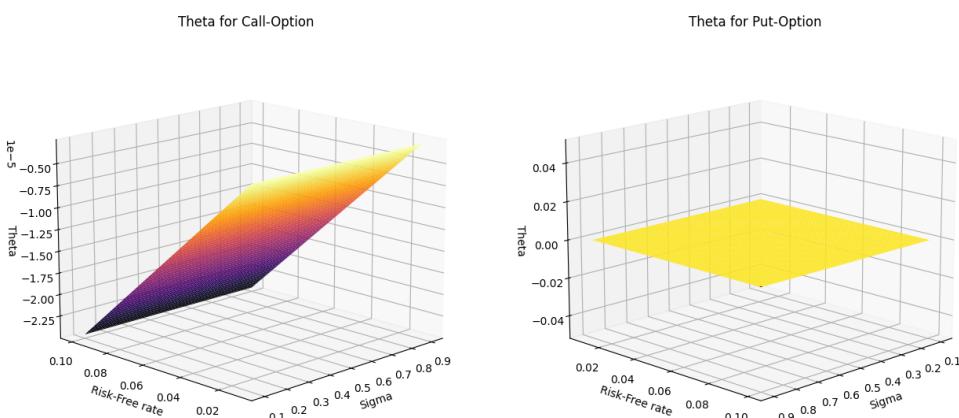
Theta vs Strike Price vs Sigma



Theta vs Strike Price vs Risk-Free rate



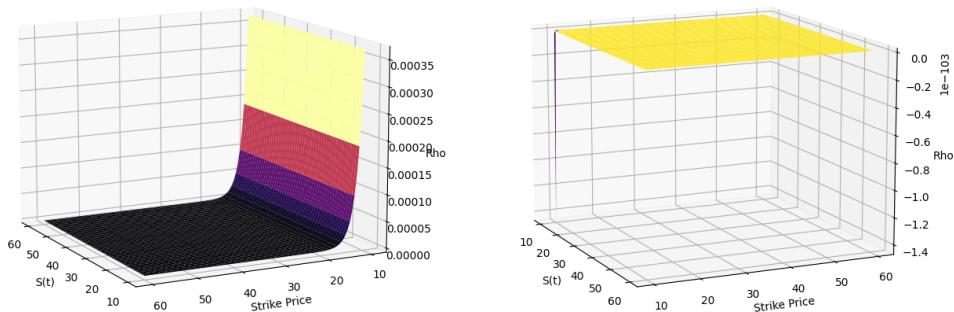
Theta vs Sigma vs Risk-Free rate



Rho vs S(t) vs Strike Price

Rho for Call-Option

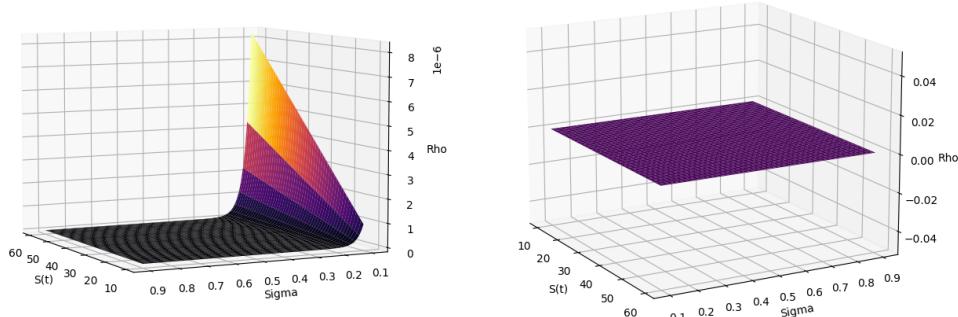
Rho for Put-Option



Rho vs S(t) vs Sigma

