



भारतीय प्रौद्योगिकी संस्थान गुवाहाटी
INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI

MA 374: Financial Engineering Lab **Lab 02**

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Note: 

1. While running the program to get 3-D Plots, it usually takes **5-10 seconds**, because of the large number of data points, so kindly wait for so long. Also while running matplotlib, please expand the result (in the running application) to full-screen mode to get the proper 3D-scatter plot (in some cases the plot doesn't load properly unless viewed in the full-screen mode once).
2. Please run programs using python3, i.e. `python3 <filename>.py`

Question 1.

Data given to determine the initial price of a European call and a European put option in the binomial model are:

$$S(0) = 100, K = 100, T = 1, M = 100, r = 8\%, \sigma = 20\%$$

Also given 2 sets of u and d:

a) Set 1 : $u = e^{\sigma\sqrt{\Delta t}}, d = e^{-\sigma\sqrt{\Delta t}}$

b) Set 2 : $u = e^{\sigma\sqrt{\Delta t} + \left(r - \frac{1}{2}\sigma^2\right)\Delta t}, d = e^{-\sigma\sqrt{\Delta t} + \left(r - \frac{1}{2}\sigma^2\right)\Delta t}$

Using them:

1. The call option price for set 1 is: **12.085380013710122**
2. The put option price for set 1 is: **4.397014652374142**
3. The call option price for set 2 is: **12.12304707401244**
4. The put option price for set 2 is: **4.434681712676475**

The **sensitivity analysis** of option price variance with **S(0), K, M, r, σ** has been done by plotting 2-D and 3-D plots (Page No. 3 Onwards).

Question 2.

The path-dependent derivative used for this question is the **Asian Option**.

The payoff for the Asian Call Option = $(S_{avg \text{ over path}} - K)^+$

The payoff for the Asian Put Option = $(K - S_{avg \text{ over path}})^+$

Here K is the strike price.

The data taken for this question is:

$$S(0) = 100, K = 100, T = 1, M = 10, r = 8\%, \sigma = 20\%$$

We have taken the value of **M as 10**. For an Asian option, we have to take all possible paths, which in our case will be 2^M . So taking a value of $M = 100$, would be computationally infeasible. The initial option price (for call and put) can be found using,

$$H(0) = \frac{1}{e^{rT}} \sum_{\text{over all paths}} p^{\text{ups}} (1-p)^{M-\text{ups}} f(S_{avg})$$

Here **ups** represents the **number of ups** in the path, **f** denotes the **payoff for the Asian option**, and S_{avg} denotes **the average stock price over the path**, which is computed as:

$$S_{avg} = \frac{\sum_{i=0}^{i=M} S\left(\frac{T * i}{M}\right)}{M + 1}$$

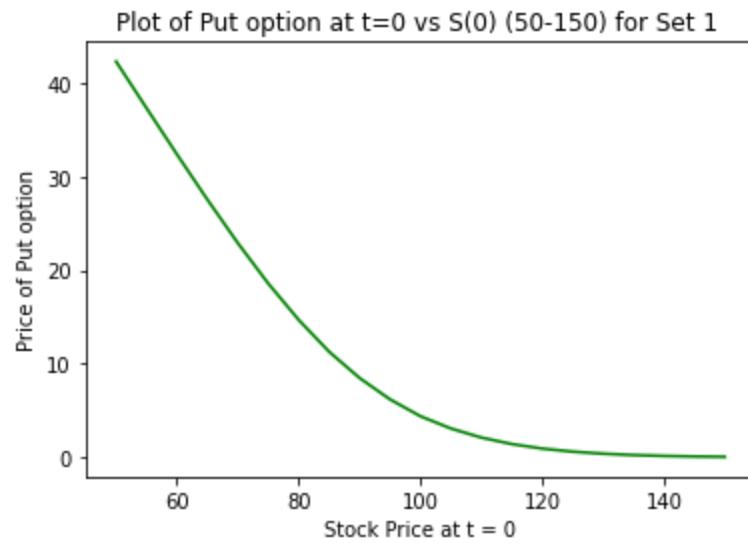
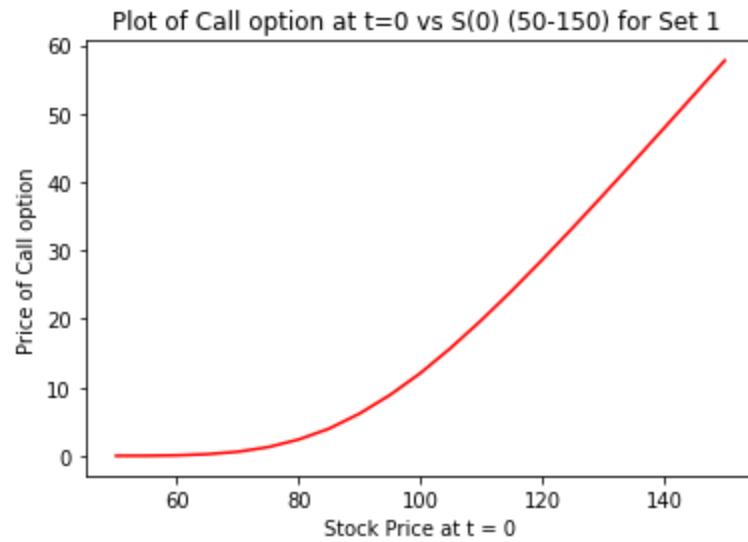
Using these formulae, we get:

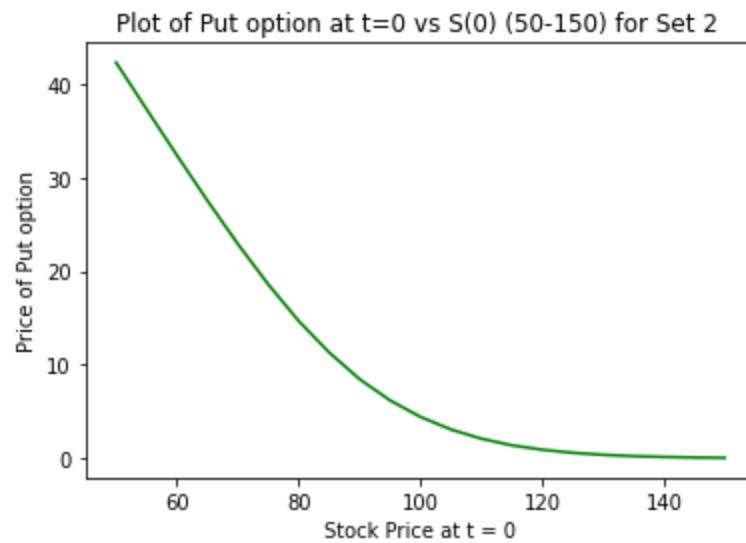
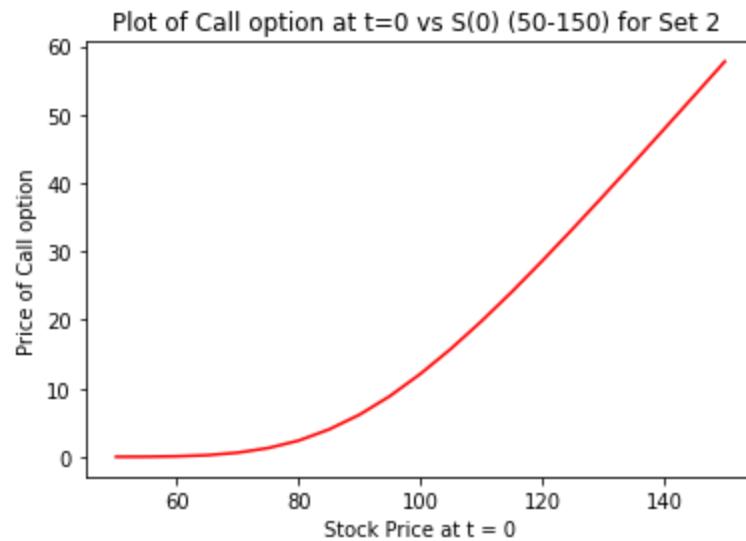
1. The Asian Call price for set 1 is: **6.476003047446573**
2. The Asian Put price for set 1 is: **2.6779455899442306**
3. The Asian Call price for set 2 is: **6.490029377643389**
4. The Asian Put price for set 2 is: **2.691971920141049**

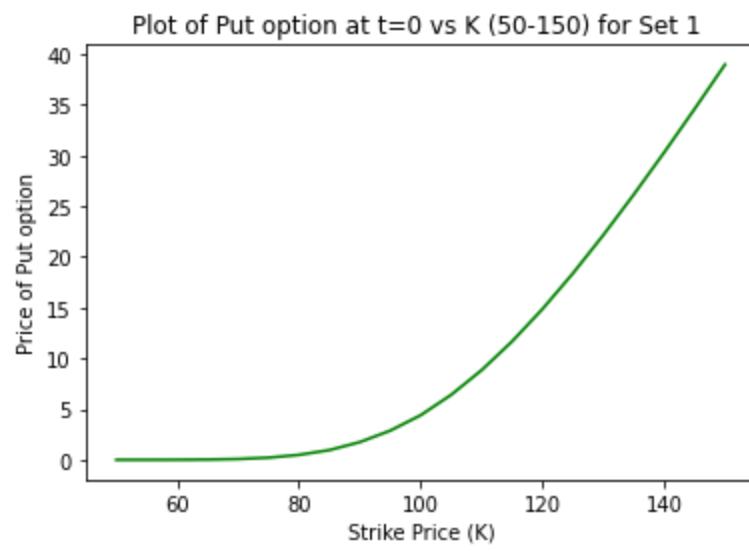
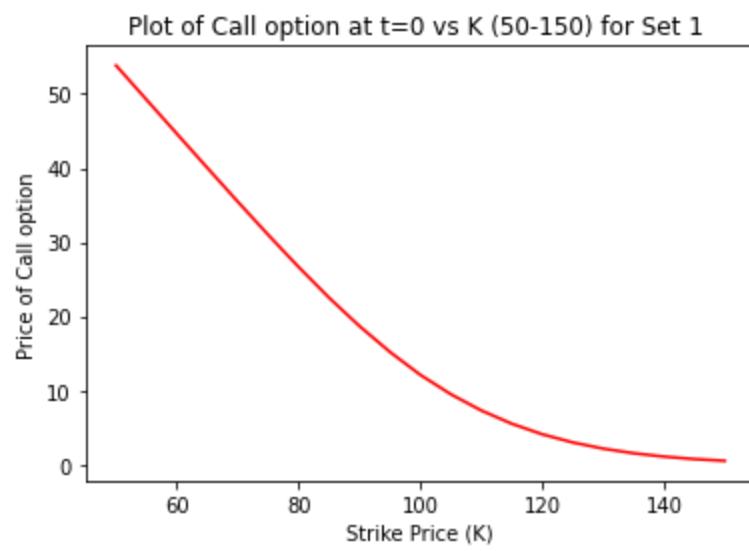
The **sensitivity analysis** of option price variance with $S(0)$, K , M , r , σ has been done by plotting 2-D and 3-D plots (Page No. 57 Onwards).

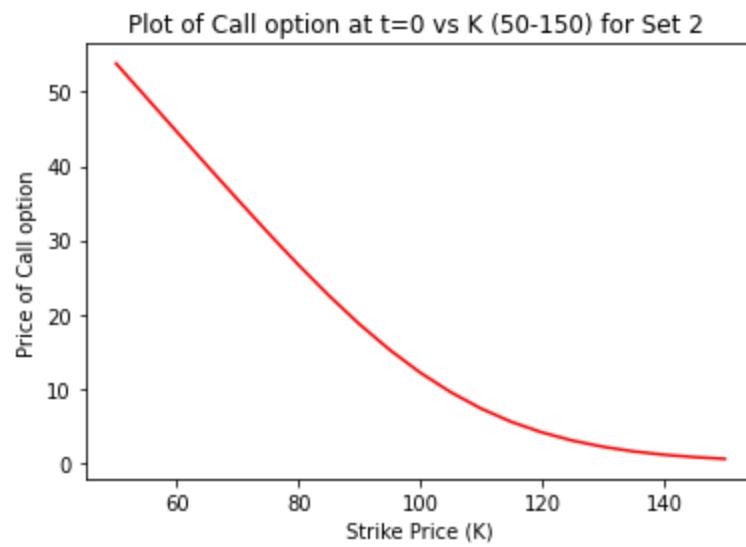
Question 1 Plots -

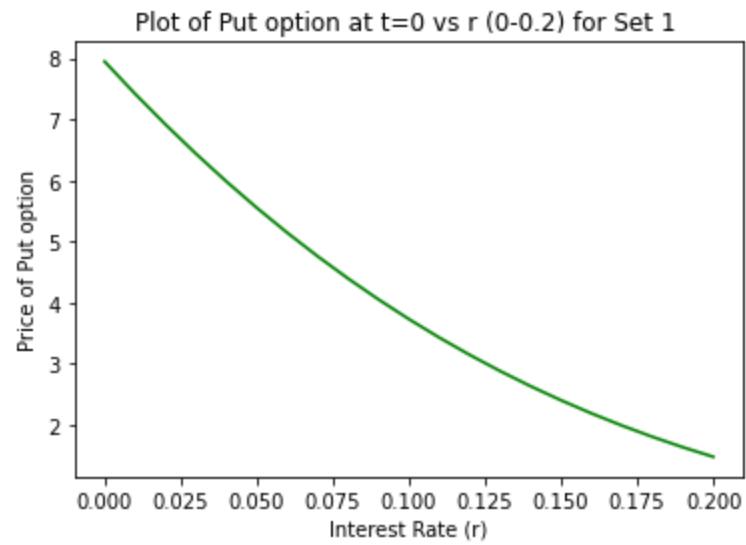
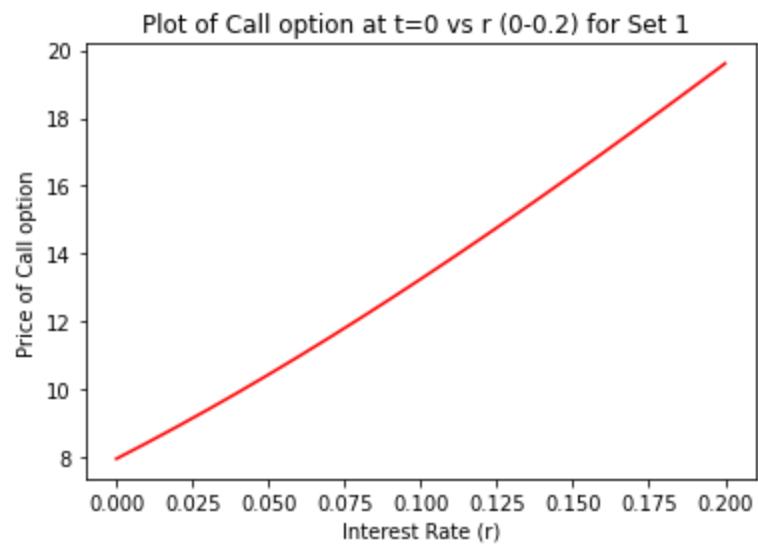
2D Plots (1 param at a time)

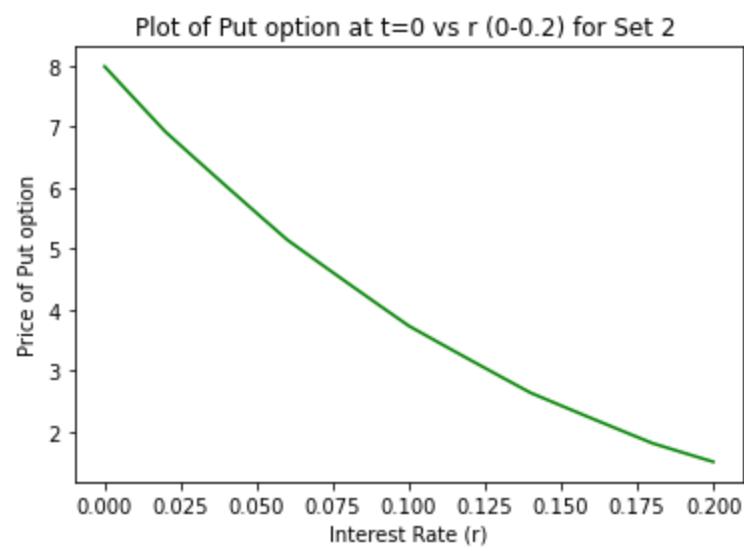
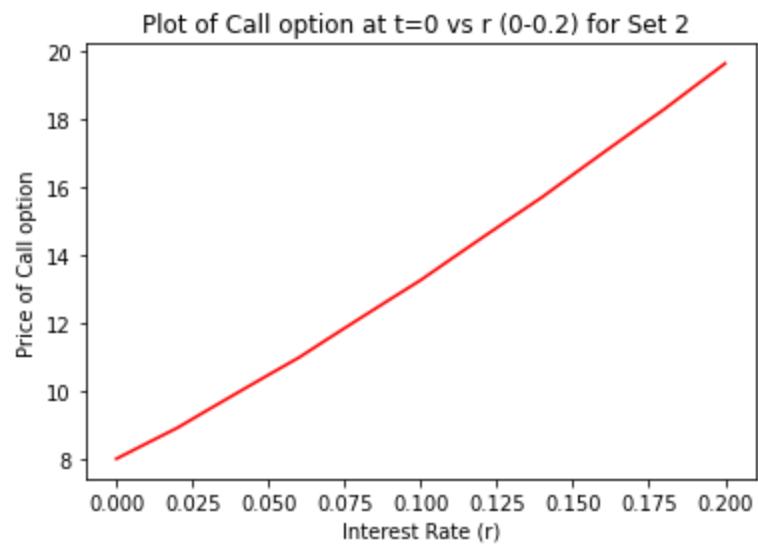


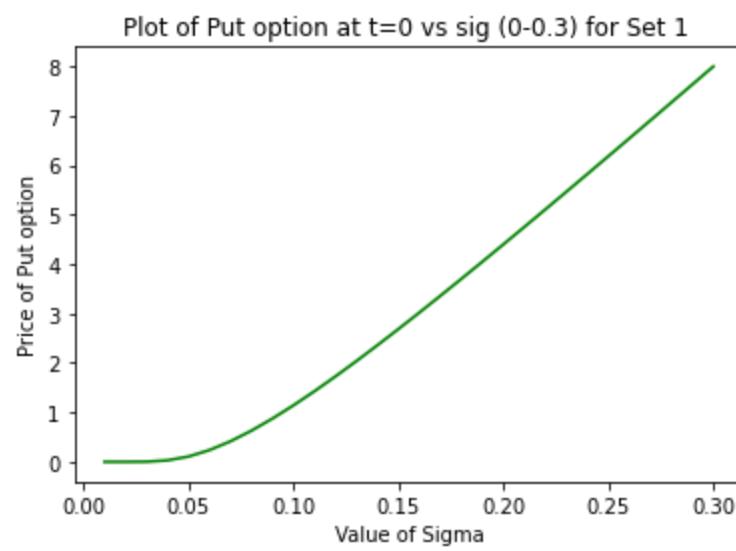


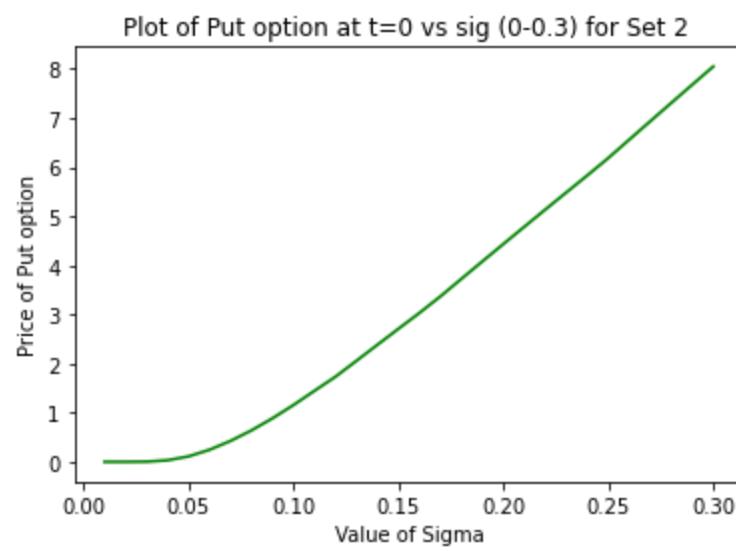
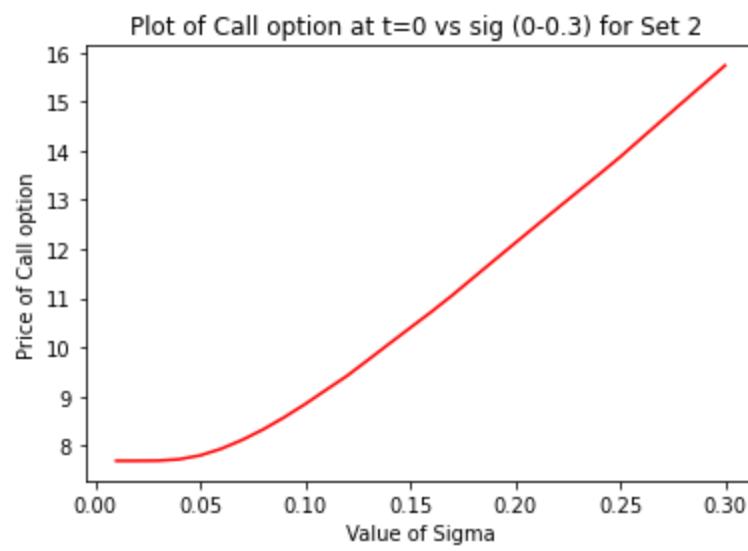


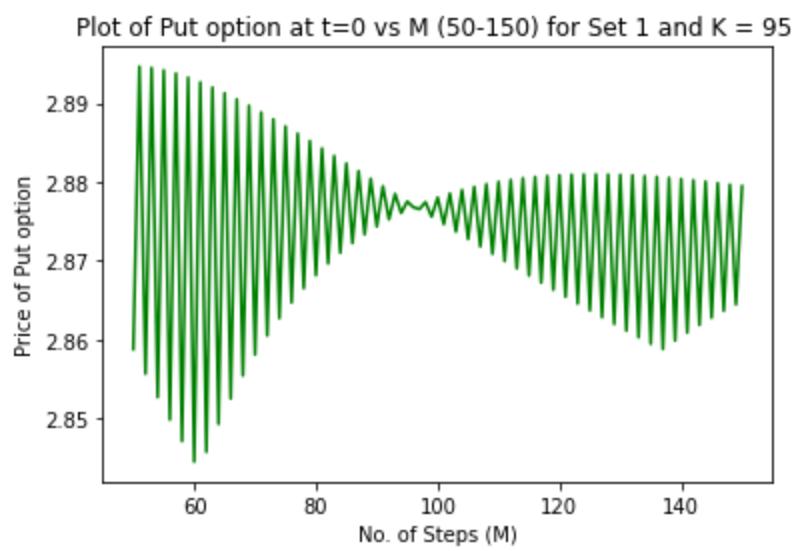
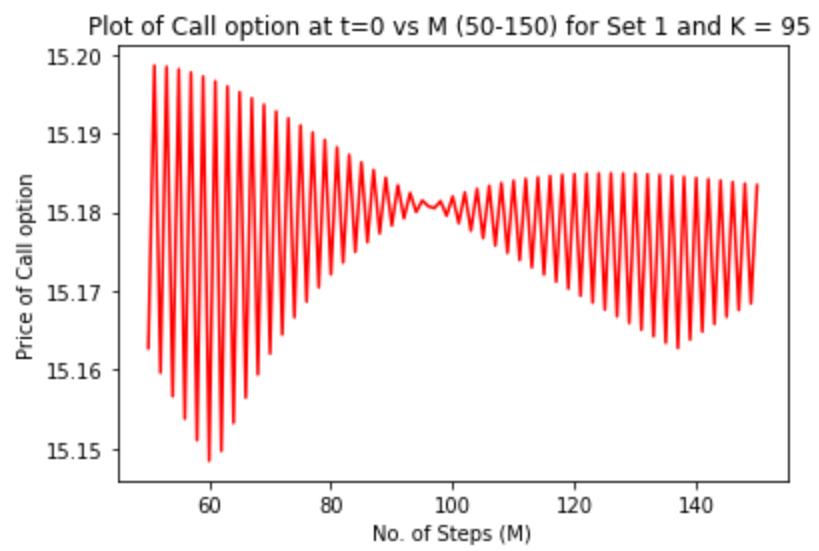


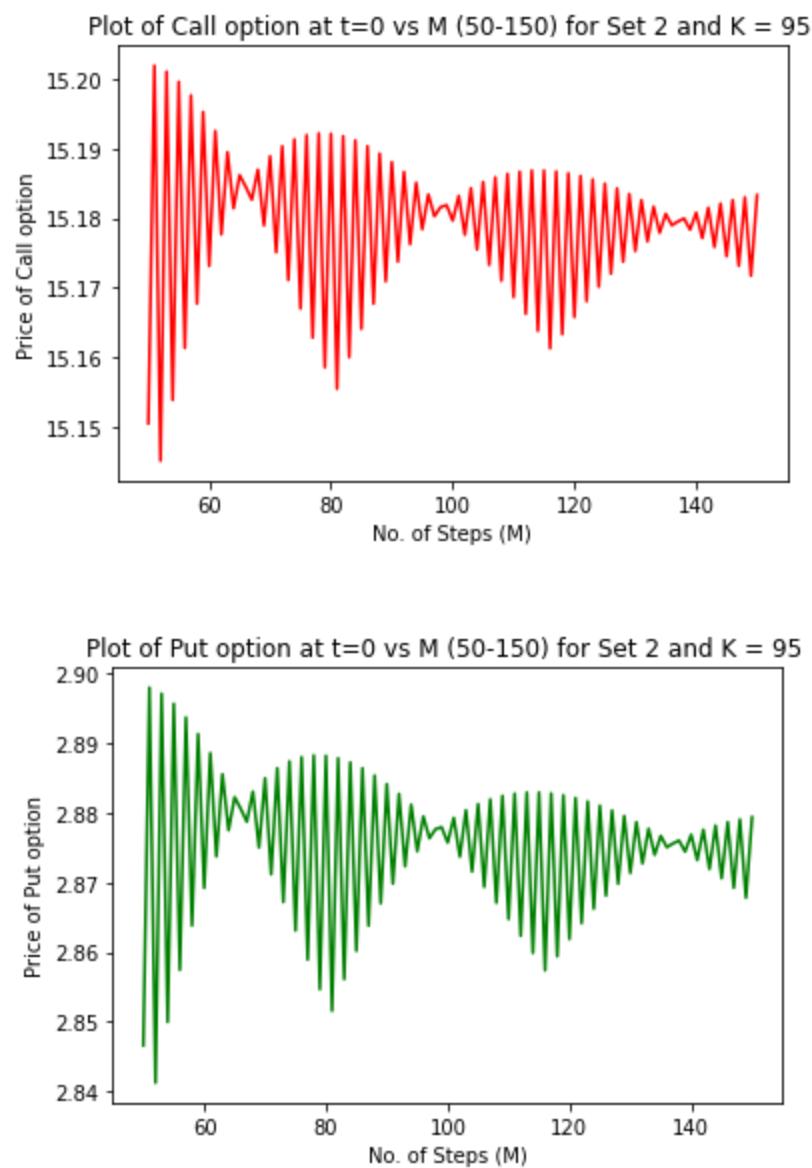




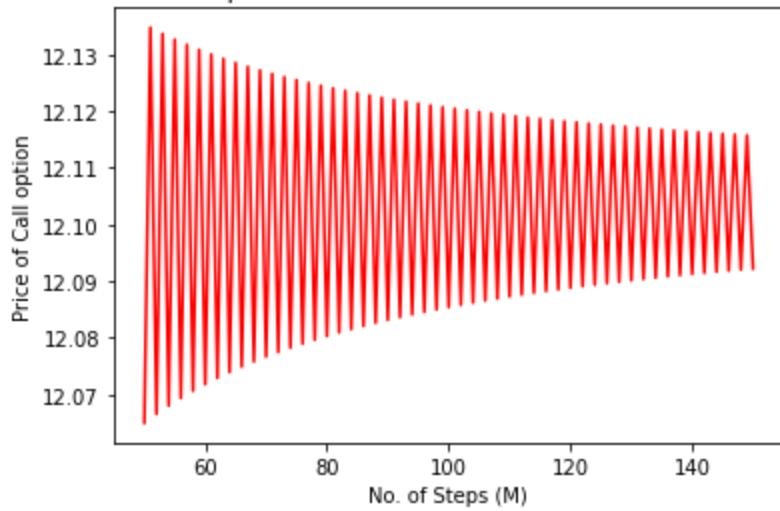




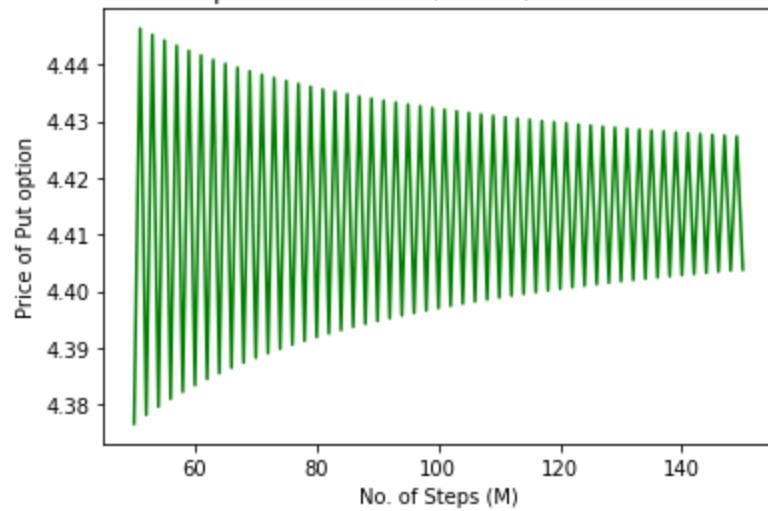


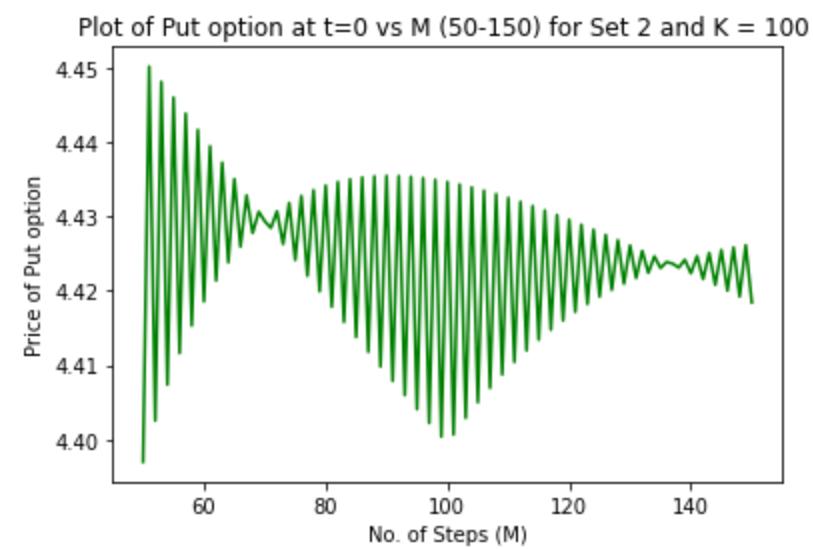
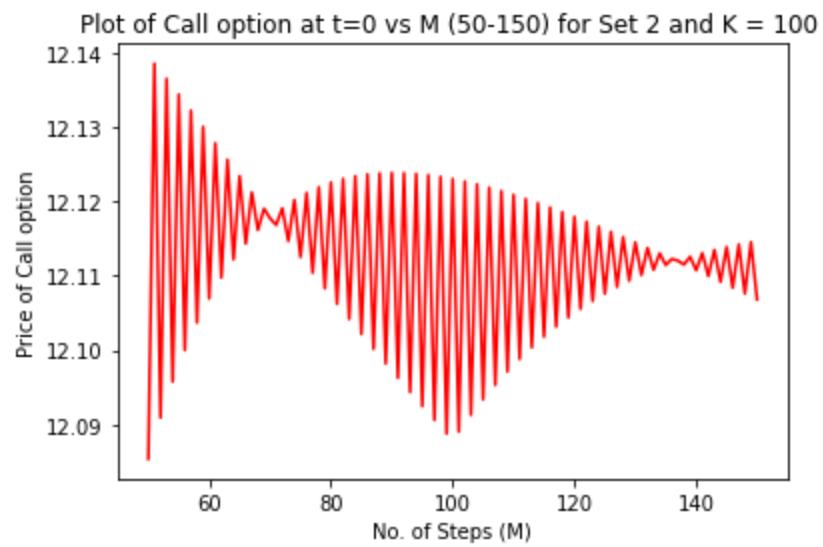


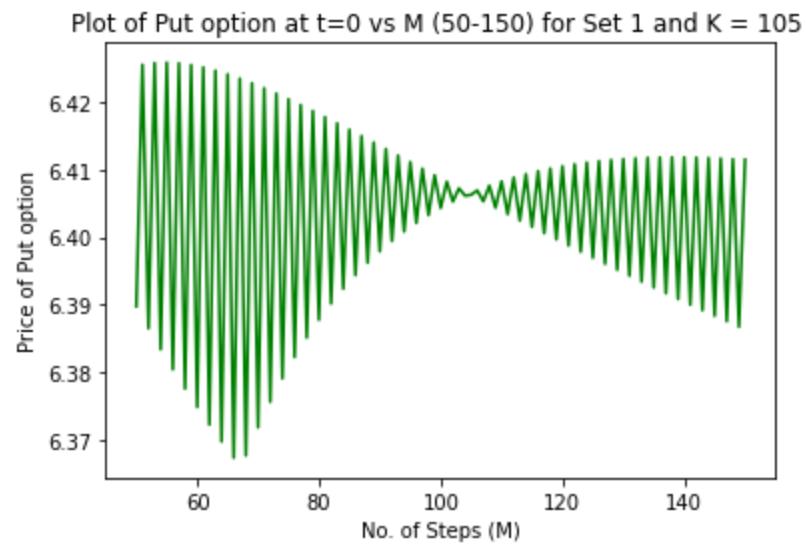
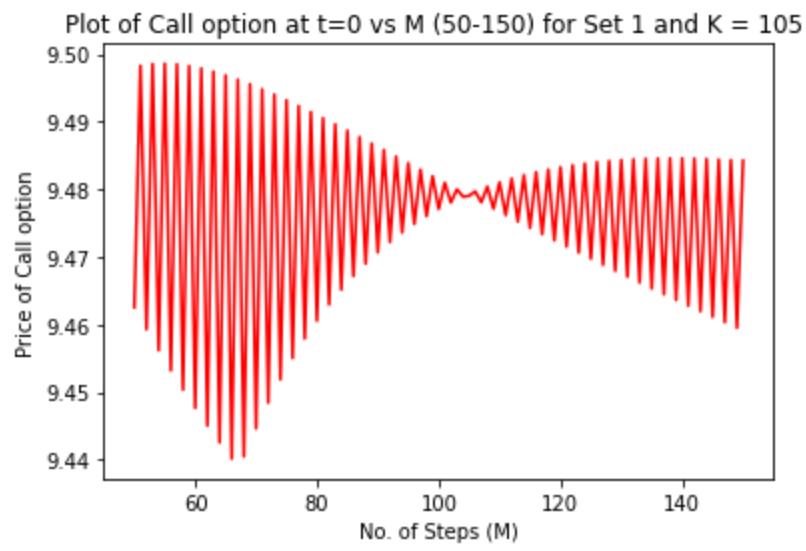
Plot of Call option at $t=0$ vs M (50-150) for Set 1 and $K = 100$

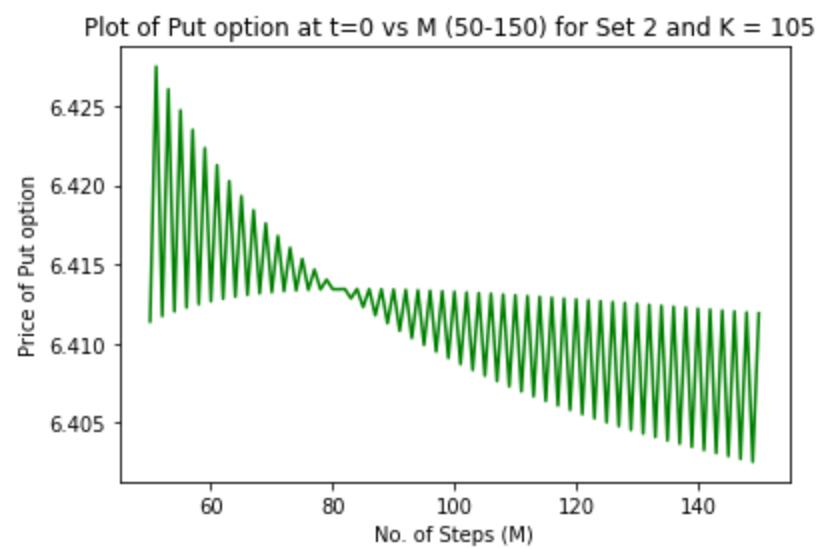
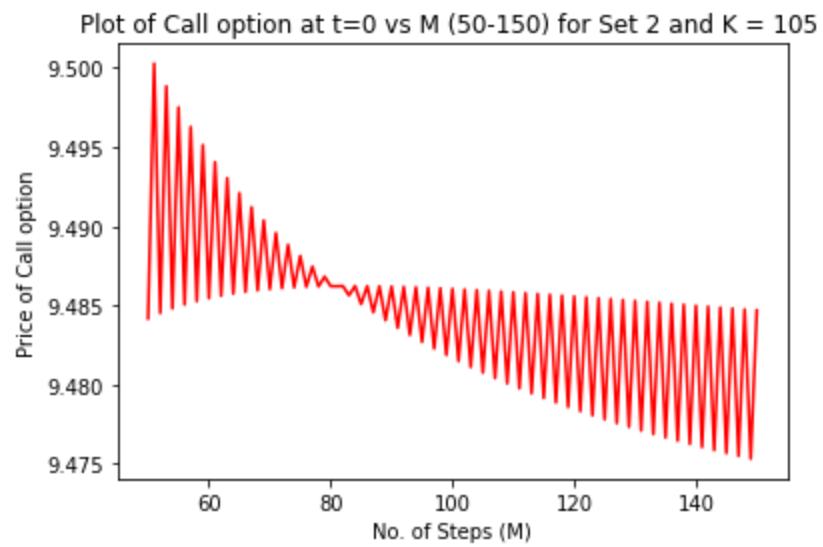


Plot of Put option at $t=0$ vs M (50-150) for Set 1 and $K = 100$



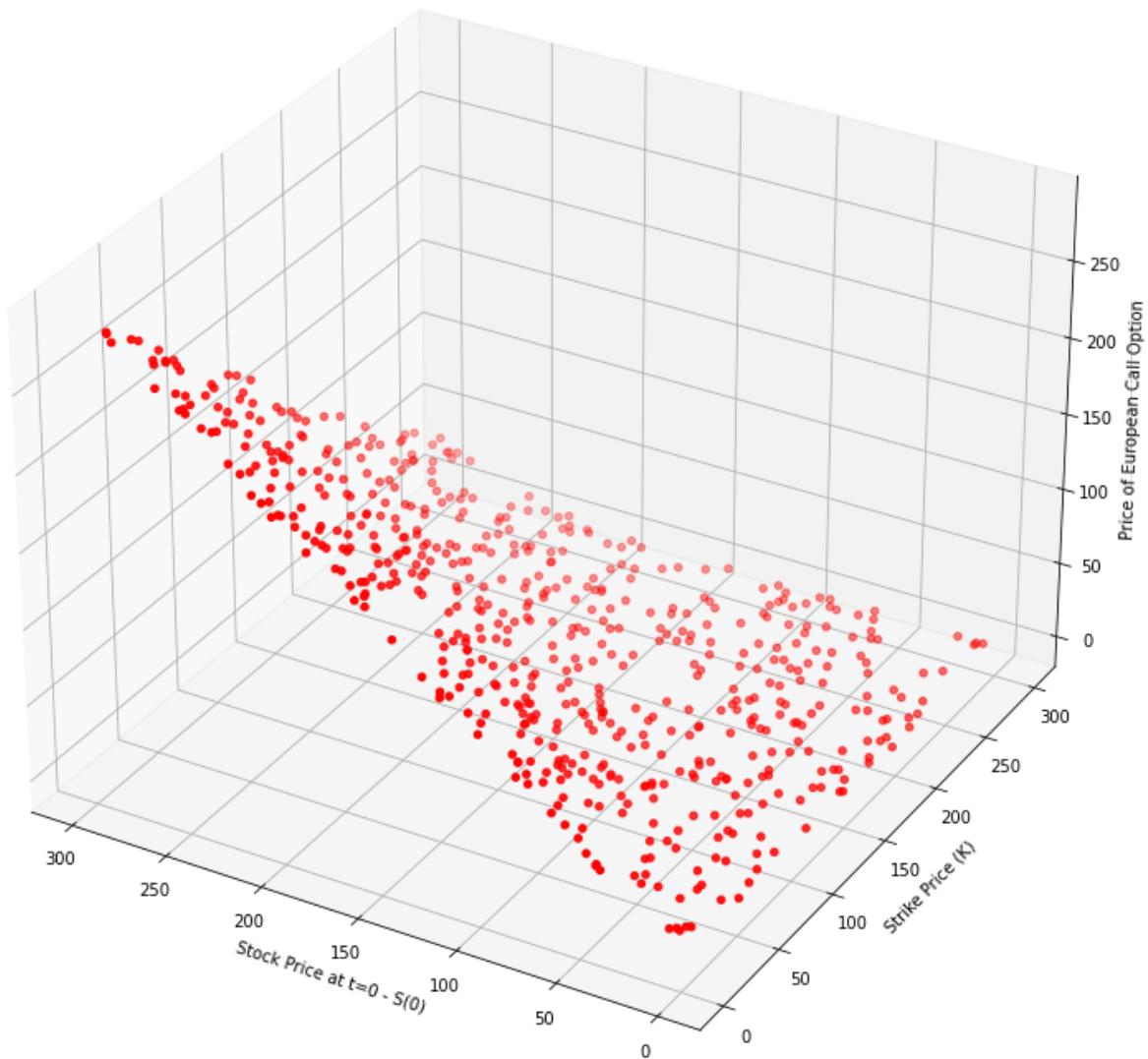




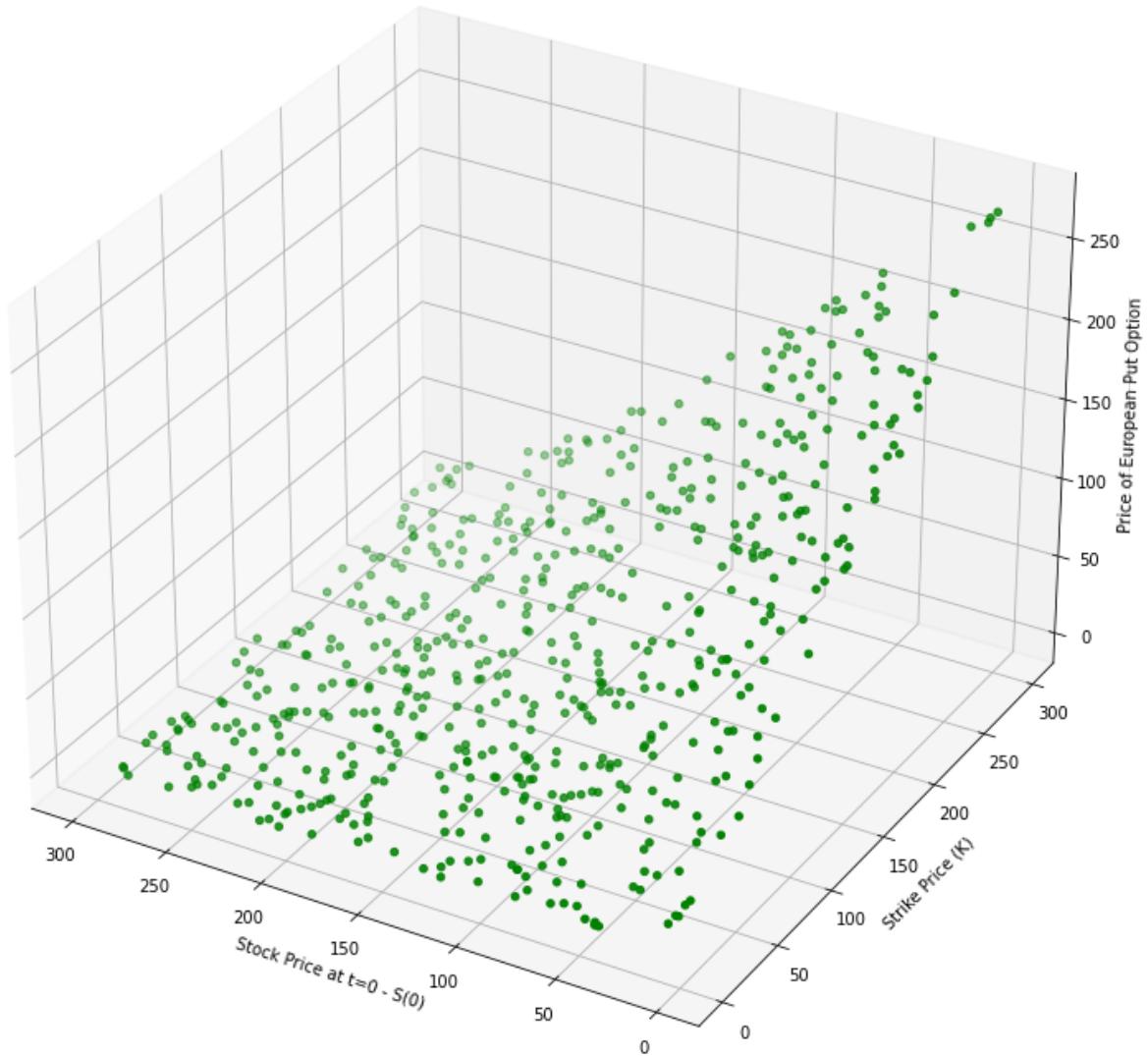


3D Plots (2 params at a time)

