भारतीय प्रौद्योगिकी संस्थान गुवाहाटी
INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI

MA 374: Financial Engineering Lab

Lab 10

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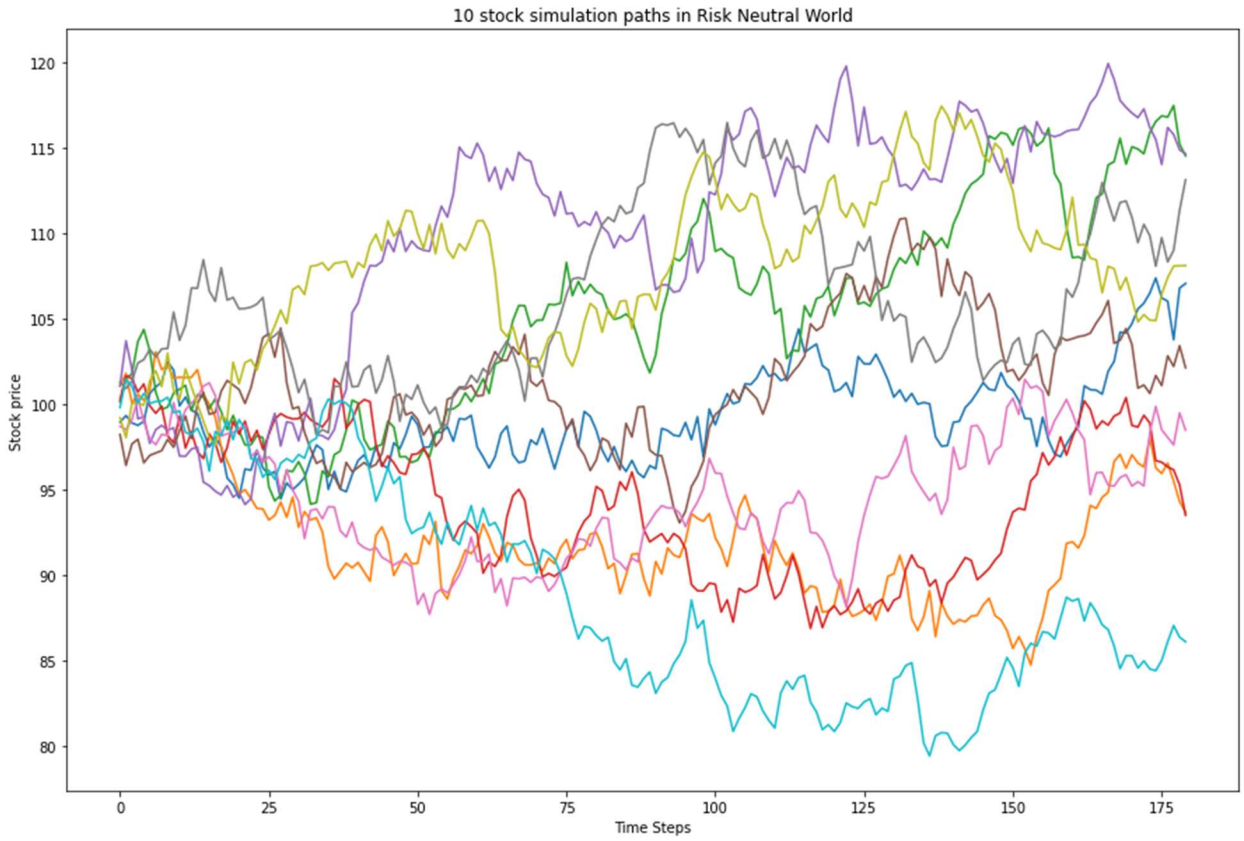
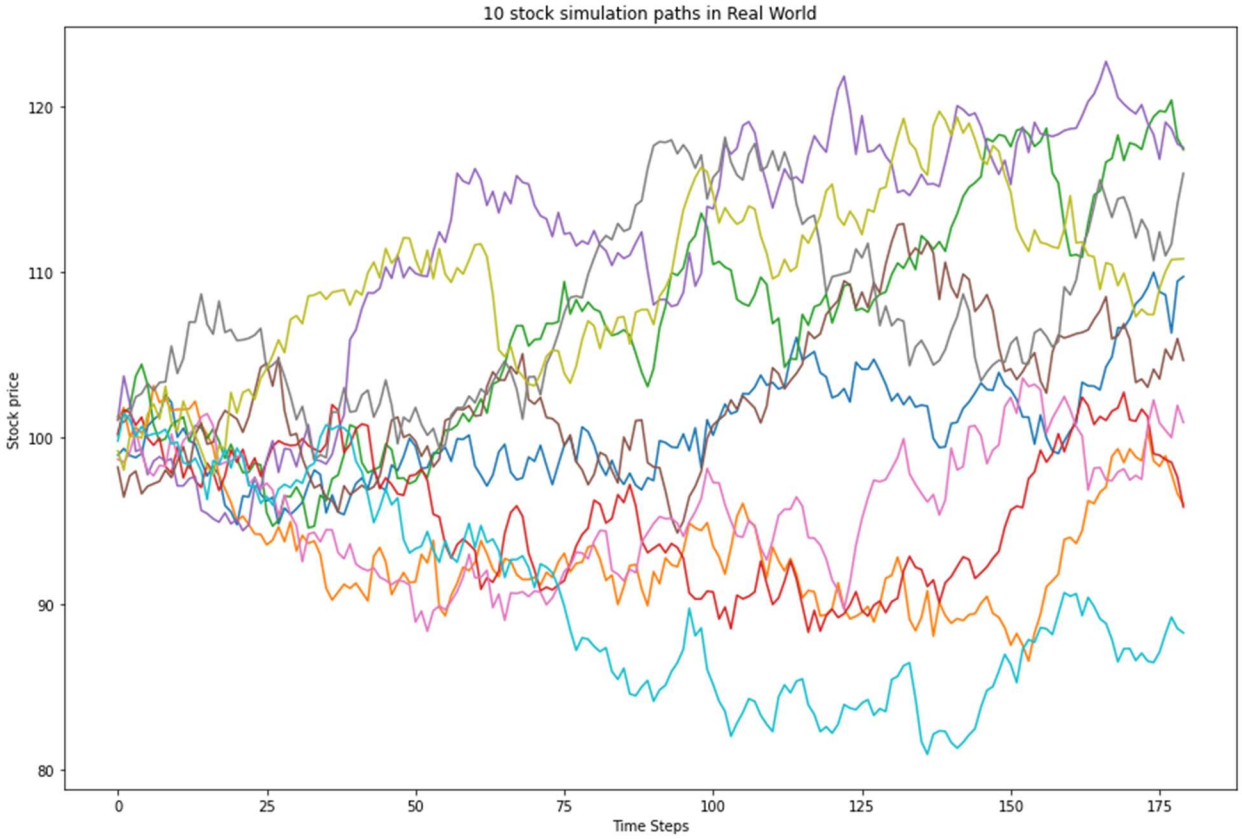
Question 01.