Rho for Call-Option

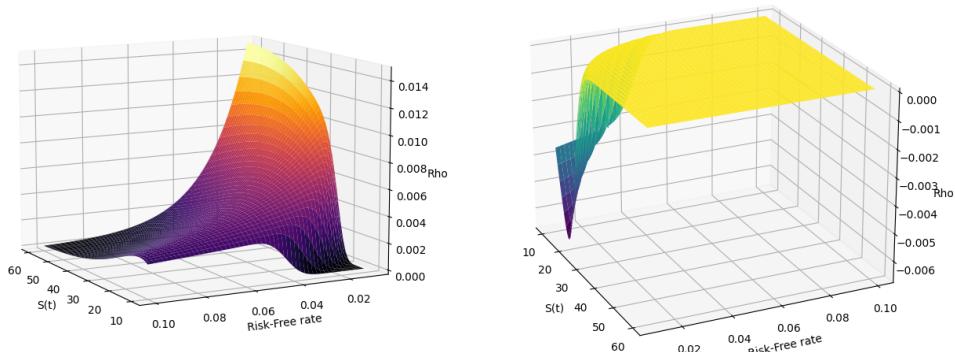
Rho for Put-Option



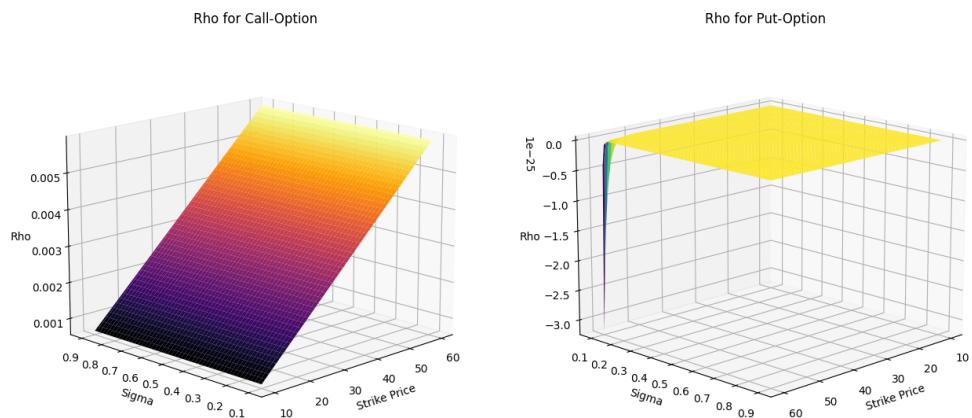
Rho vs S(t) vs Risk-Free rate

Rho for Call-Option

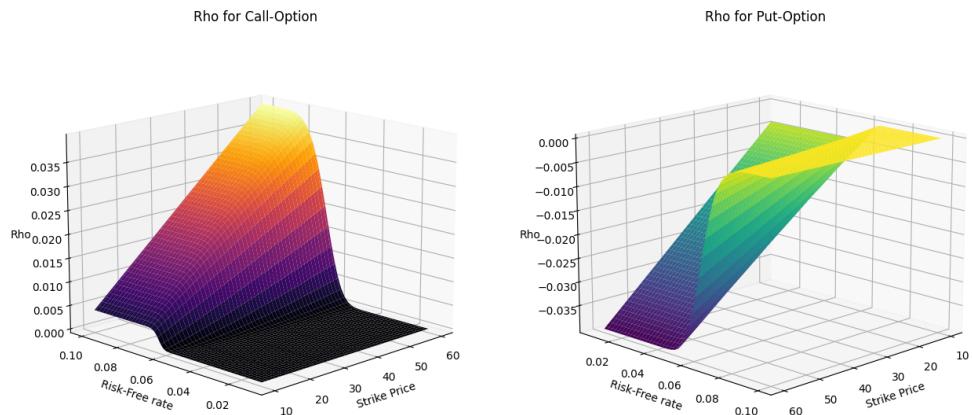
Rho for Put-Option



Rho vs Strike Price vs Sigma



Rho vs Strike Price vs Risk-Free rate



Rho vs Sigma vs Risk-Free rate