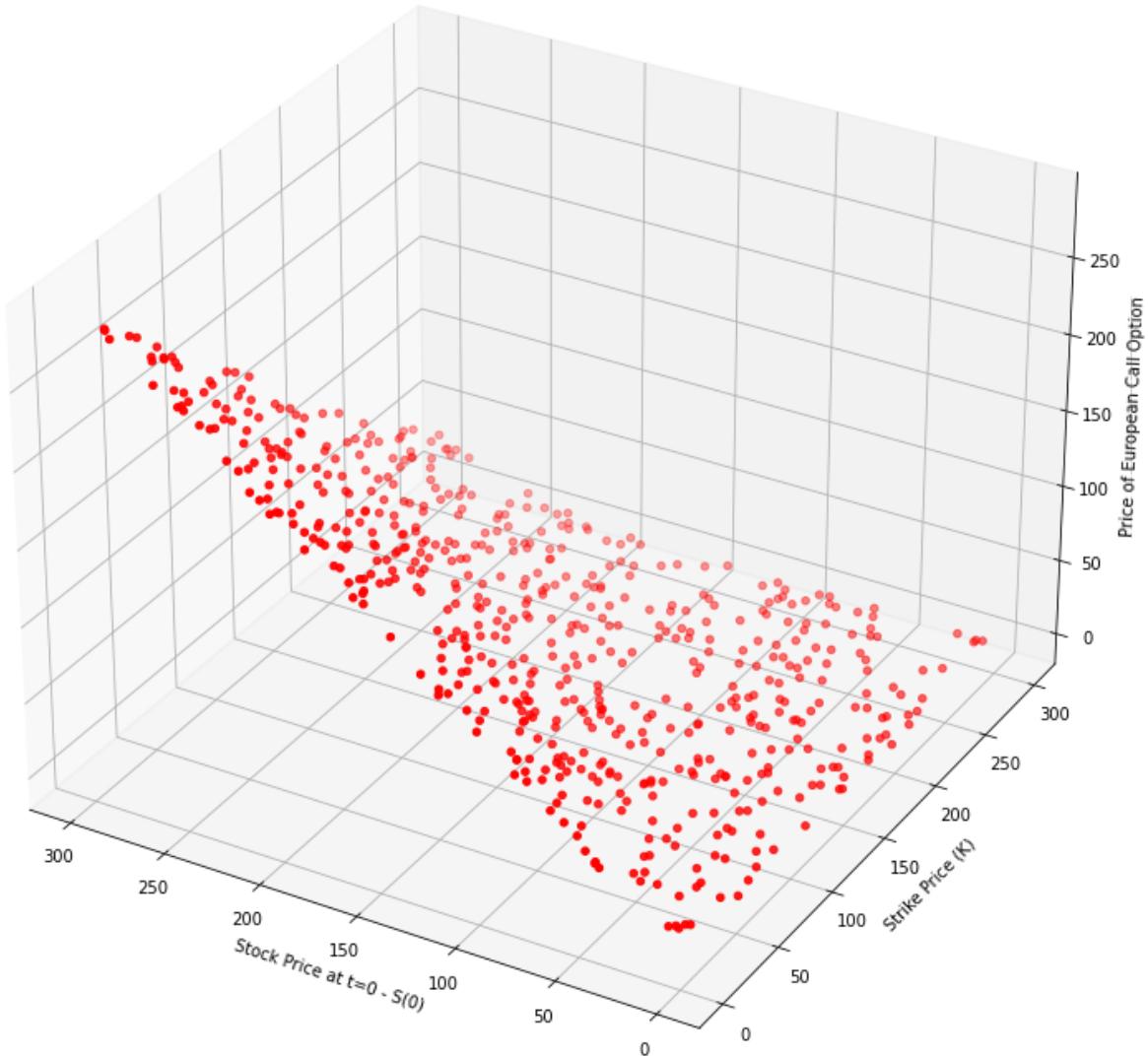
Scatter Plot of Initial Option Price with $S(0)$ and K (Set 1)



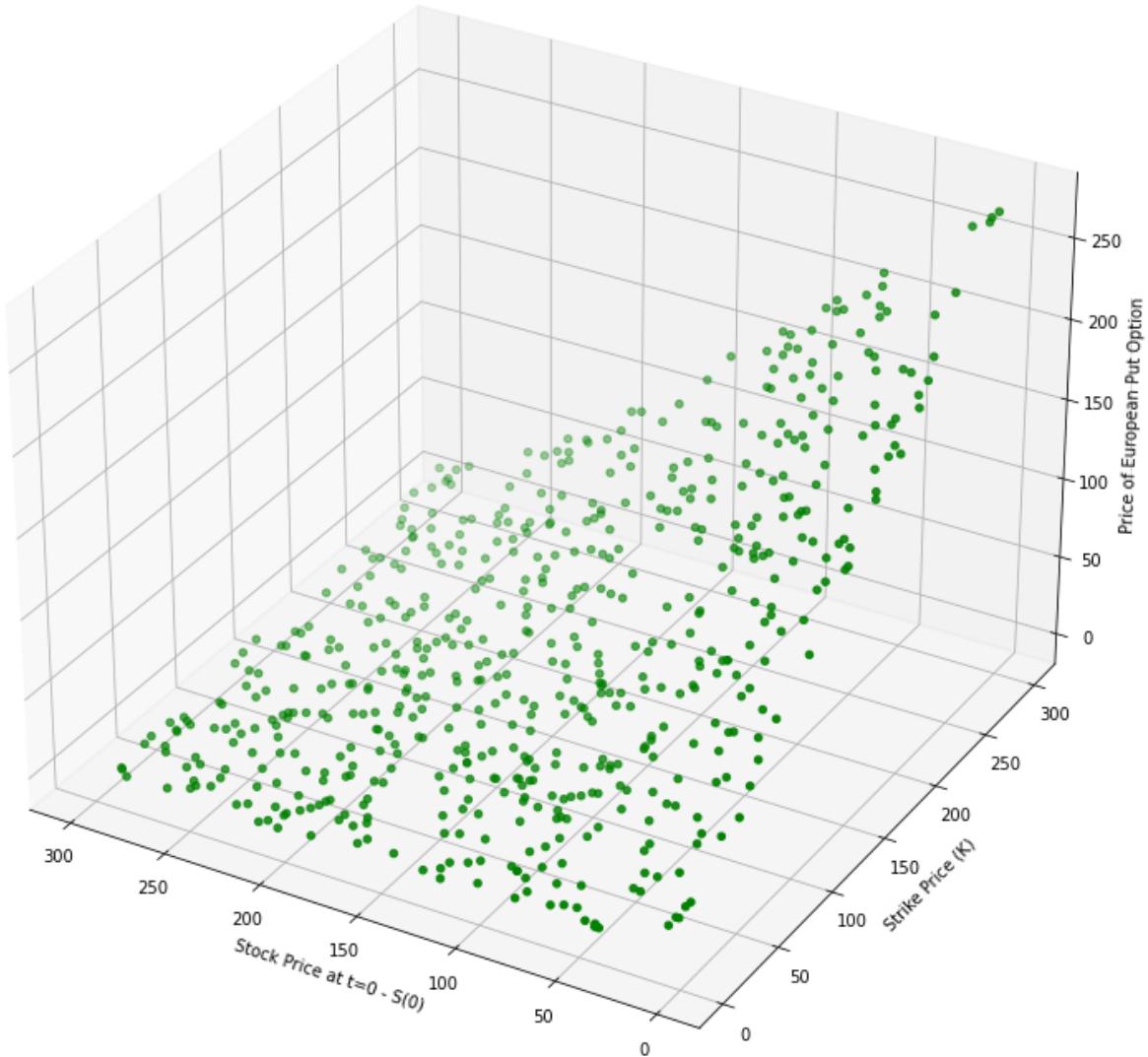
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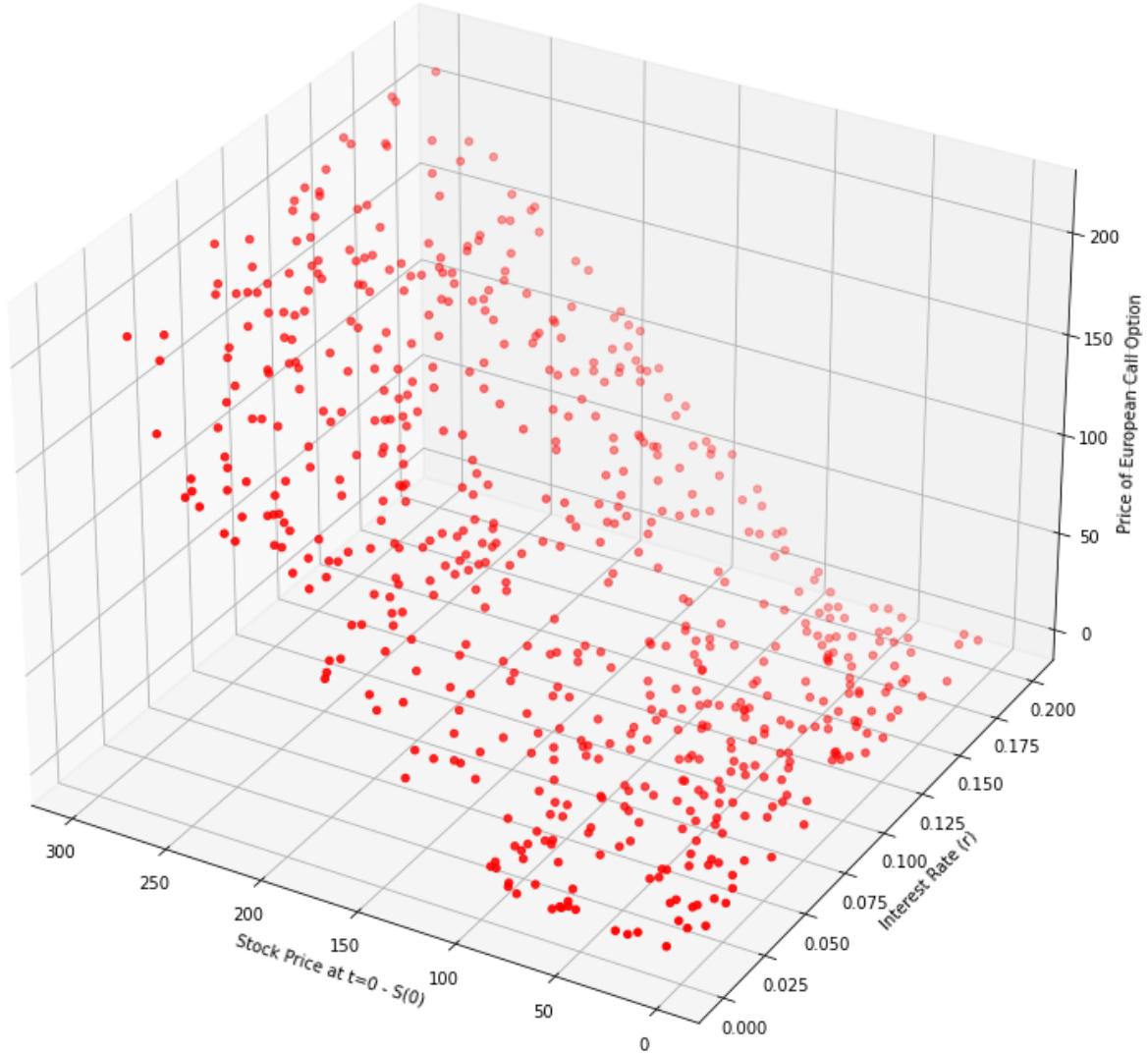
Scatter Plot of Initial Option Price with $S(0)$ and K (Set 2)



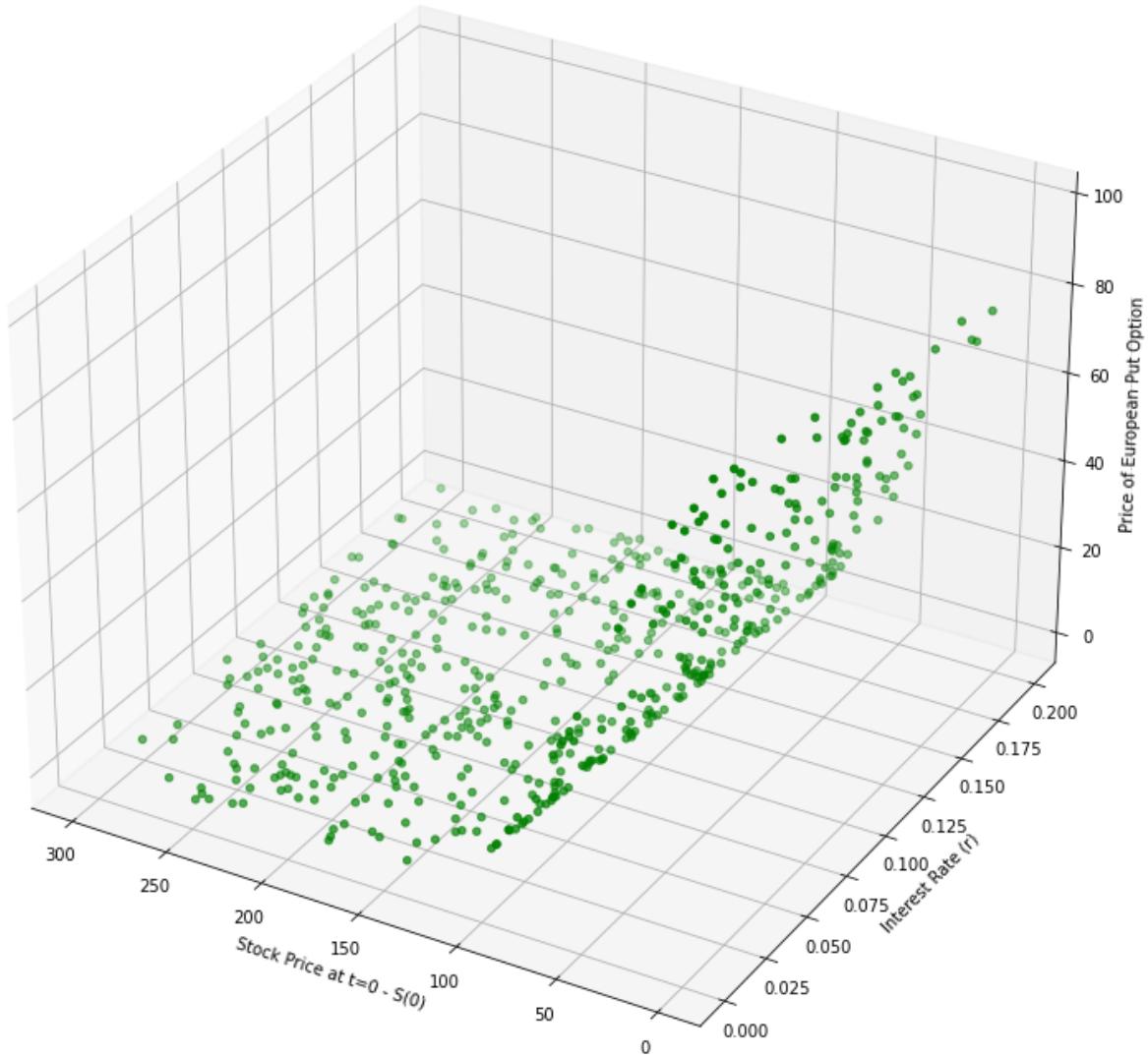
Scatter Plot of Initial Option Price with $S(0)$ and K (Set 2)



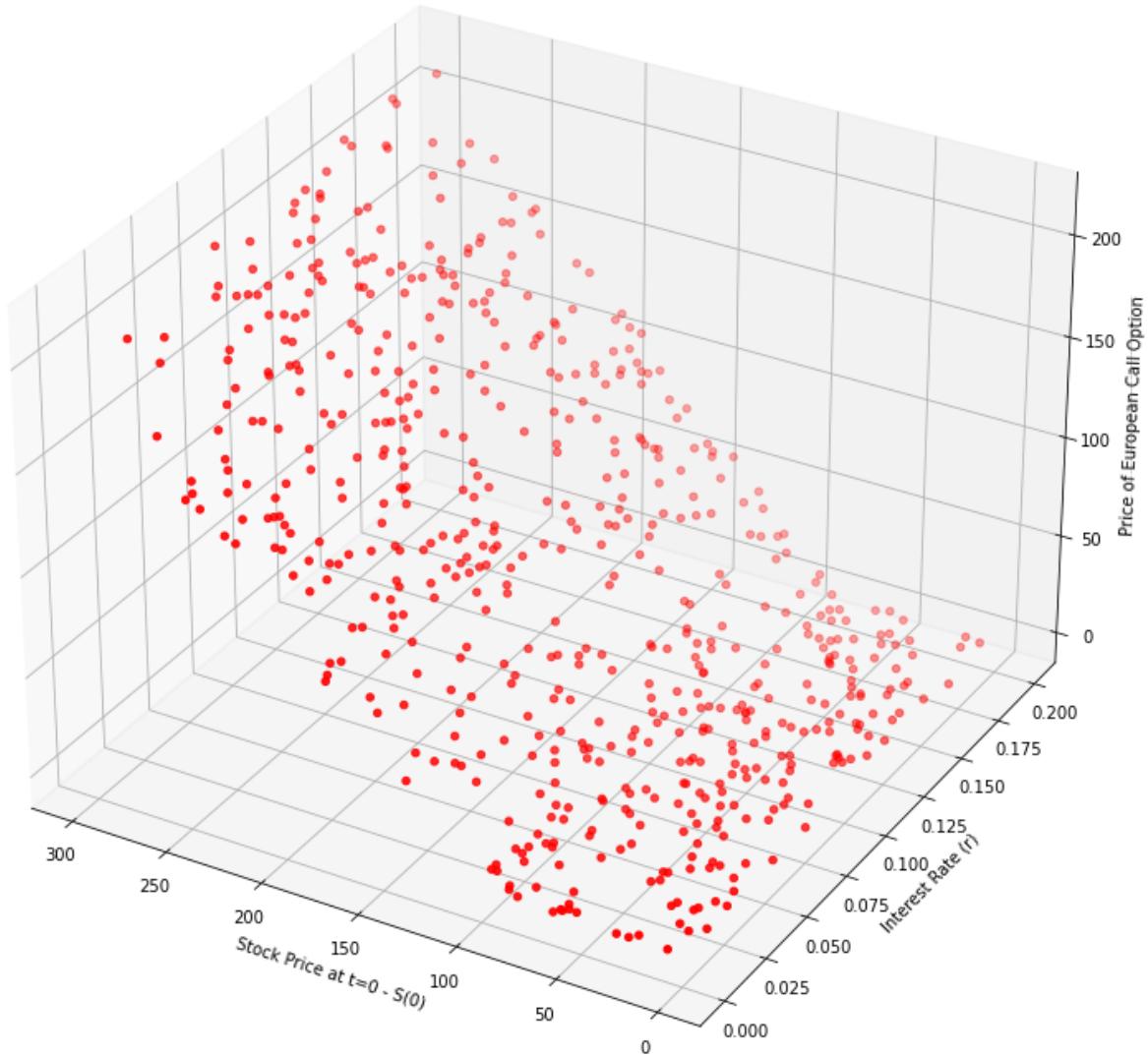
Scatter Plot of Initial Option Price with $S(0)$ and r (Set 1)



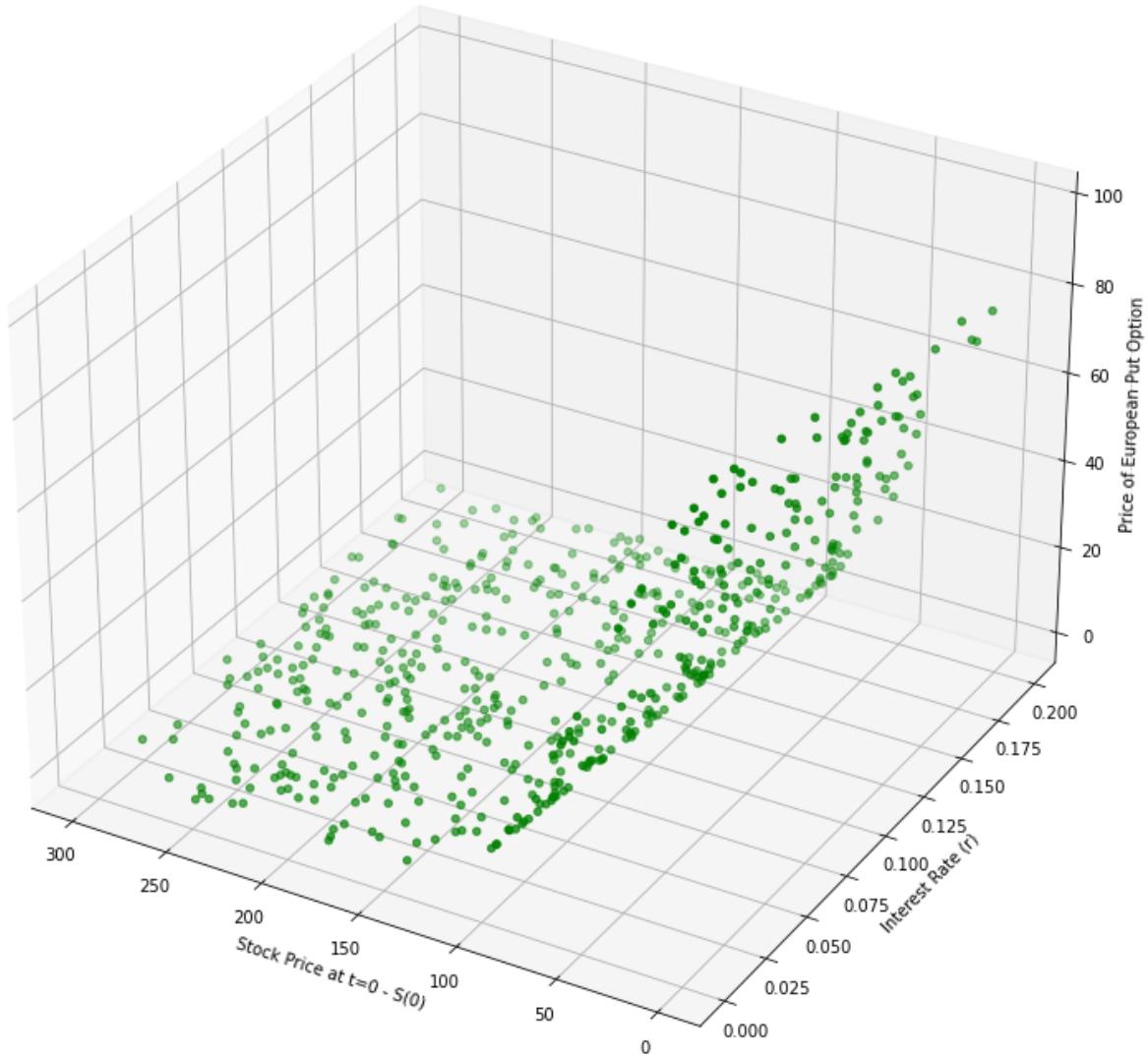
Scatter Plot of Initial Option Price with $S(0)$ and r (Set 1)



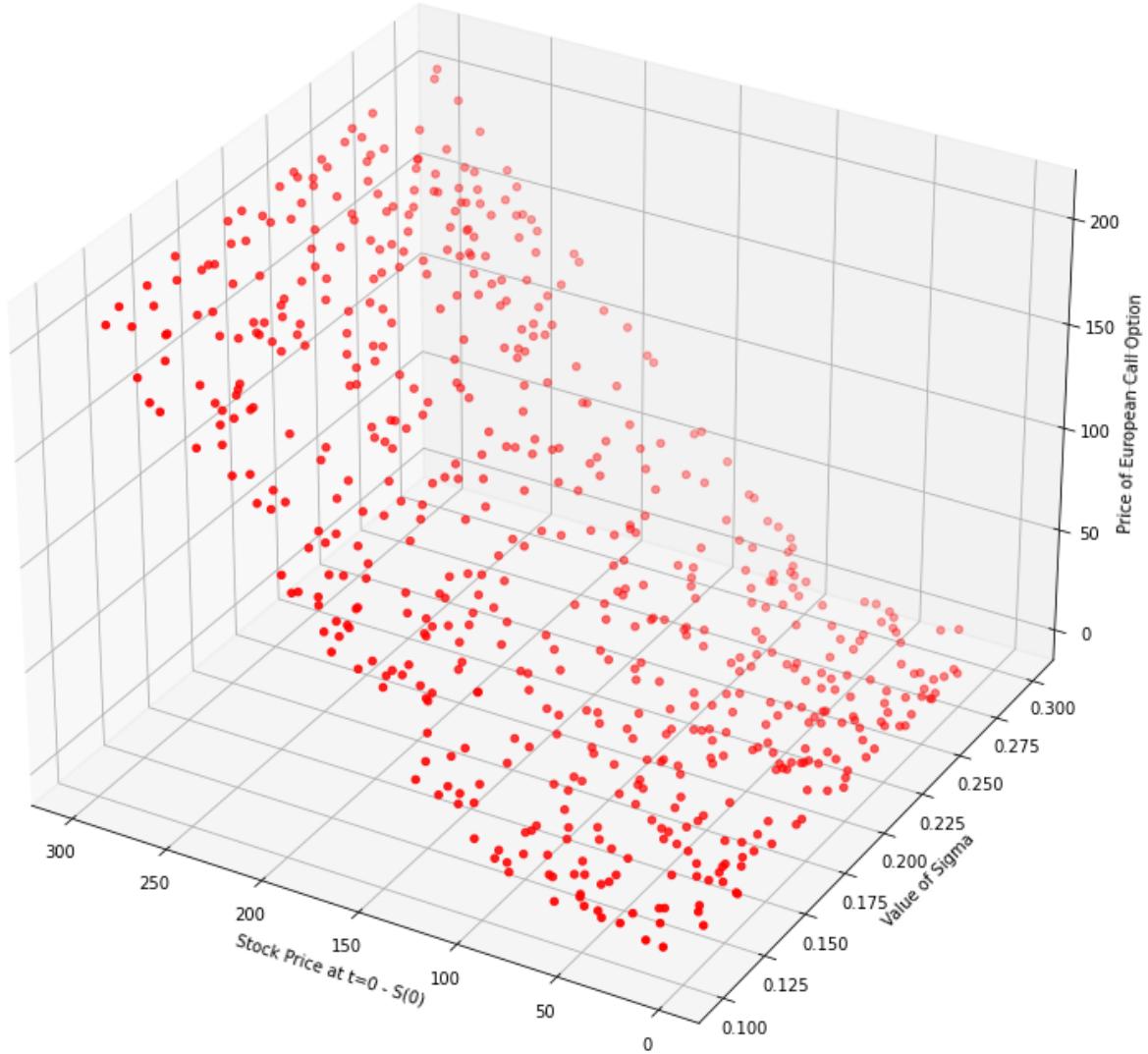
Scatter Plot of Initial Option Price with $S(0)$ and r (Set 2)



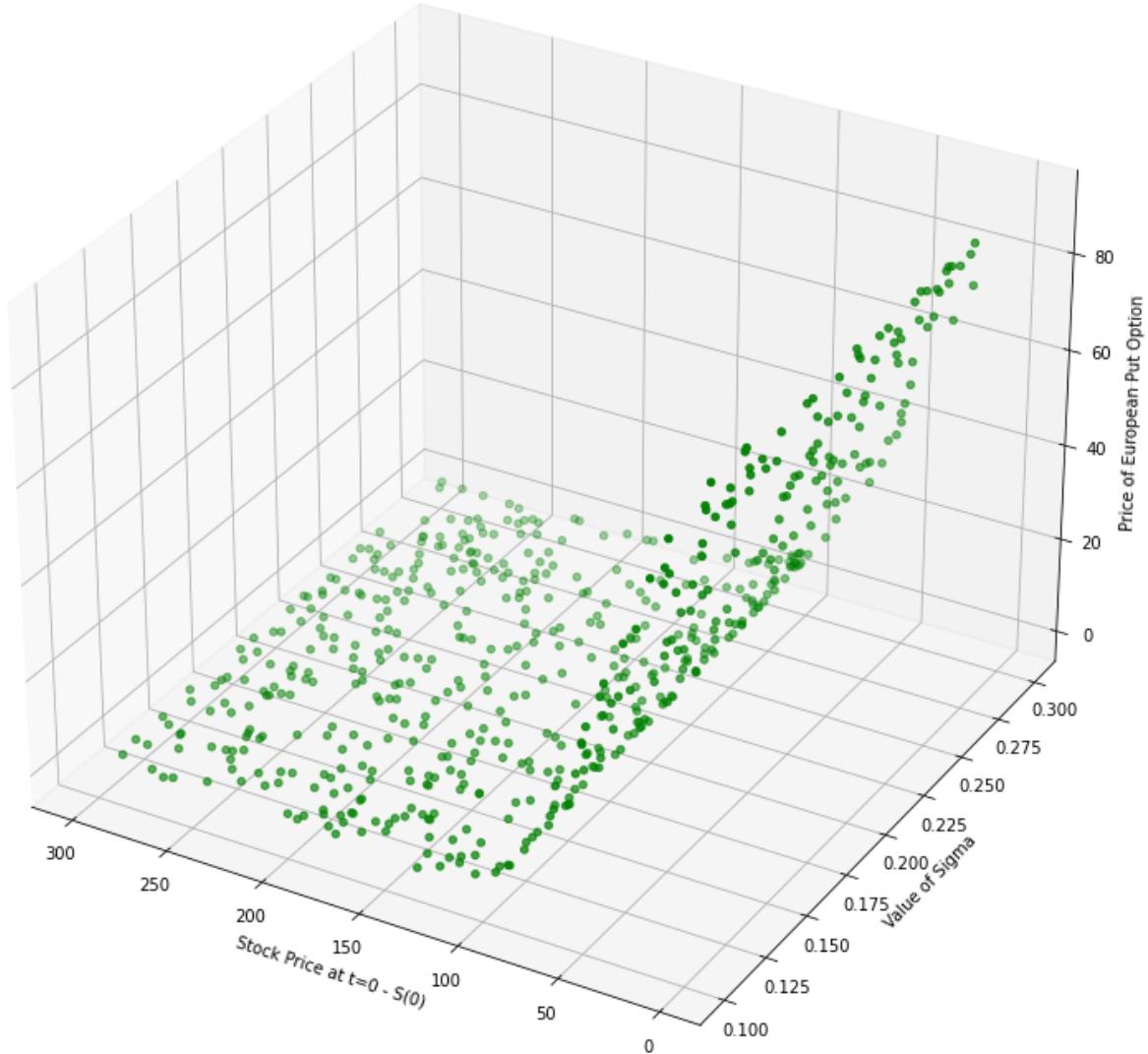
Scatter Plot of Initial Option Price with $S(0)$ and r (Set 2)



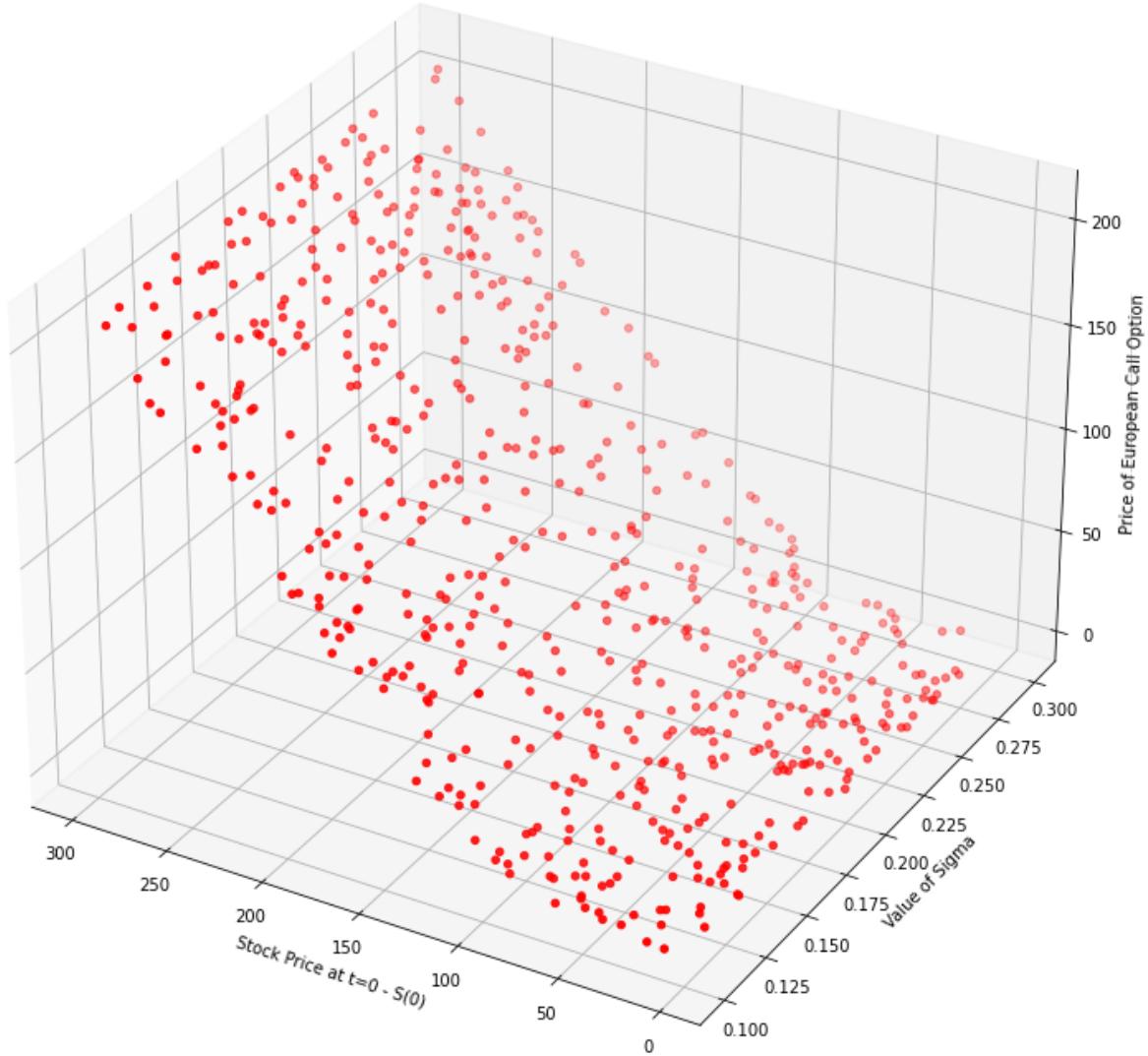
Scatter Plot of Initial Option Price with $S(0)$ and σ (Set 1)



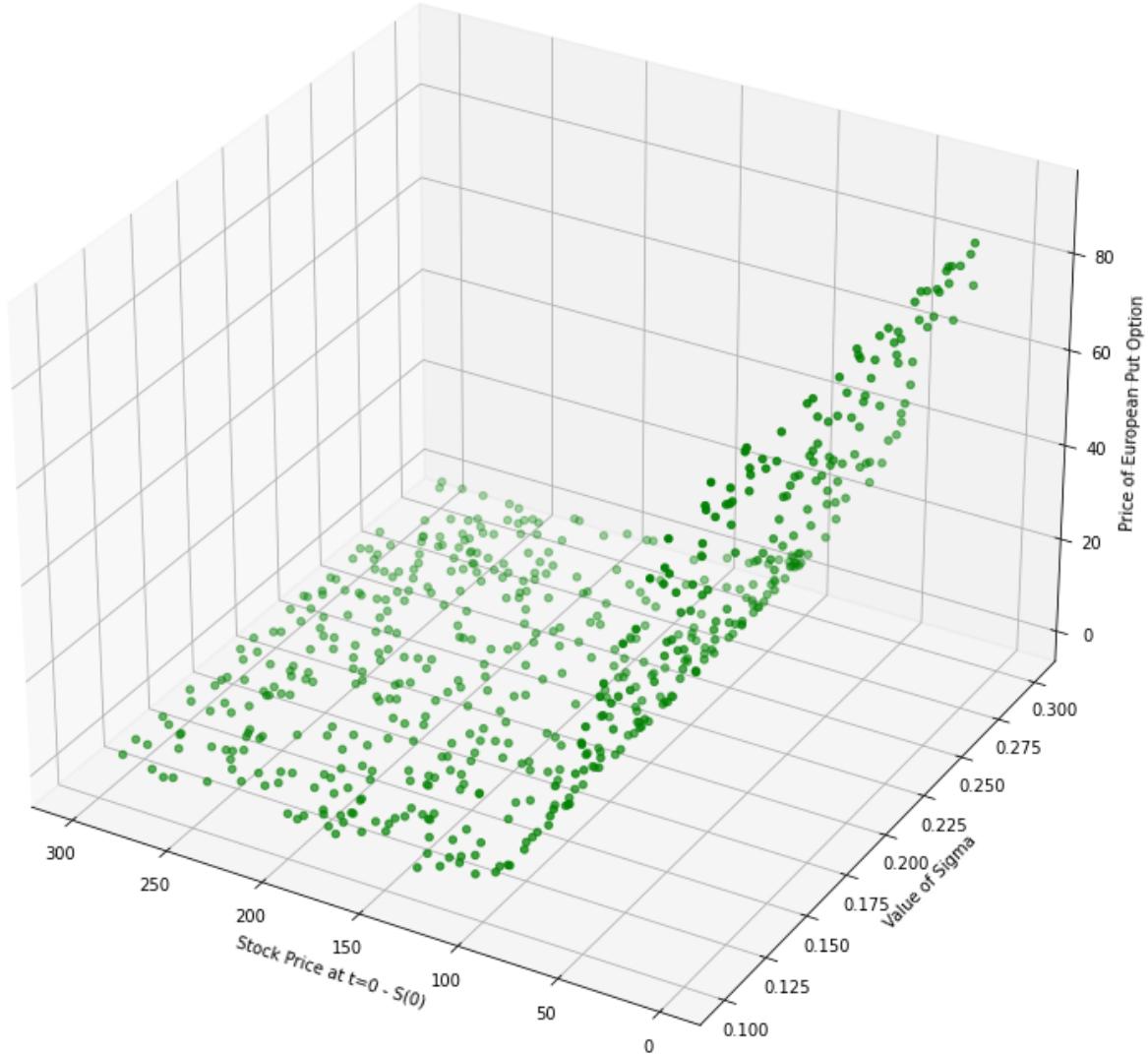
Scatter Plot of Initial Option Price with $S(0)$ and sig (Set 1)



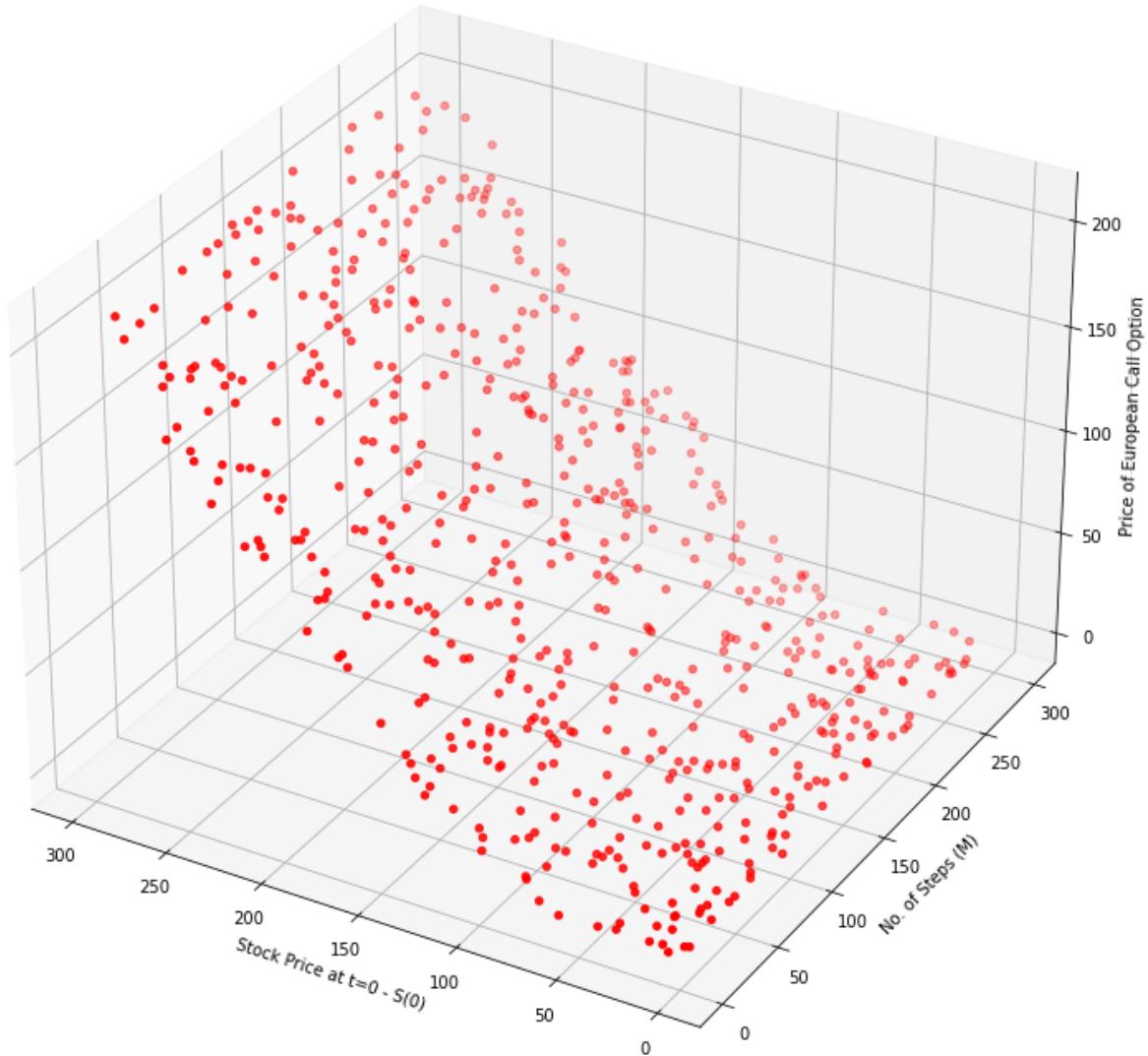
Scatter Plot of Initial Option Price with $S(0)$ and σ (Set 2)



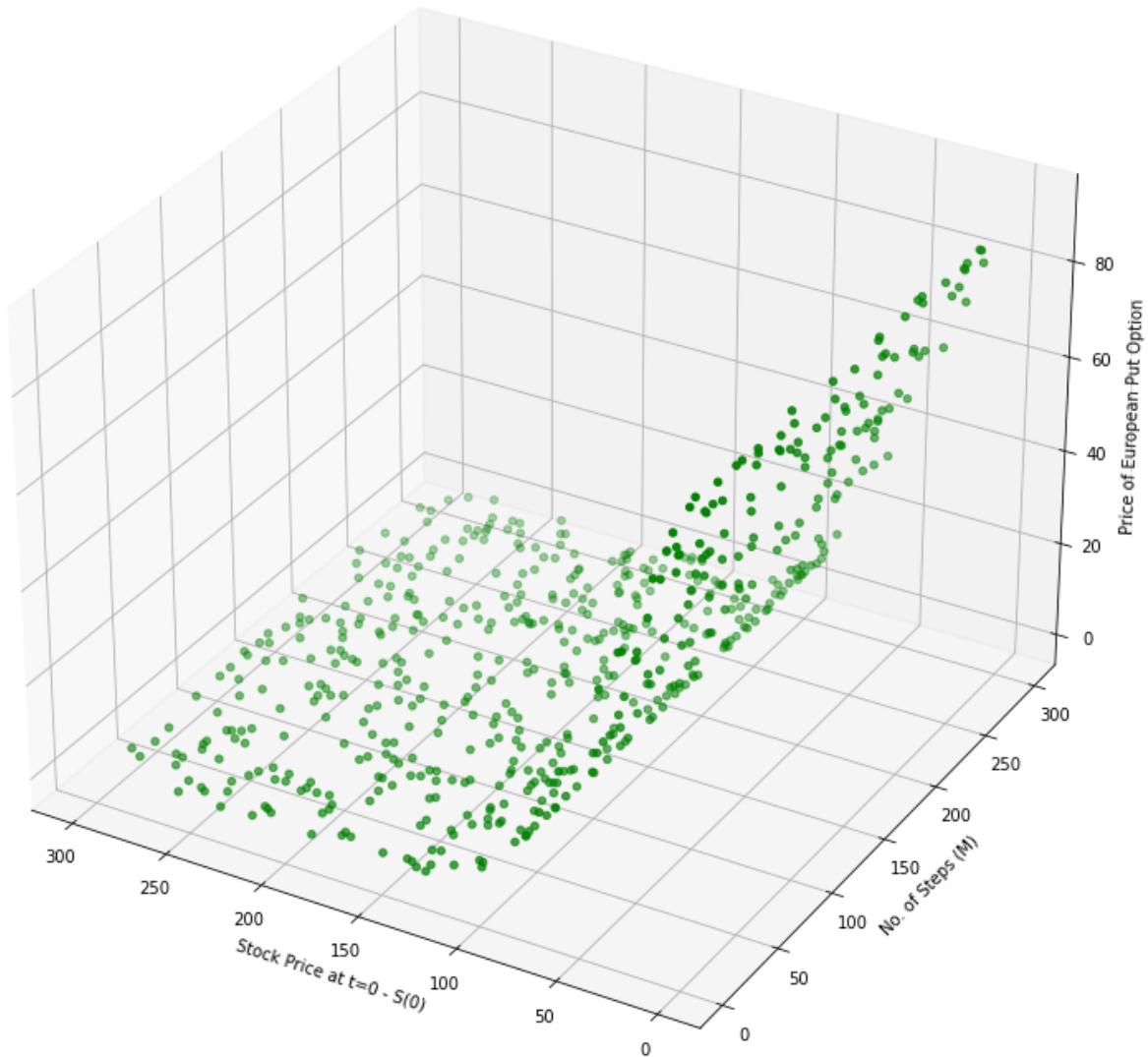
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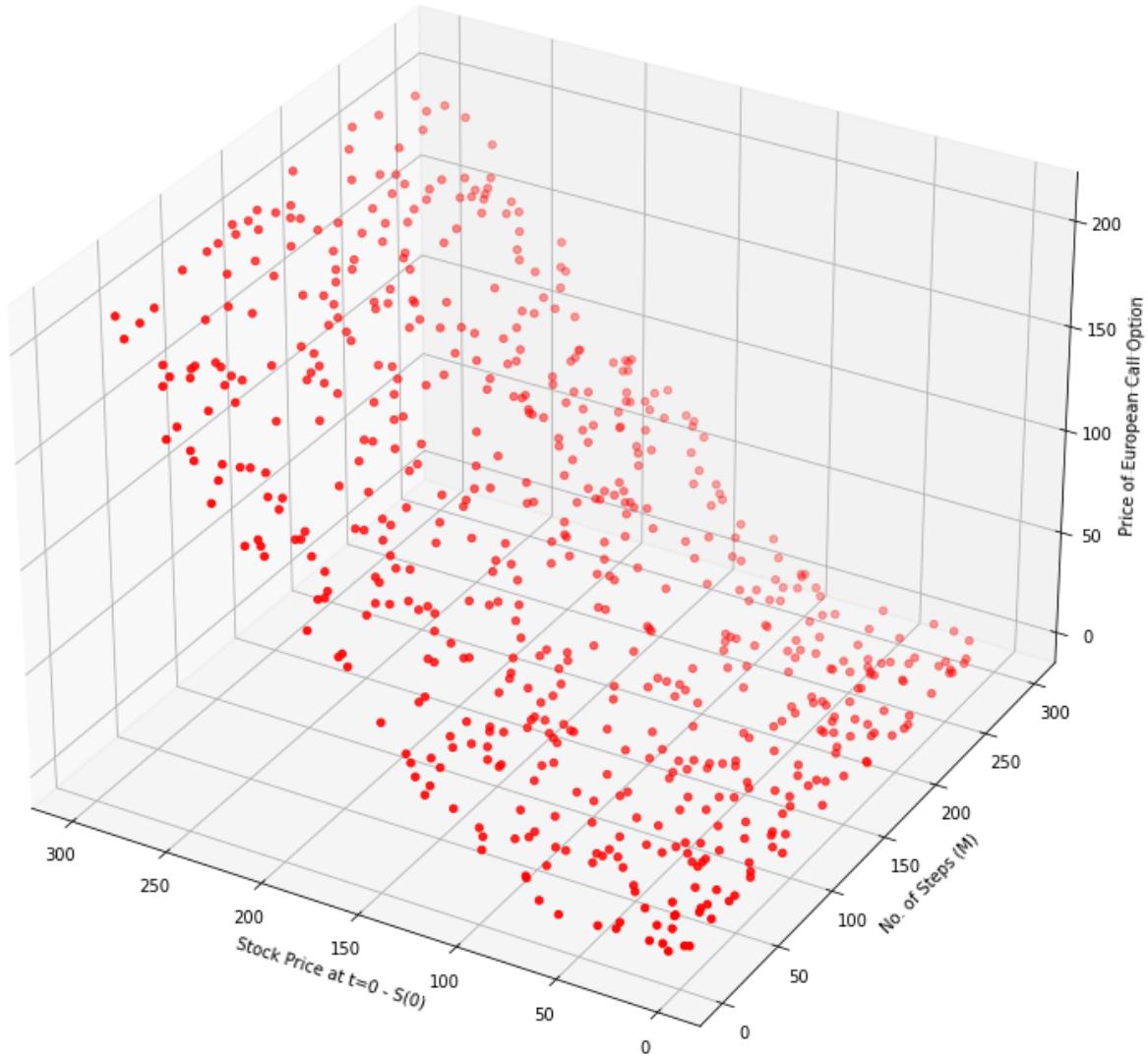
Scatter Plot of Initial Option Price with $S(0)$ and M (Set 1)