- In this question, we first simulate 10 different paths of the asset price making use of the GBM model for risk-free and real worlds. The plots are attached below.



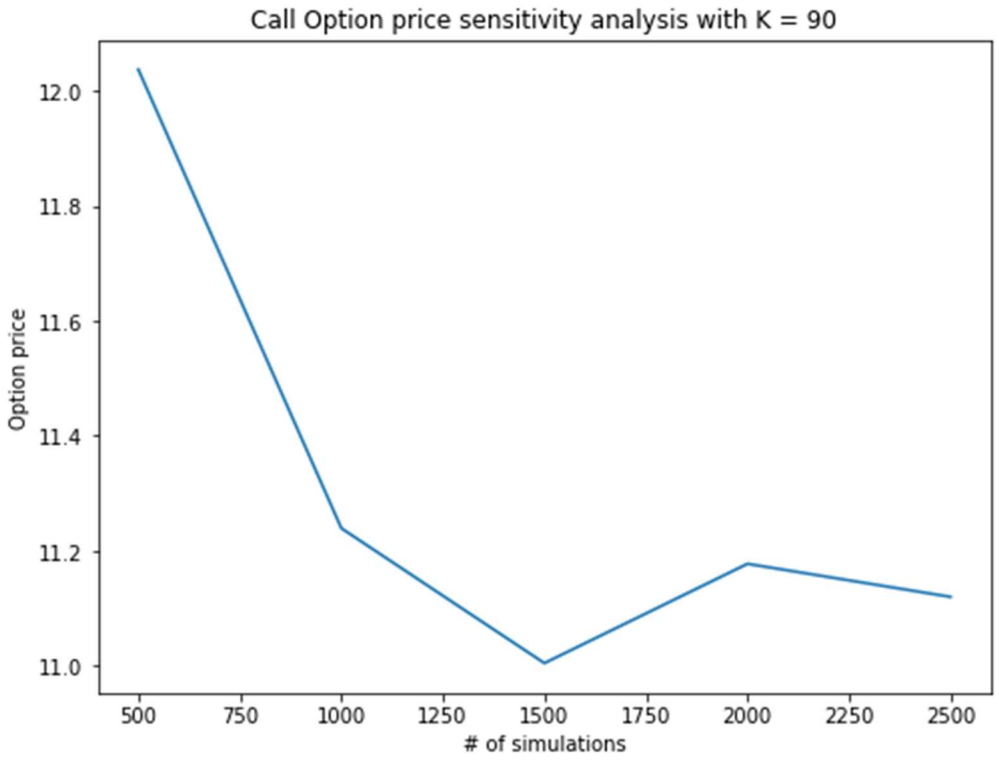


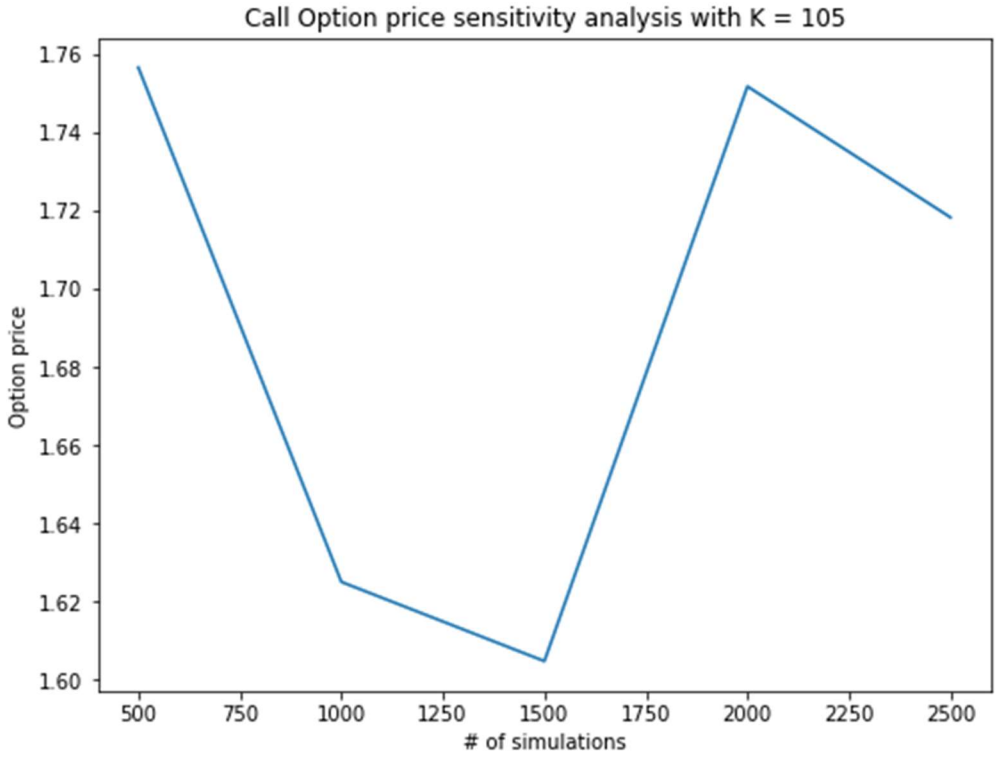
- We then compare the stock prices for real and risk-free worlds.

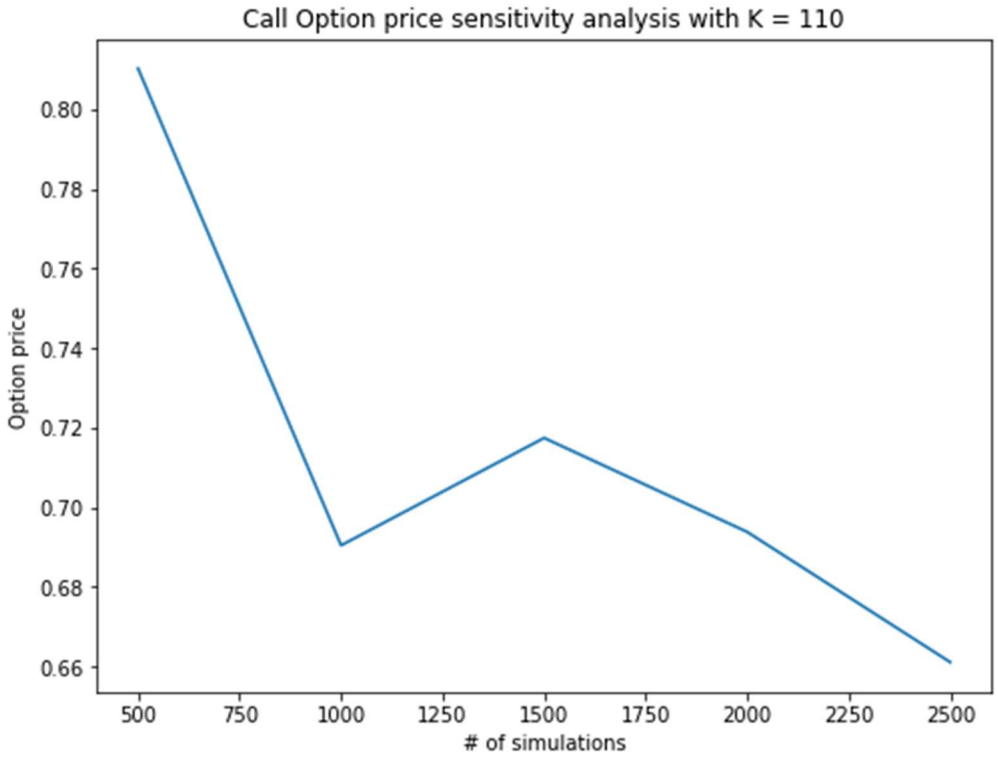
- The price of a 6 month fixed-strike Asian option with a strike price of 105 (K = 105) for both **call** and **put** options are computed. We also repeat the same for other values of K namely - K = 90 and K = 110.
- The computed option prices are:

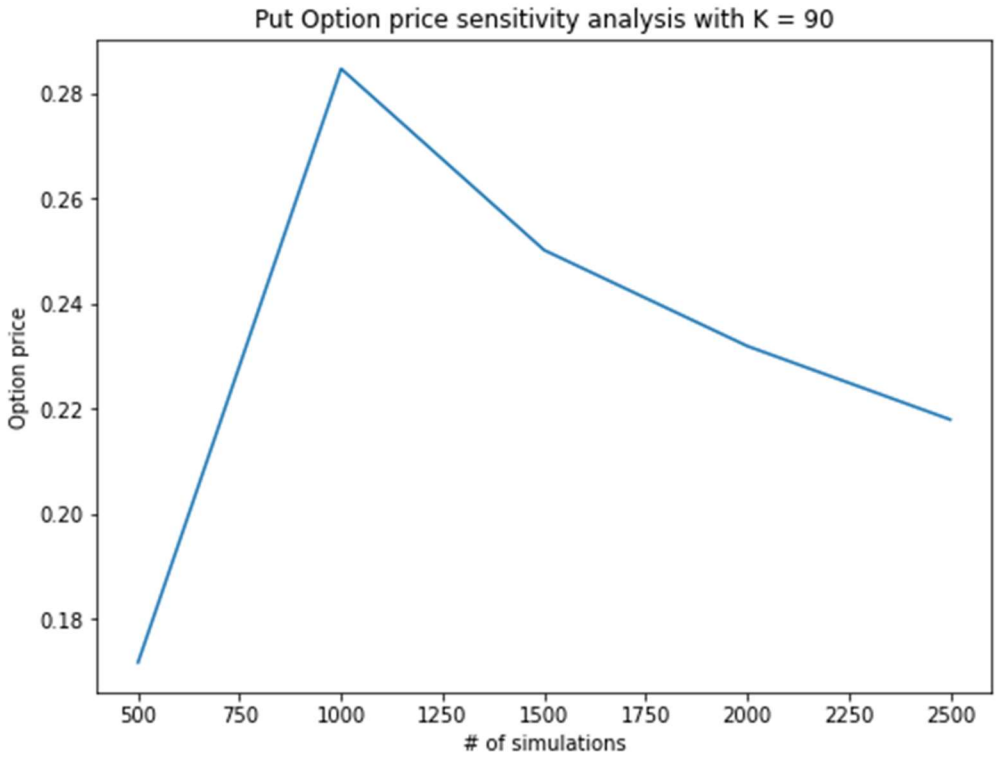
  - ❖ Call Option price for K = 90 is 11.09926
  - ❖ Call Option price for K = 105 is 1.71275
  - ❖ Call Option price for K = 110 is 0.65917
  - ❖ Put Option price for K = 90 is 0.26274
  - ❖ Put Option price for K = 105 is 5.45548
  - ❖ Put Option price for K = 110 is 9.24344