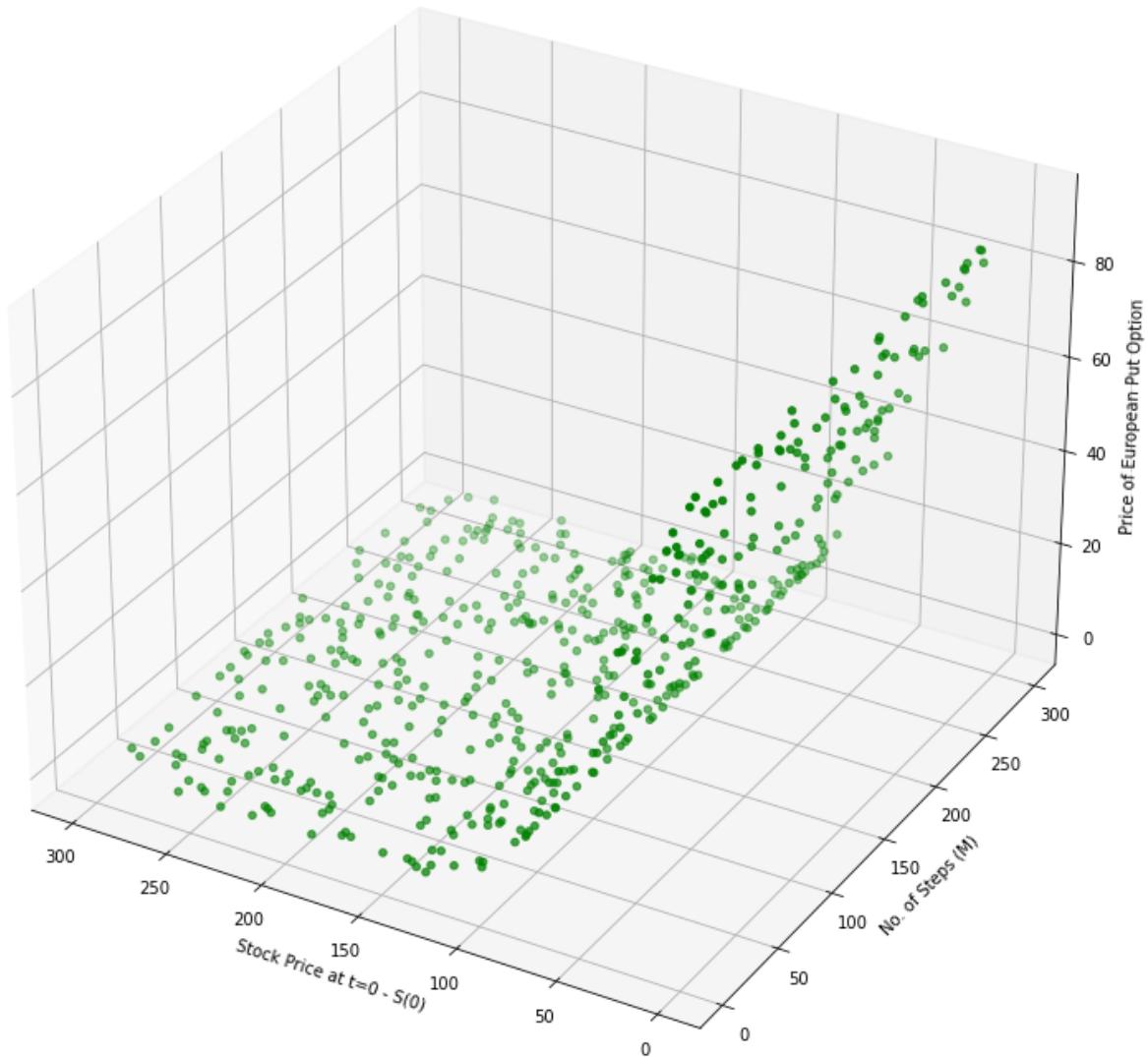
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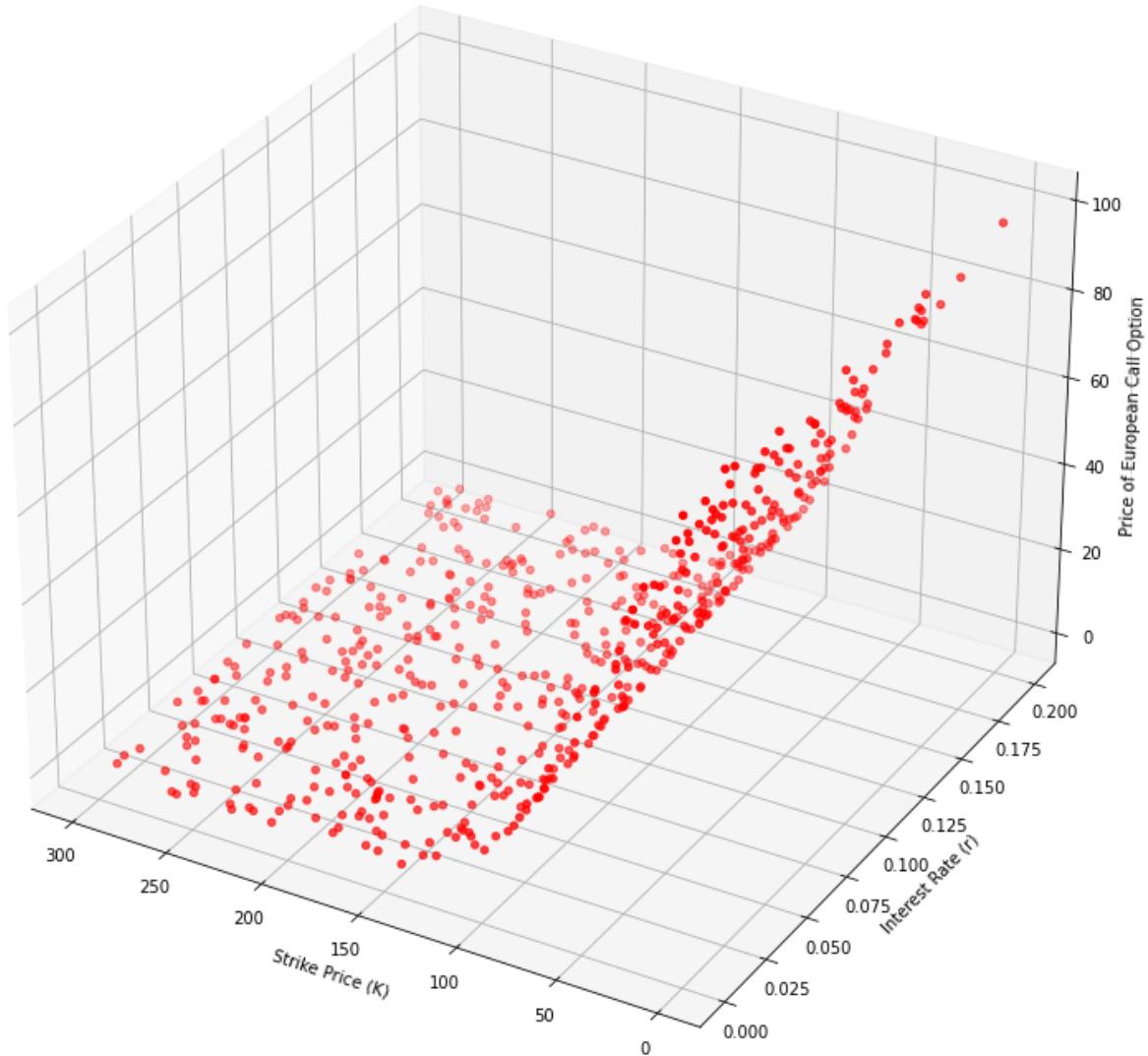
Scatter Plot of Initial Option Price with $S(0)$ and M (Set 2)



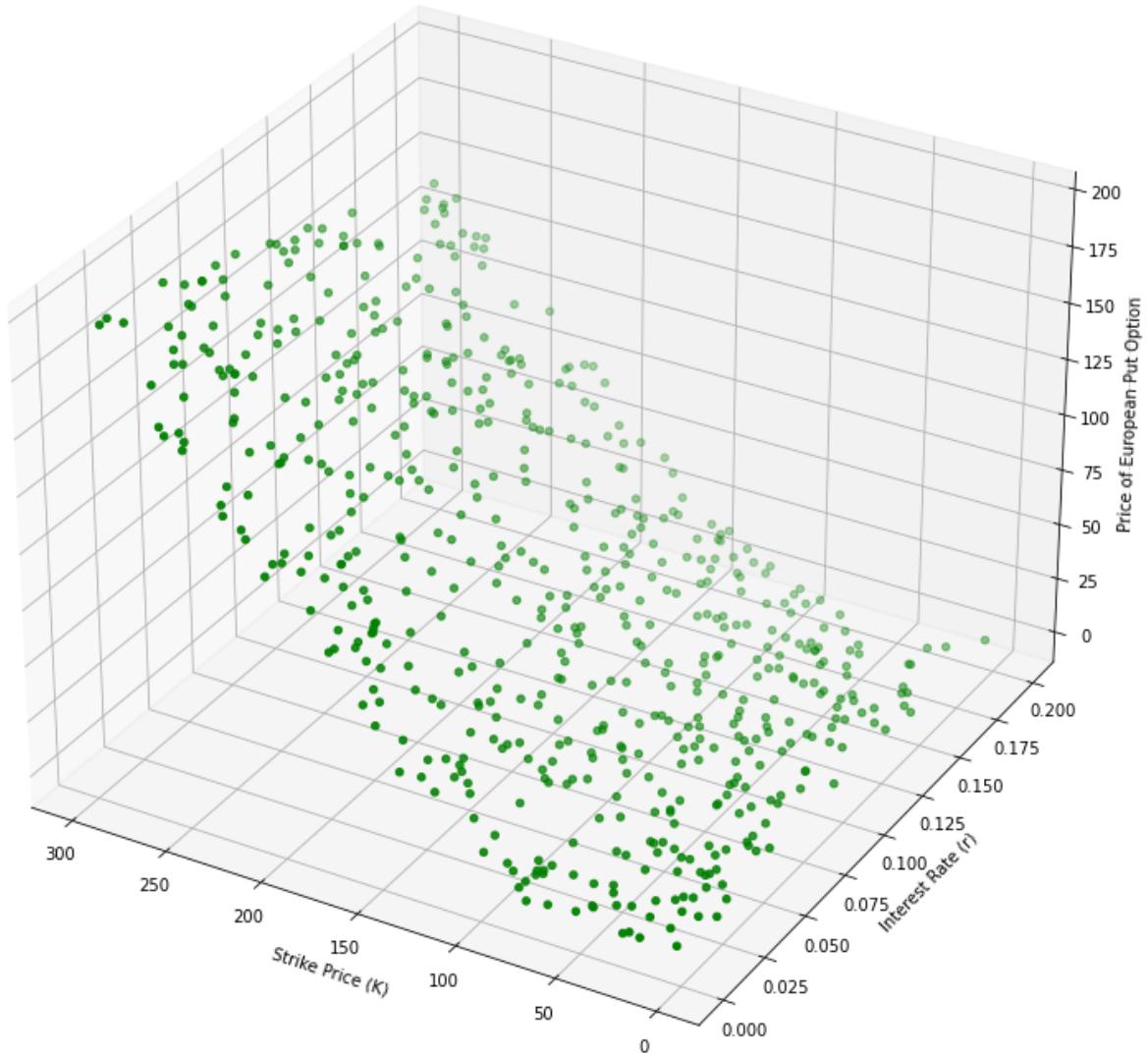
Scatter Plot of Initial Option Price with $S(0)$ and M (Set 2)



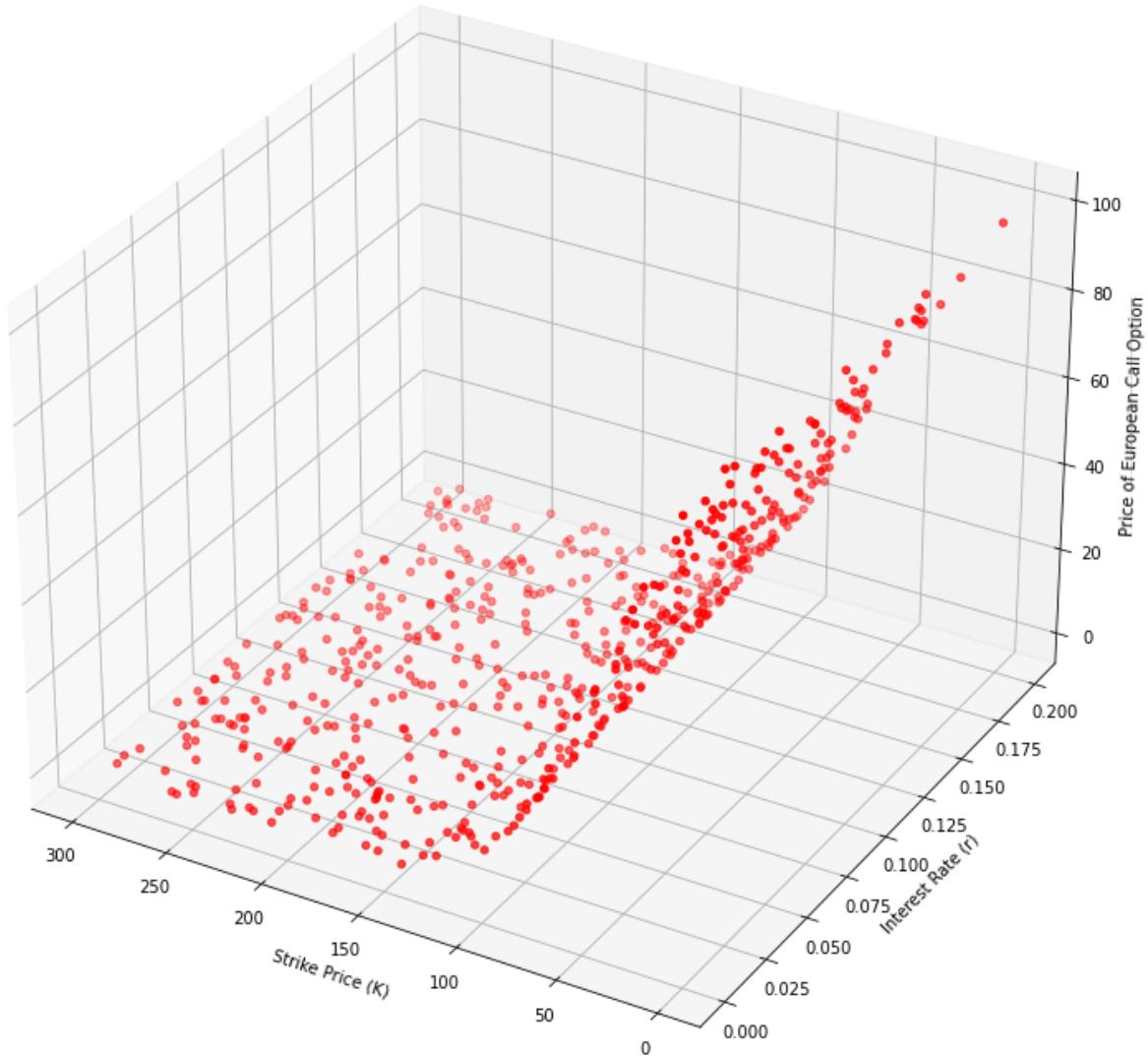
Scatter Plot of Initial Option Price with K and r (Set 1)



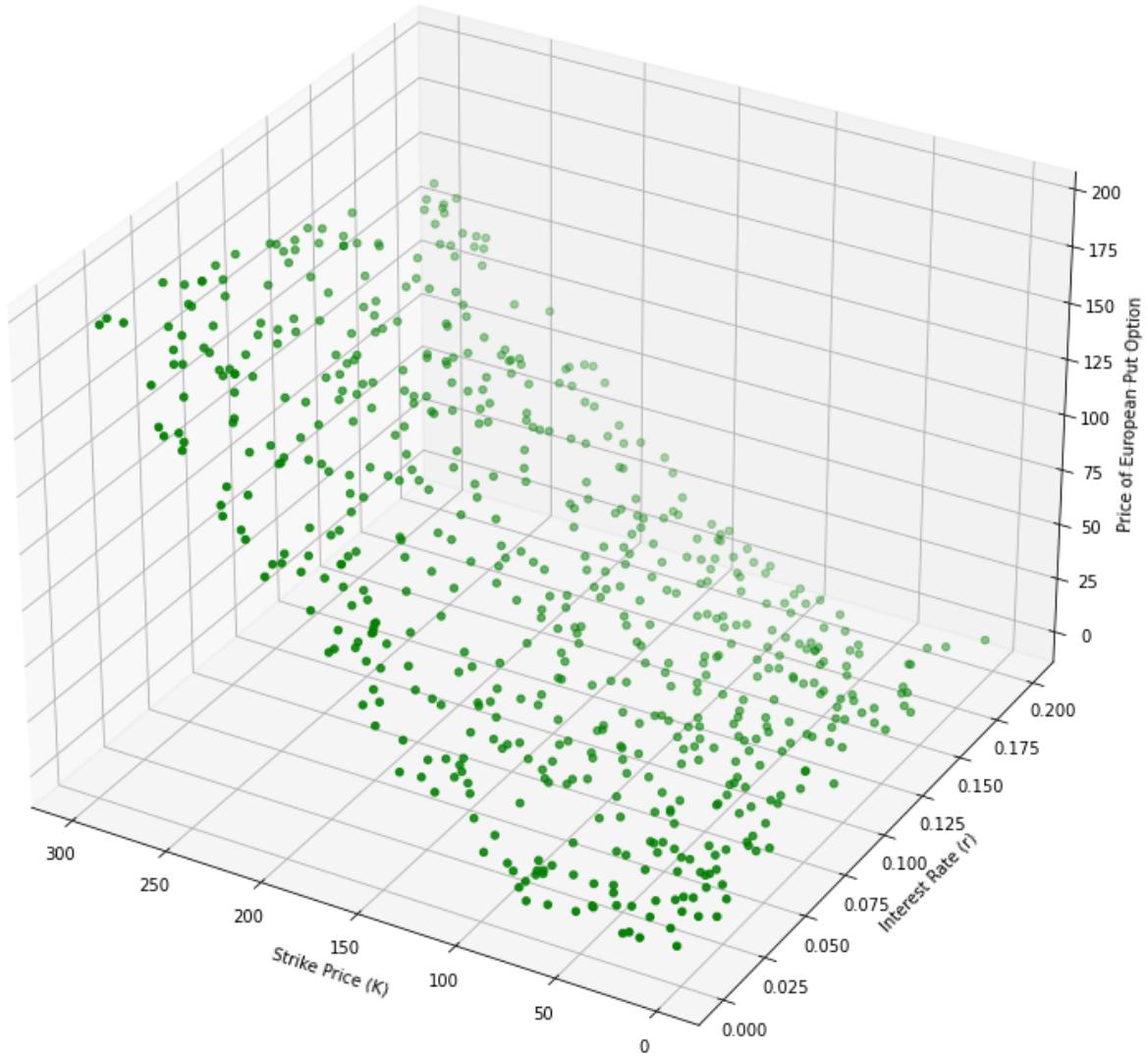
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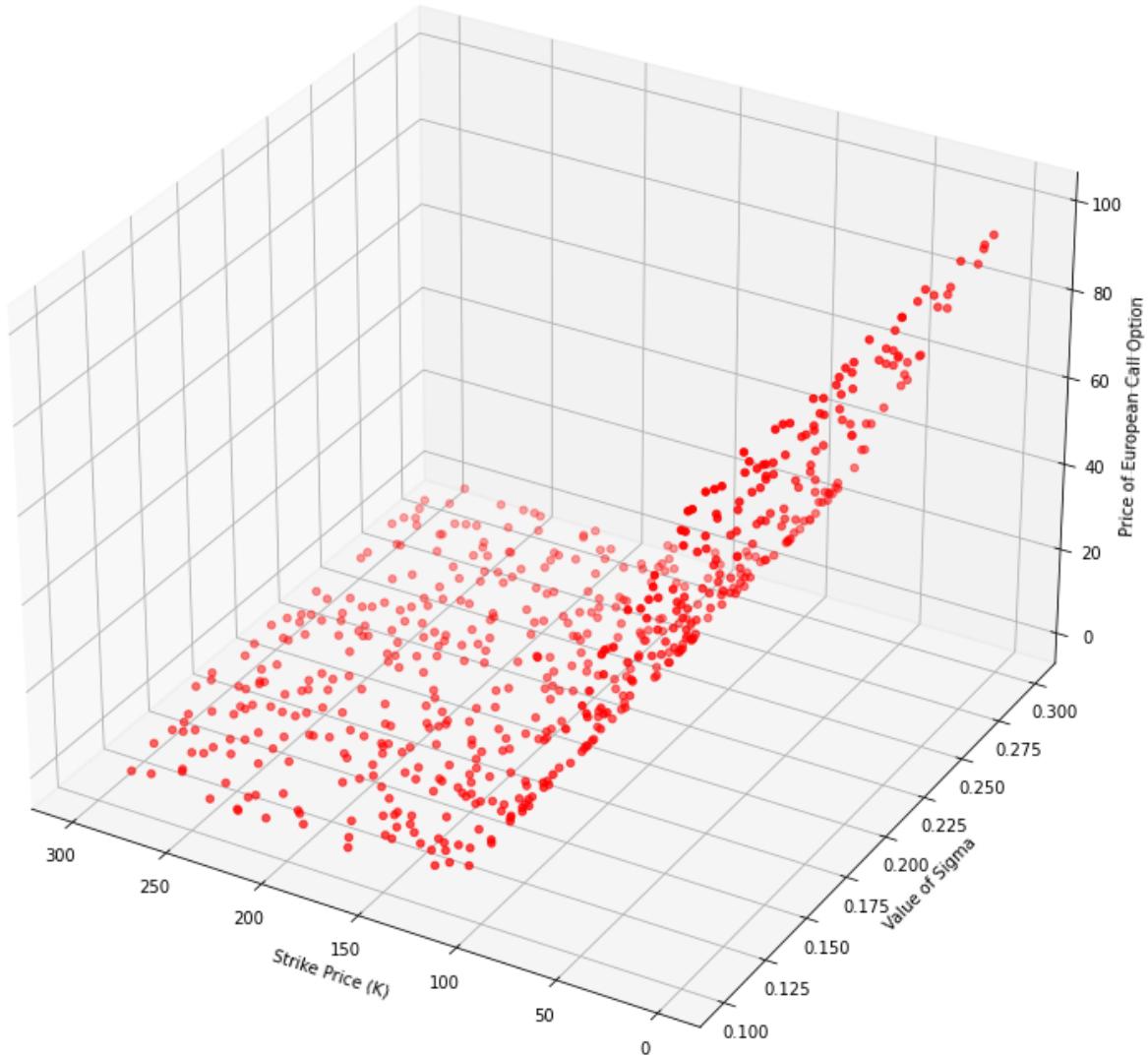
Scatter Plot of Initial Option Price with K and r (Set 2)



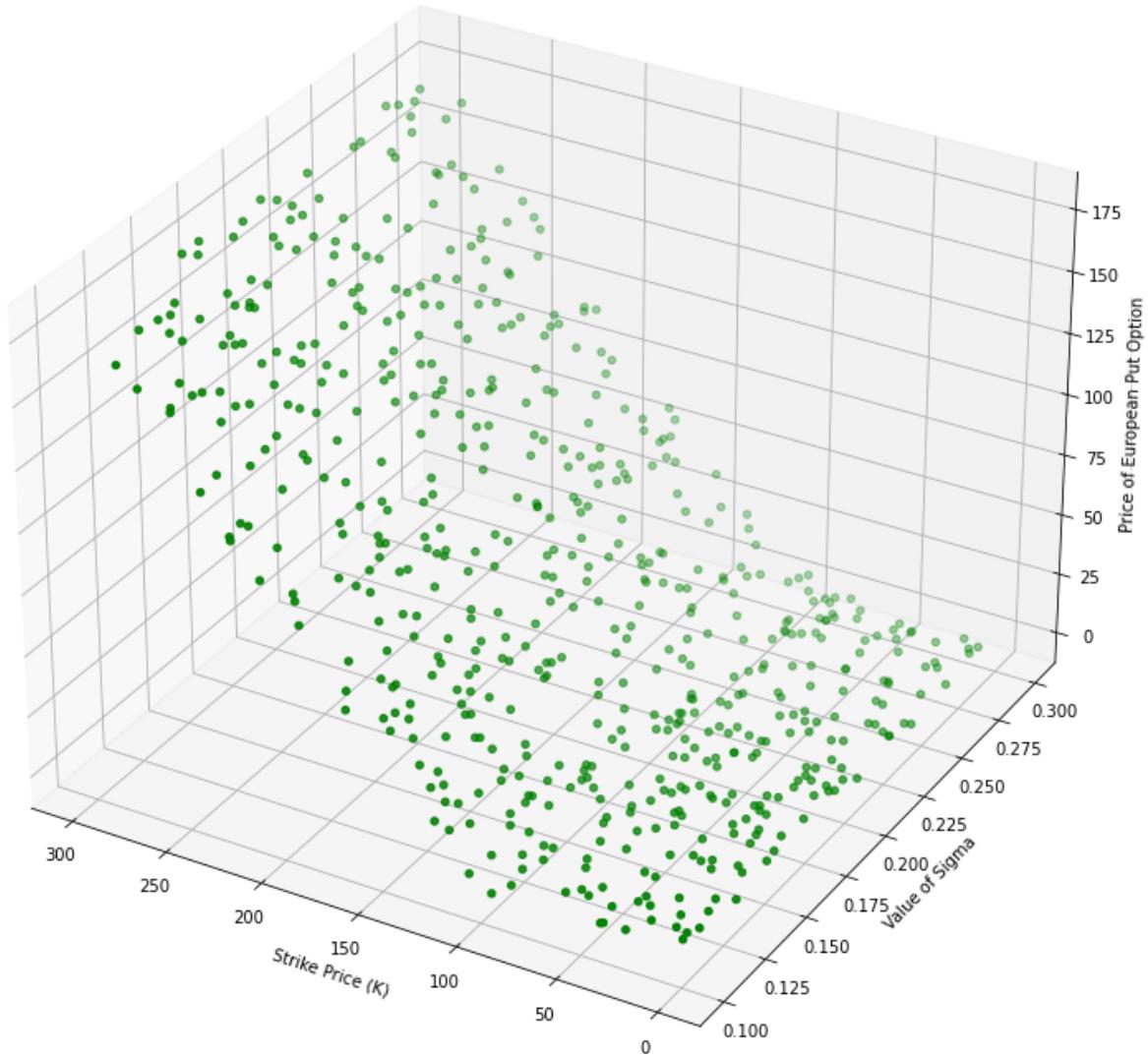
Scatter Plot of Initial Option Price with K and r (Set 2)



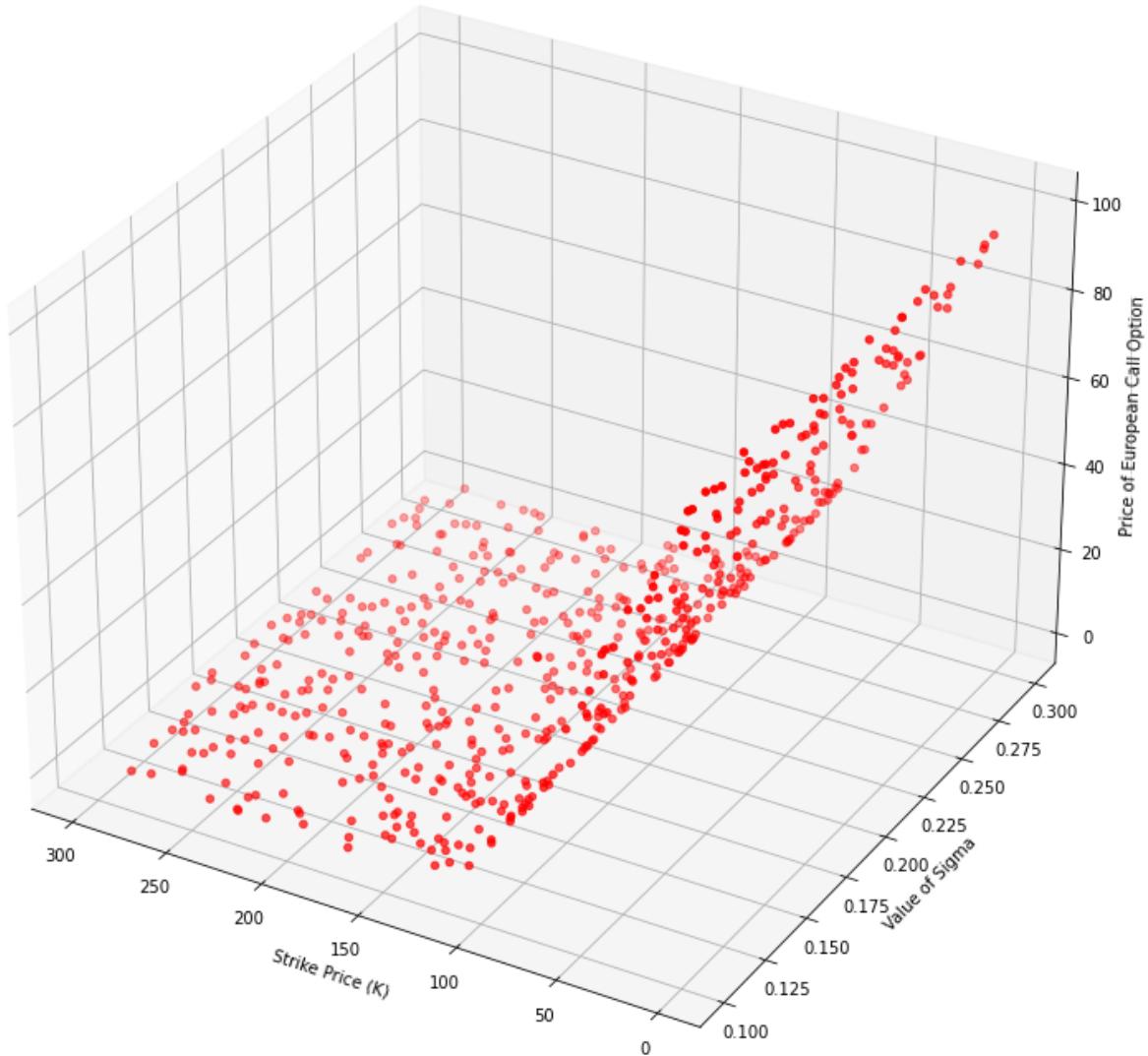
Scatter Plot of Initial Option Price with K and sig (Set 1)



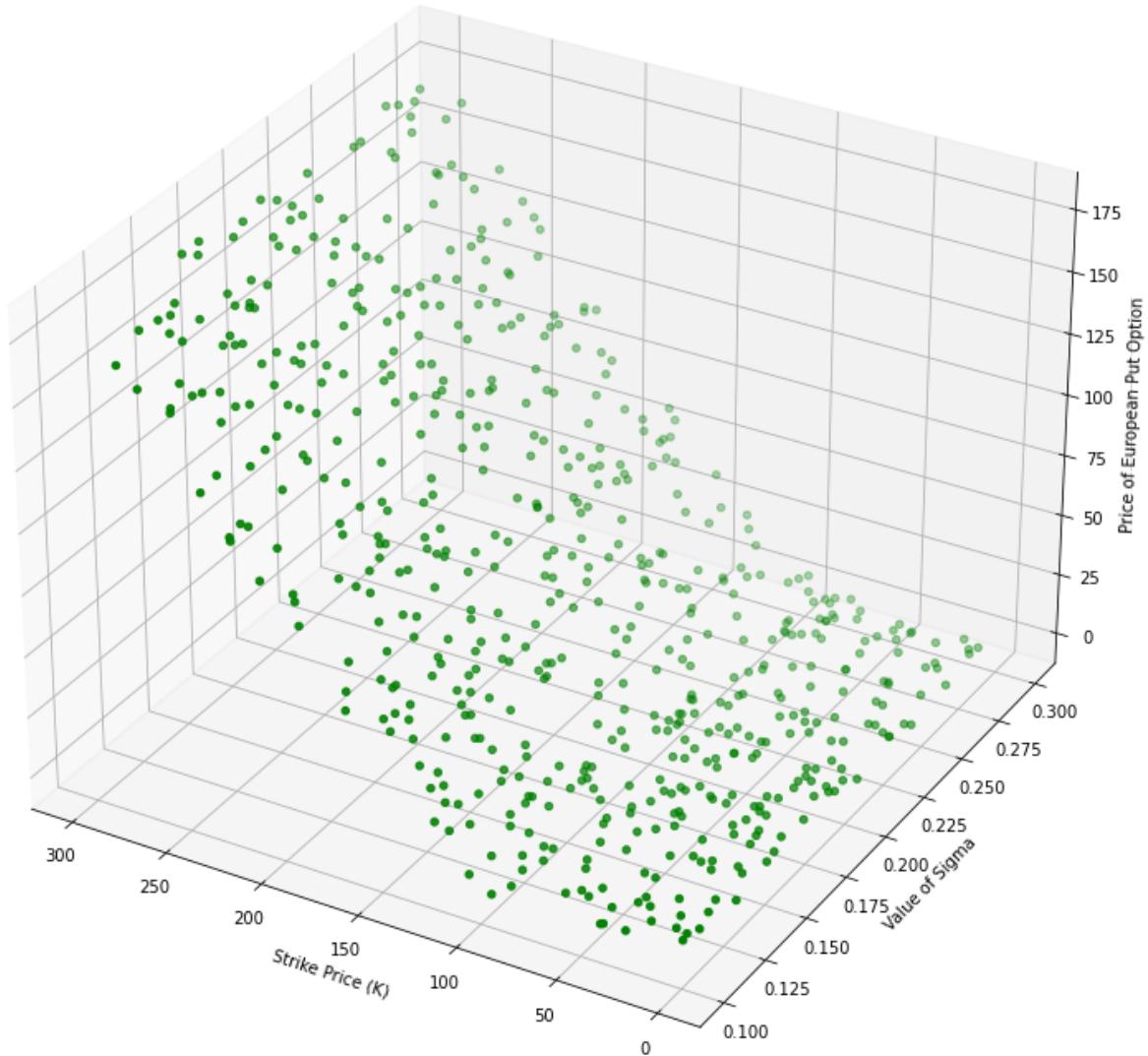
Scatter Plot of Initial Option Price with K and sig (Set 1)



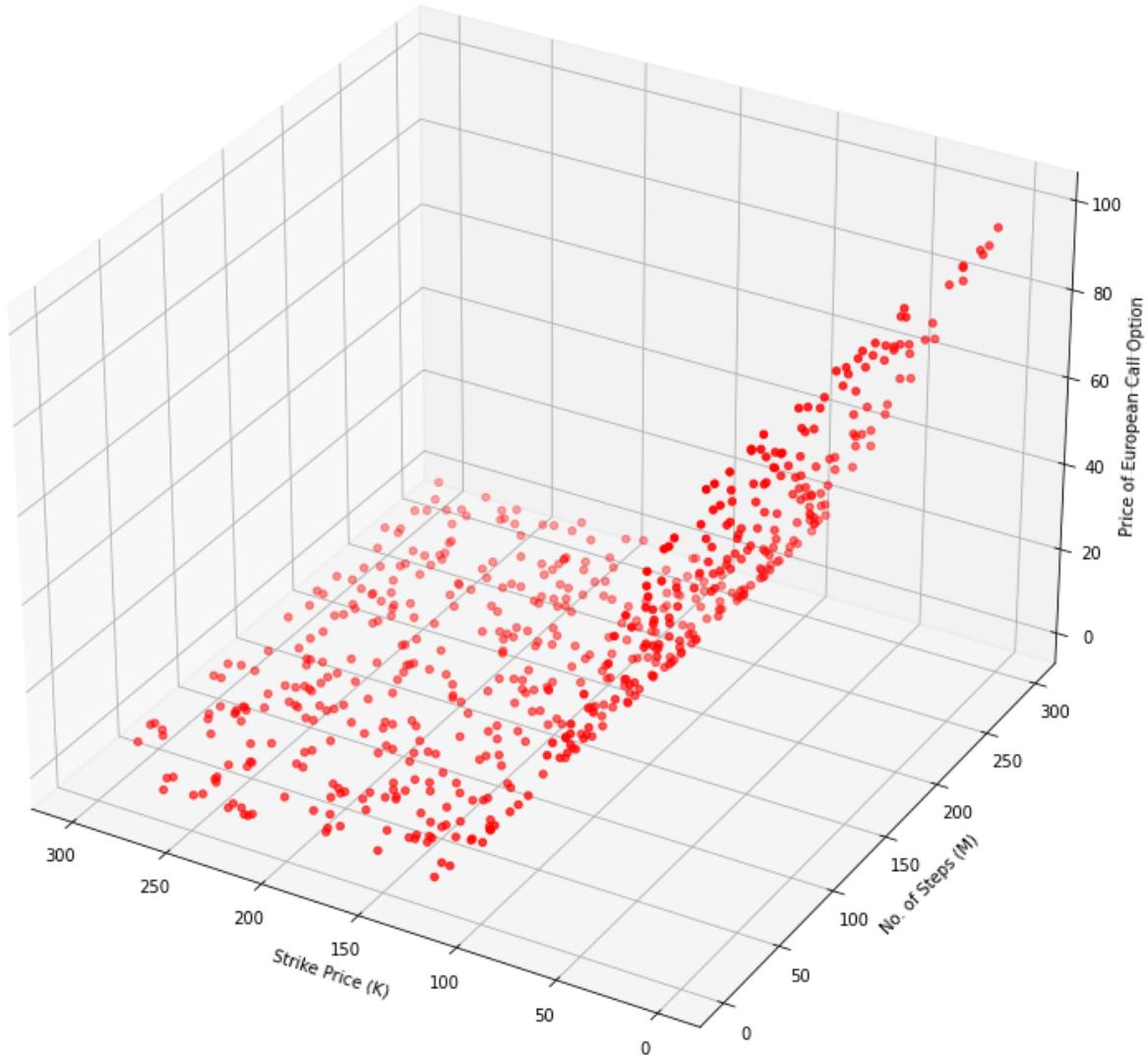
Scatter Plot of Initial Option Price with K and sig (Set 2)



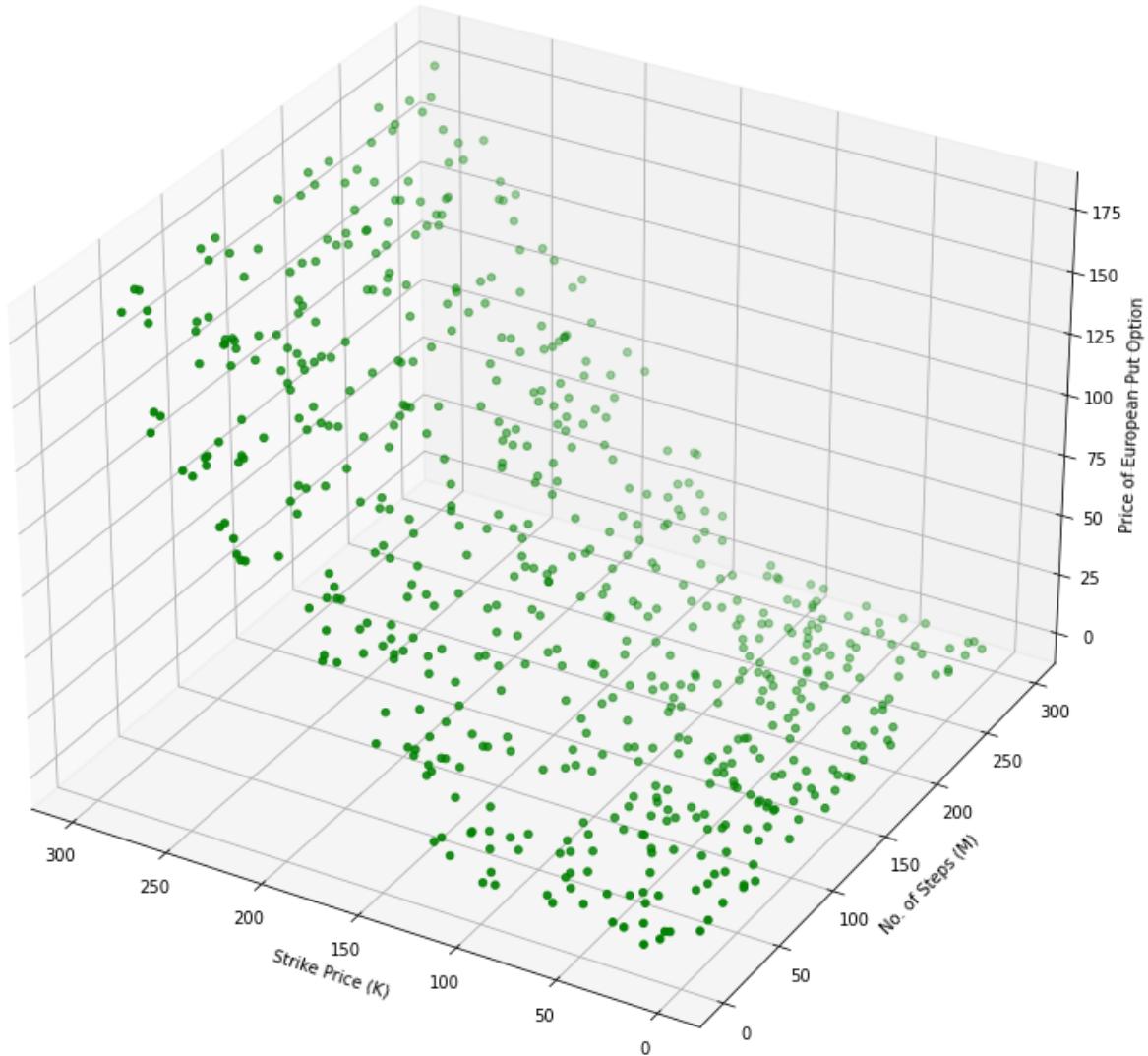
Scatter Plot of Initial Option Price with K and sig (Set 2)



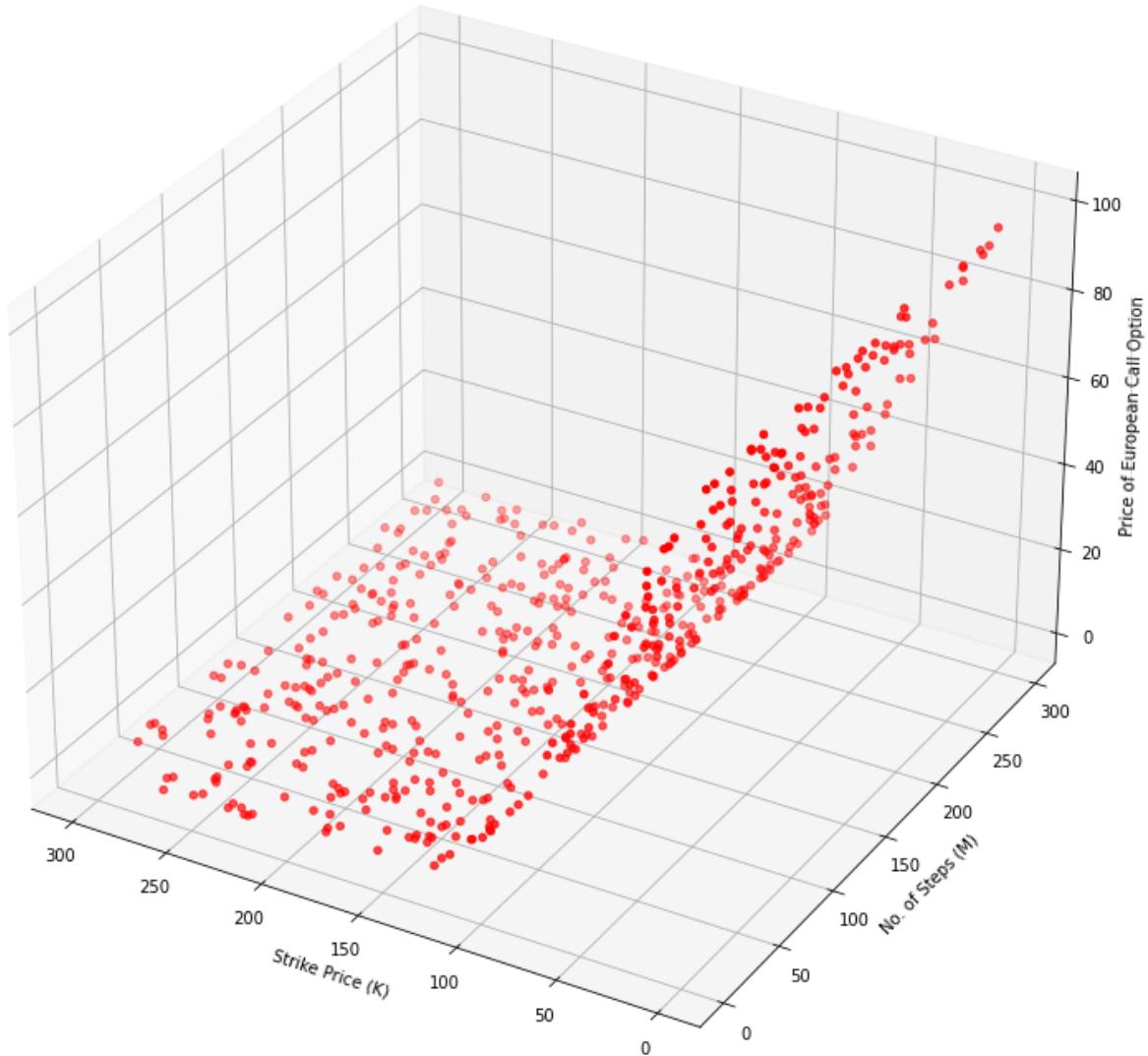
Scatter Plot of Initial Option Price with K and M (Set 1)