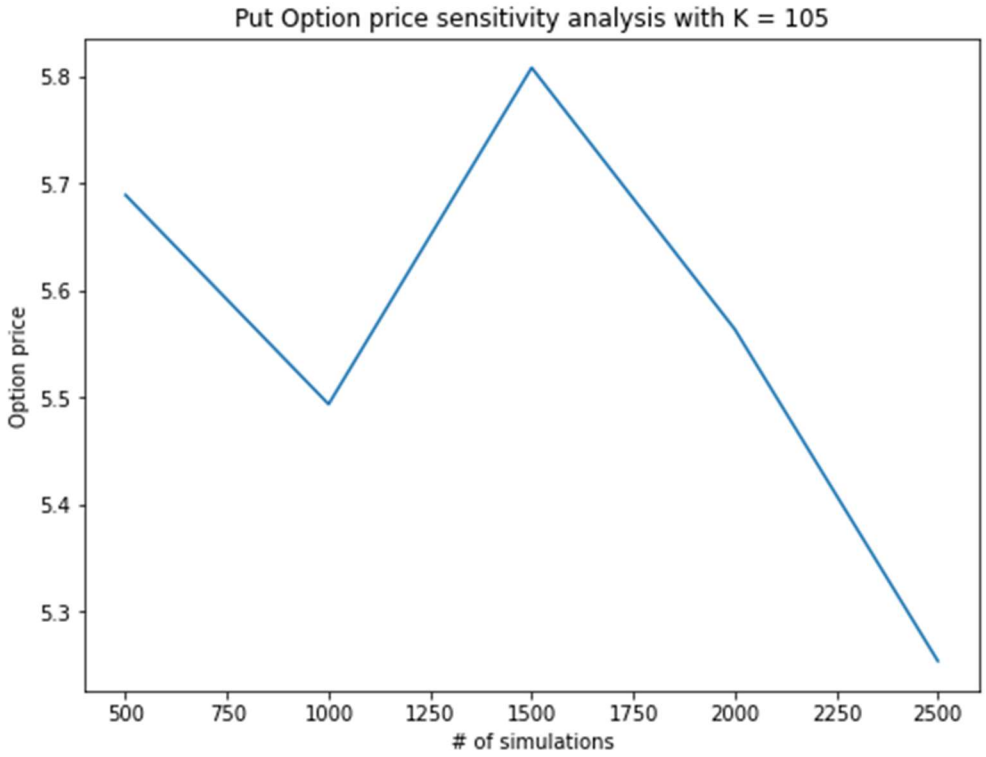
- We now plot these against the number of simulations and get the following graphs.

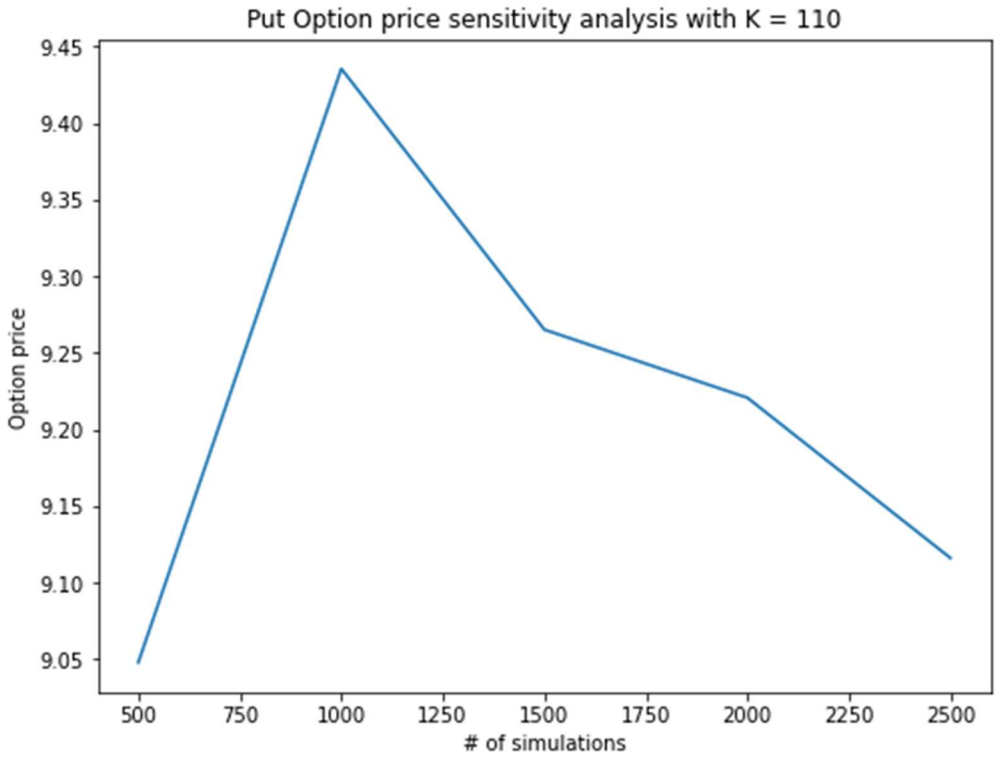



Call Option price sensitivity analysis with K = 105
Option price
1.76
1.74
1.72
1.70
1.68
1.66
1.64
1.62
1.60
500
750
1000
1250
1500
1750
2000
2250
2500
# of simulations


Call Option price sensitivity analysis with K = 110
Option price
0.80
0.78
0.76
0.74
0.72
0.70
0.68
0.66
500
750
1000
1250
1500
1750
2000
2250
2500
# of simulations

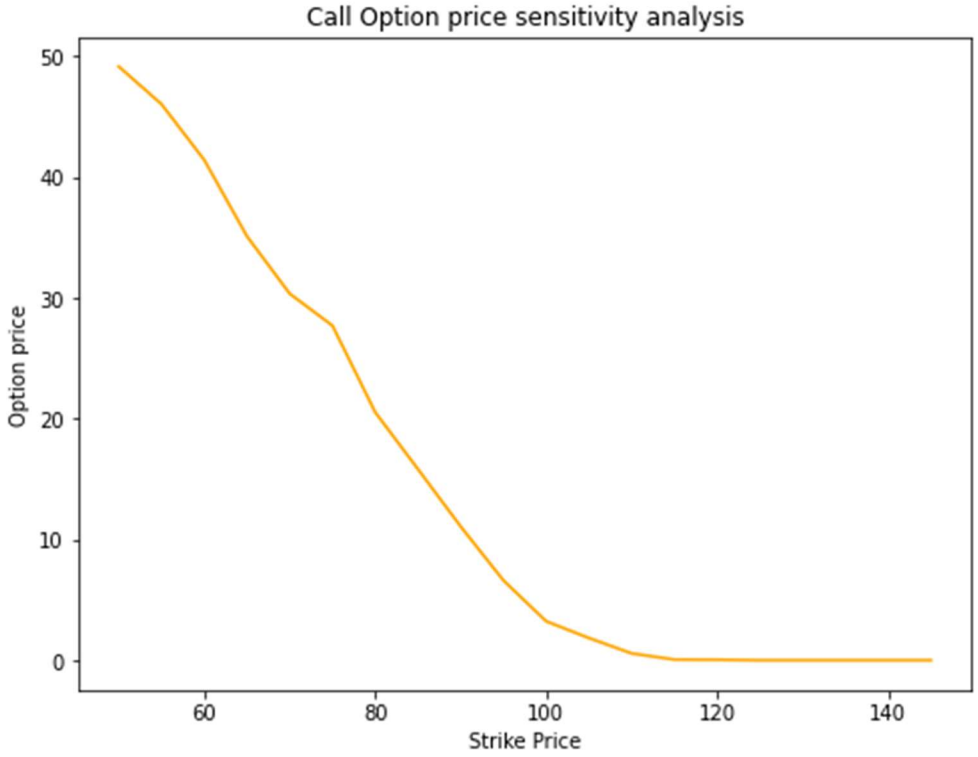

Put Option price sensitivity analysis with K = 90
Option price
0.28
0.26
0.24
0.22
0.20
0.18
500
750
1000
1250
1500
1750
2000
2250
2500
# of simulations

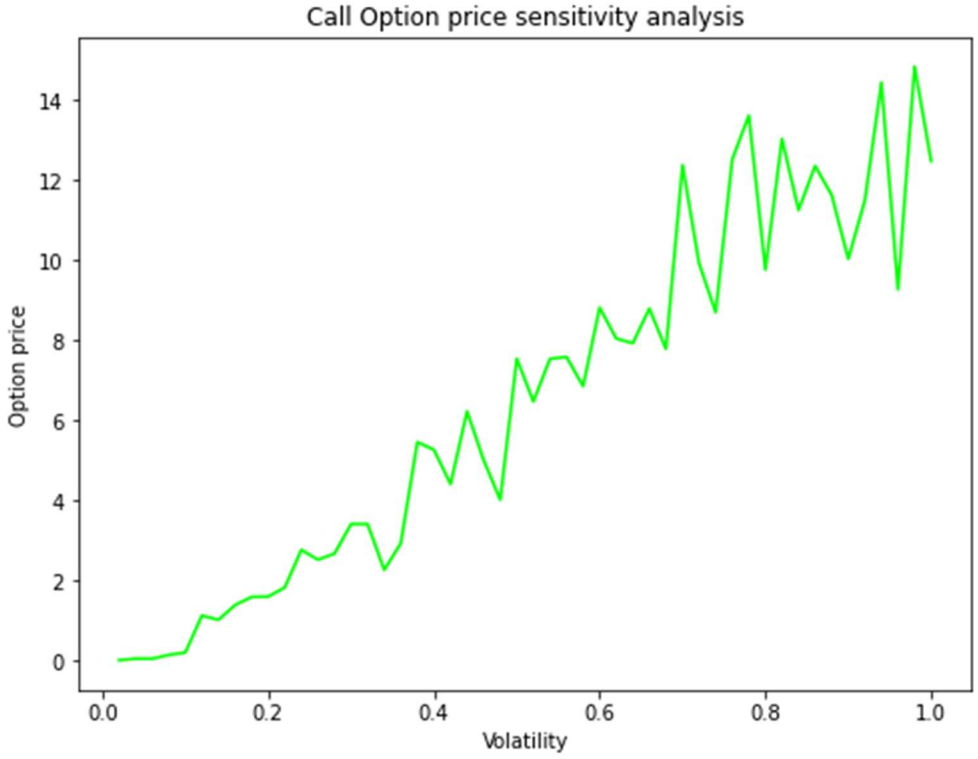

Put Option price sensitivity analysis with K = 105
Option price
5.8
5.7
5.6
5.5
5.4
5.3
500
750
1000
1250
1500
1750
2000
2250
2500
# of simulations