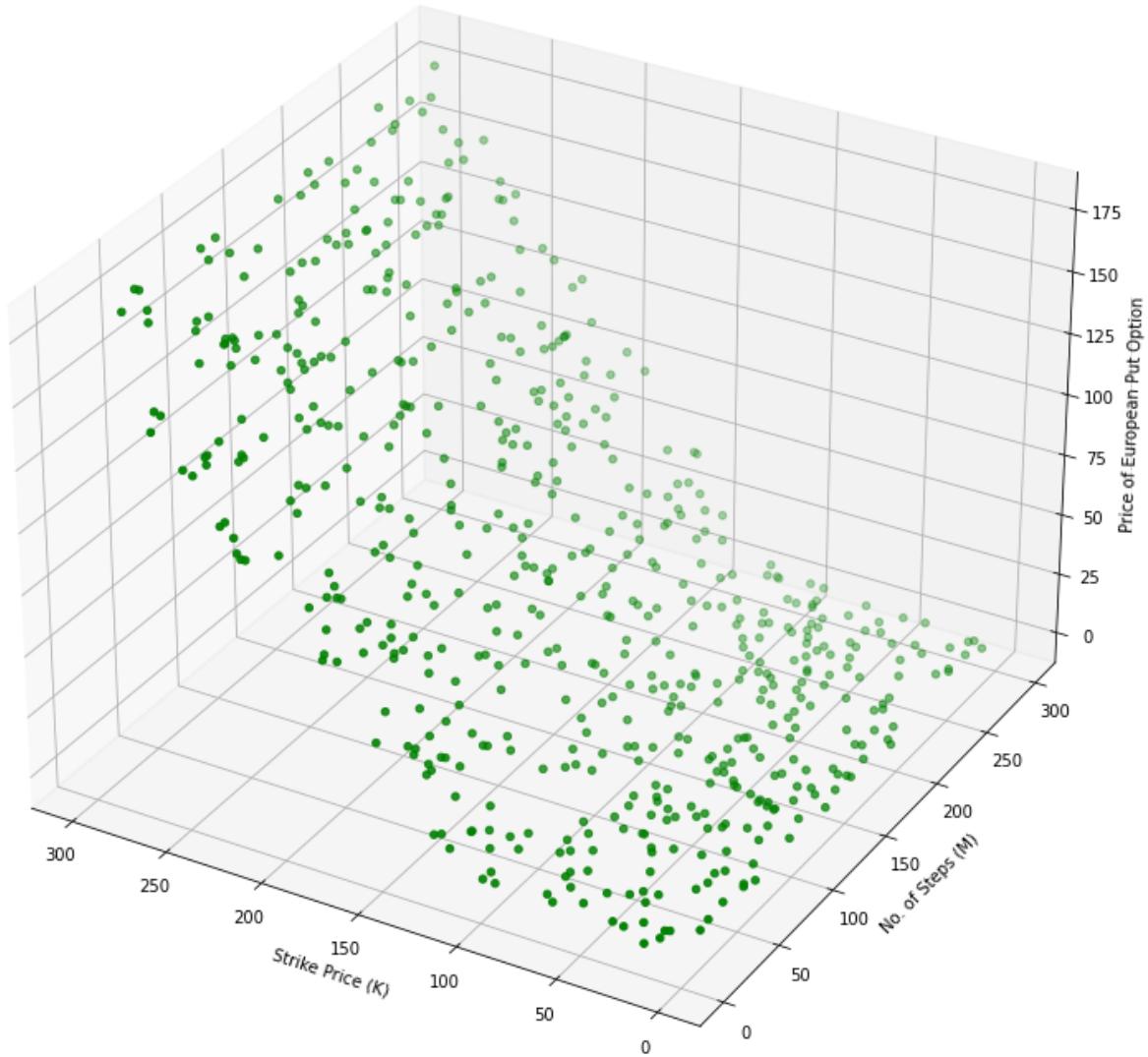
Scatter Plot of Initial Option Price with K and M (Set 1)



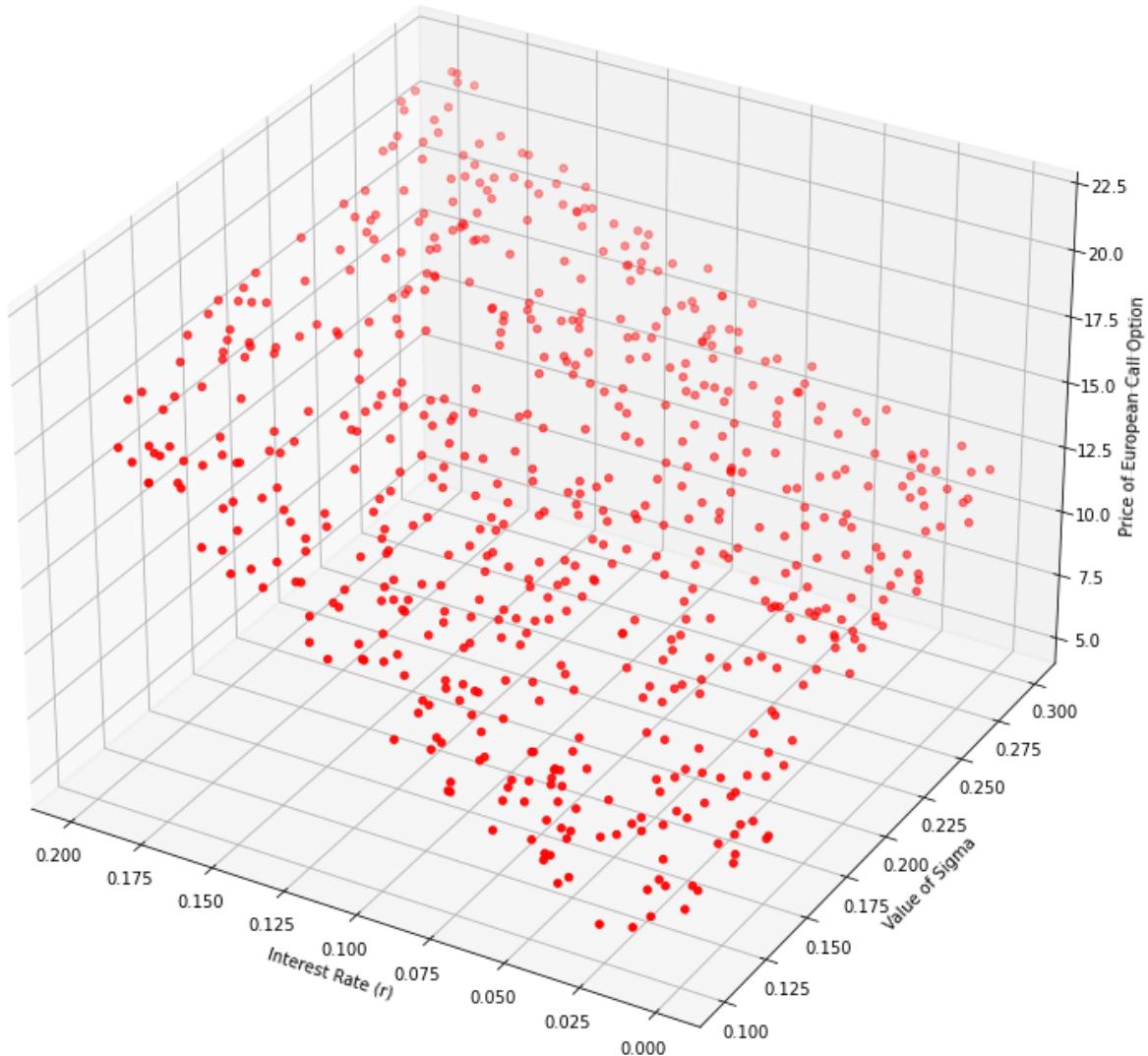
Scatter Plot of Initial Option Price with K and M (Set 2)



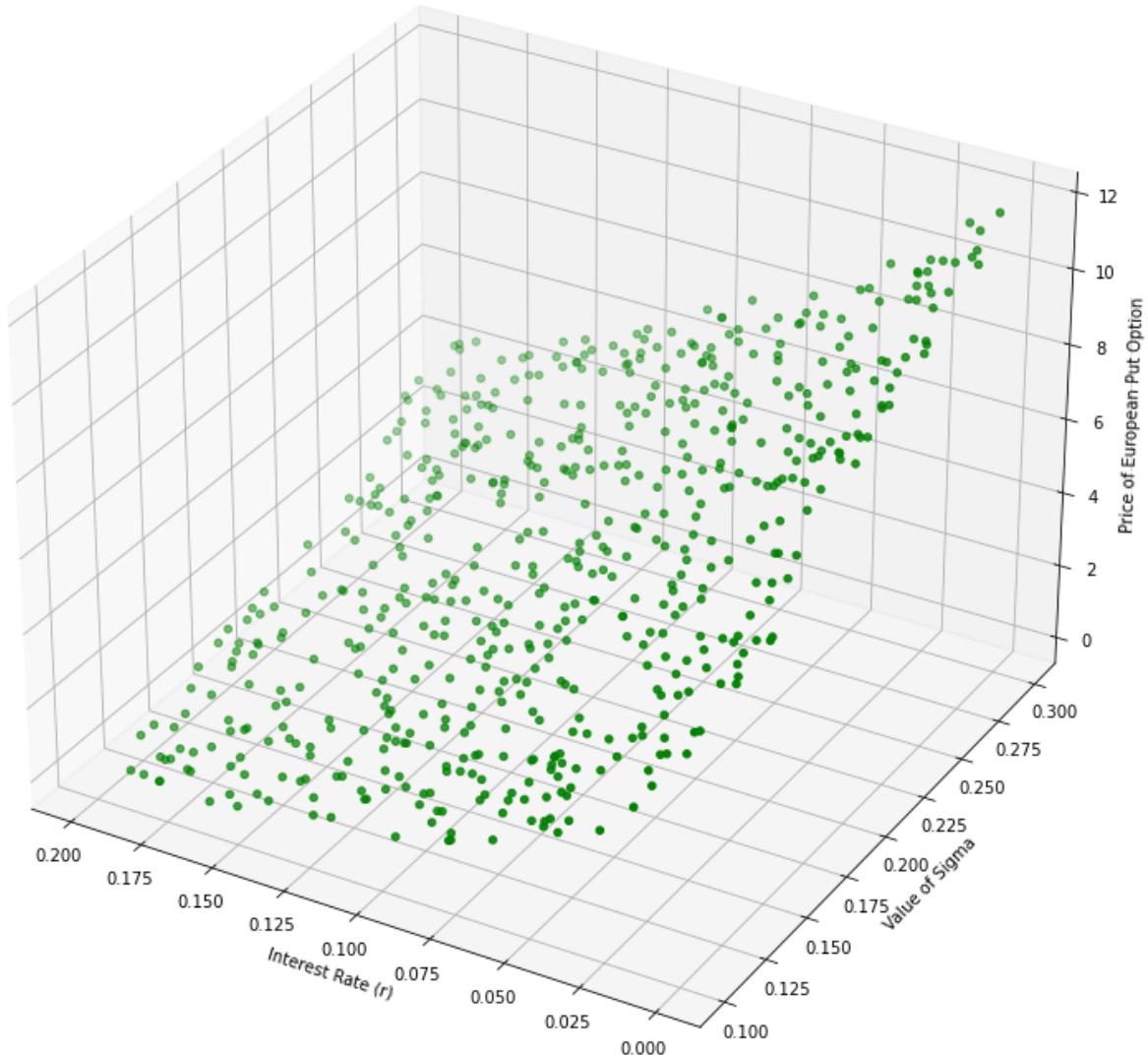
Scatter Plot of Initial Option Price with K and M (Set 2)



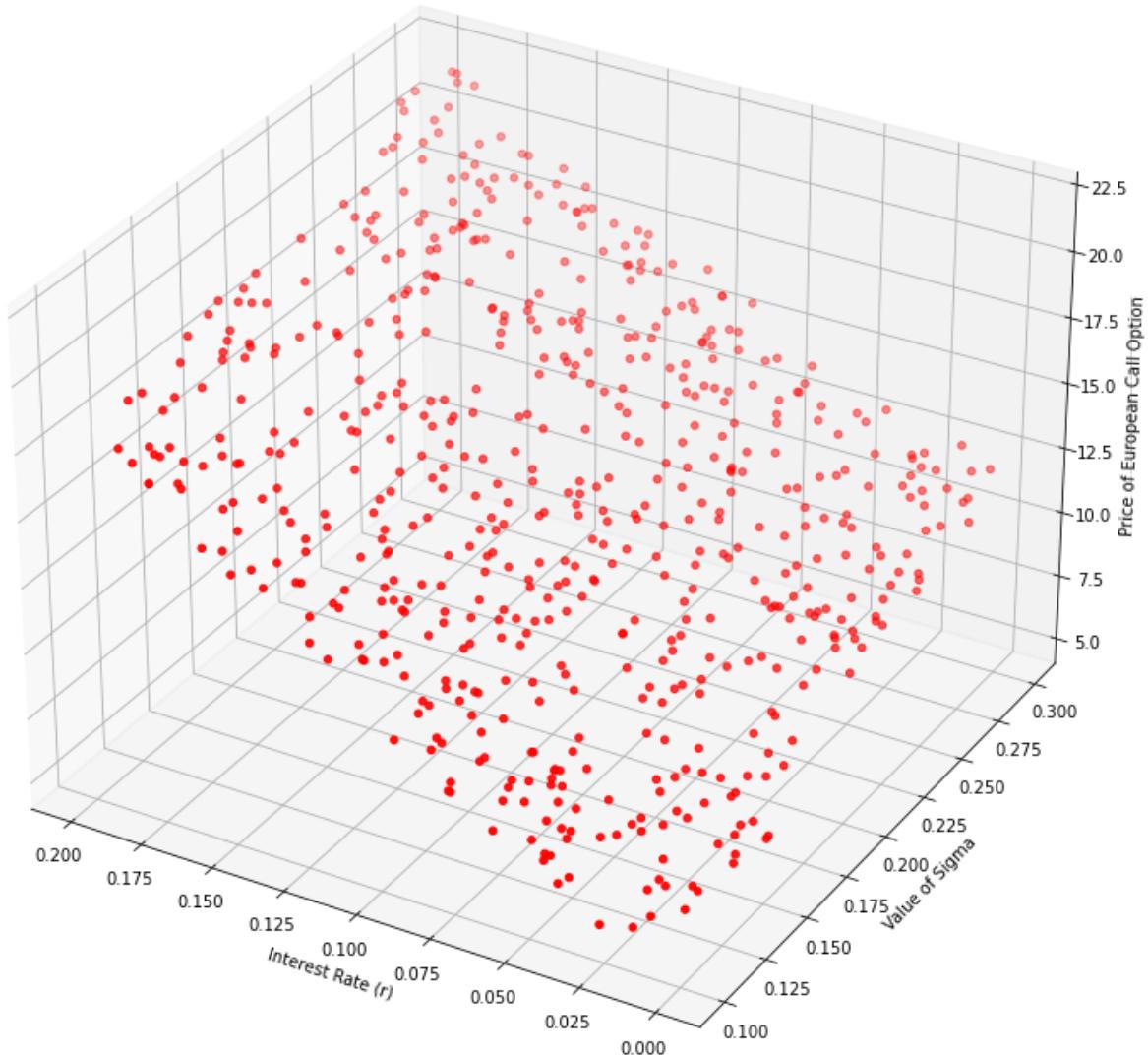
Scatter Plot of Initial Option Price with r and σ (Set 1)



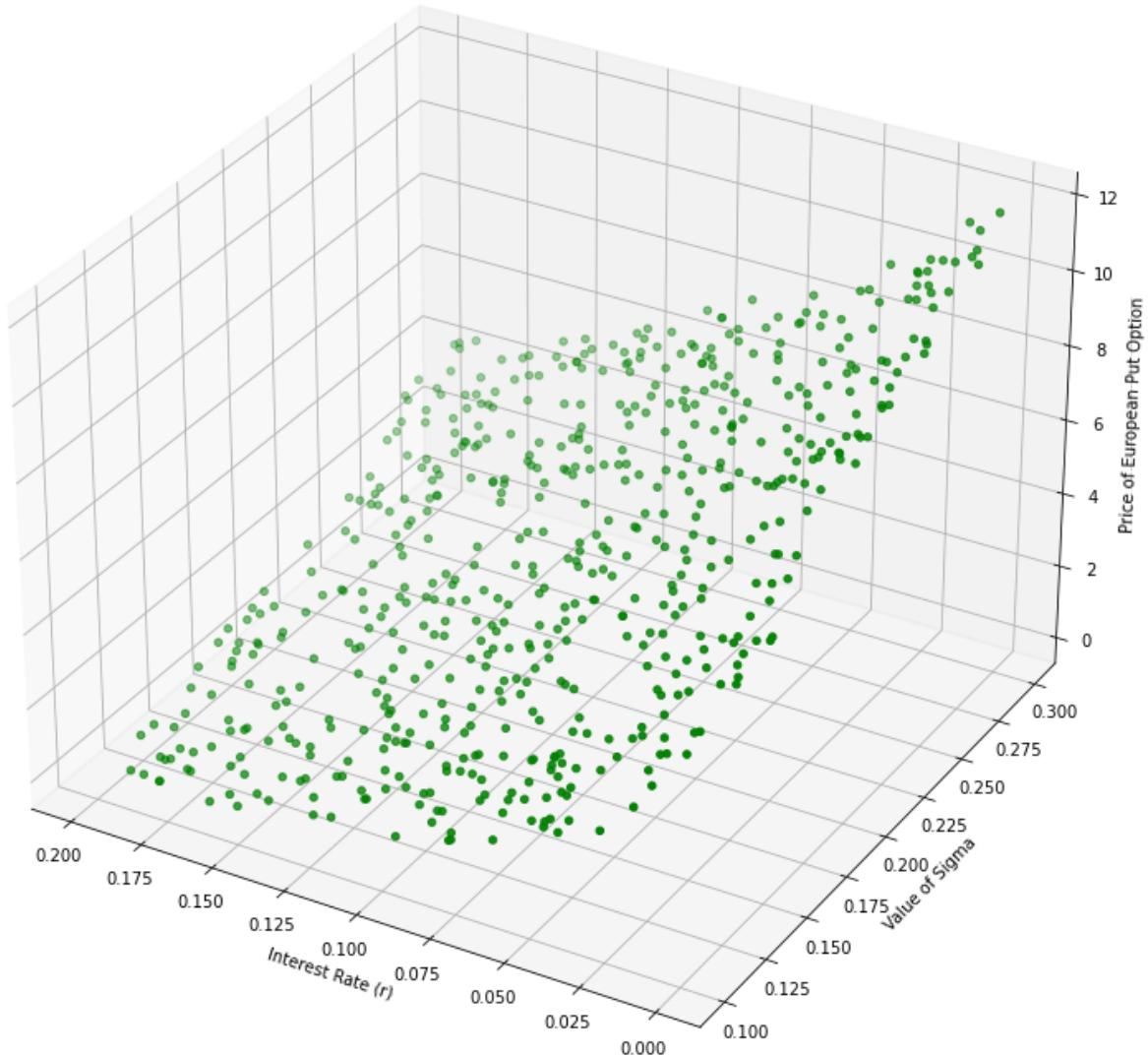
Scatter Plot of Initial Option Price with r and σ (Set 1)



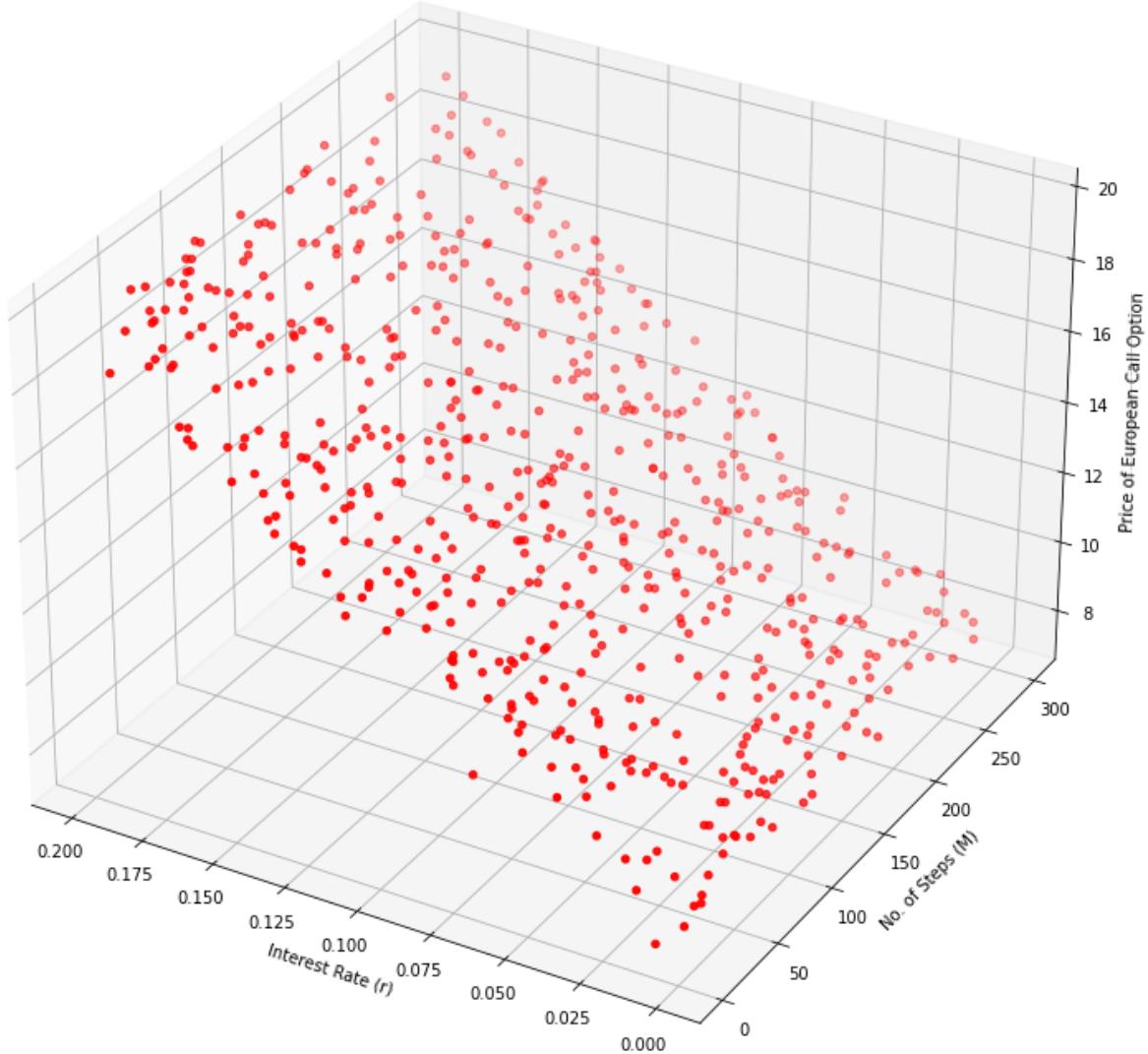
Scatter Plot of Initial Option Price with r and σ (Set 2)



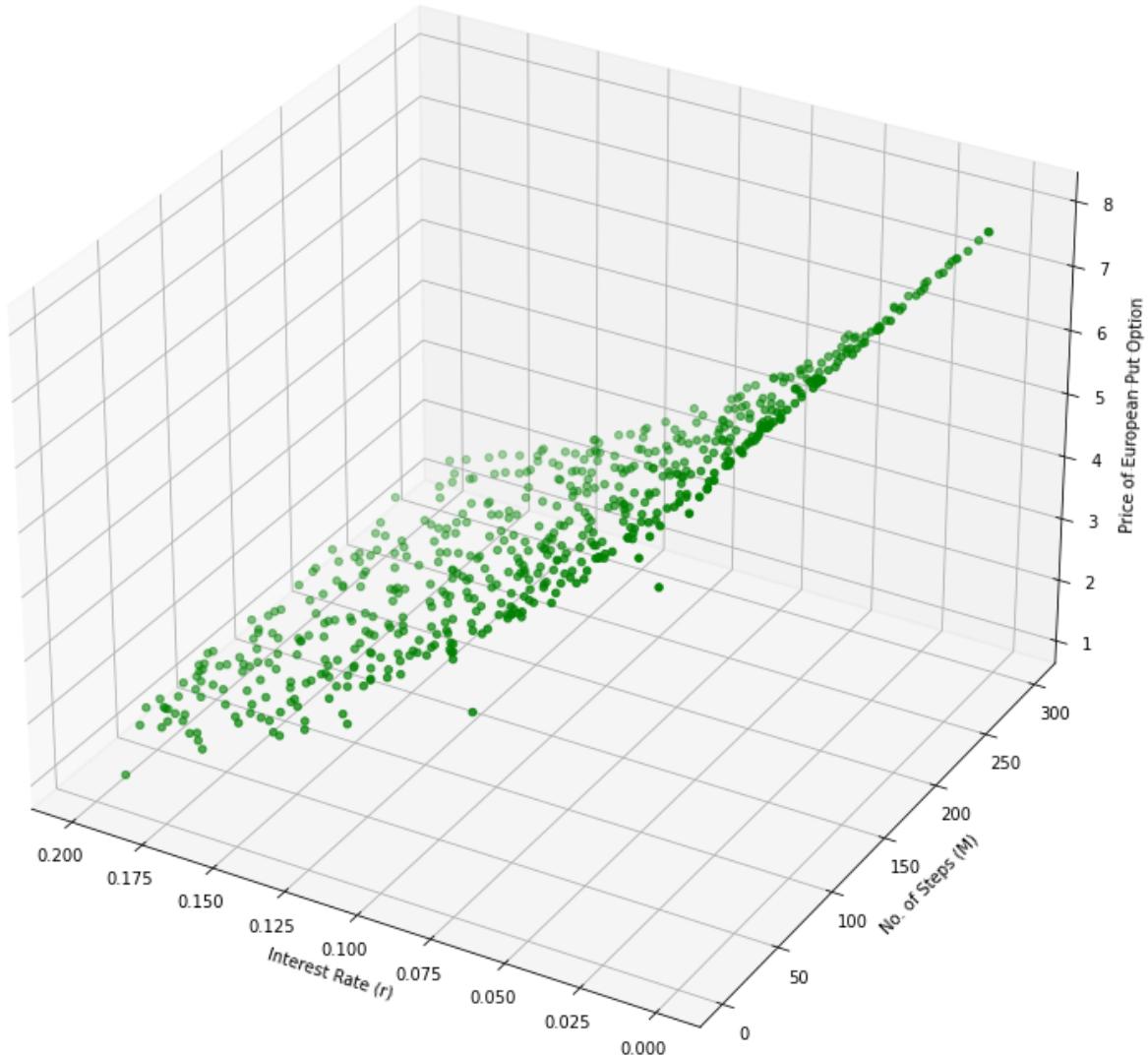
Scatter Plot of Initial Option Price with r and σ (Set 2)



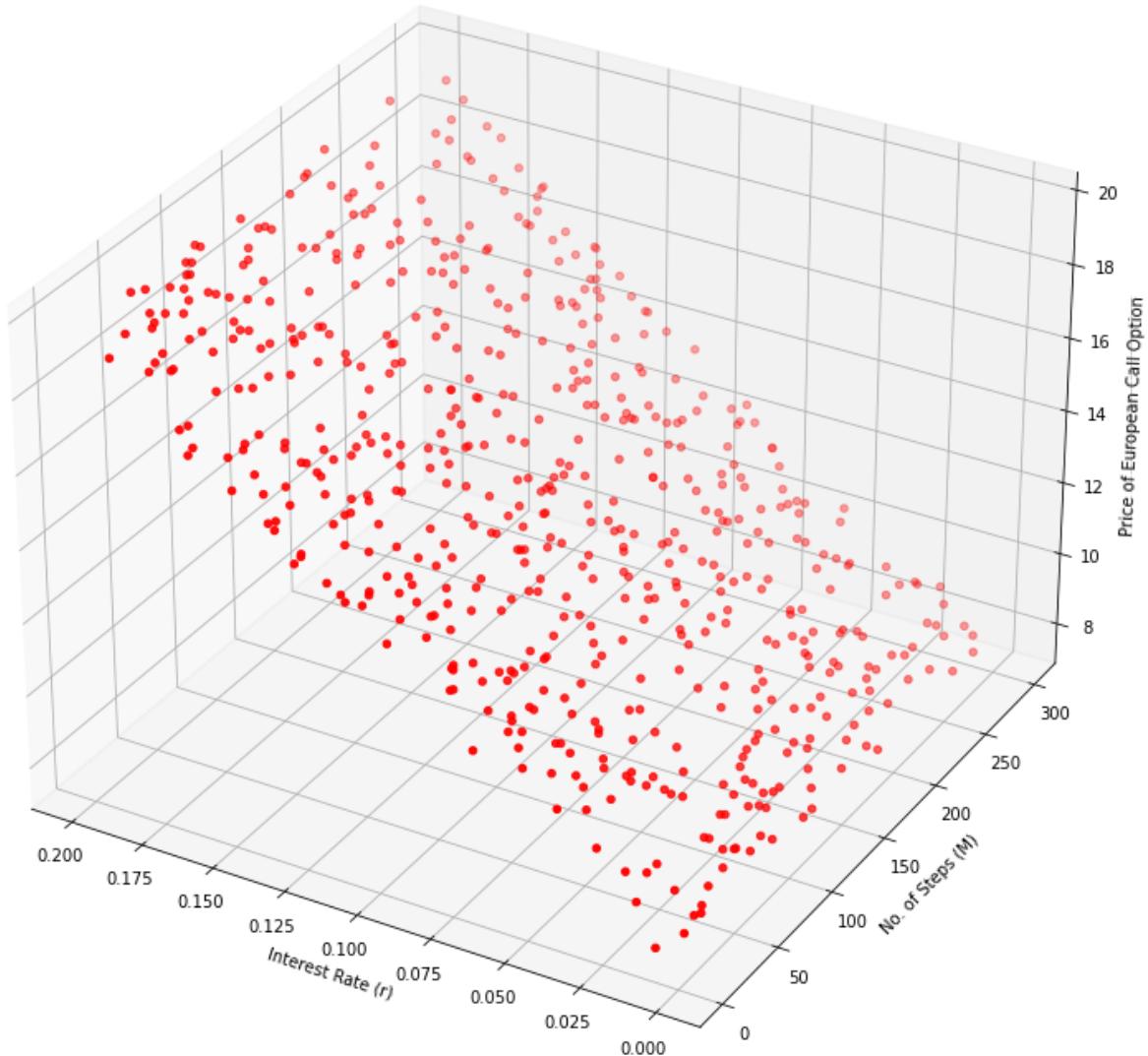
Scatter Plot of Initial Option Price with r and M (Set 1)



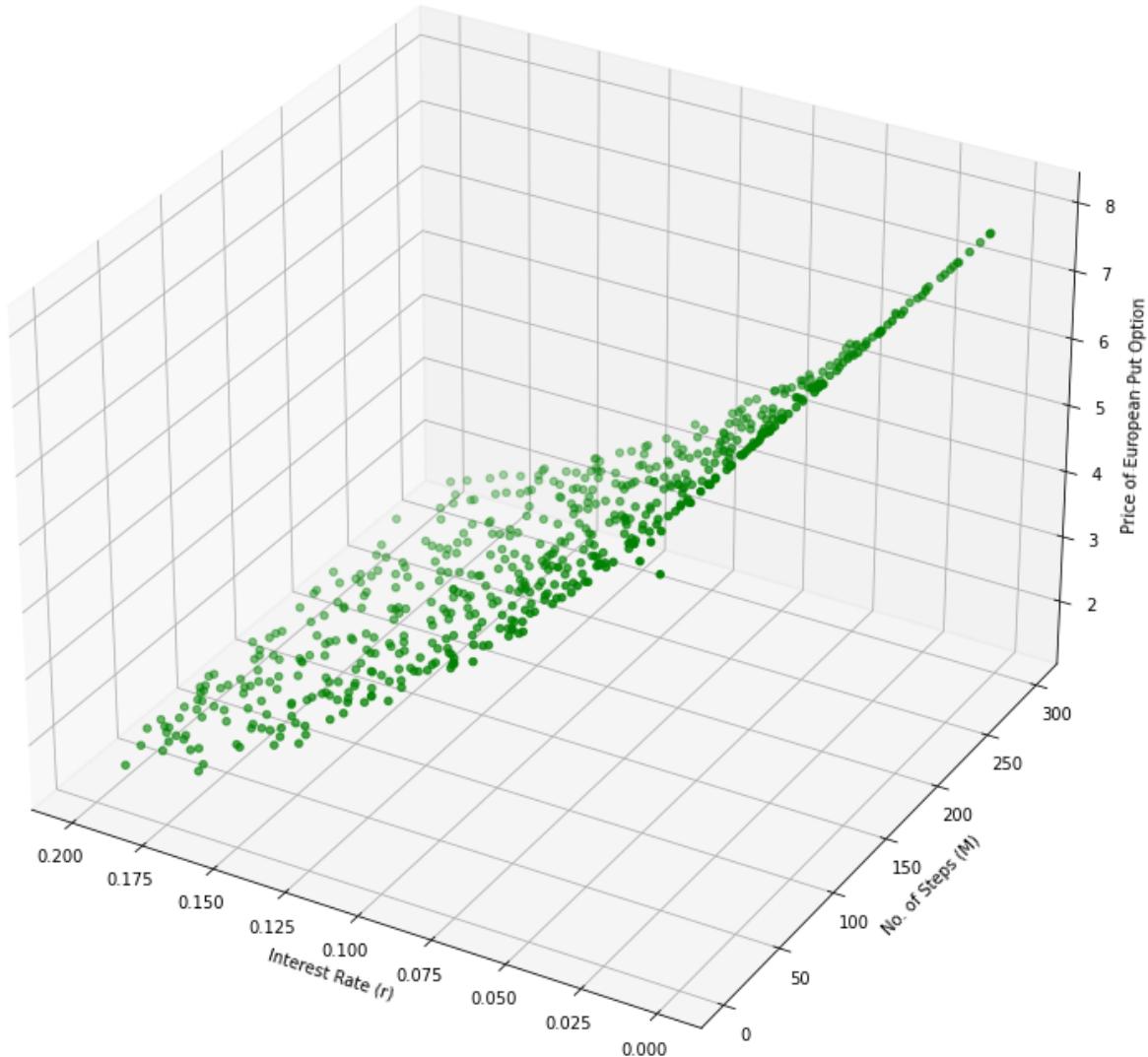
Scatter Plot of Initial Option Price with r and M (Set 1)



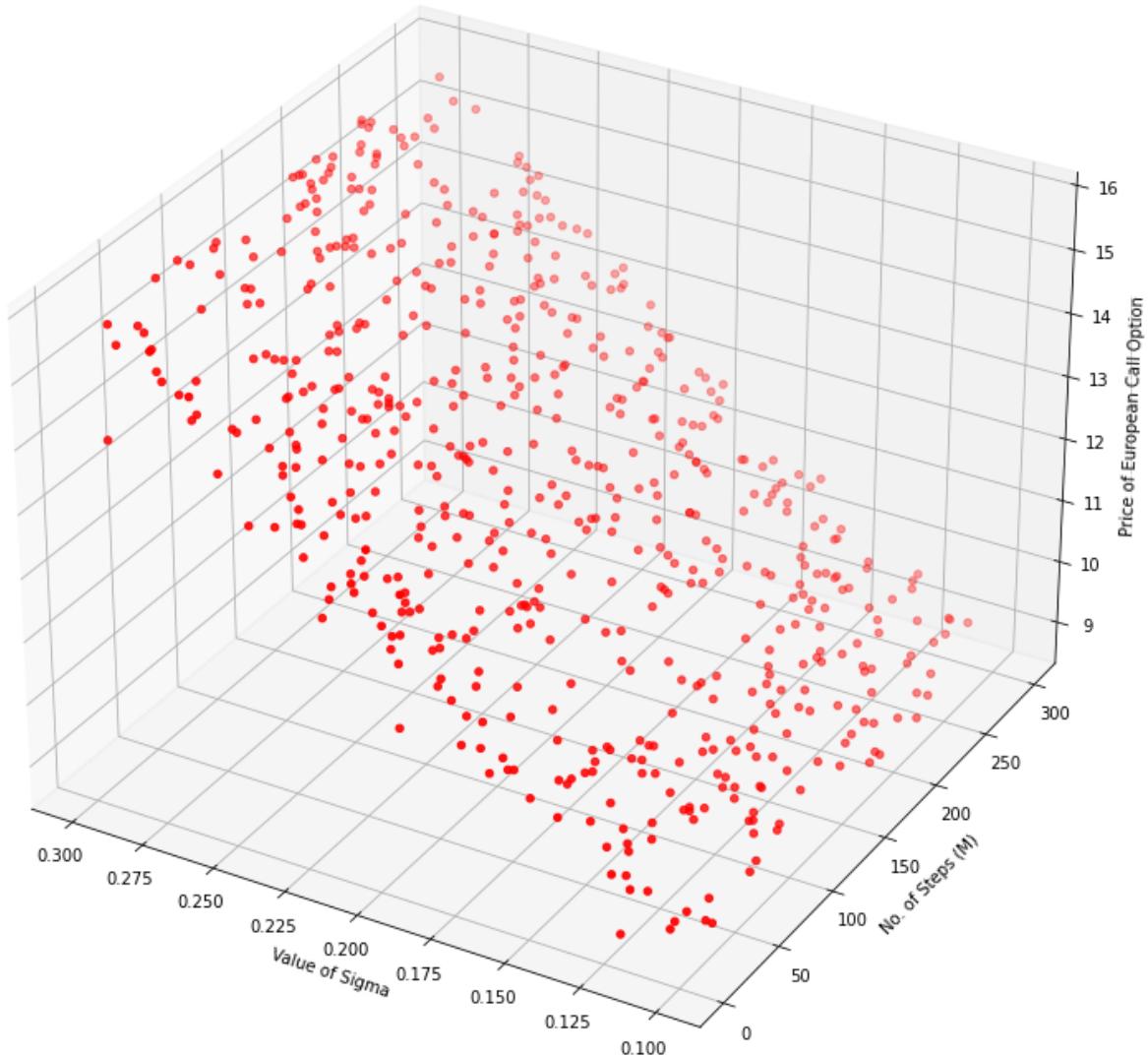
Scatter Plot of Initial Option Price with r and M (Set 2)



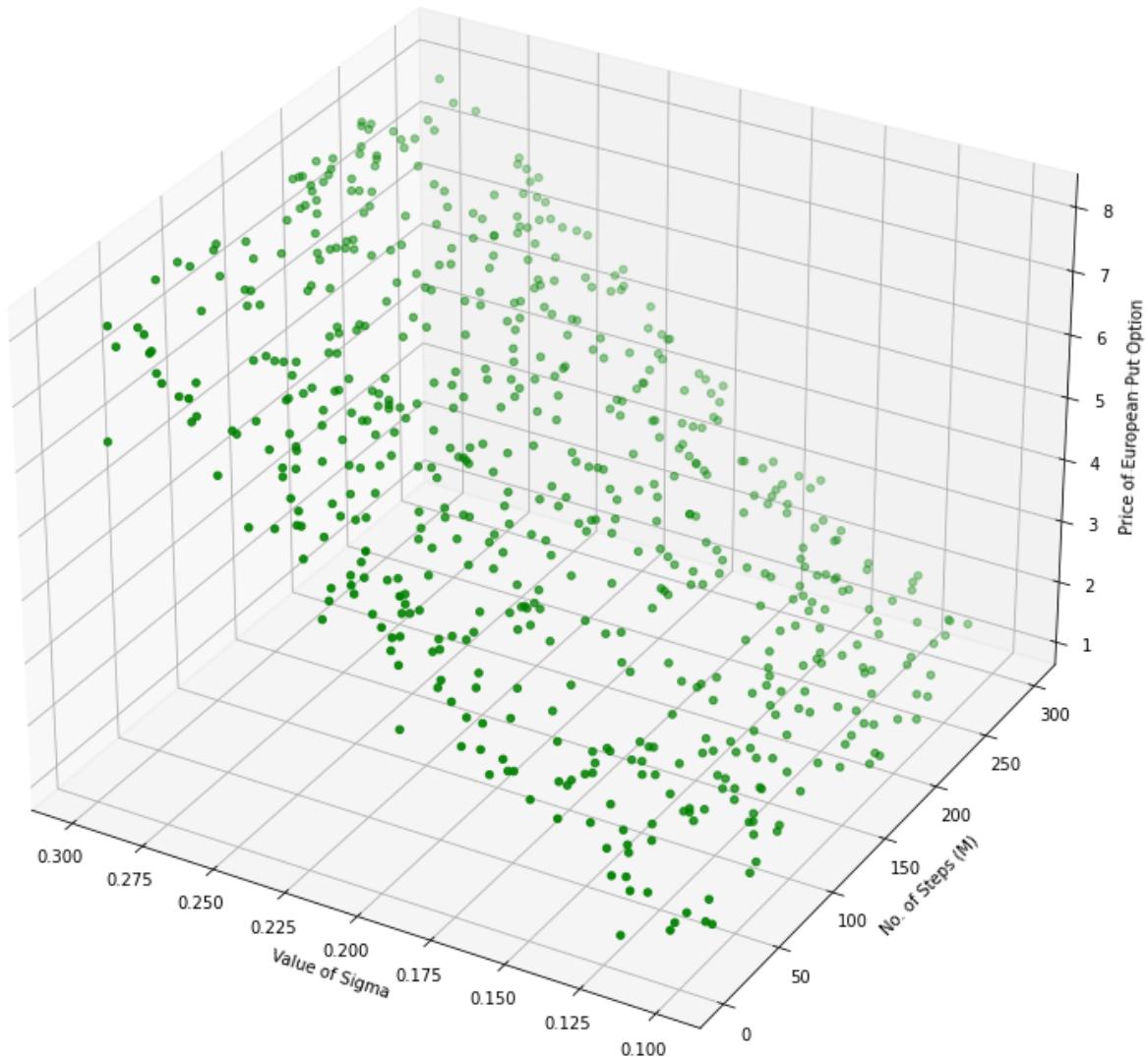
Scatter Plot of Initial Option Price with r and M (Set 2)



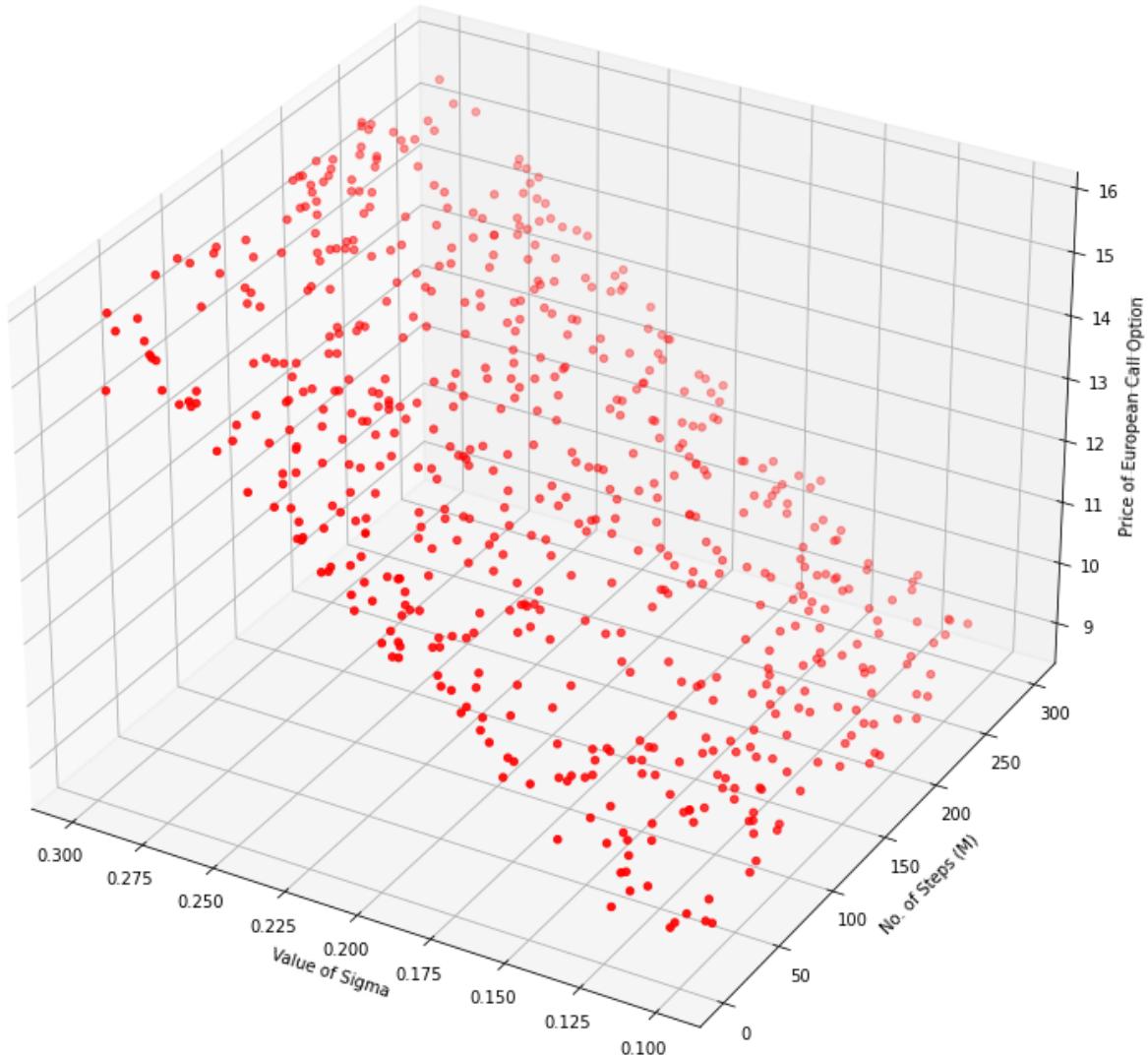
Scatter Plot of Initial Option Price with sig and M (Set 1)



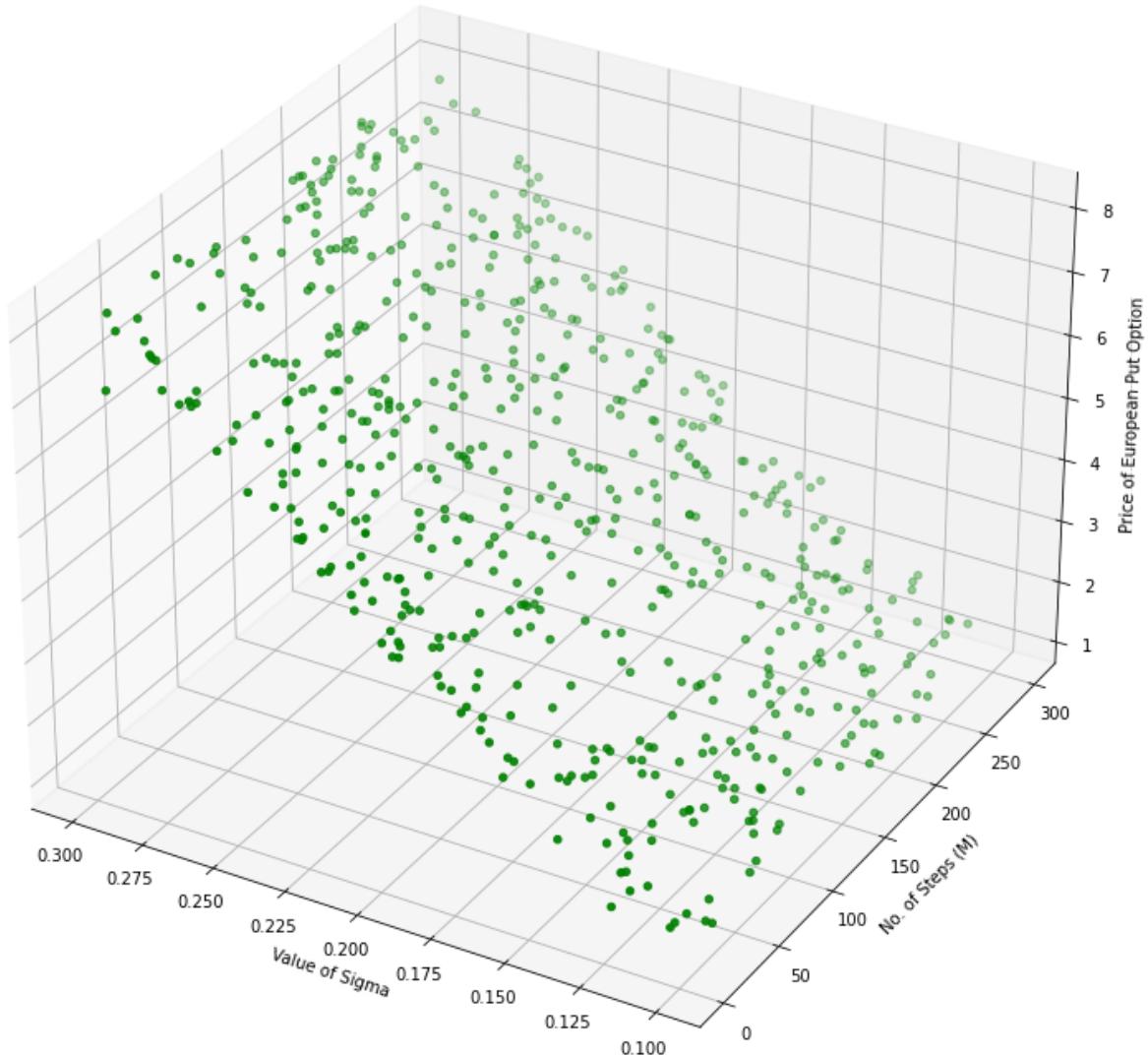
Scatter Plot of Initial Option Price with sig and M (Set 1)



Scatter Plot of Initial Option Price with sig and M (Set 2)

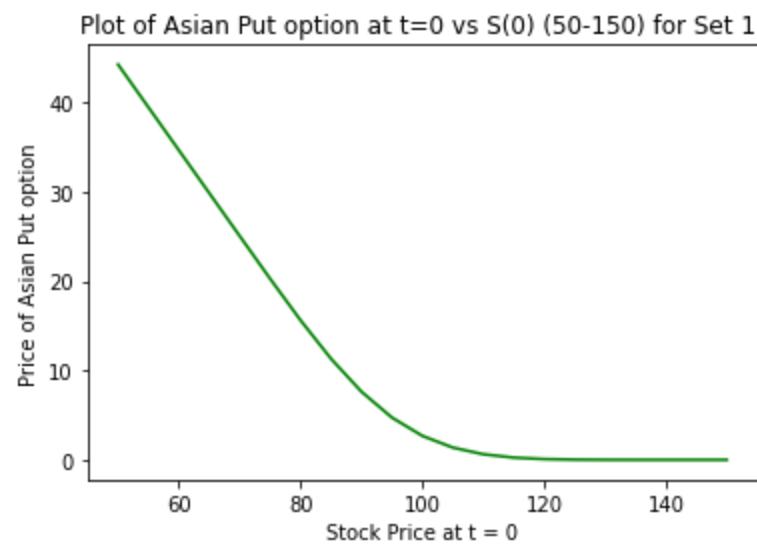
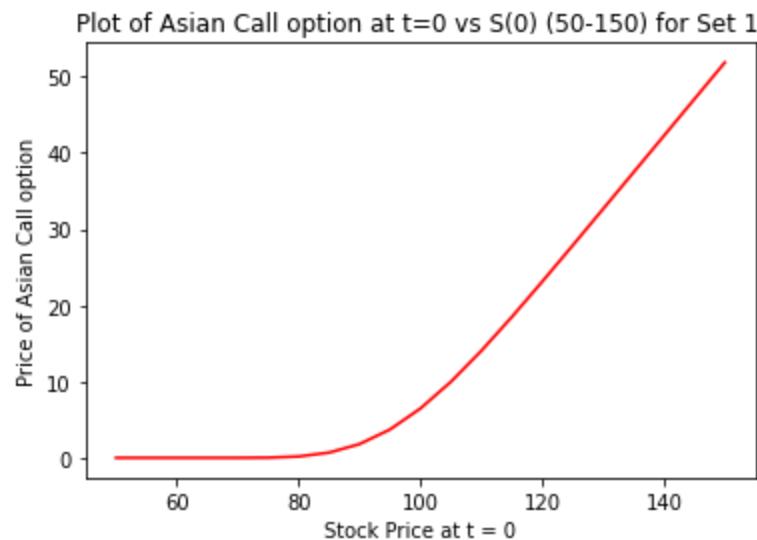


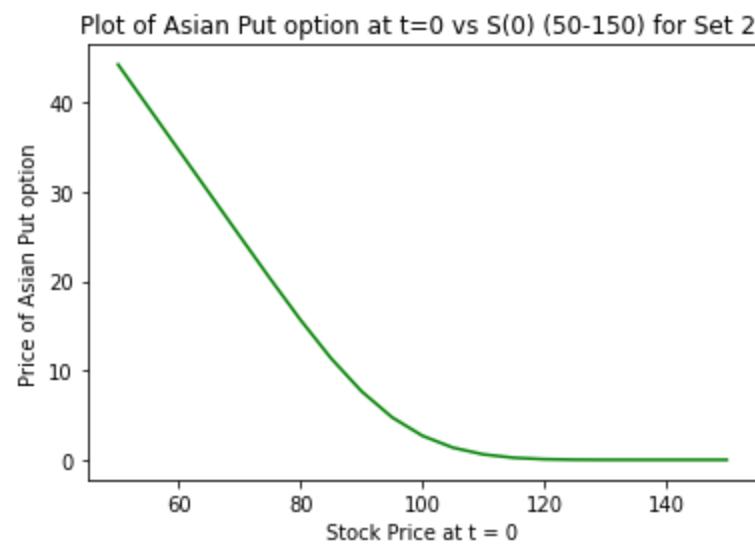
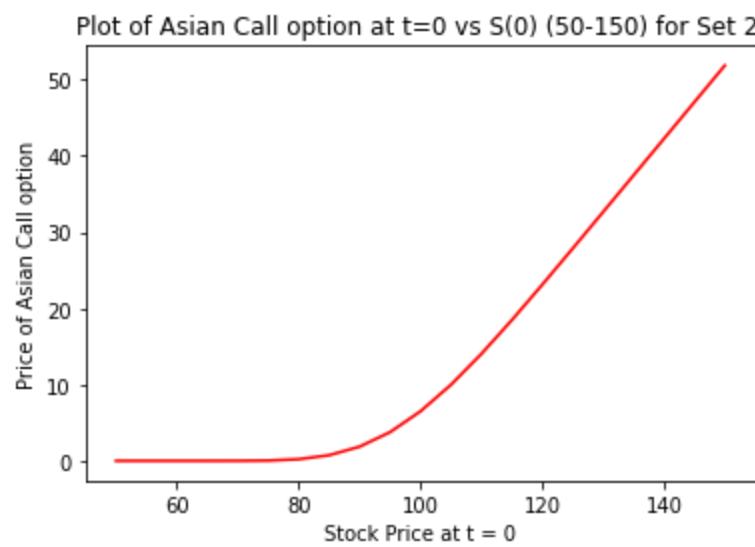
Scatter Plot of Initial Option Price with sig and M (Set 2)

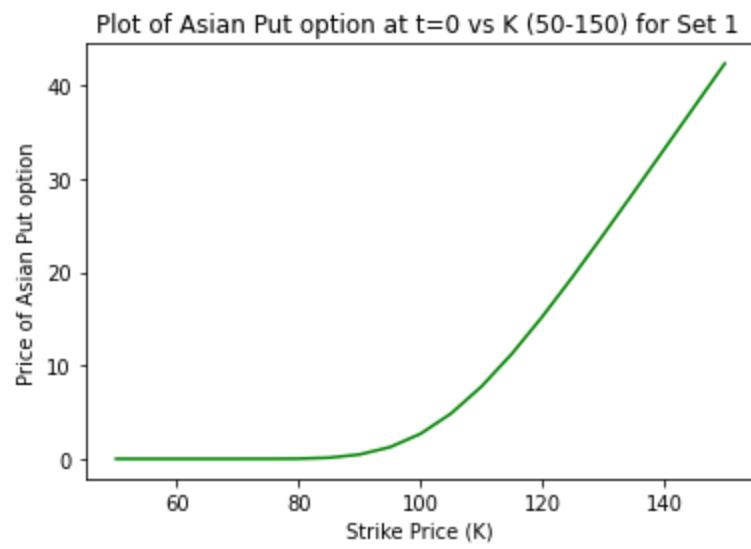
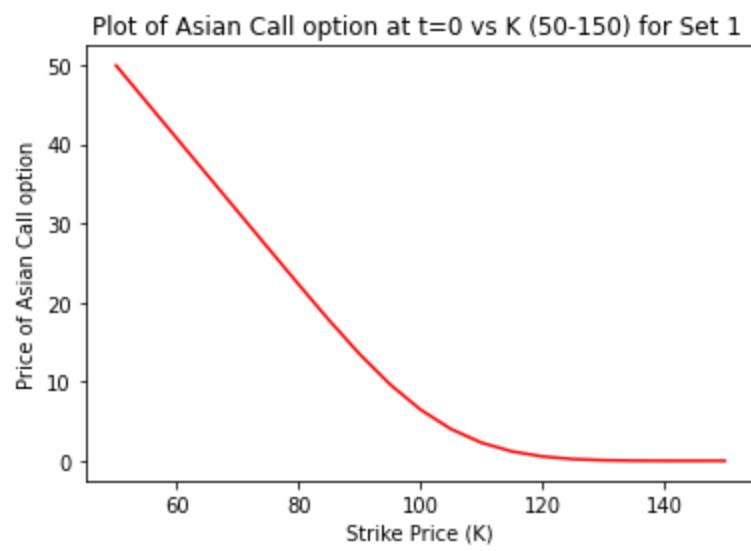


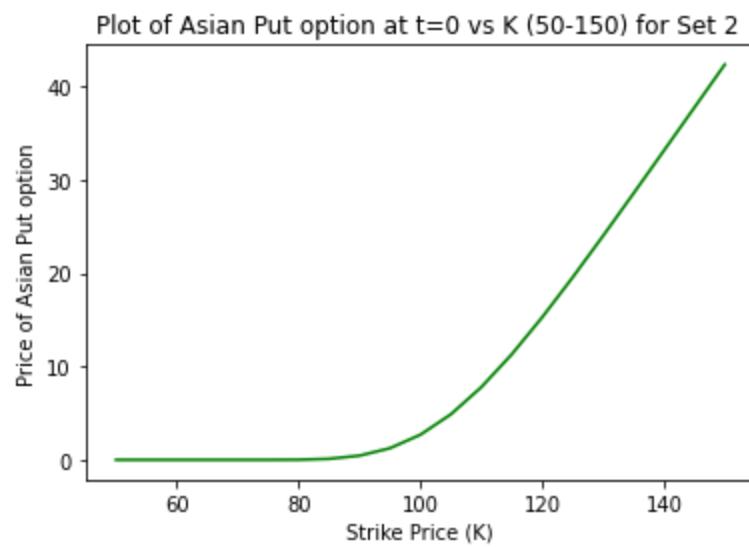
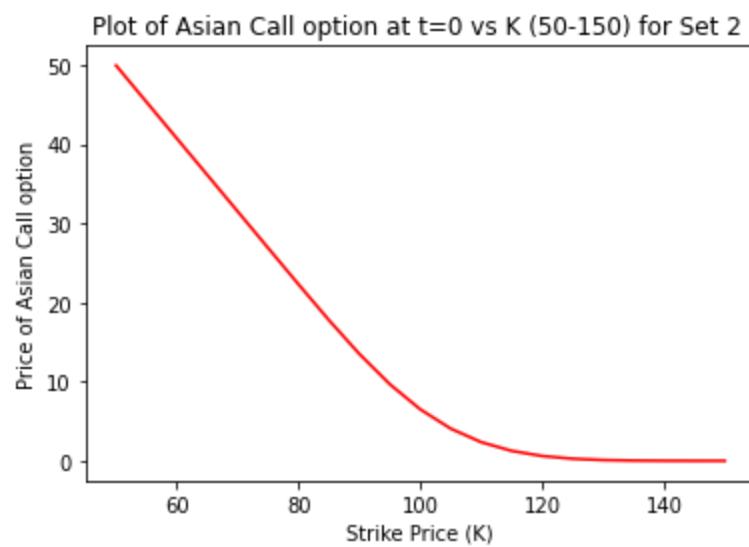
Question 2 Plots -

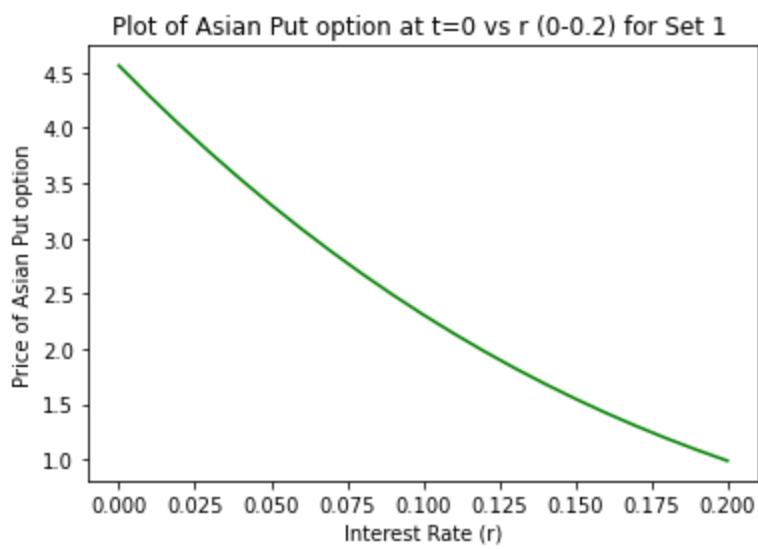
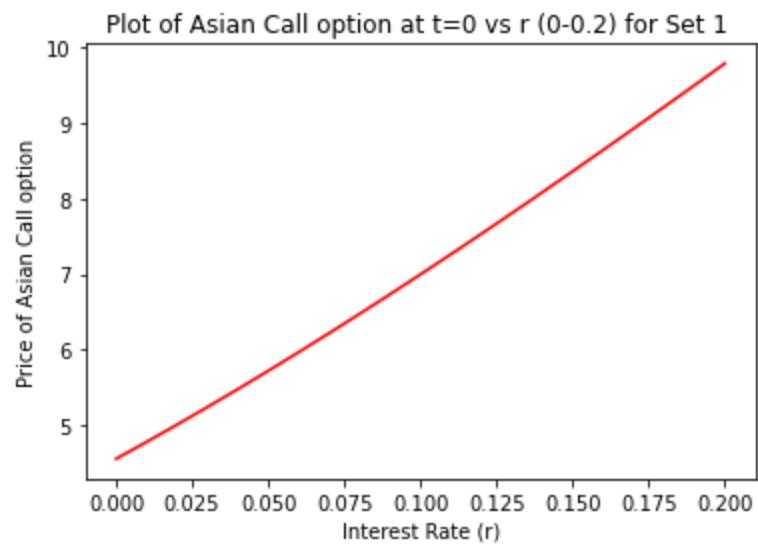
2D Plots (1 param at a time)

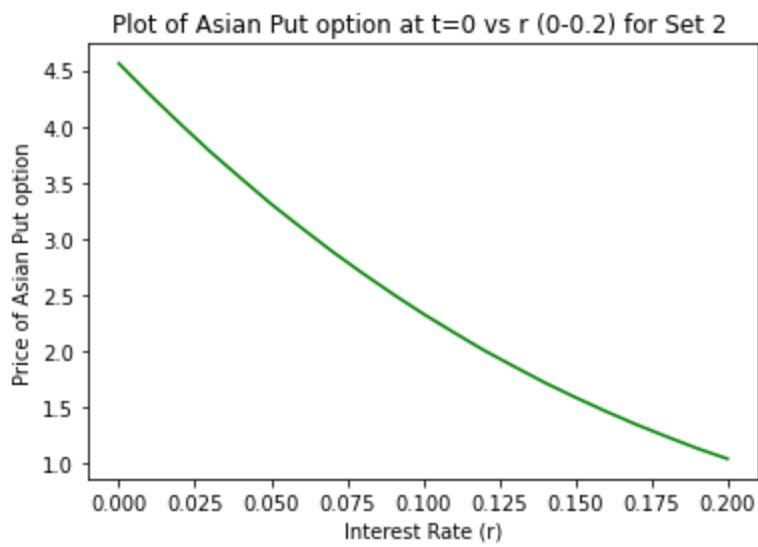
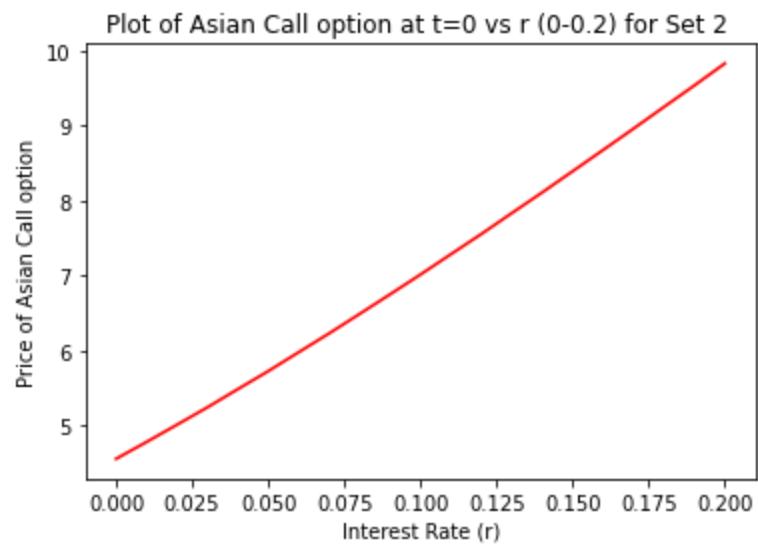


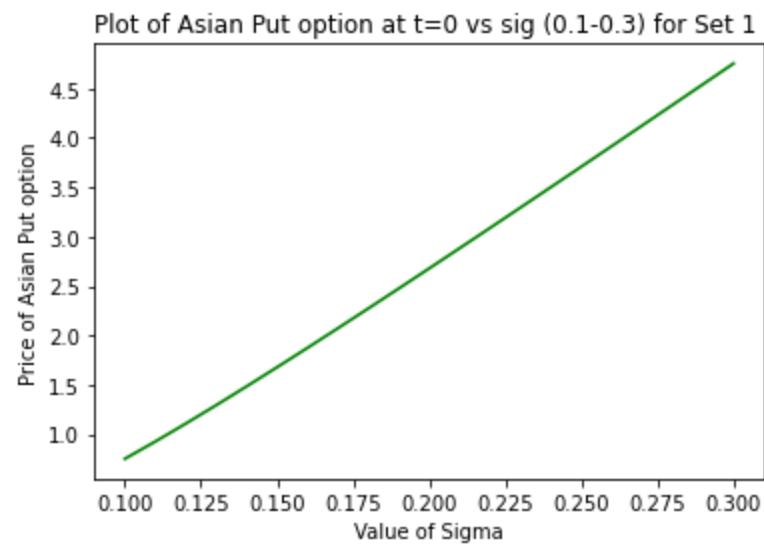
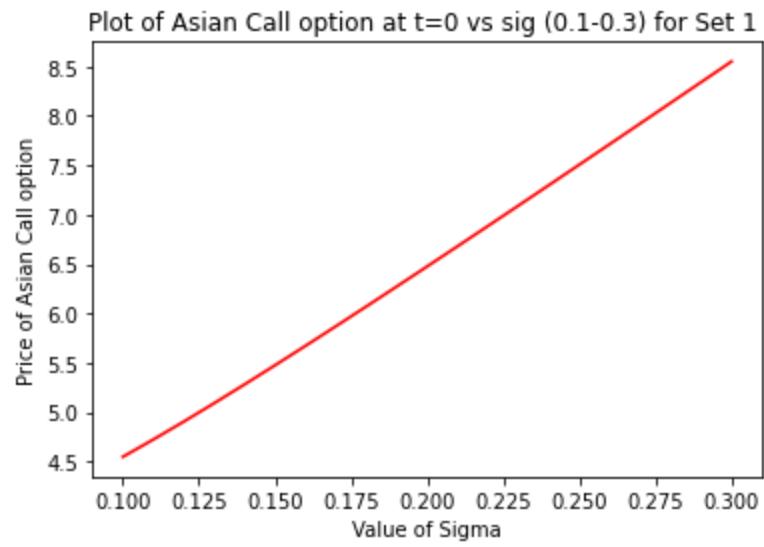


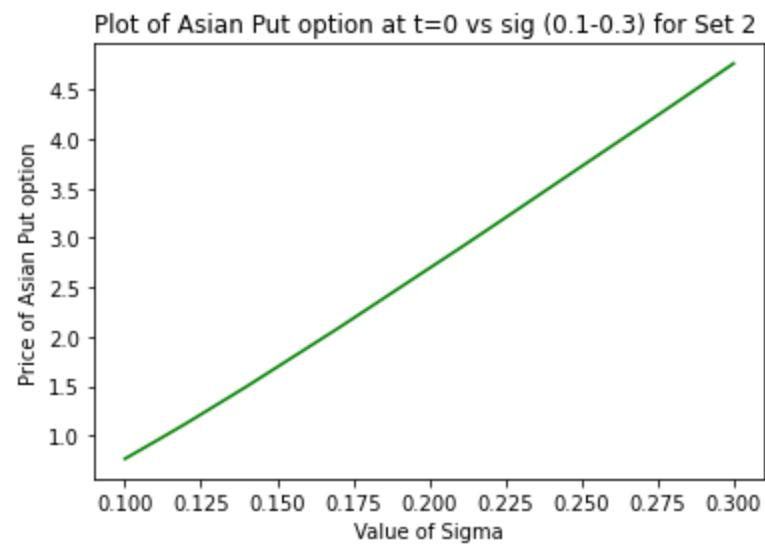
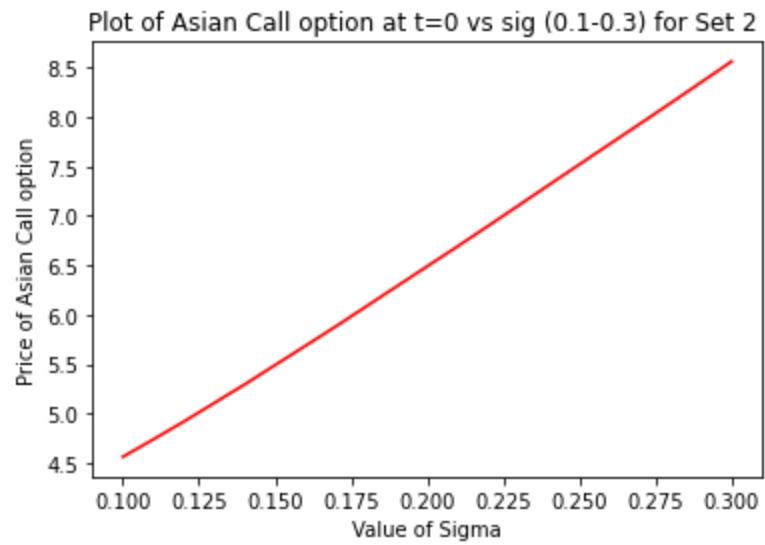


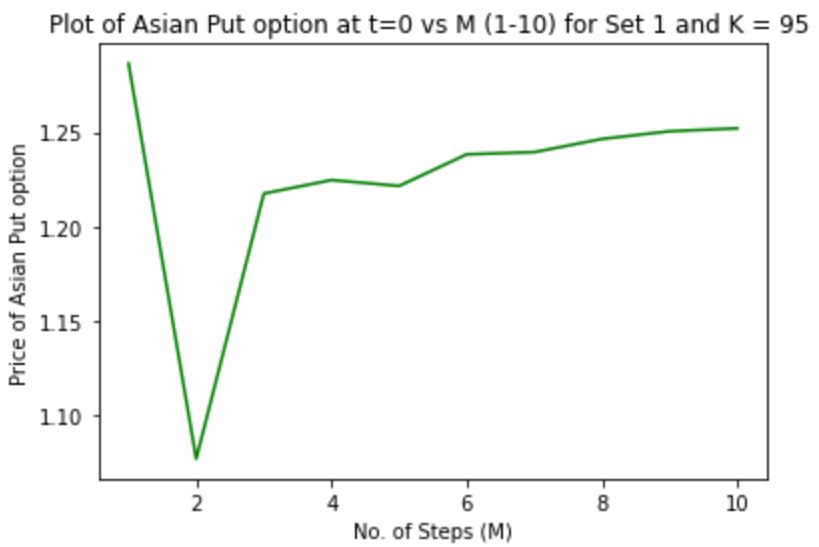
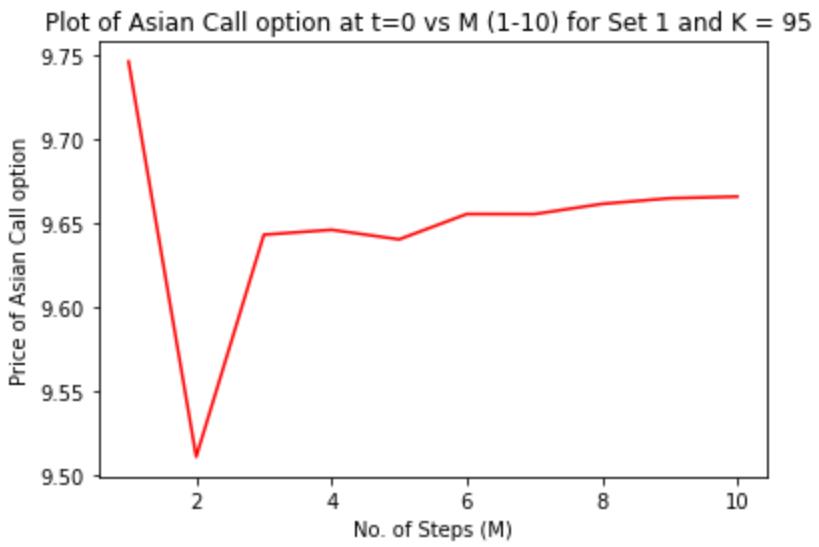




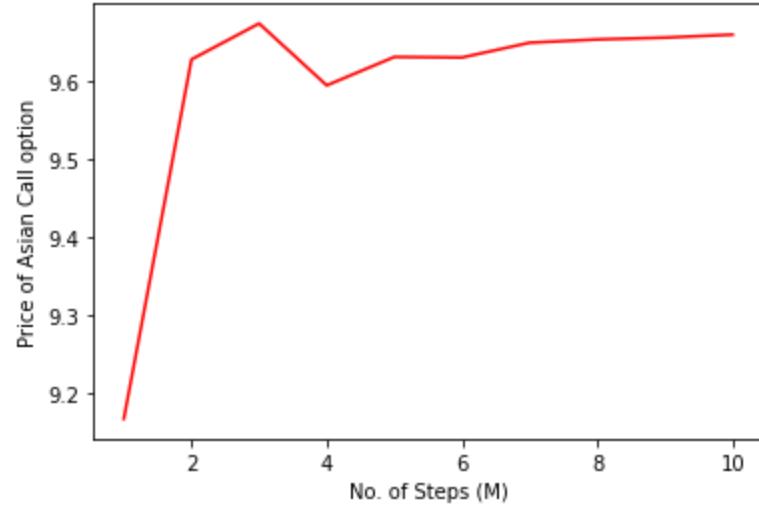




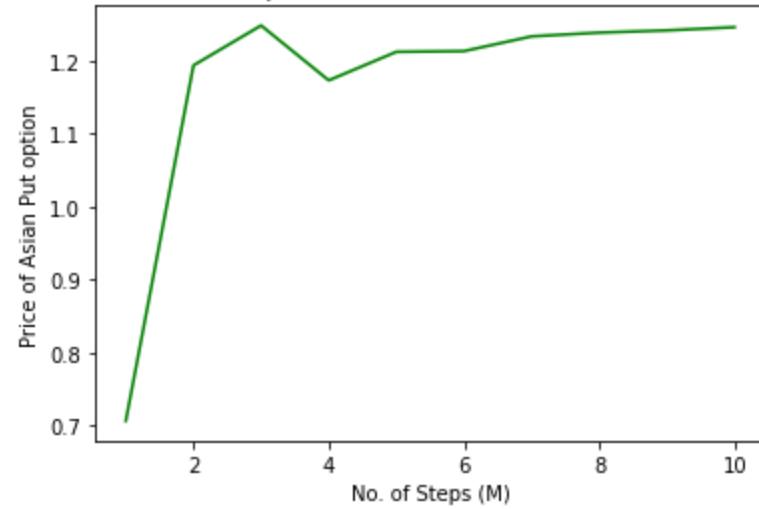




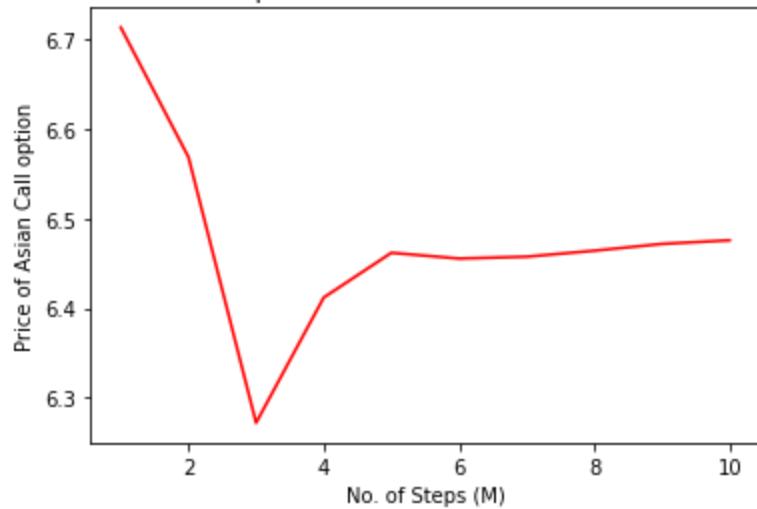
Plot of Asian Call option at $t=0$ vs M (1-10) for Set 2 and $K = 95$



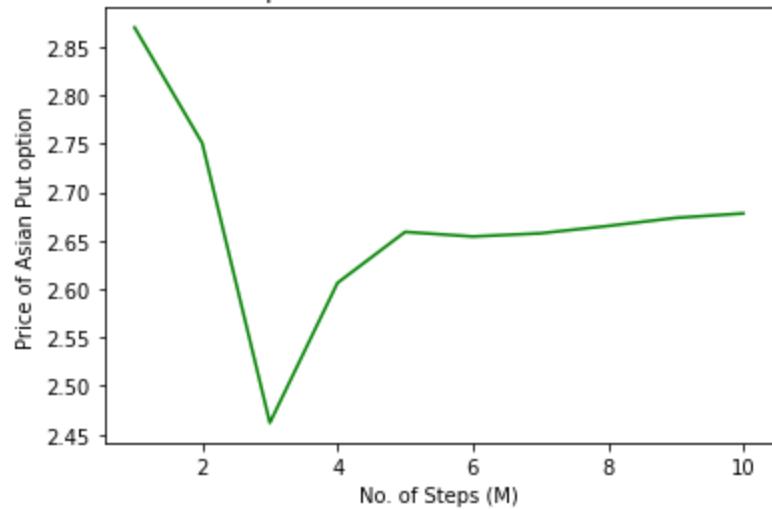
Plot of Asian Put option at $t=0$ vs M (1-10) for Set 2 and $K = 95$



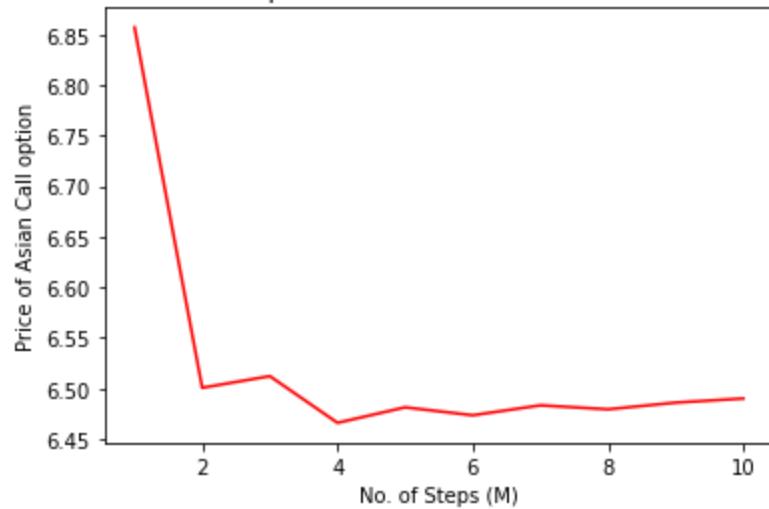
Plot of Asian Call option at $t=0$ vs M (1-10) for Set 1 and $K = 100$



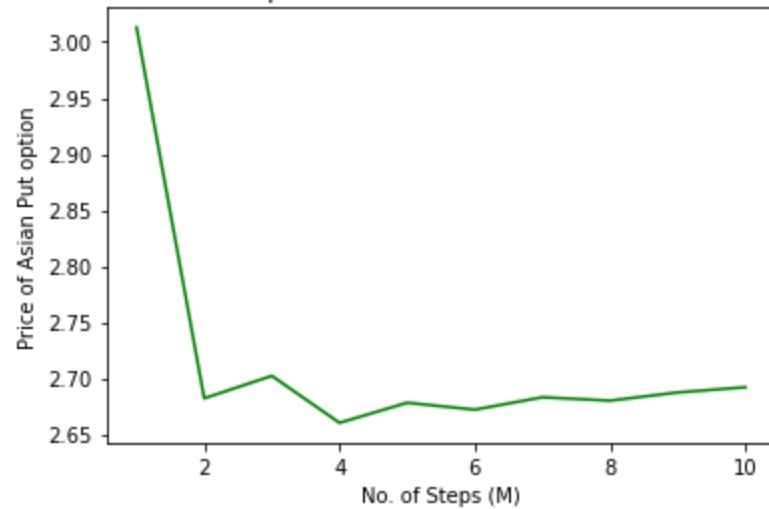
Plot of Asian Put option at $t=0$ vs M (1-10) for Set 1 and $K = 100$



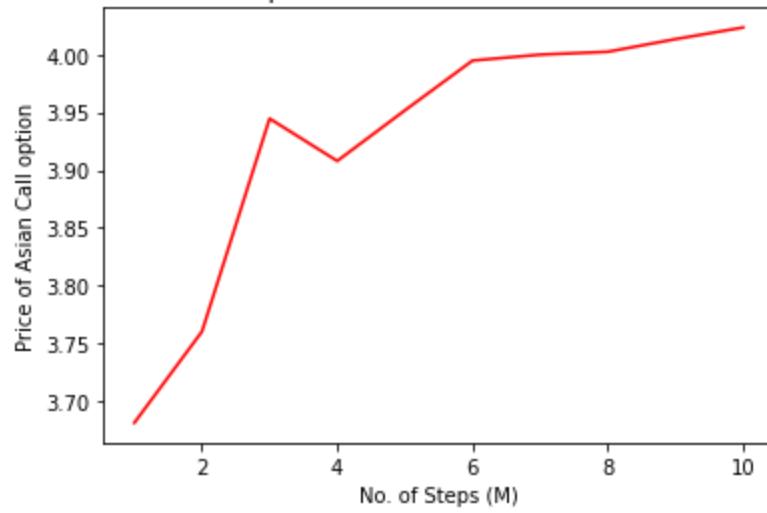
Plot of Asian Call option at $t=0$ vs M (1-10) for Set 2 and $K = 100$



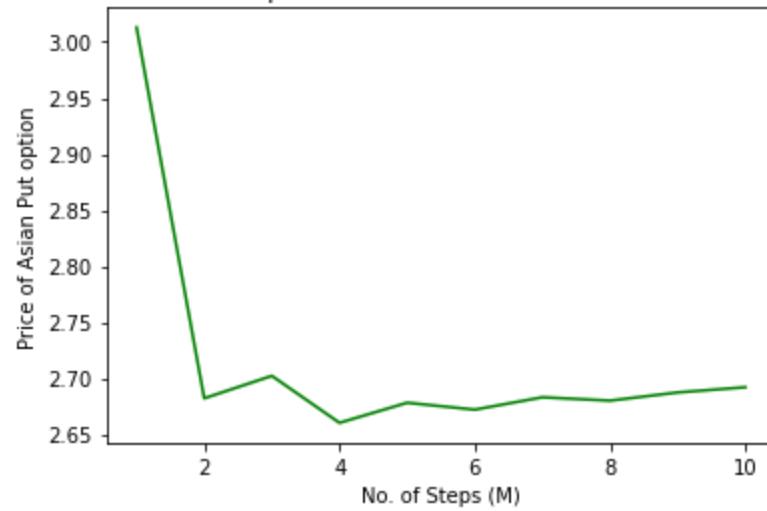
Plot of Asian Put option at $t=0$ vs M (1-10) for Set 2 and $K = 100$



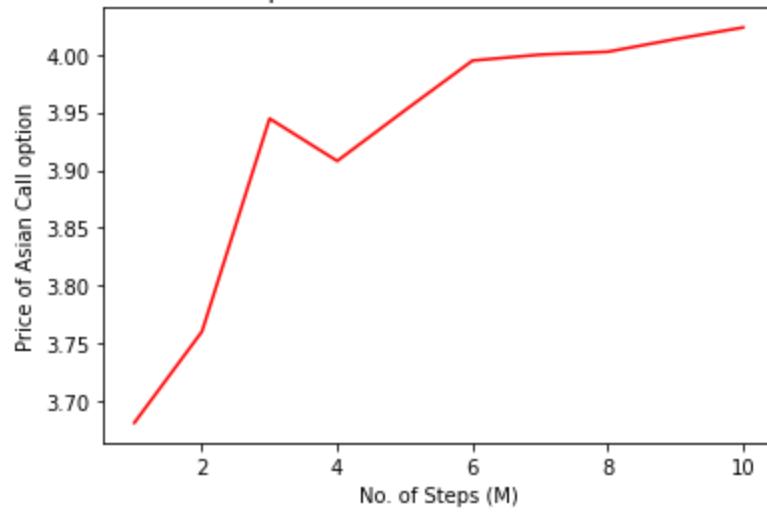
Plot of Asian Call option at $t=0$ vs M (1-10) for Set 1 and $K = 105$



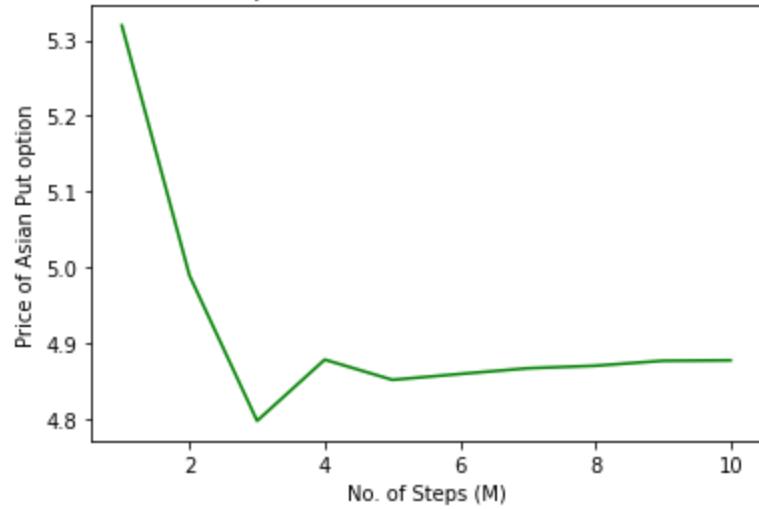
Plot of Asian Put option at $t=0$ vs M (1-10) for Set 2 and $K = 100$



Plot of Asian Call option at $t=0$ vs M (1-10) for Set 1 and $K = 105$

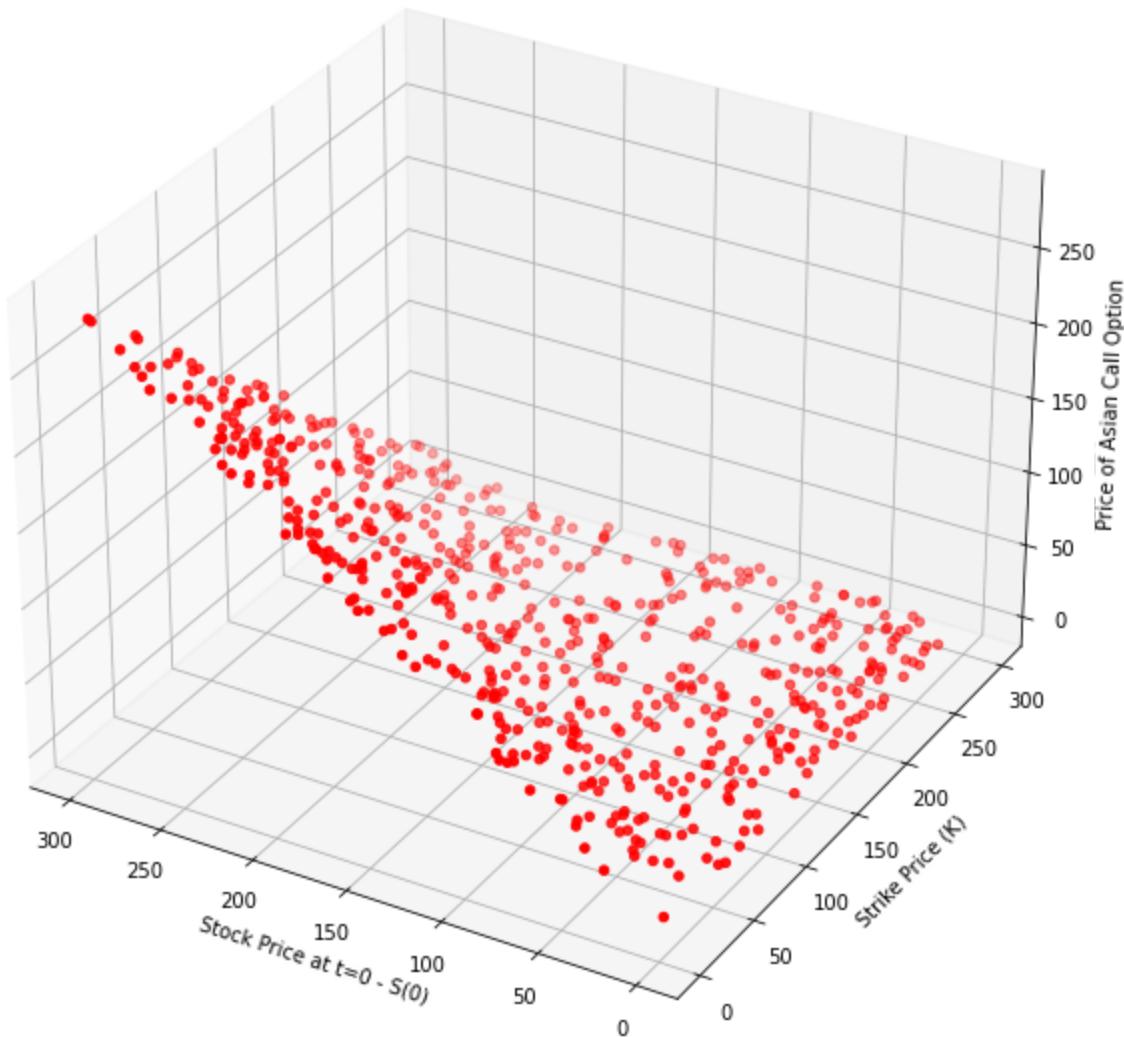


Plot of Asian Put option at $t=0$ vs M (1-10) for Set 2 and $K = 105$

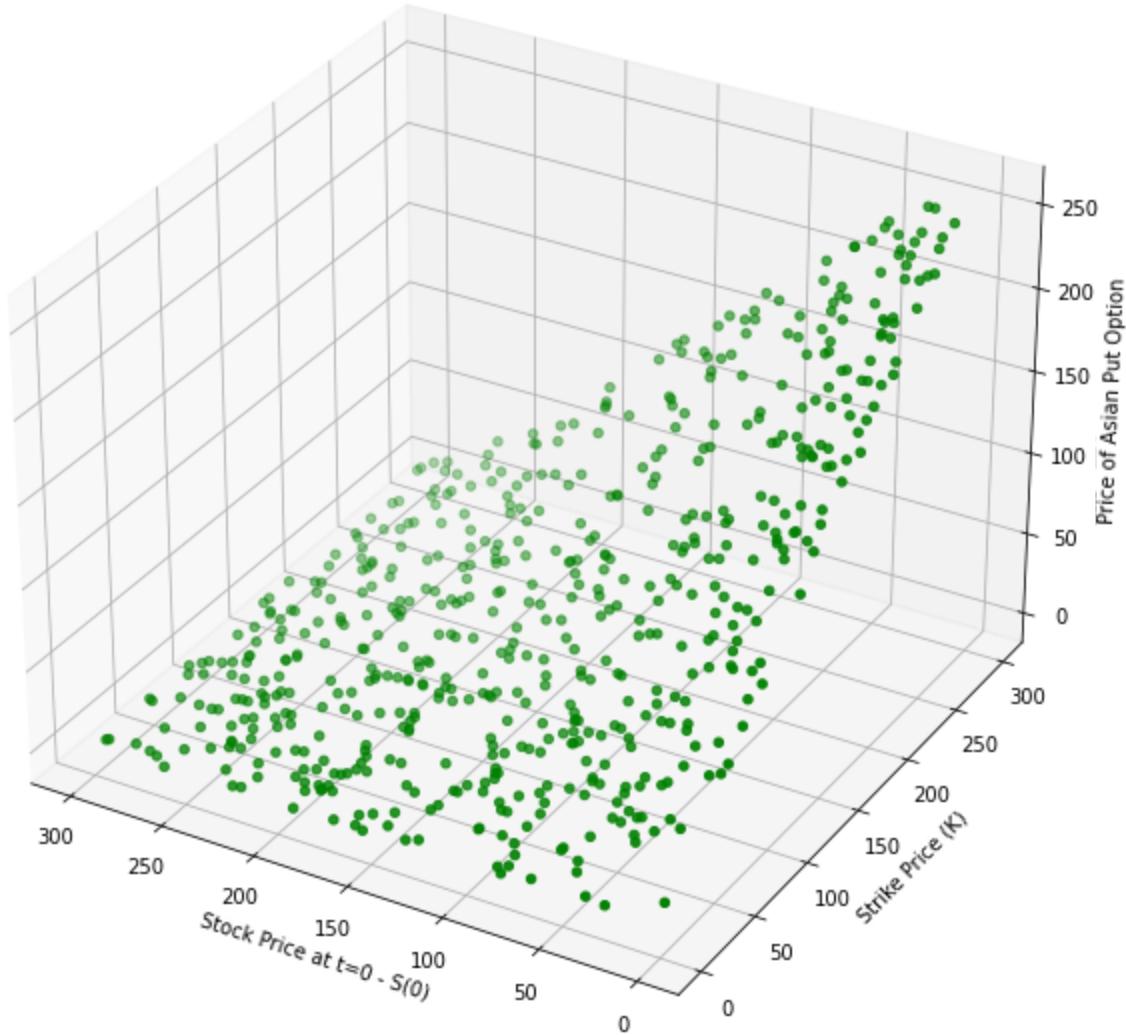


3D Plots (2 params at a time)