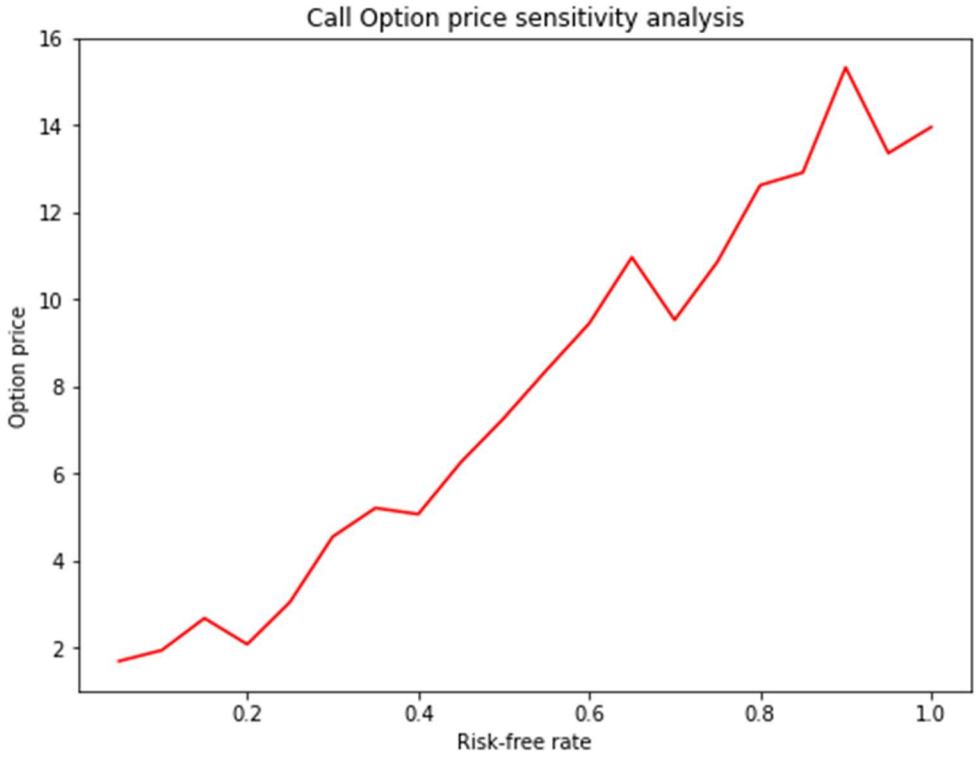


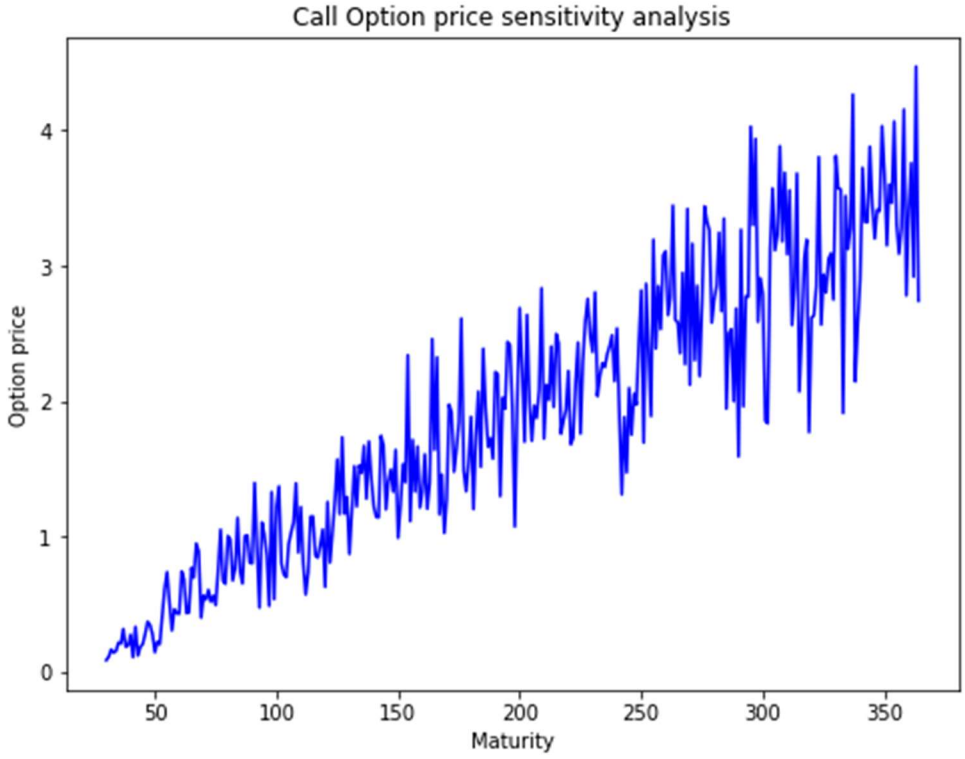
- From the data we can quickly observe that:
  - **Asian call option price decreases with increase in K from 90-110.**
  - **Asian put option price increases with increase in K from 90-110**
- The observation is in accordance with the expected behavior.
- This behavior is more clearly seen in the sensitivity analysis of option prices versus K.