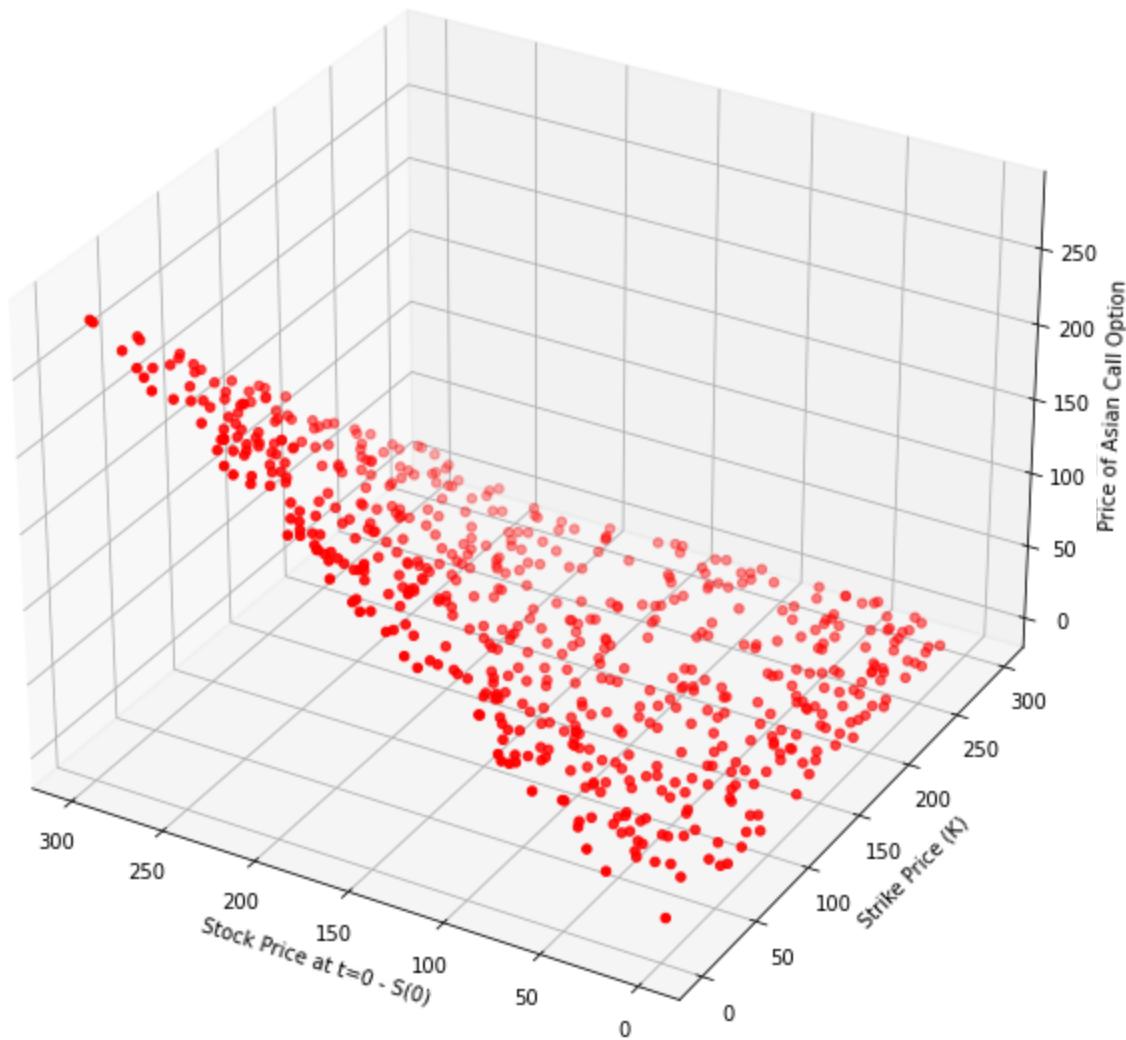
Scatter Plot of Initial Option Price with $S(0)$ and K (Set 1)



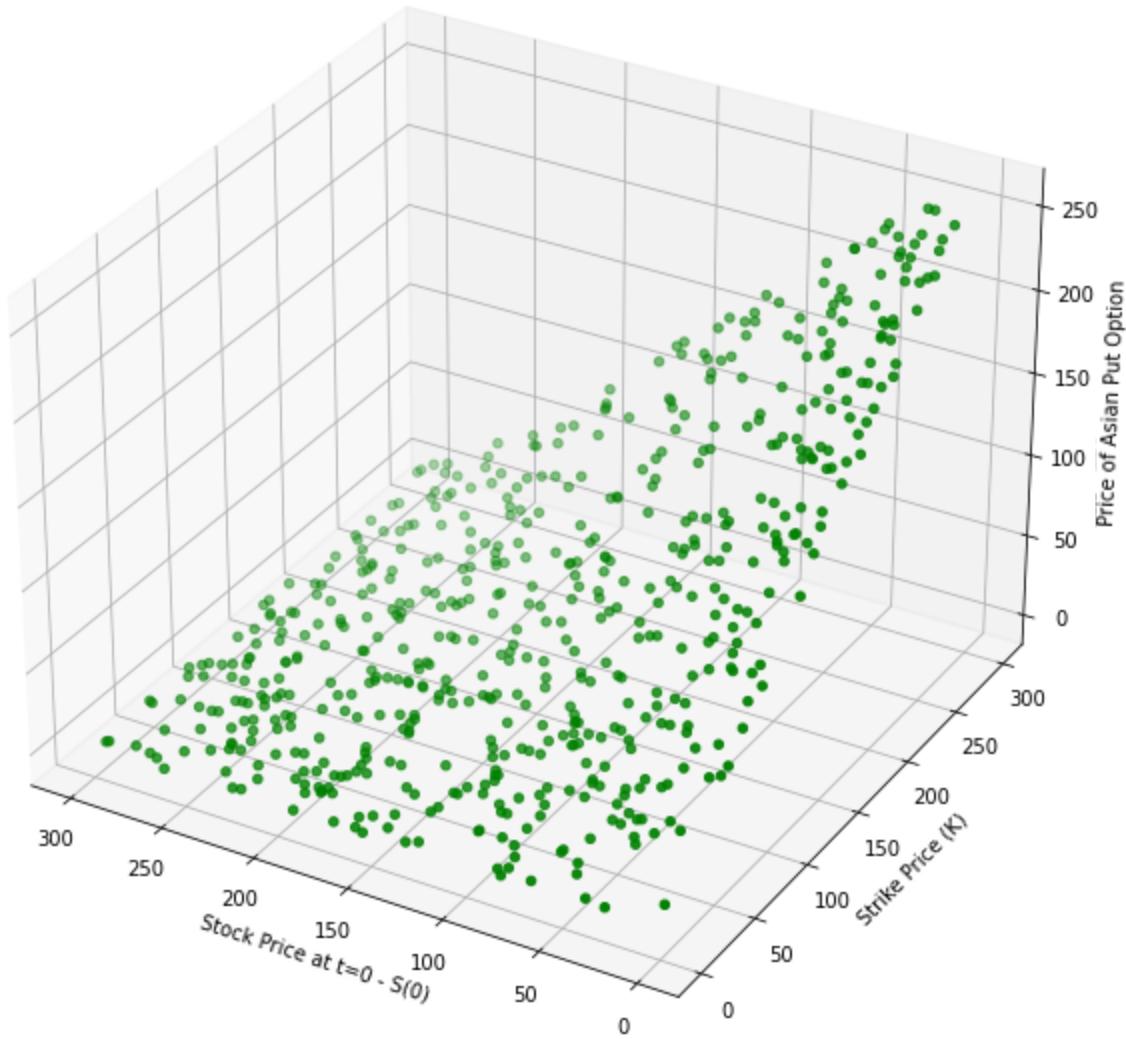
Scatter Plot of Initial Option Price with $S(0)$ and K (Set 1)



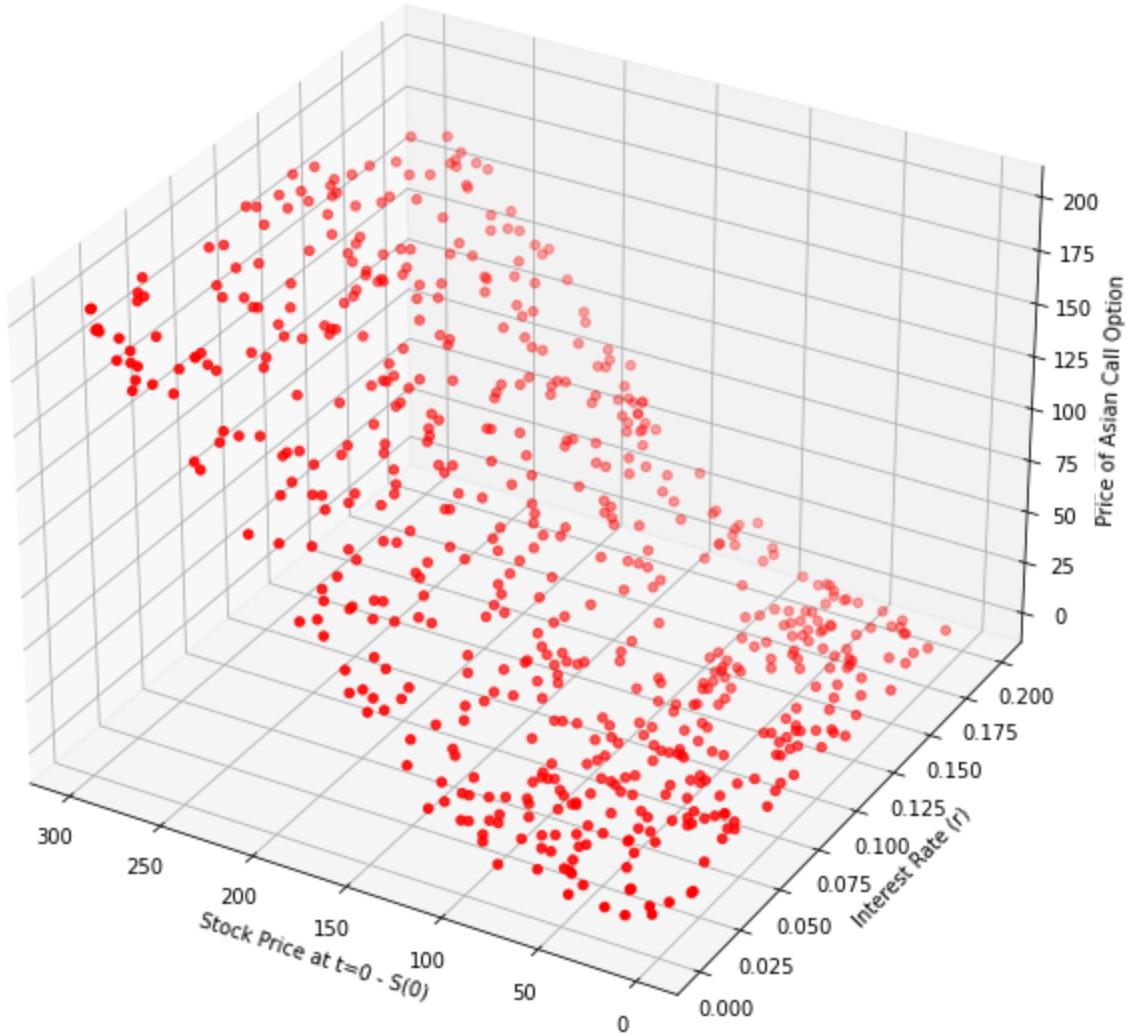
Scatter Plot of Initial Option Price with $S(0)$ and K (Set 2)



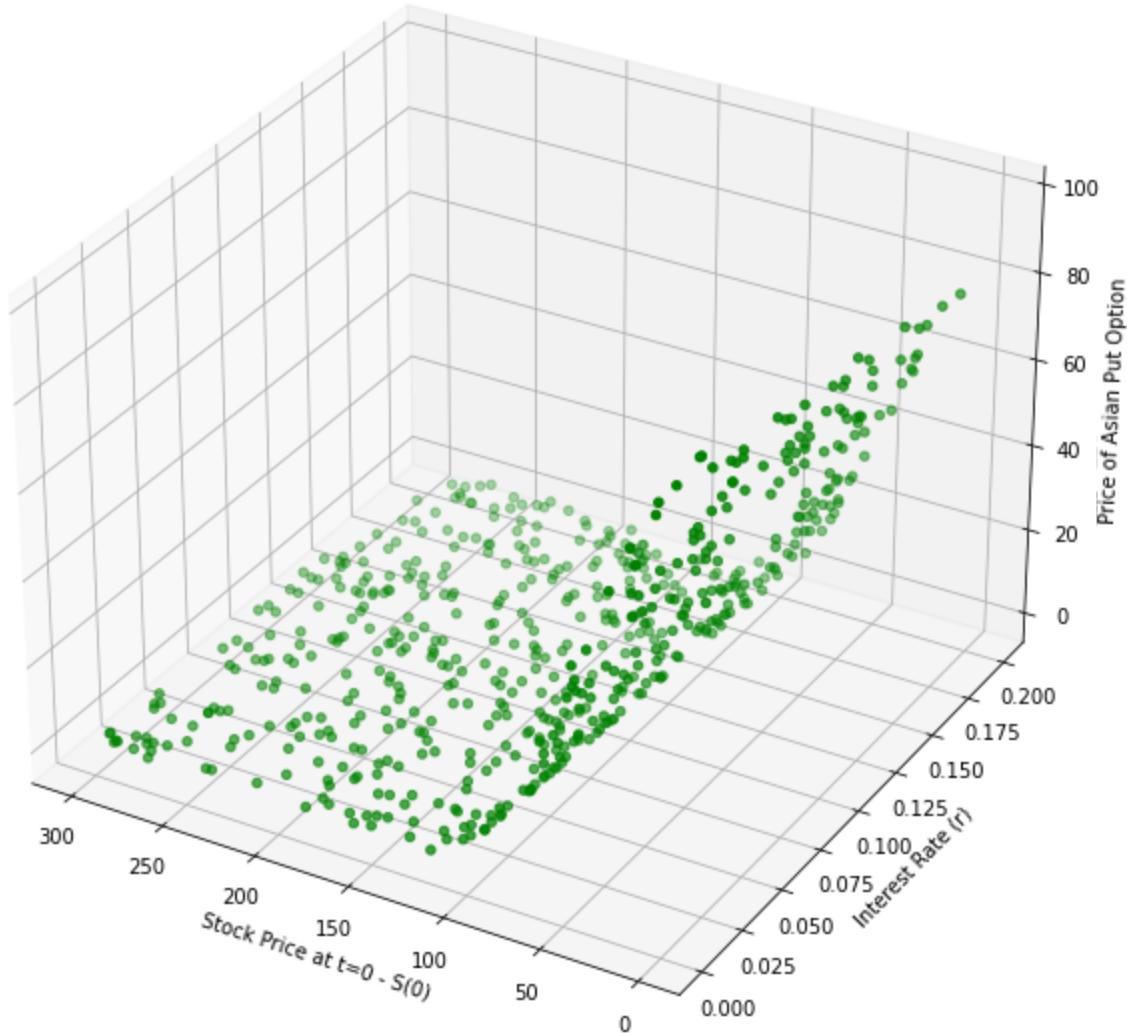
Scatter Plot of Initial Option Price with $S(0)$ and K (Set 2)



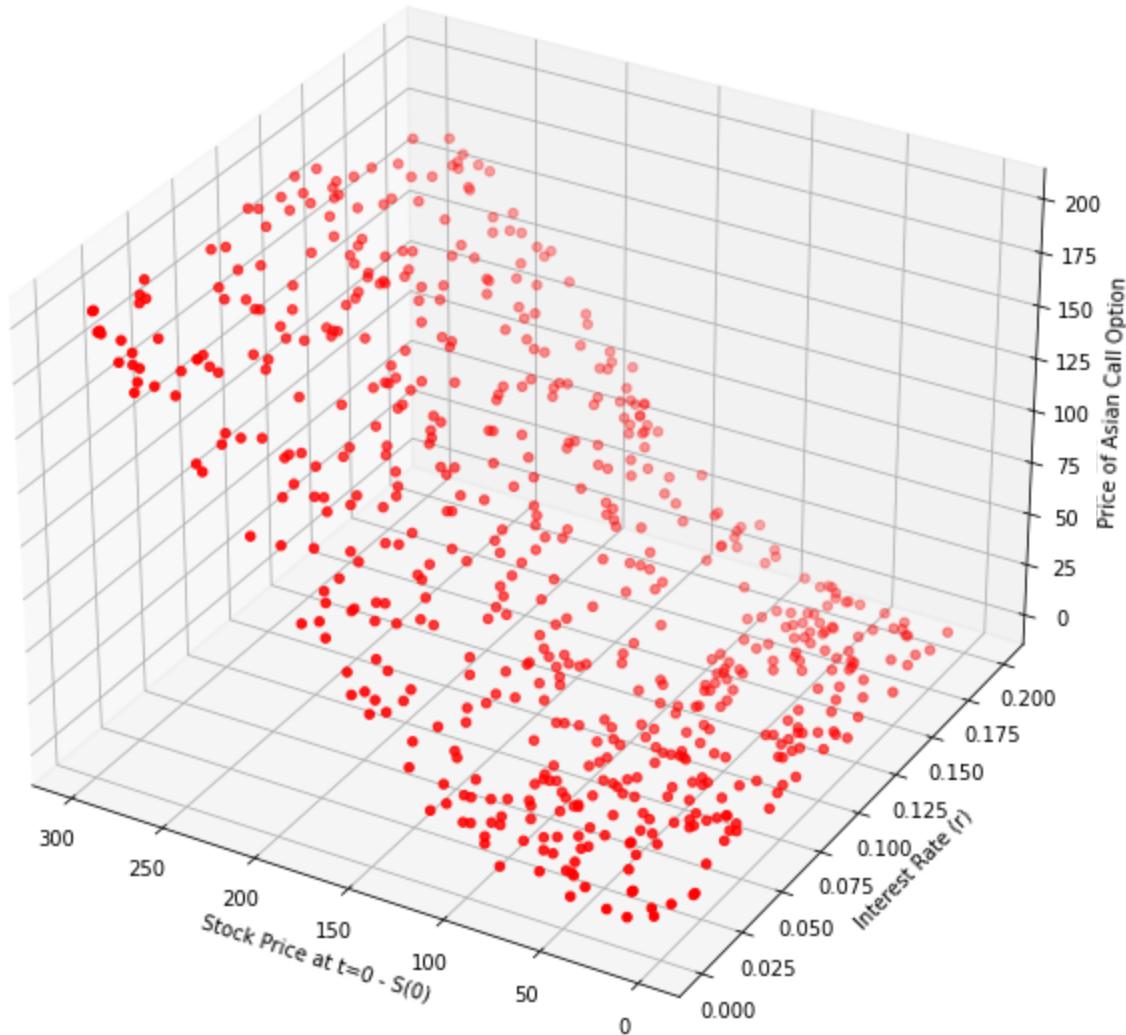
Scatter Plot of Initial Option Price with $S(0)$ and r (Set 1)



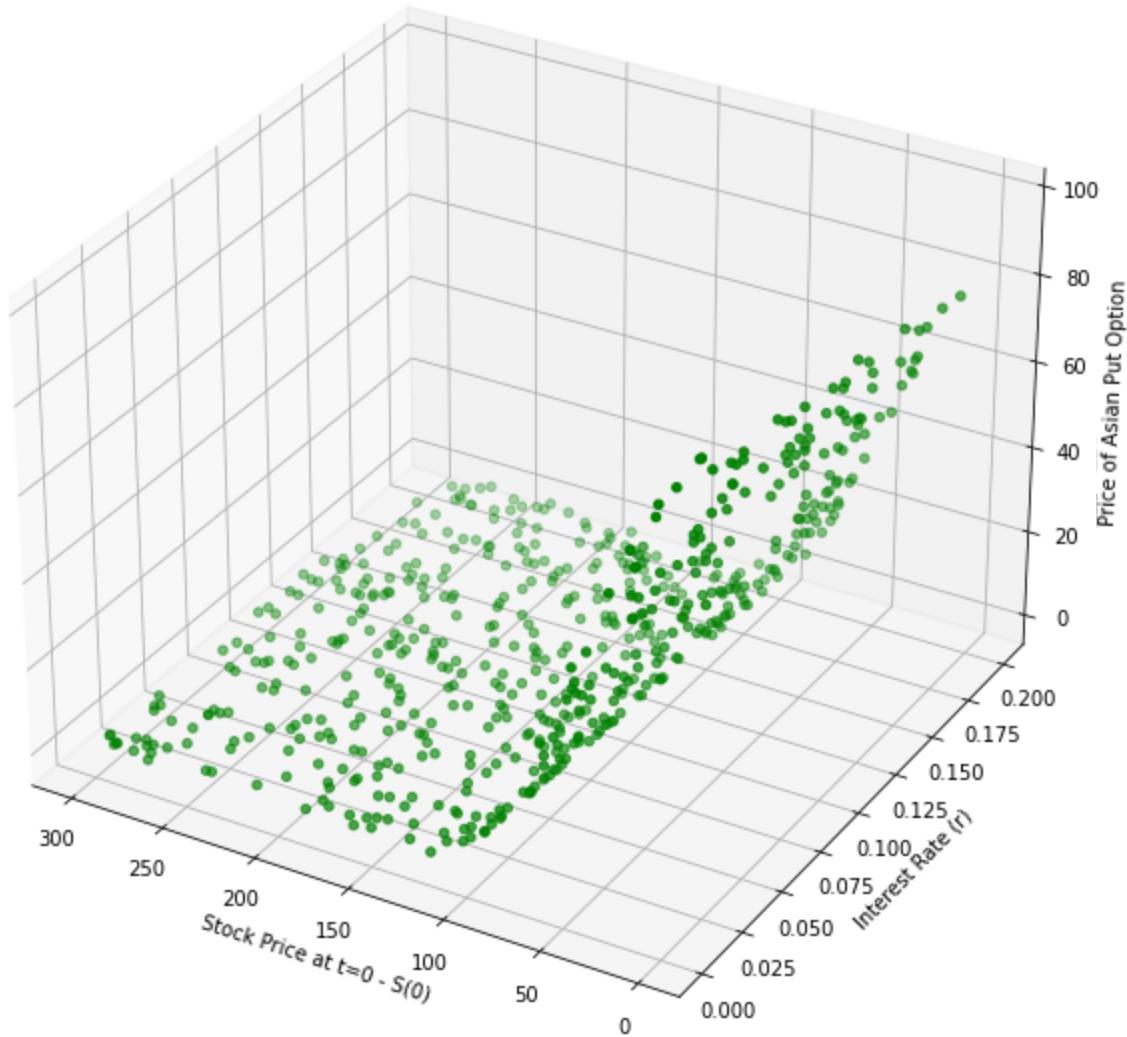
Scatter Plot of Initial Option Price with $S(0)$ and r (Set 1)



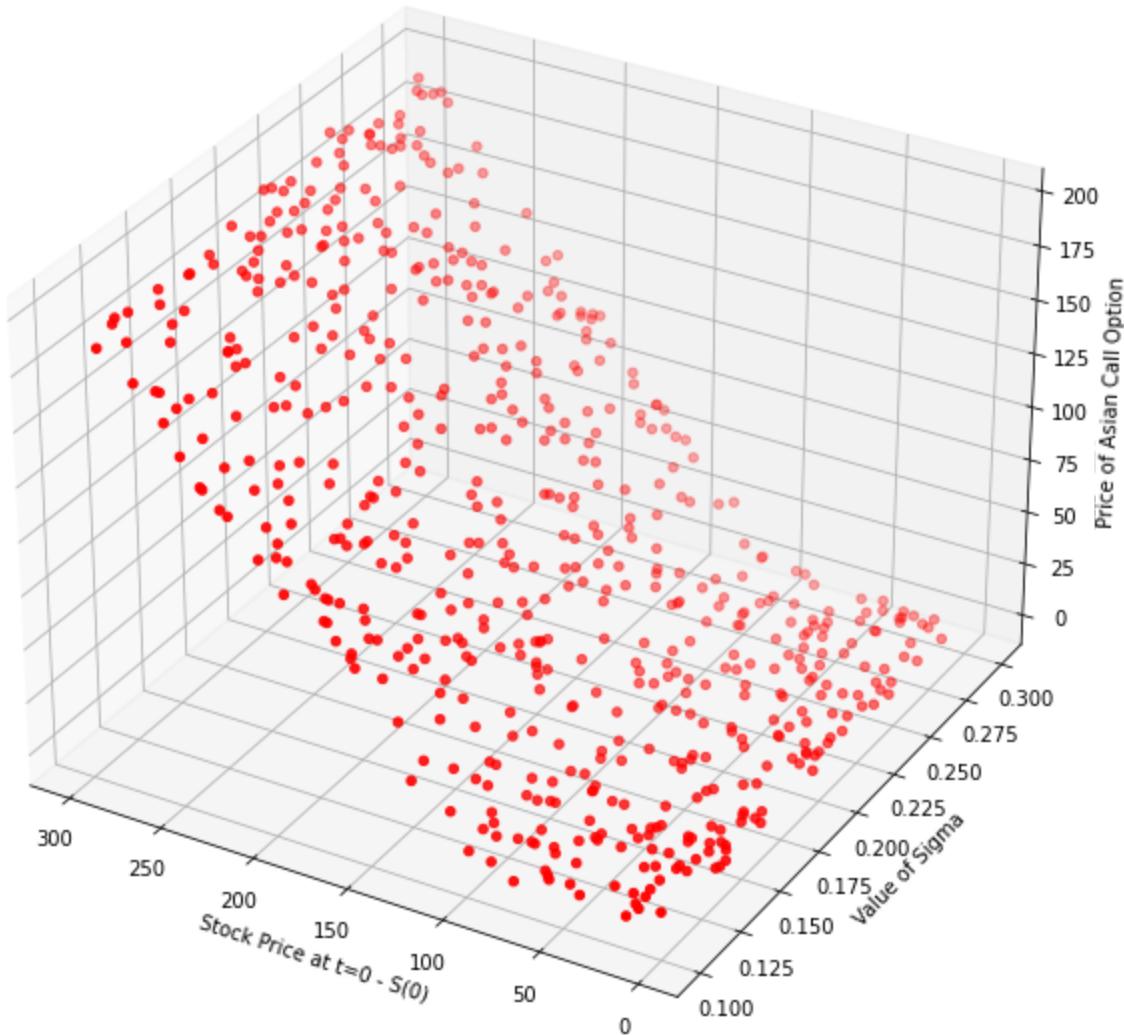
Scatter Plot of Initial Option Price with $S(0)$ and r (Set 2)



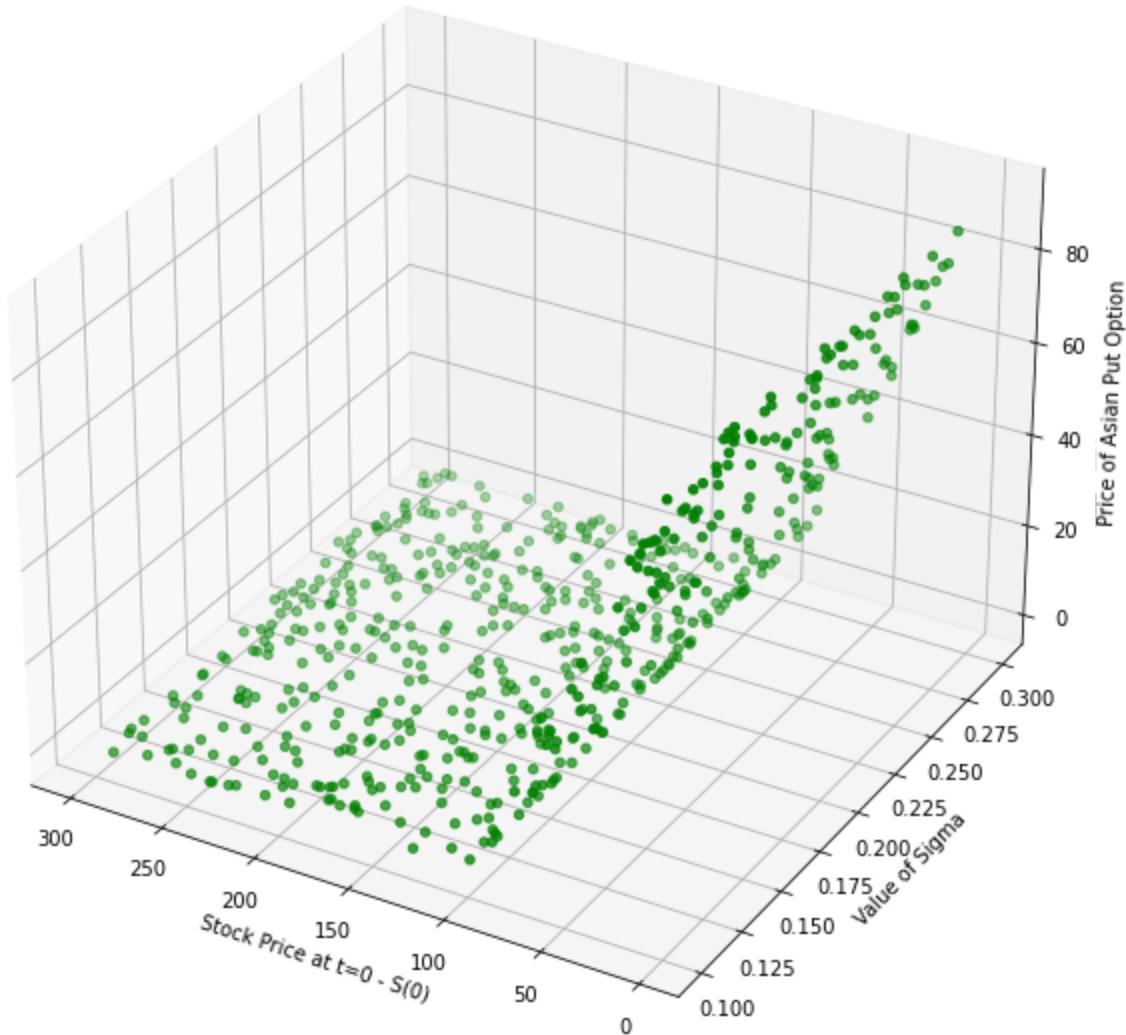
Scatter Plot of Initial Option Price with $S(0)$ and r (Set 2)



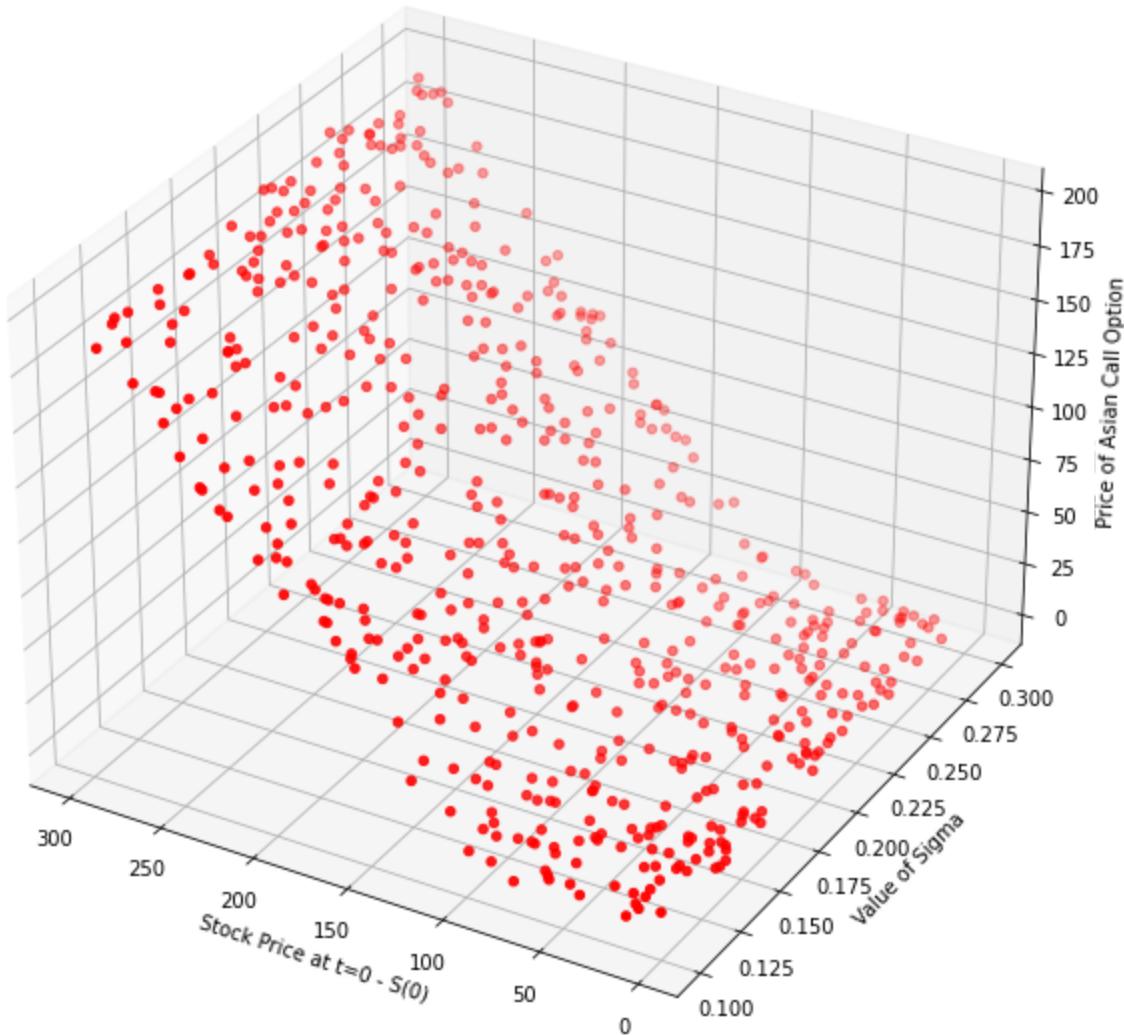
Scatter Plot of Initial Option Price with $S(0)$ and σ (Set 1)



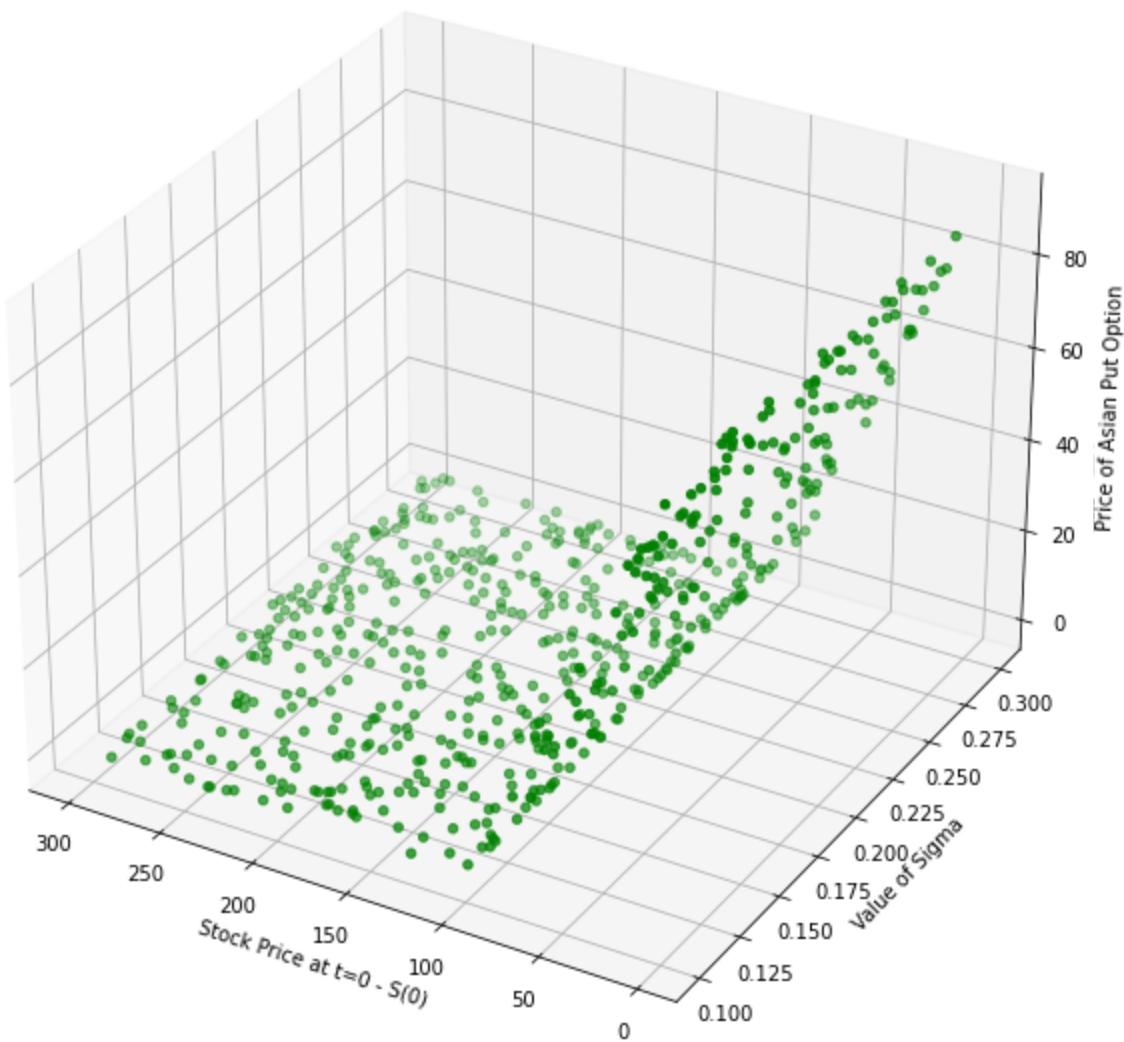
Scatter Plot of Initial Option Price with $S(0)$ and σ (Set 1)



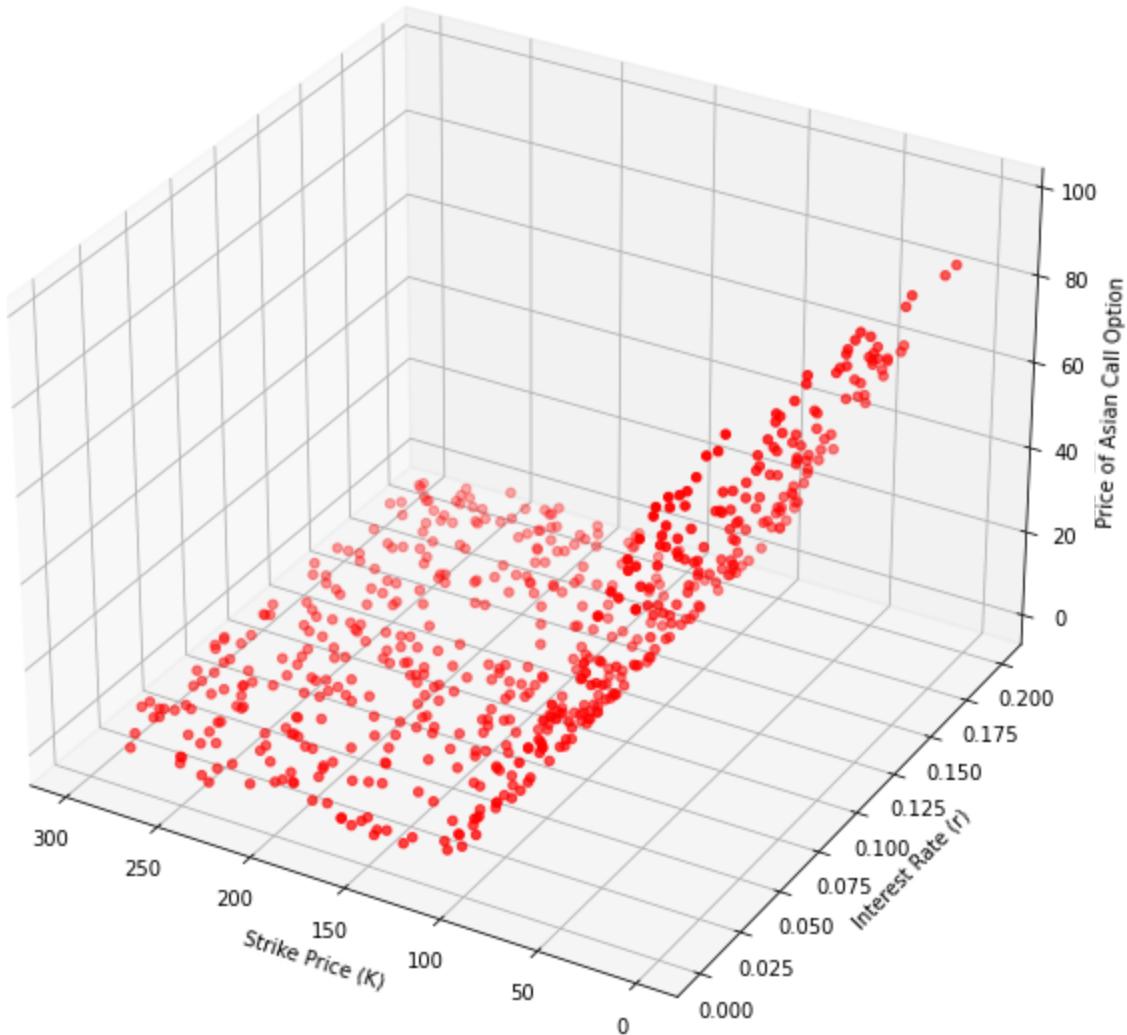
Scatter Plot of Initial Option Price with $S(0)$ and σ (Set 2)



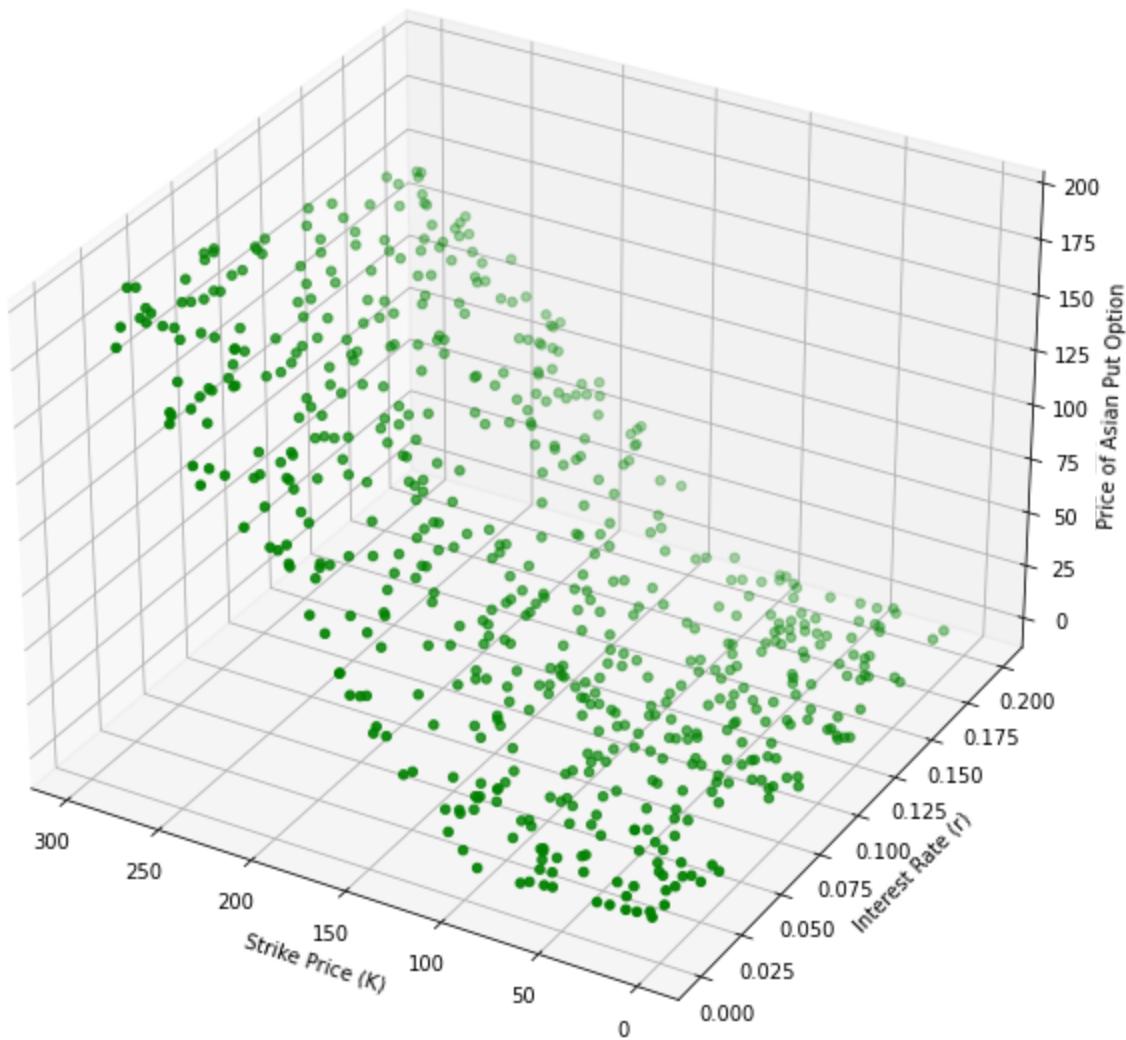
Scatter Plot of Initial Option Price with $S(0)$ and sig (Set 2)



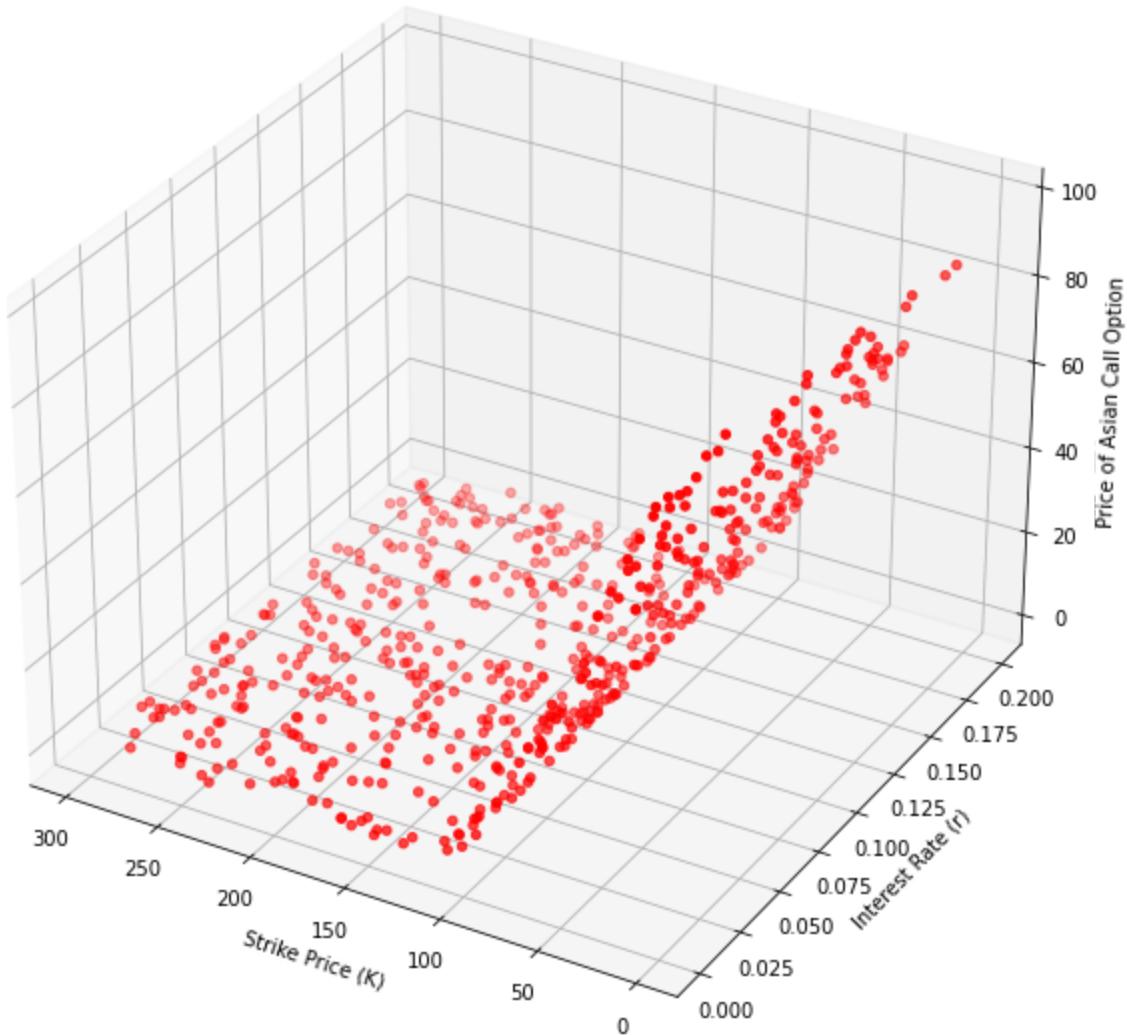
Scatter Plot of Initial Option Price with K and r (Set 1)



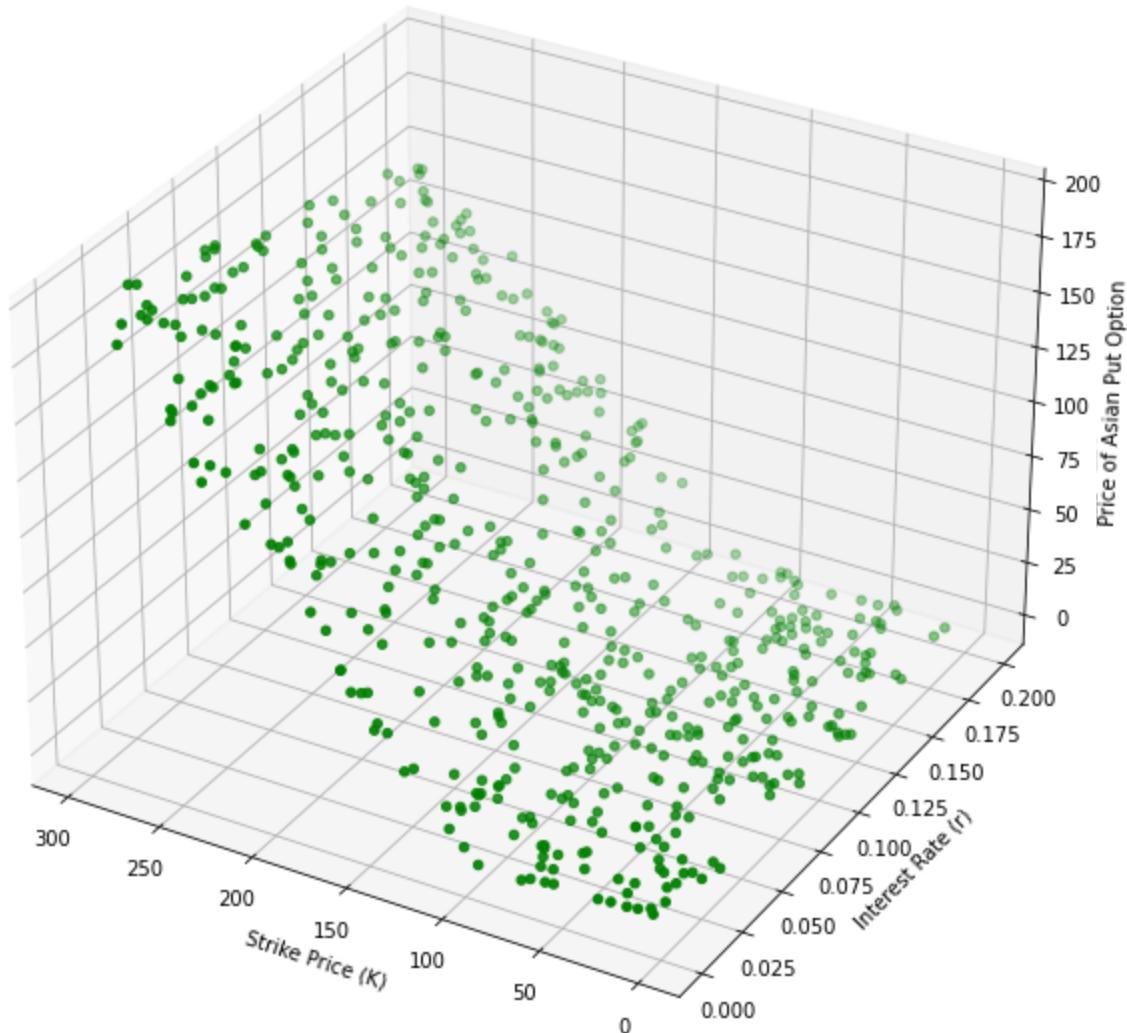
Scatter Plot of Initial Option Price with K and r (Set 1)



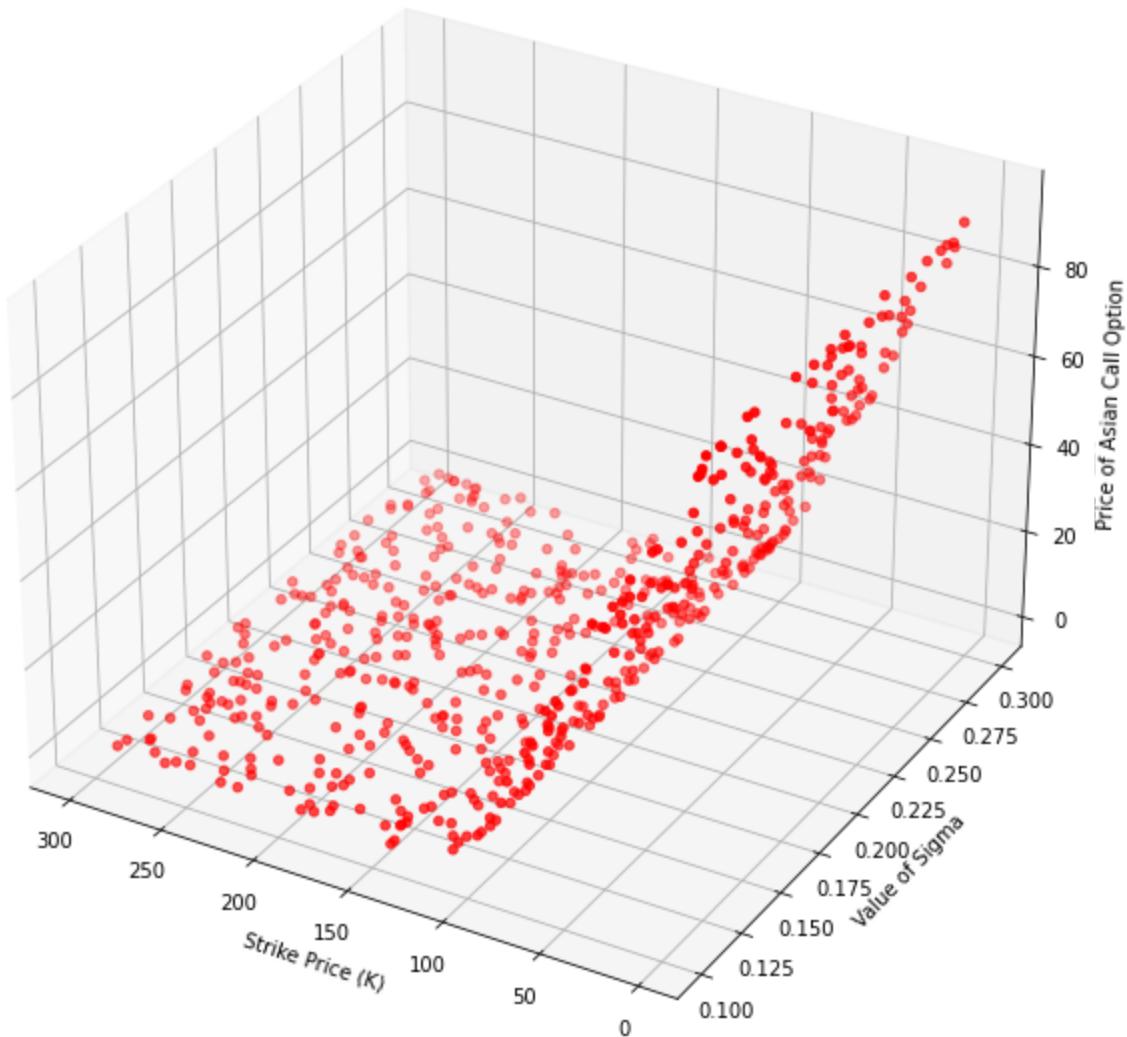
Scatter Plot of Initial Option Price with K and r (Set 2)



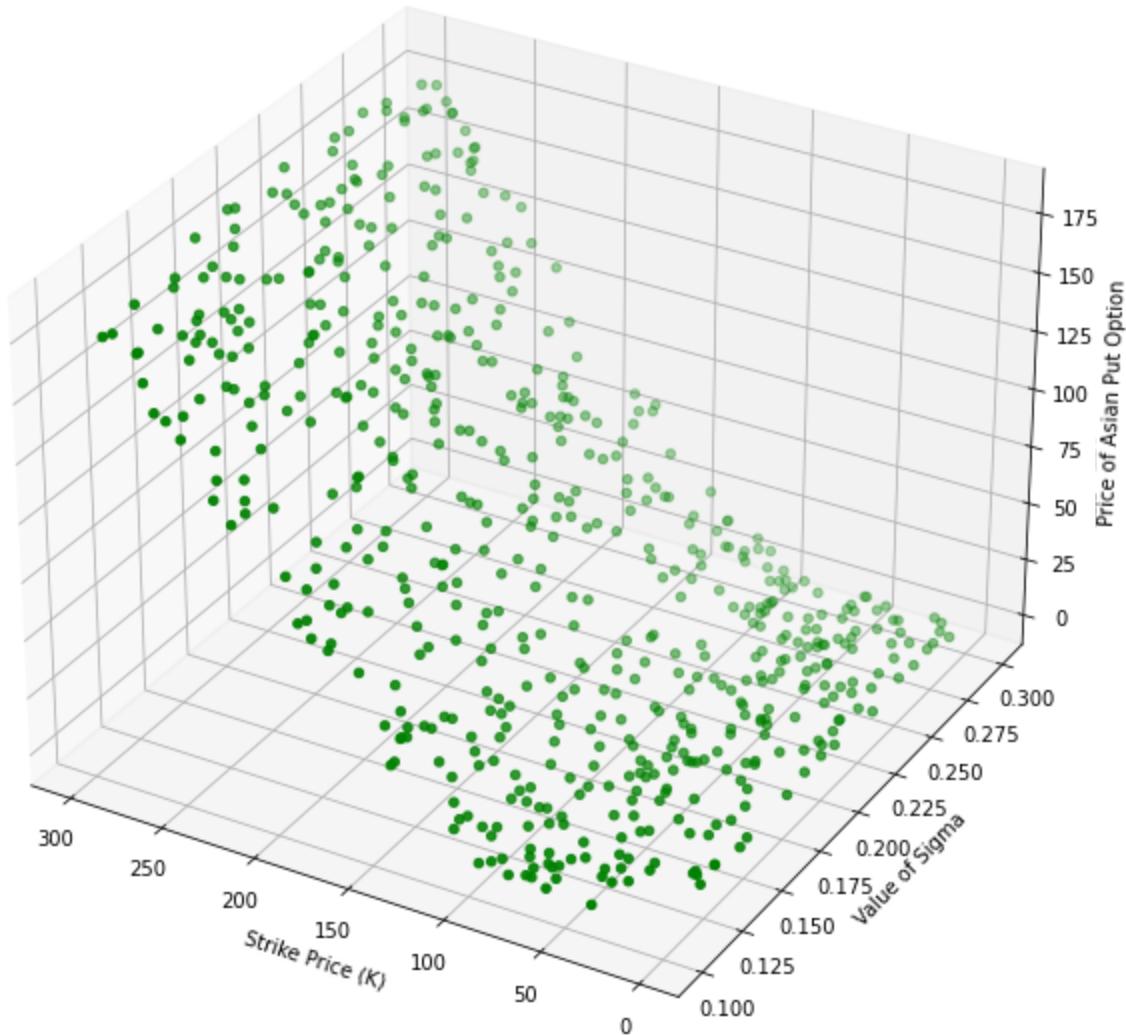
Scatter Plot of Initial Option Price with K and r (Set 2)



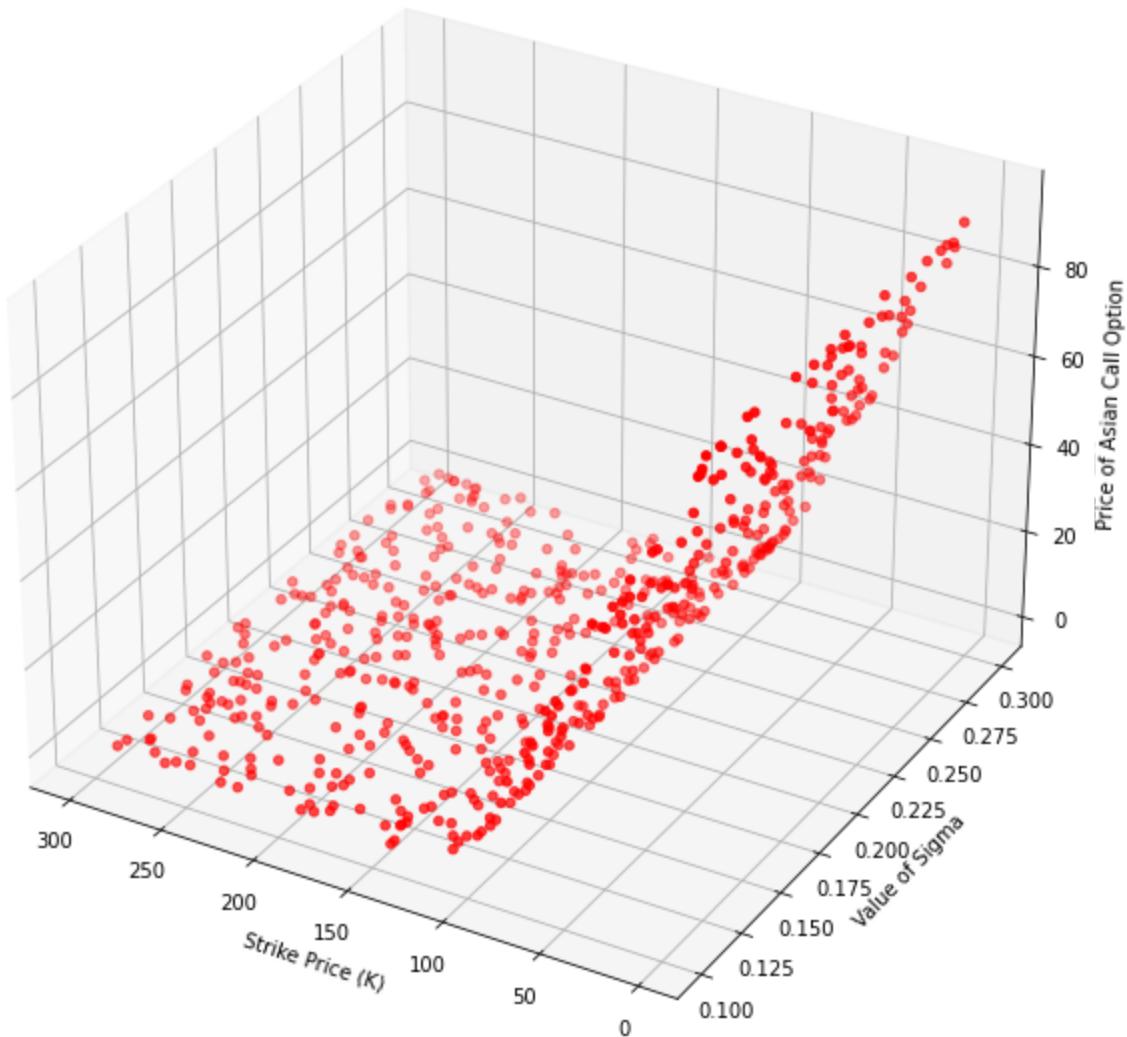
Scatter Plot of Initial Option Price with K and sig (Set 1)



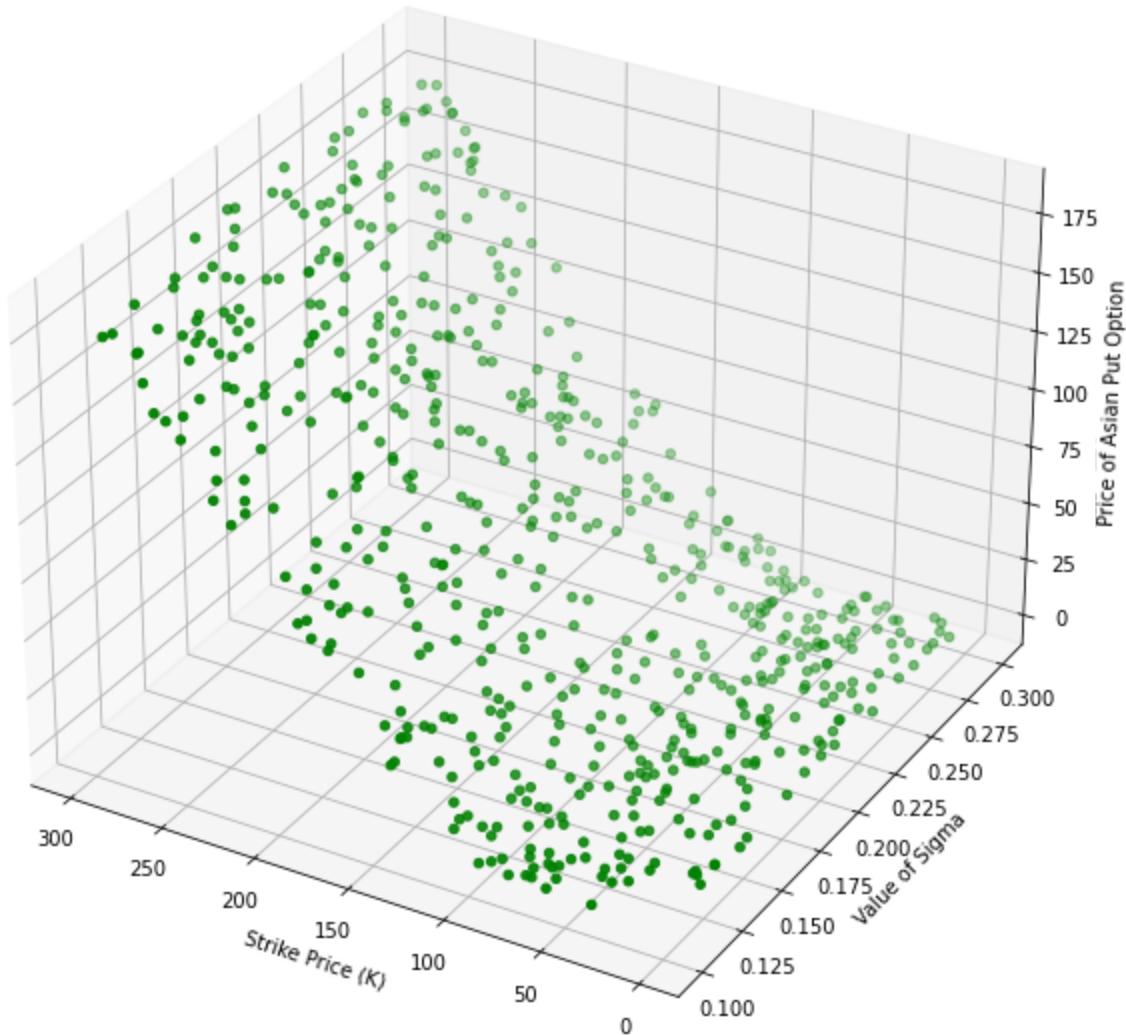
Scatter Plot of Initial Option Price with K and sig (Set 1)



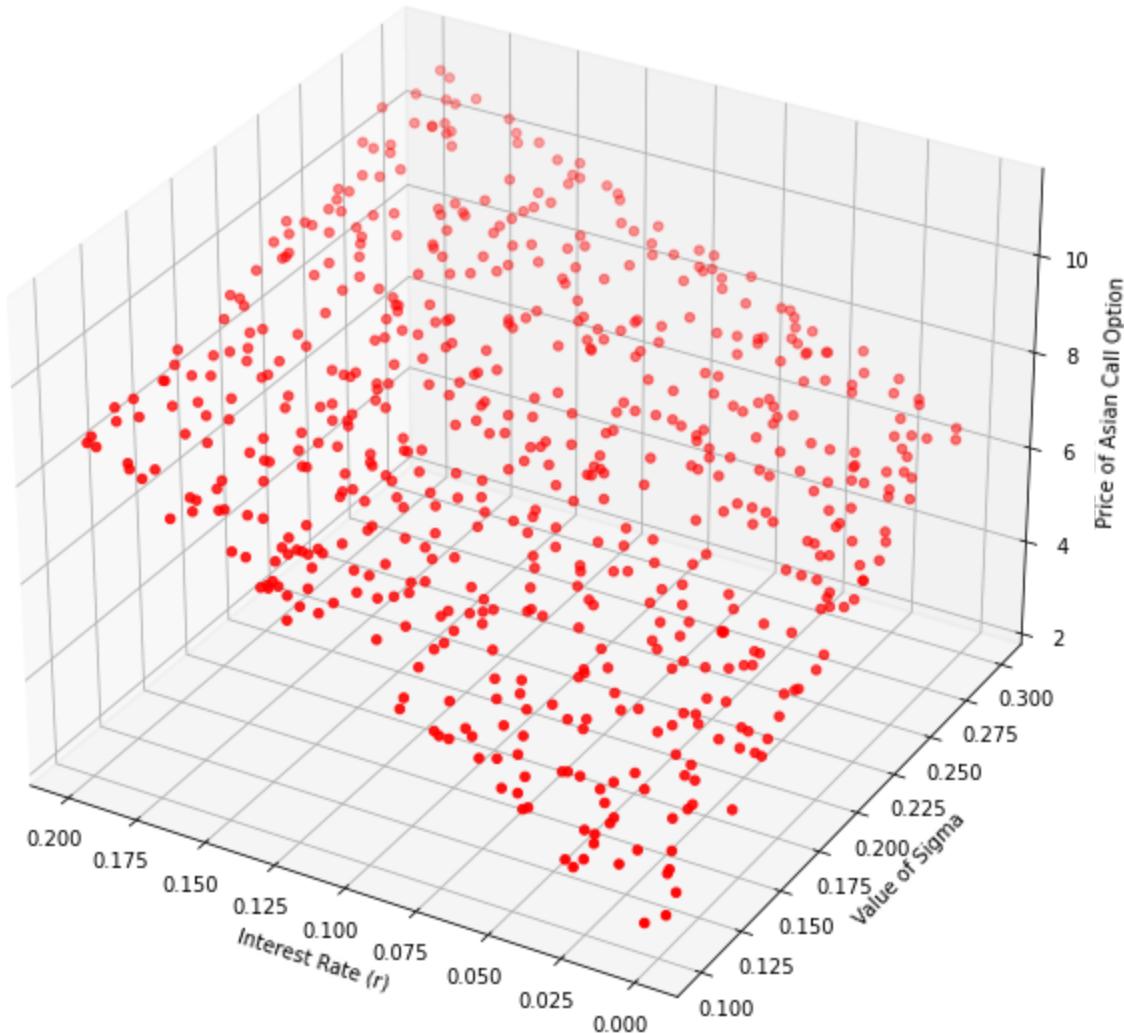
Scatter Plot of Initial Option Price with K and sig (Set 2)



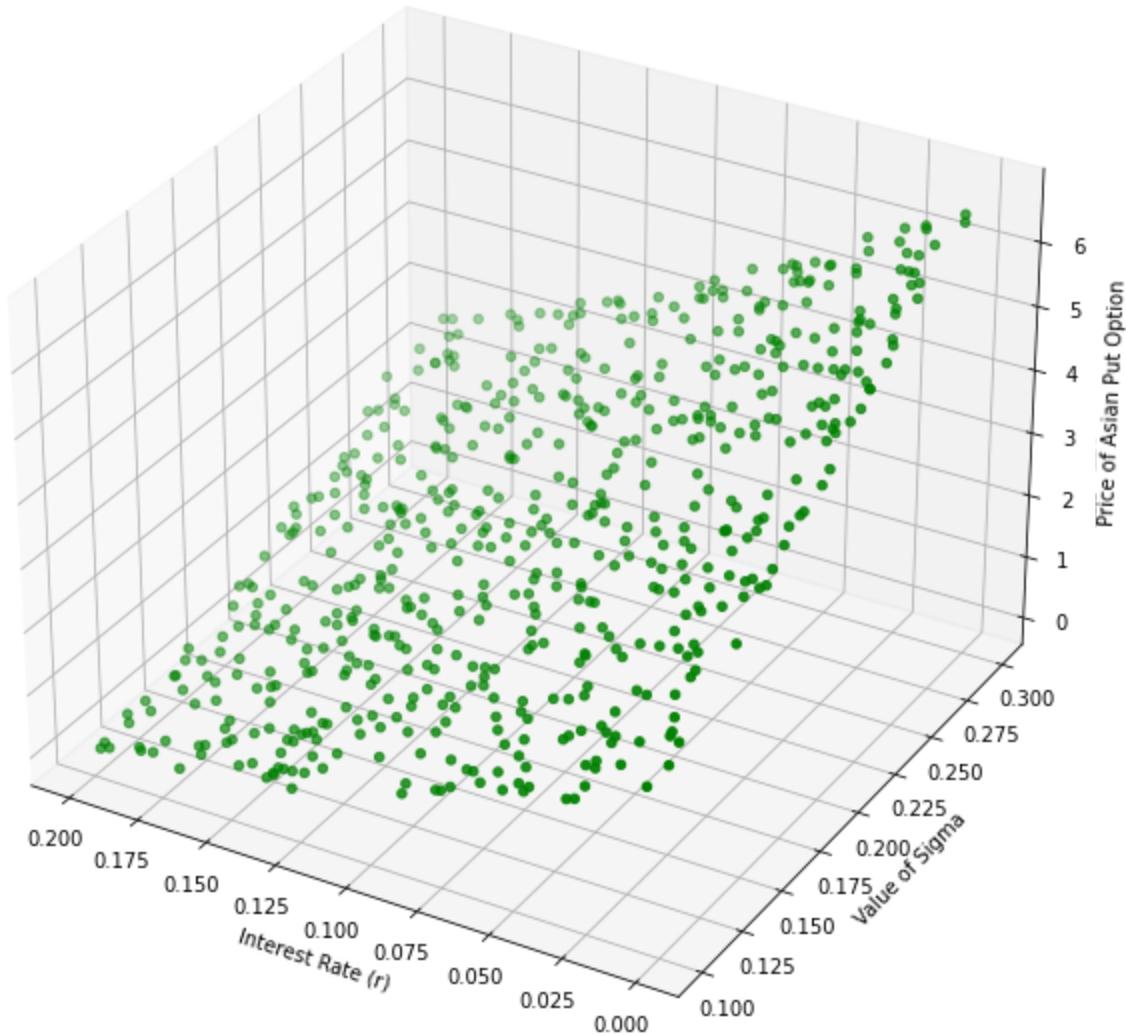
Scatter Plot of Initial Option Price with K and sig (Set 2)



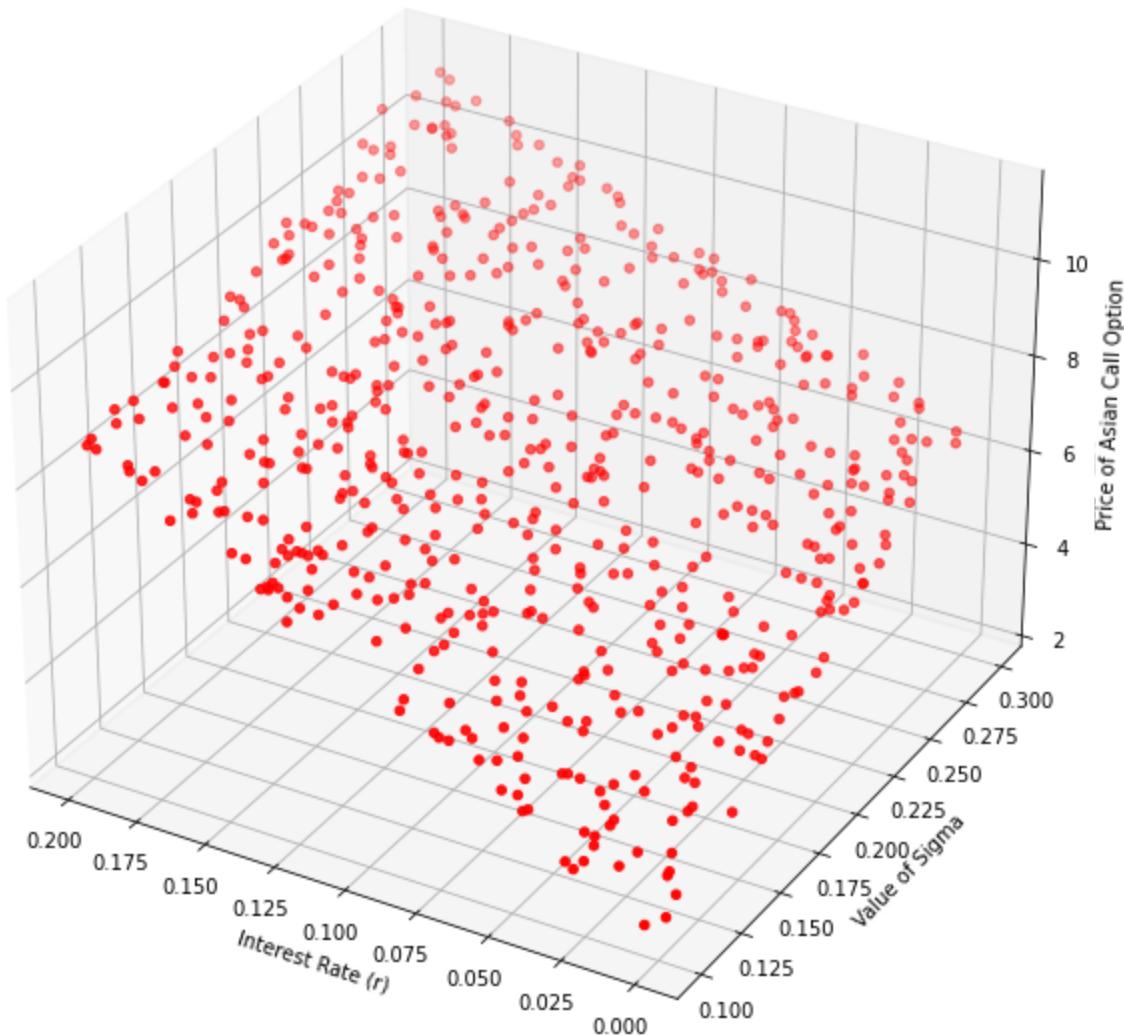
Scatter Plot of Initial Option Price with r and σ (Set 1)



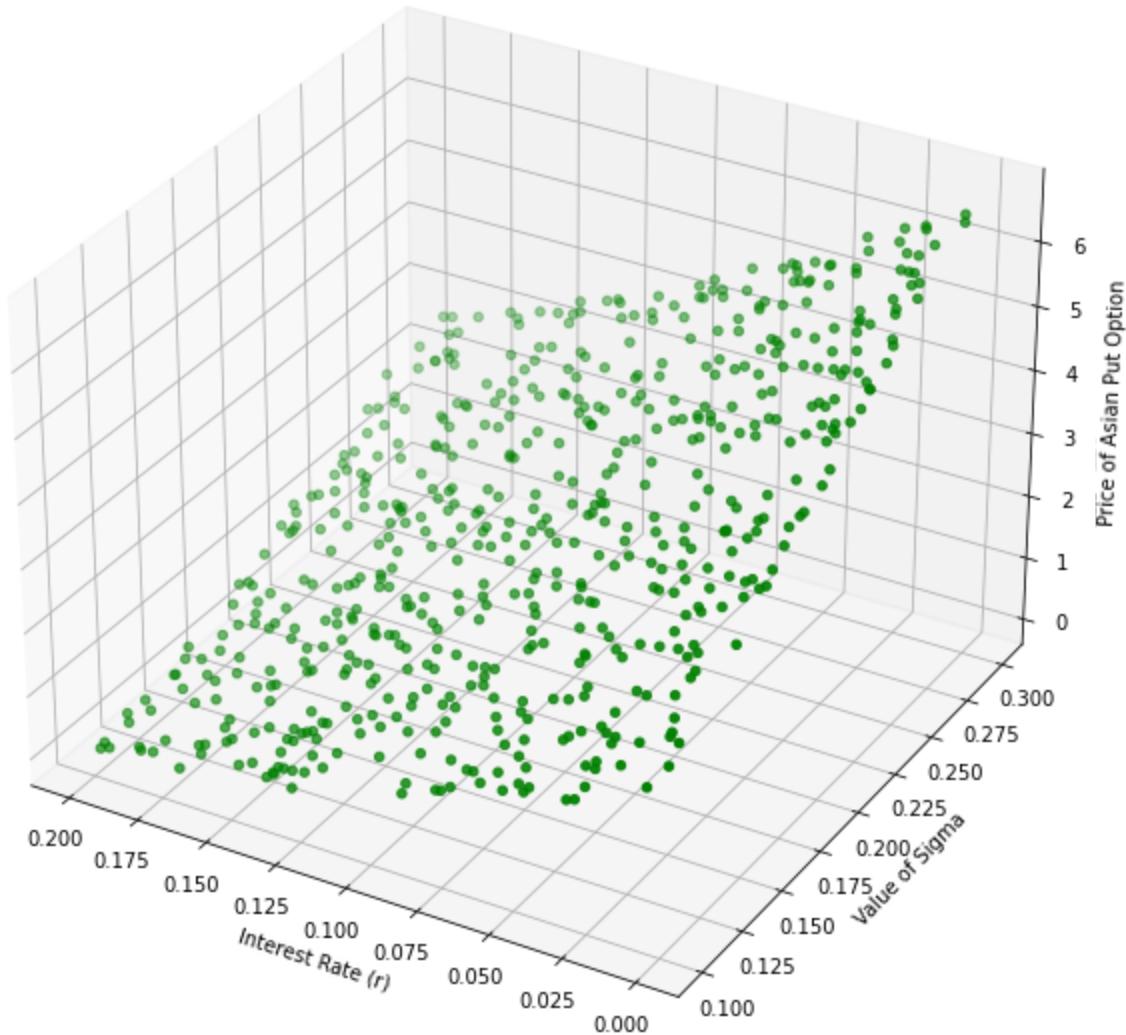
Scatter Plot of Initial Option Price with r and σ (Set 1)



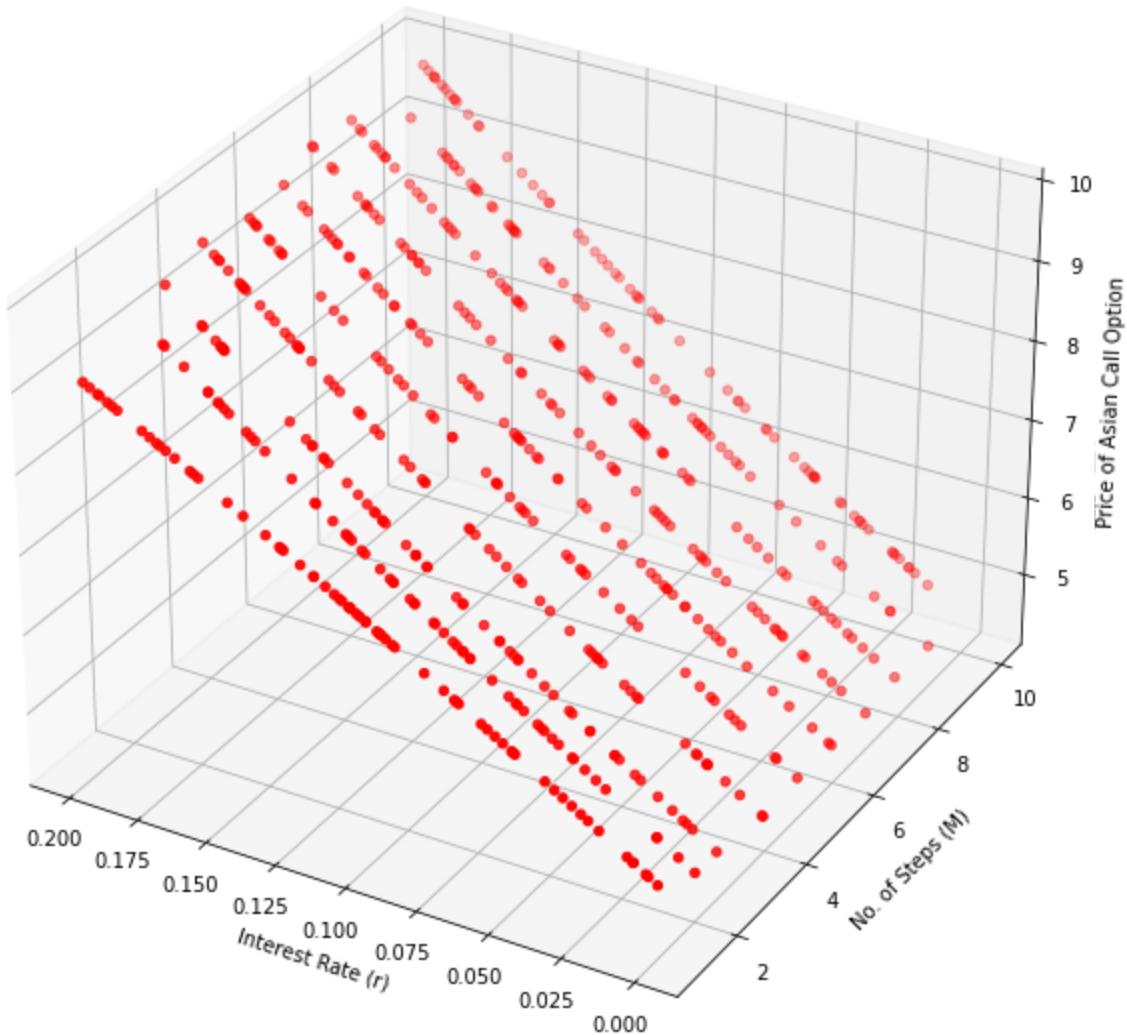
Scatter Plot of Initial Option Price with r and σ (Set 2)



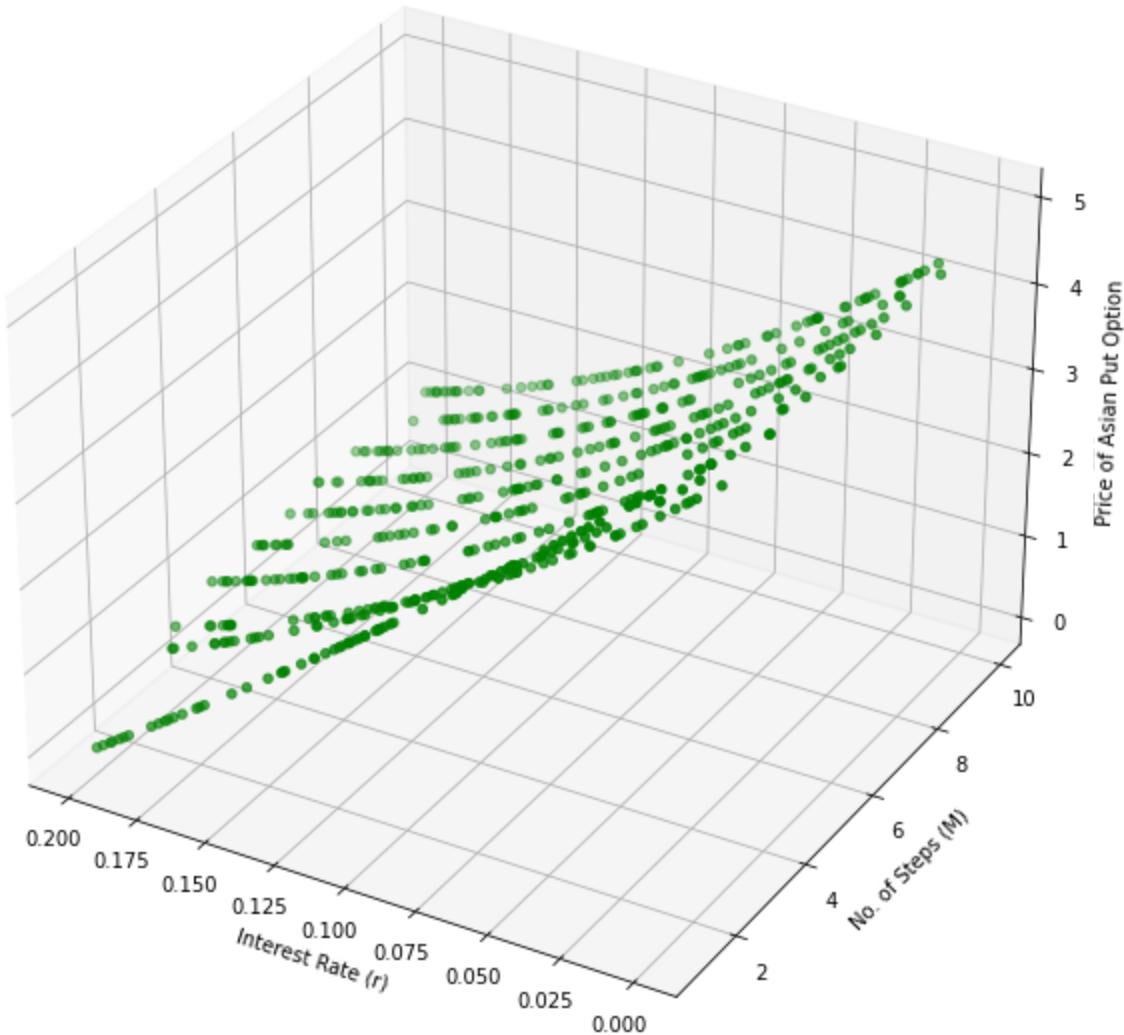
Scatter Plot of Initial Option Price with r and σ (Set 2)



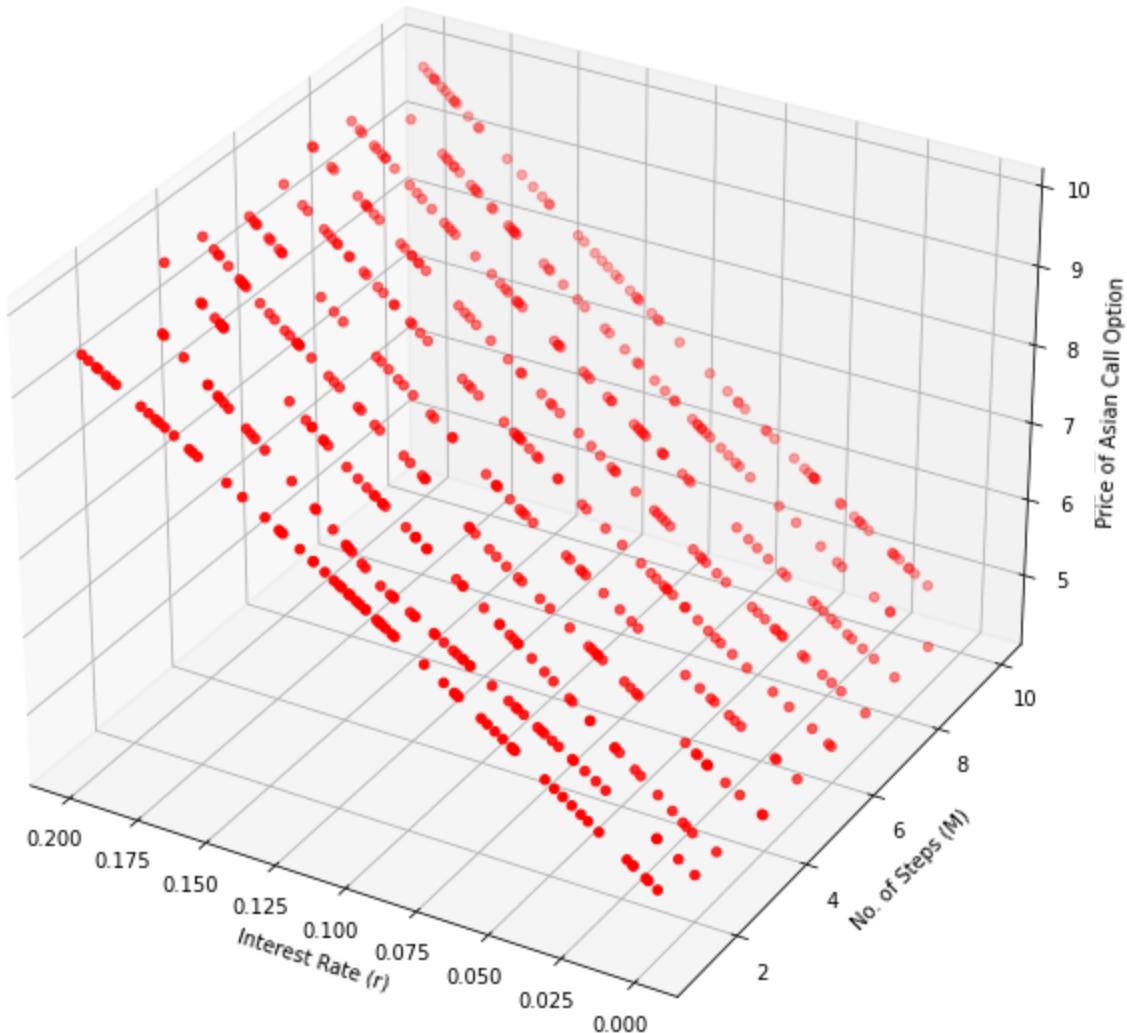
Scatter Plot of Initial Option Price with r and M (Set 1)