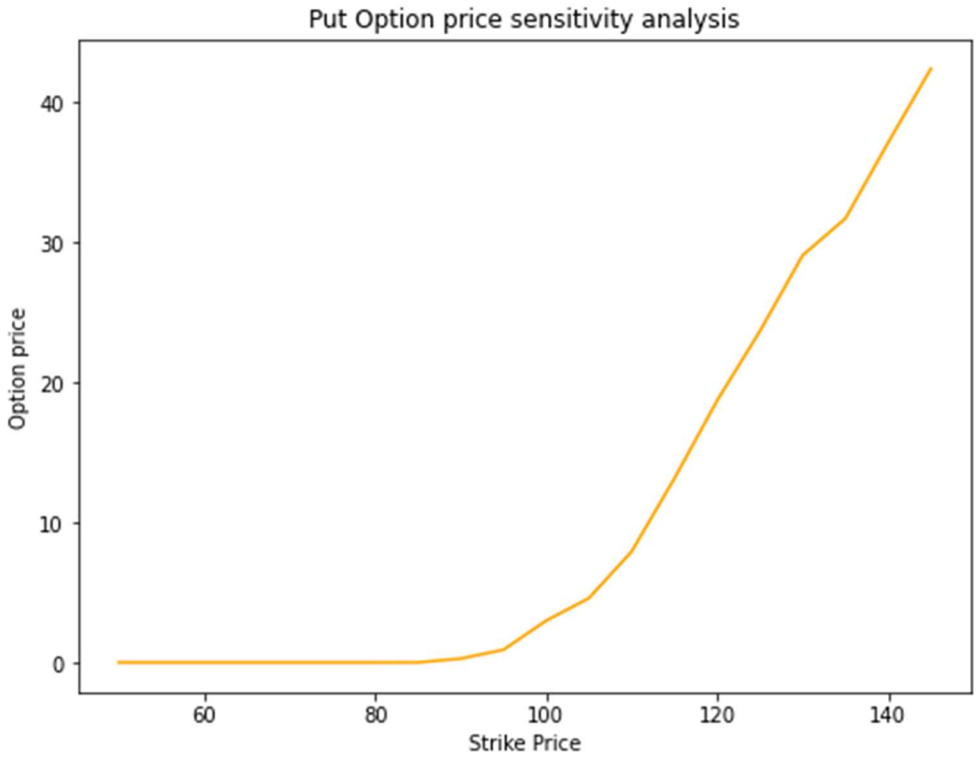
- We now carry out a **sensitivity analysis.** For this we vary **K (strike price), r (risk-free rate), sigma (volatility), and T (maturity)** and plot 2D graphs.