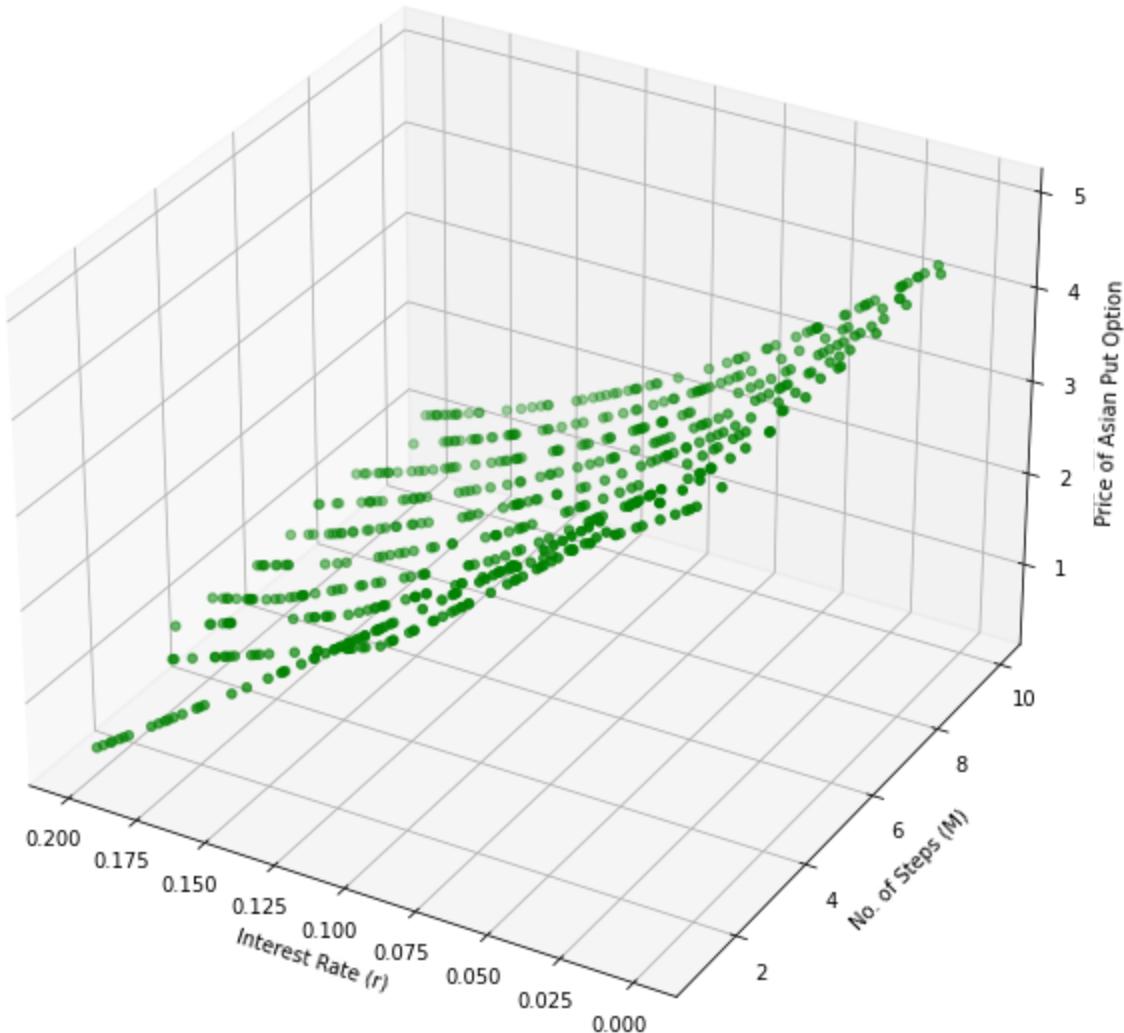
Scatter Plot of Initial Option Price with r and M (Set 1)



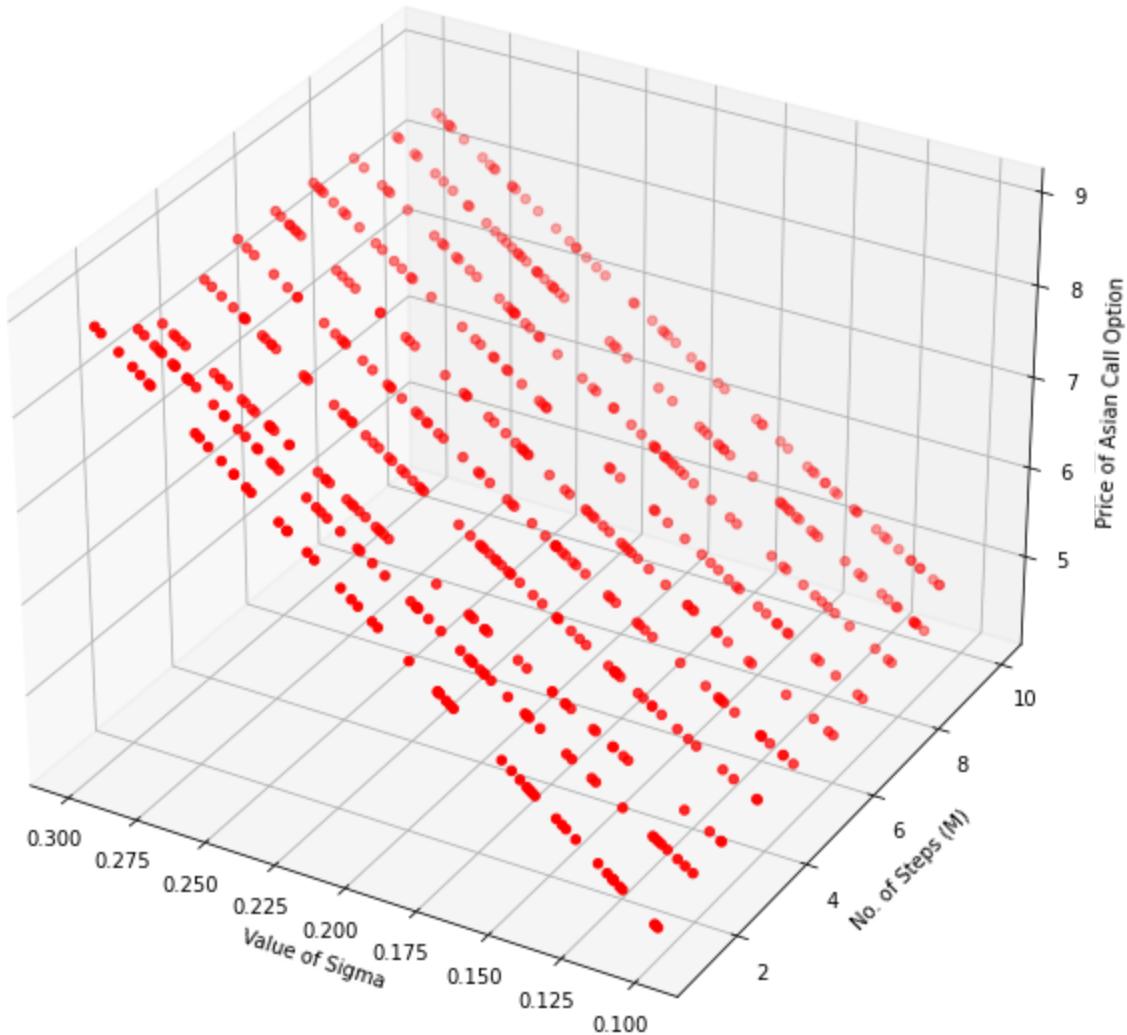
Scatter Plot of Initial Option Price with r and M (Set 2)



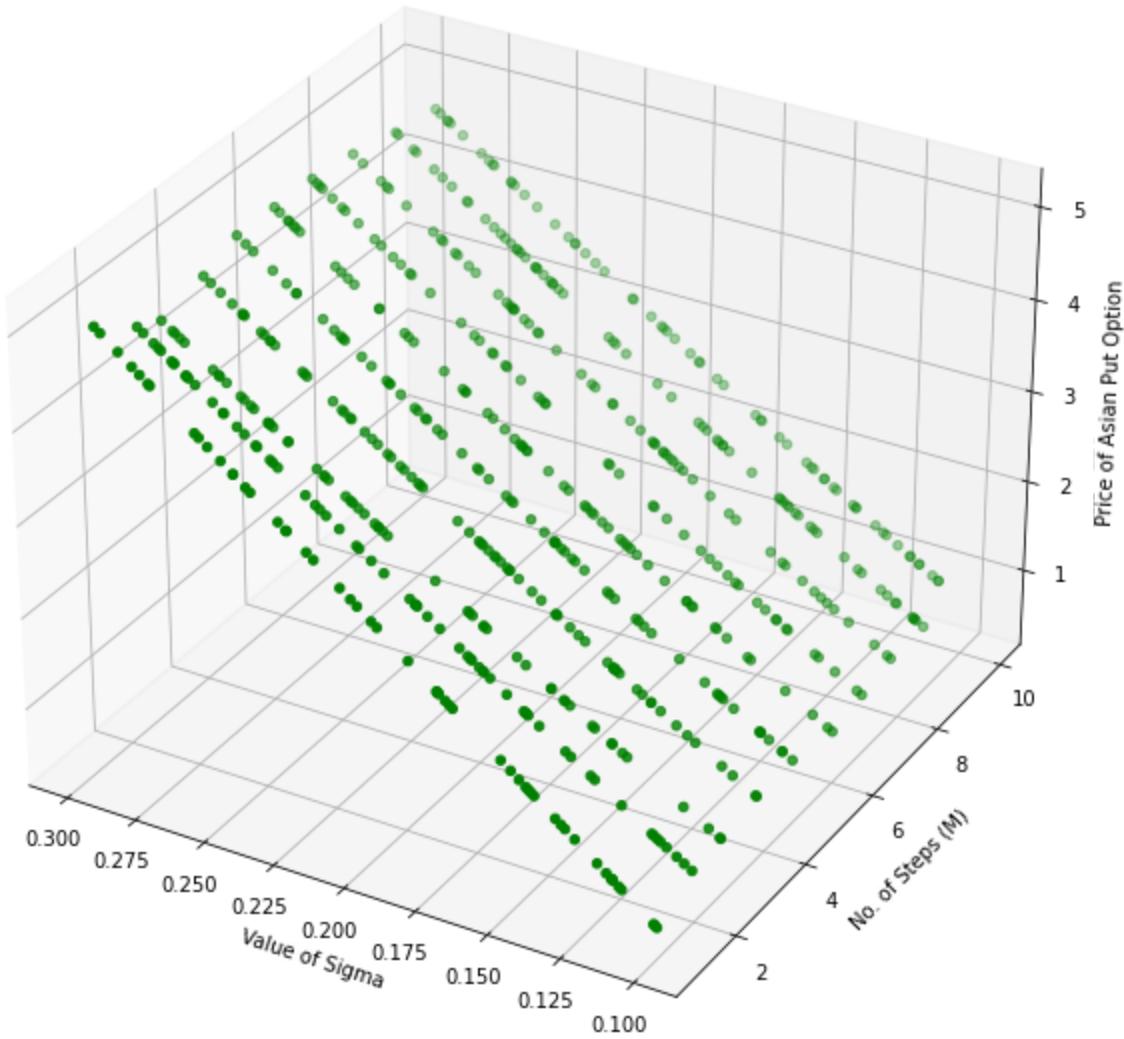
Scatter Plot of Initial Option Price with r and M (Set 2)



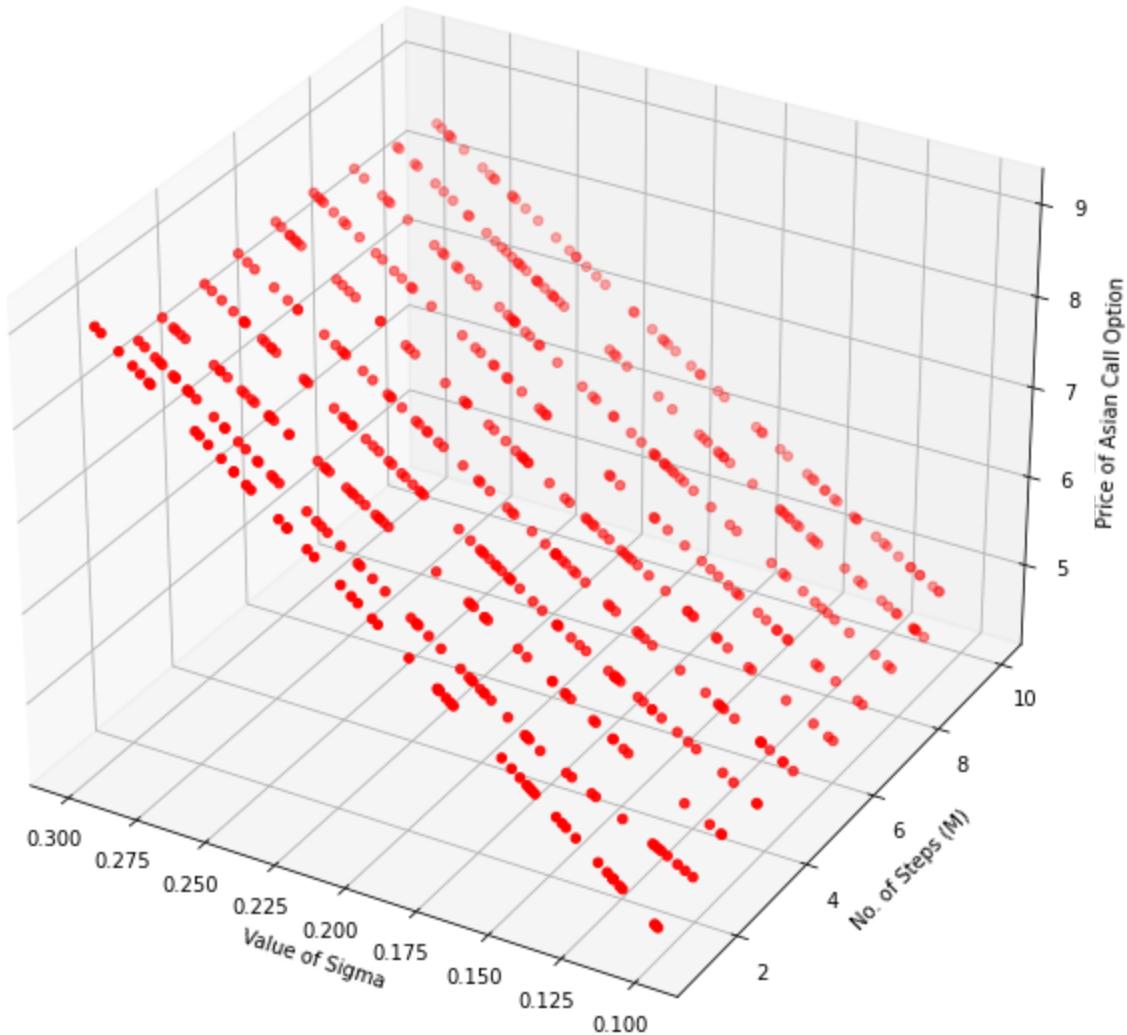
Scatter Plot of Initial Option Price with sig and M (Set 1)



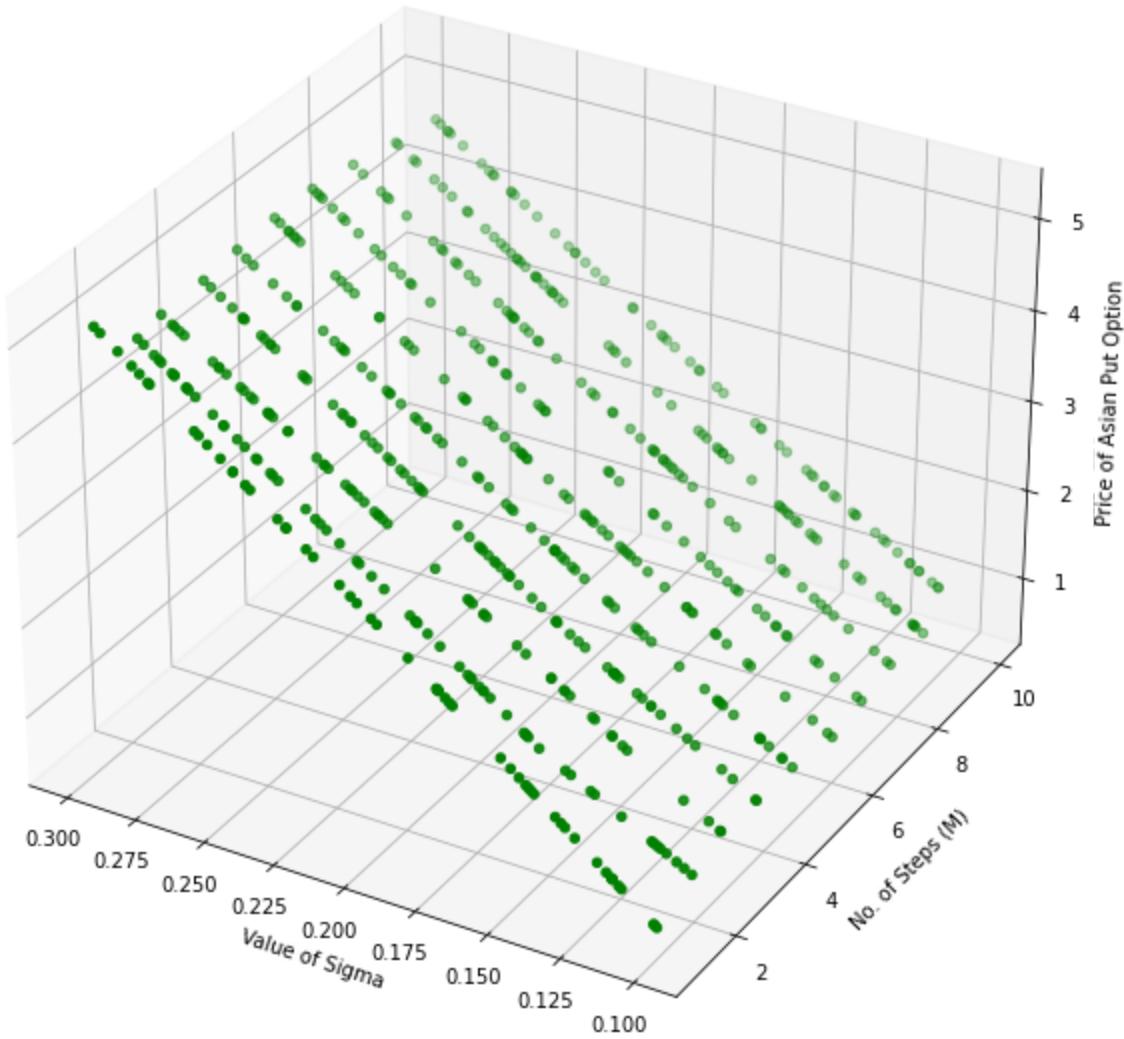
Scatter Plot of Initial Option Price with sig and M (Set 1)



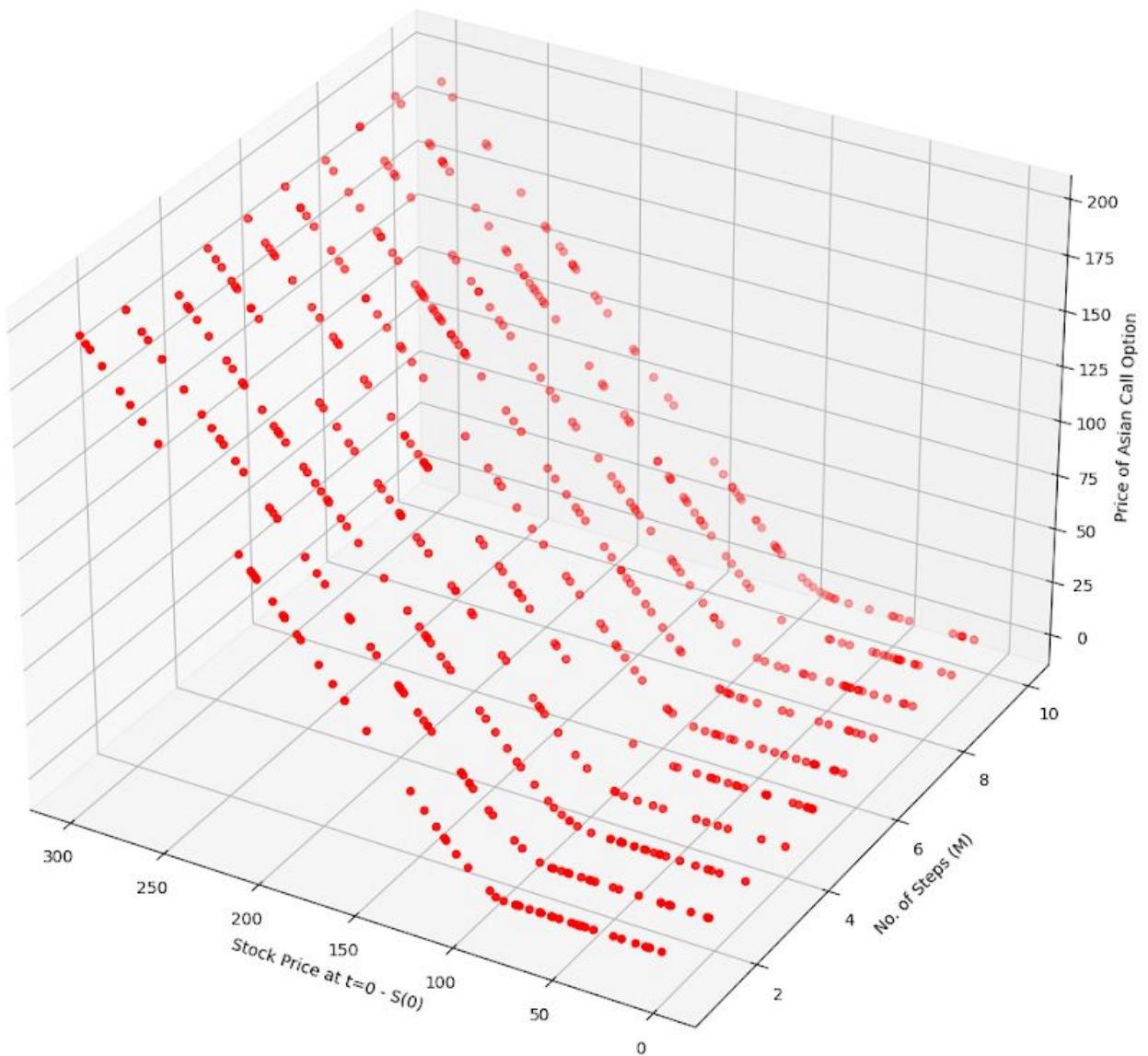
Scatter Plot of Initial Option Price with sig and M (Set 2)



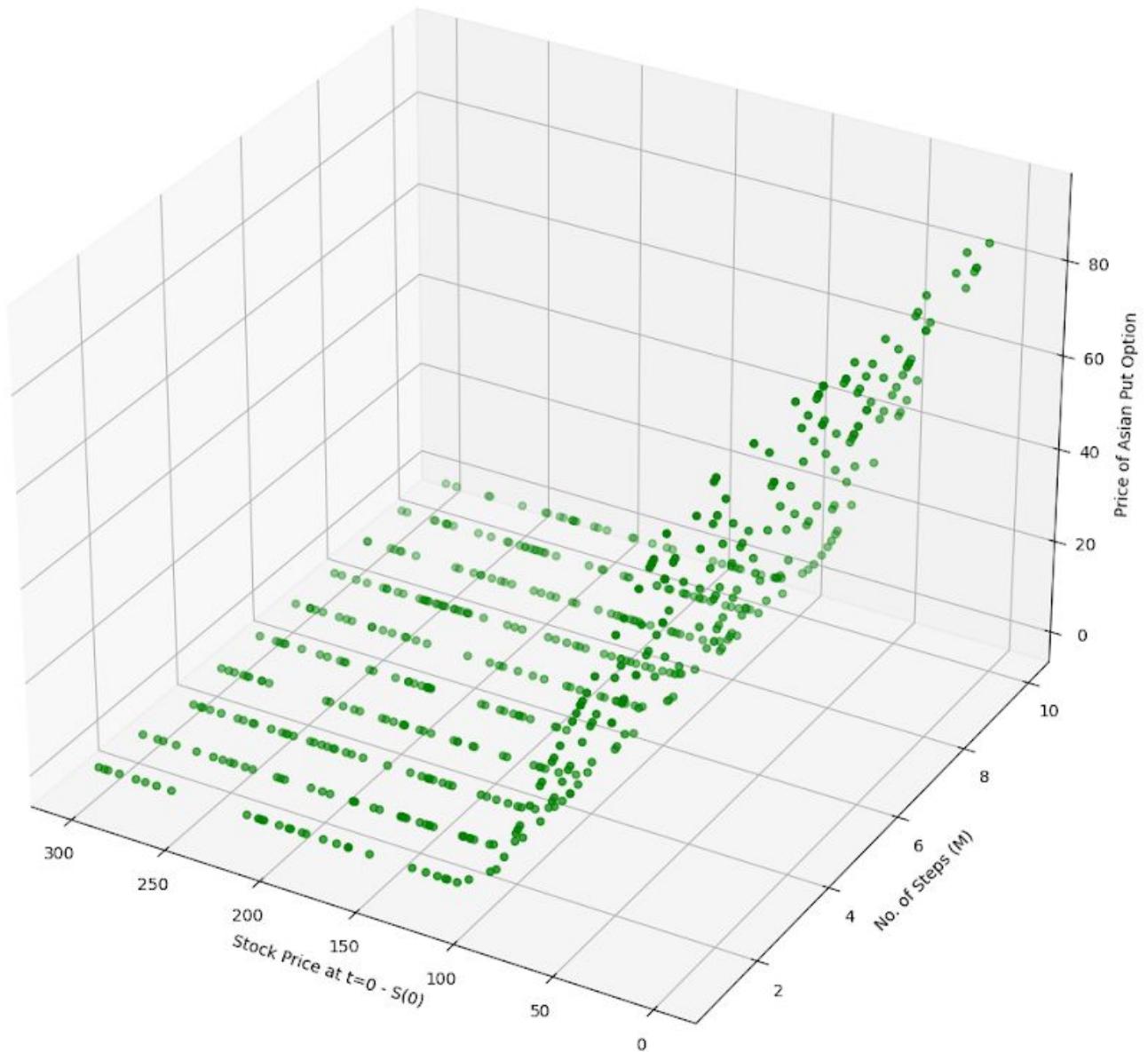
Scatter Plot of Initial Option Price with sig and M (Set 2)



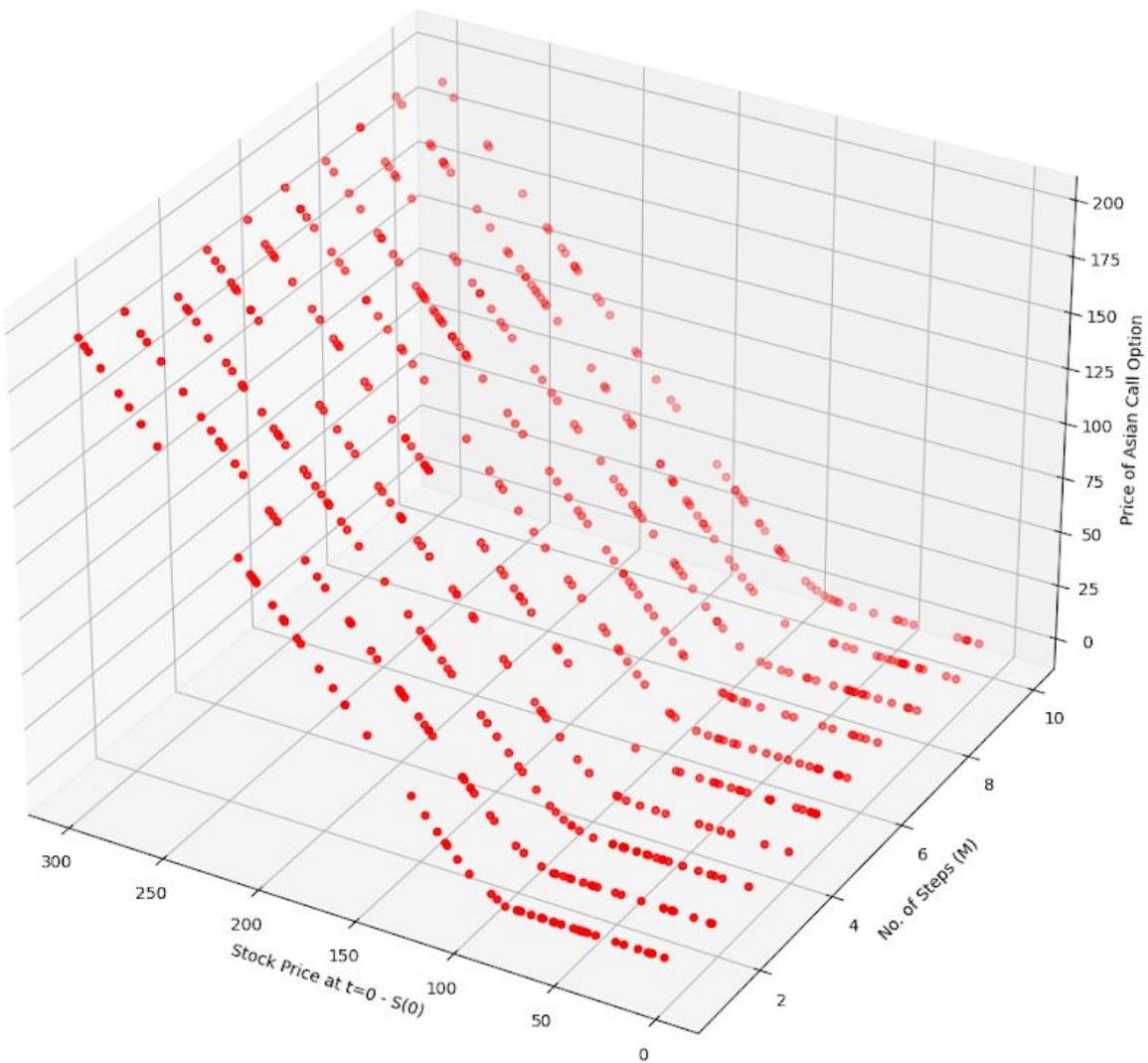
Scatter Plot of Initial Option Price with S_0 and M (Set 1)



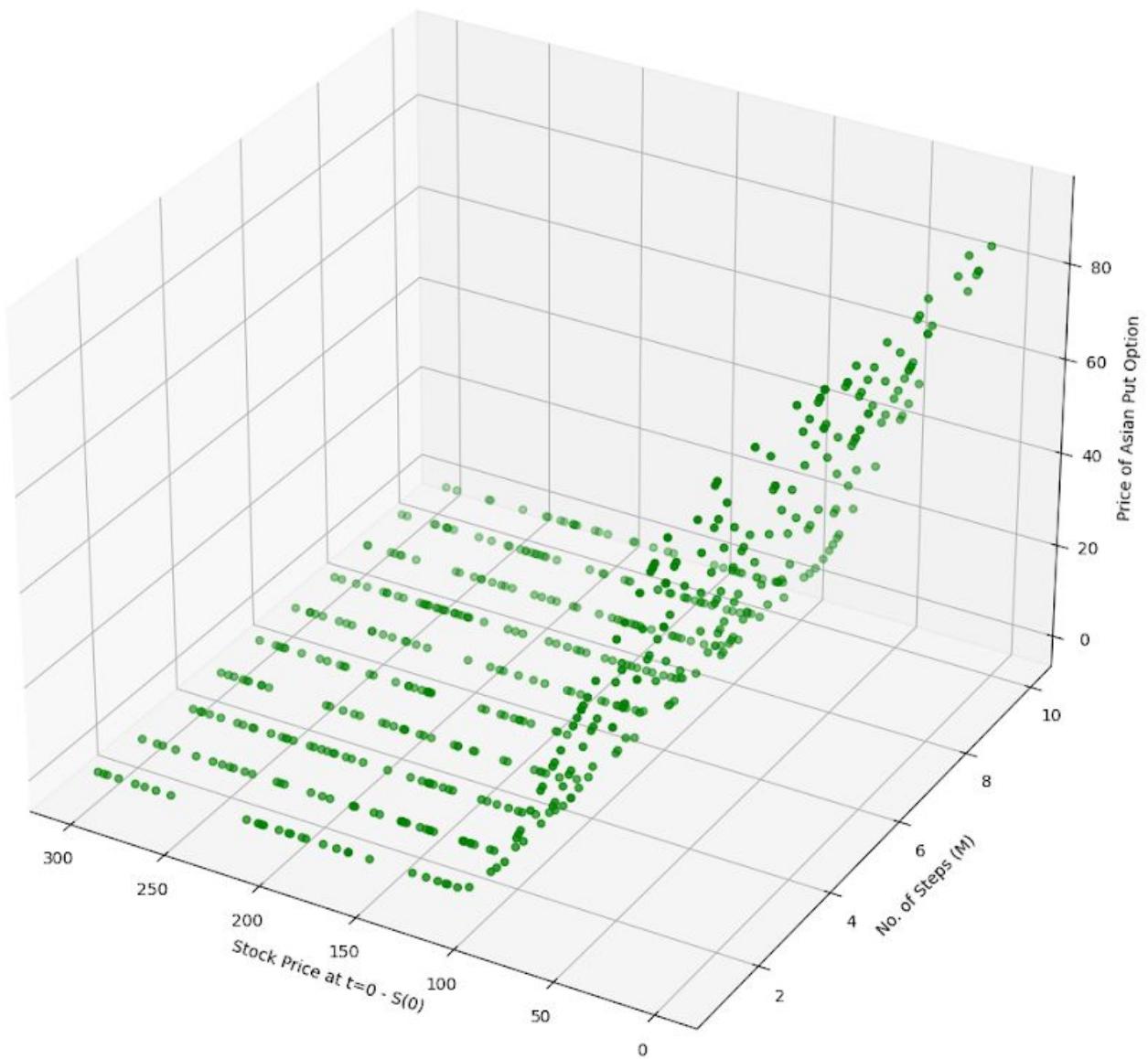
Scatter Plot of Initial Option Price with S_0 and M (Set 1)



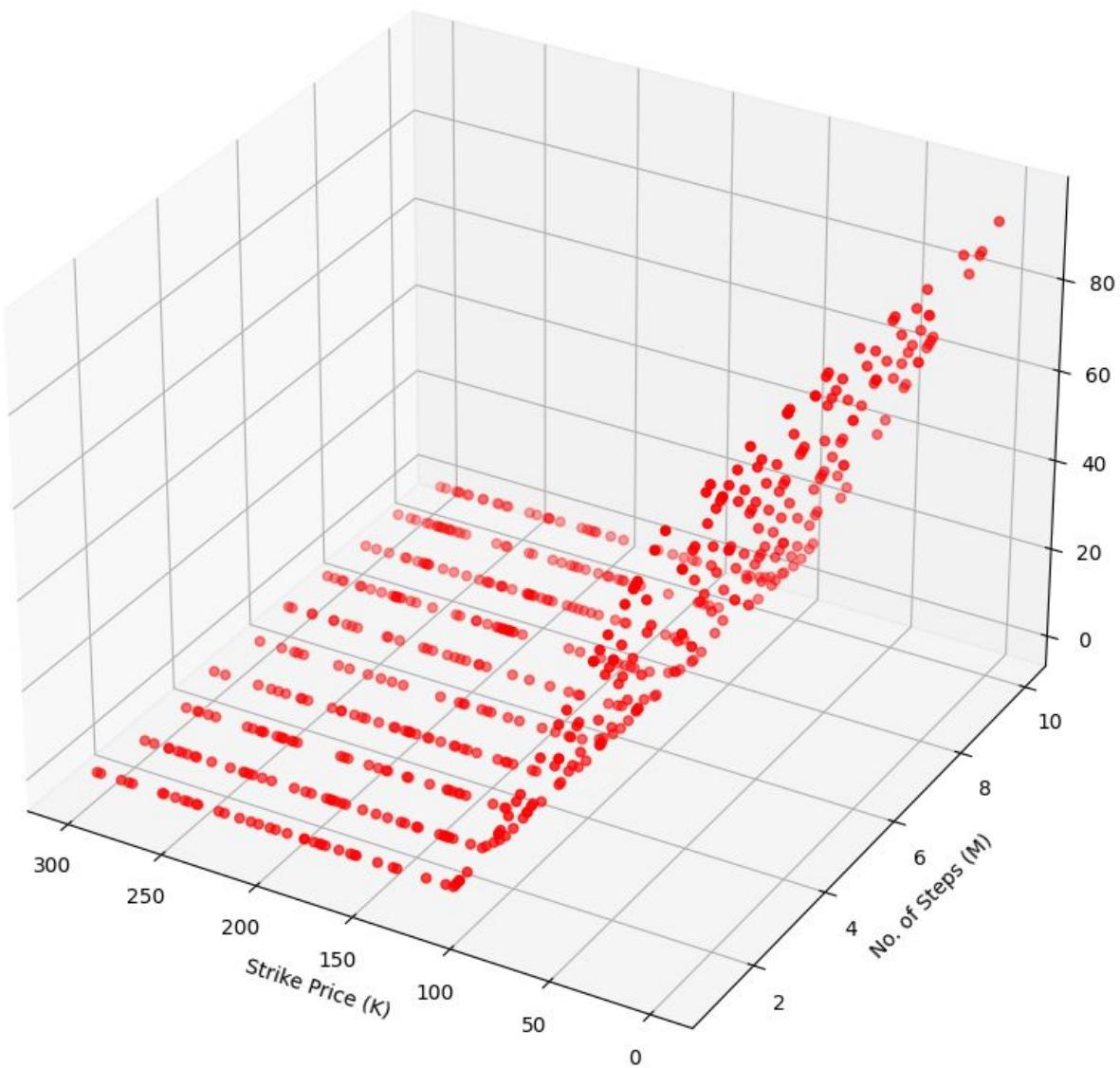
Scatter Plot of Initial Option Price with S_0 and M (Set 2)



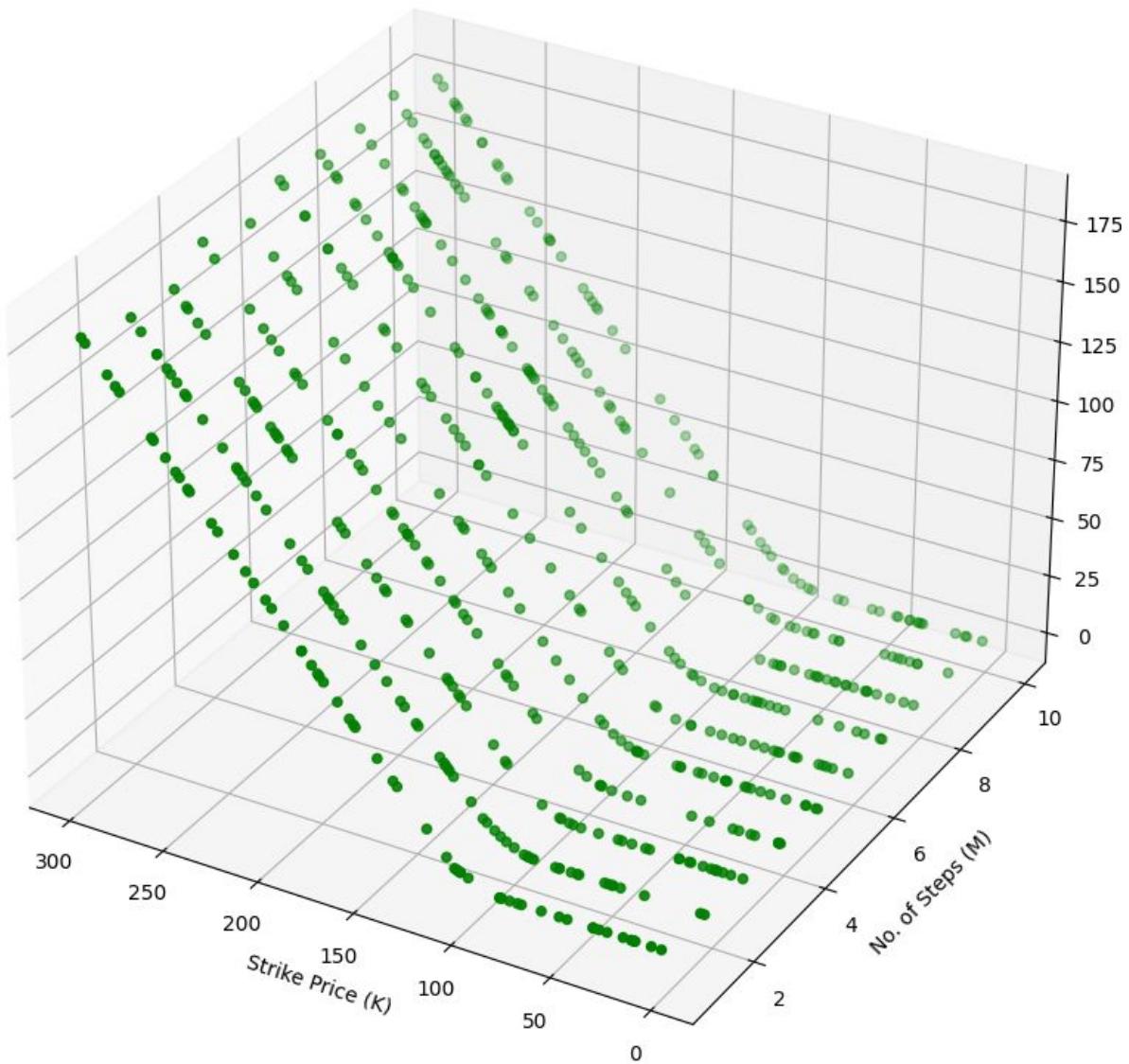
Scatter Plot of Initial Option Price with S_0 and M (Set 2)



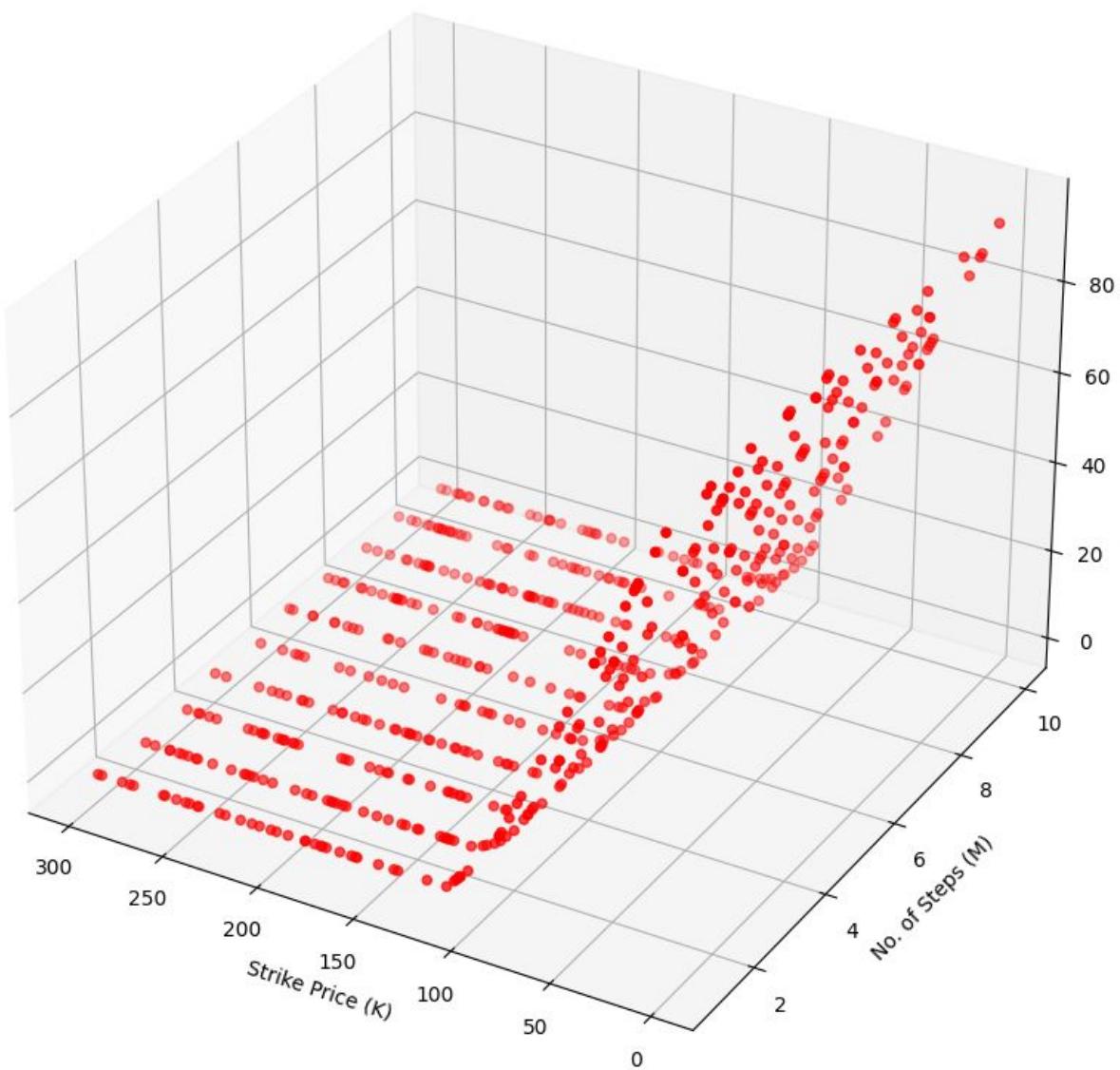
Scatter Plot of Initial Option Price with K and M (Set 1)



Scatter Plot of Initial Option Price with K and M (Set 1)



Scatter Plot of Initial Option Price with K and M (Set 2)



Scatter Plot of Initial Option Price with K and M (Set 2)