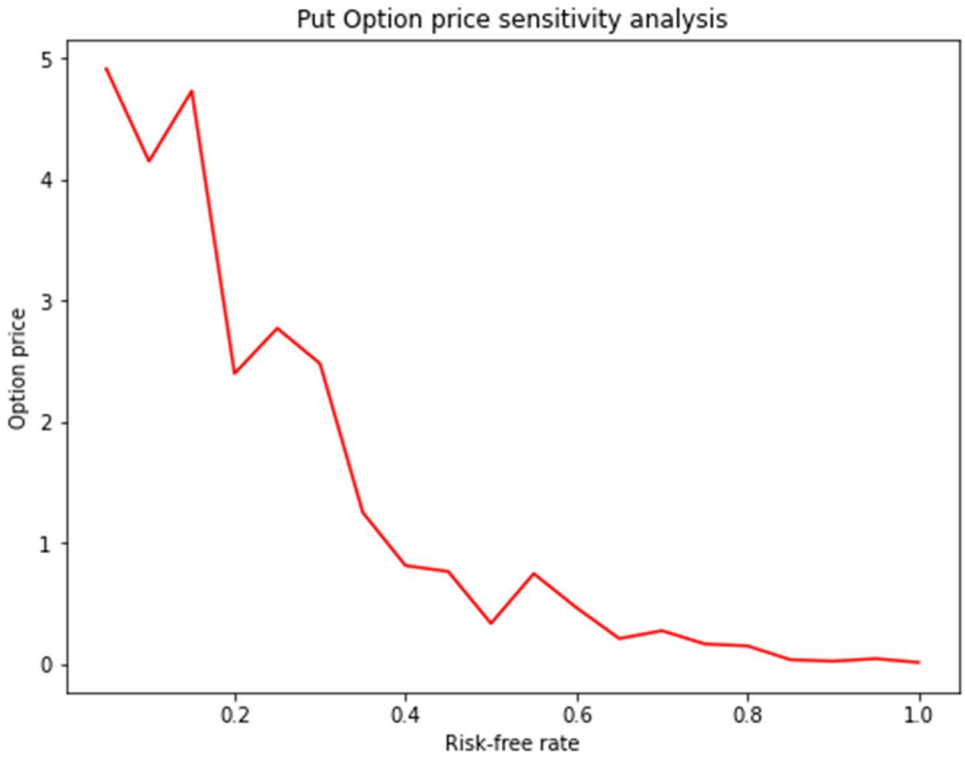


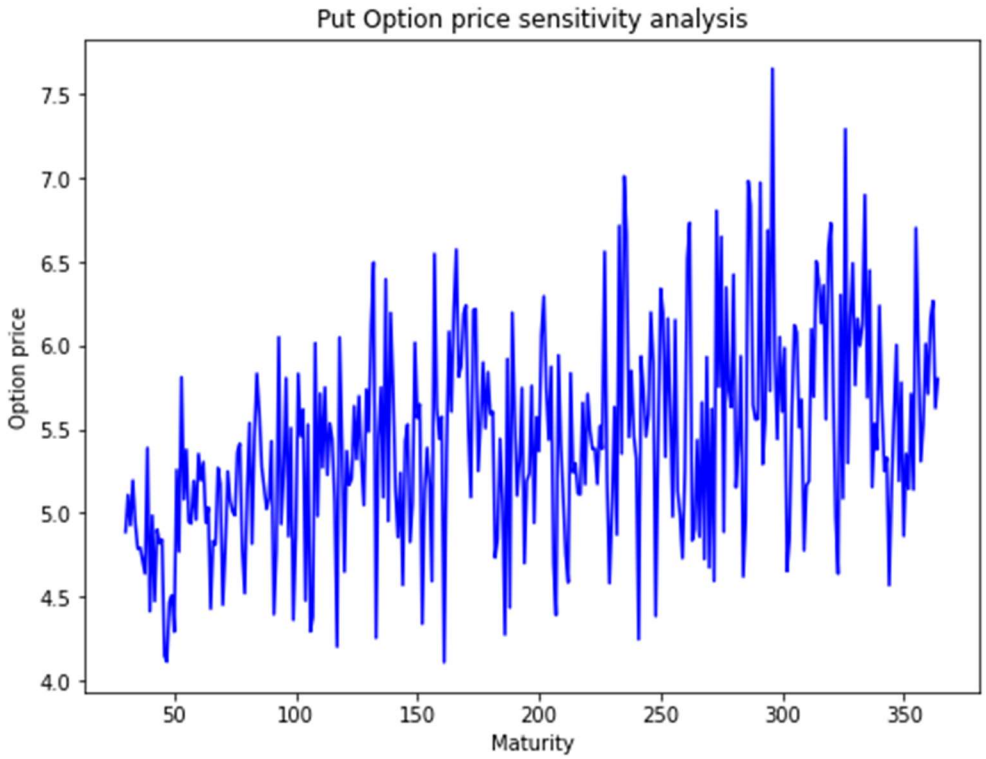

Call Option price sensitivity analysis
Option price
Risk-free rate
16
14
12
10
8
6
4
2
0.2
0.4
0.6
0.8
1.0


Call Option price sensitivity analysis
Option price
Maturity
4
3
2
1
0
50
100
150
200
250
300
350


Put Option price sensitivity analysis
Option price
Strike Price
0
10
20
30
40
60
80
100
120
140


Put Option price sensitivity analysis
Option price
Volatility
4
6
8
10
12
14
16
18
20
0.0
0.2
0.4
0.6
0.8
1.0

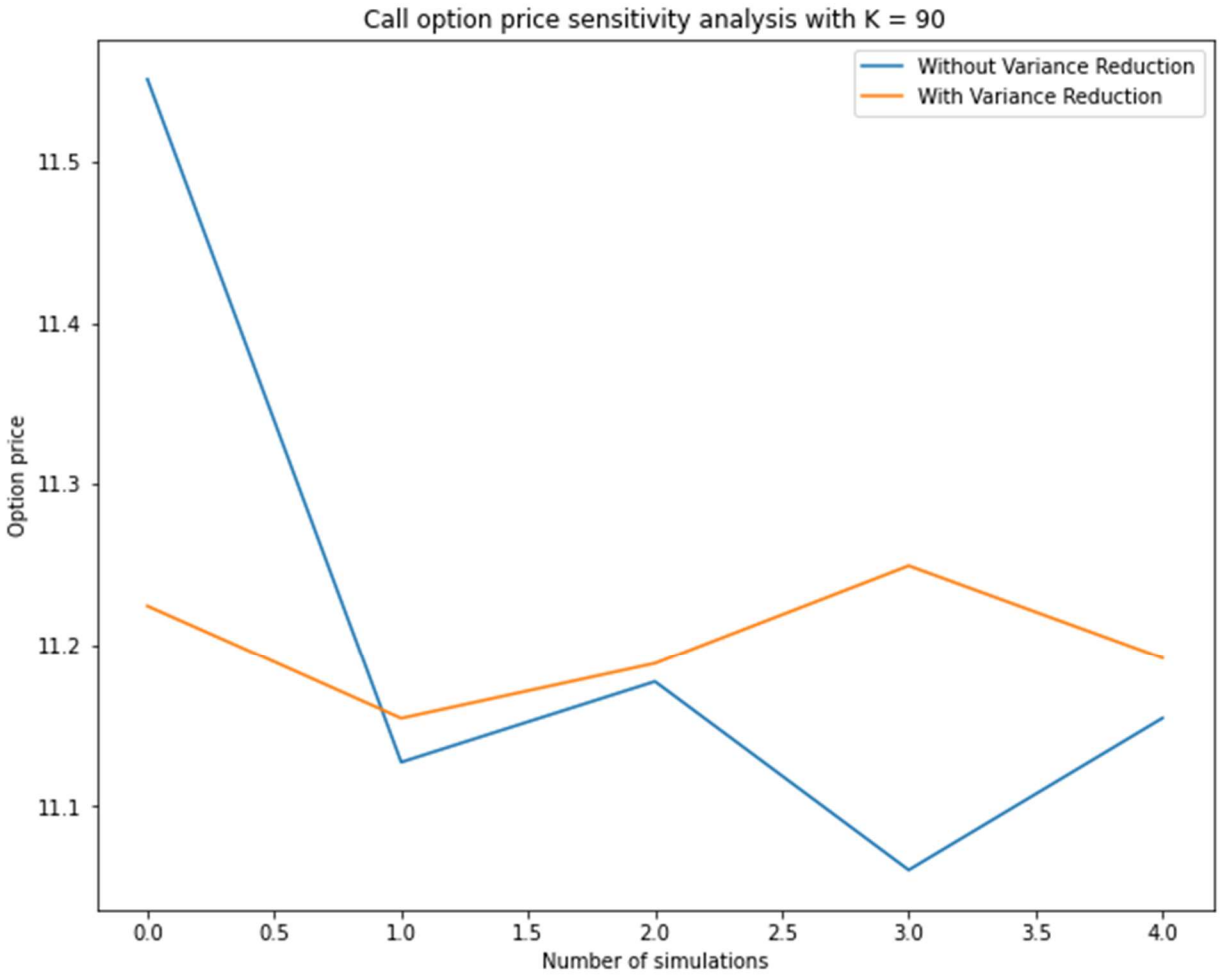

Put Option price sensitivity analysis
Option price
Risk-free rate
0
1
2
3
4
5
0.2
0.4
0.6
0.8
1.0


Put Option price sensitivity analysis
Option price
Maturity
4.0
4.5
5.0
5.5
6.0
6.5
7.0
7.5
50
100
150
200
250
300
350

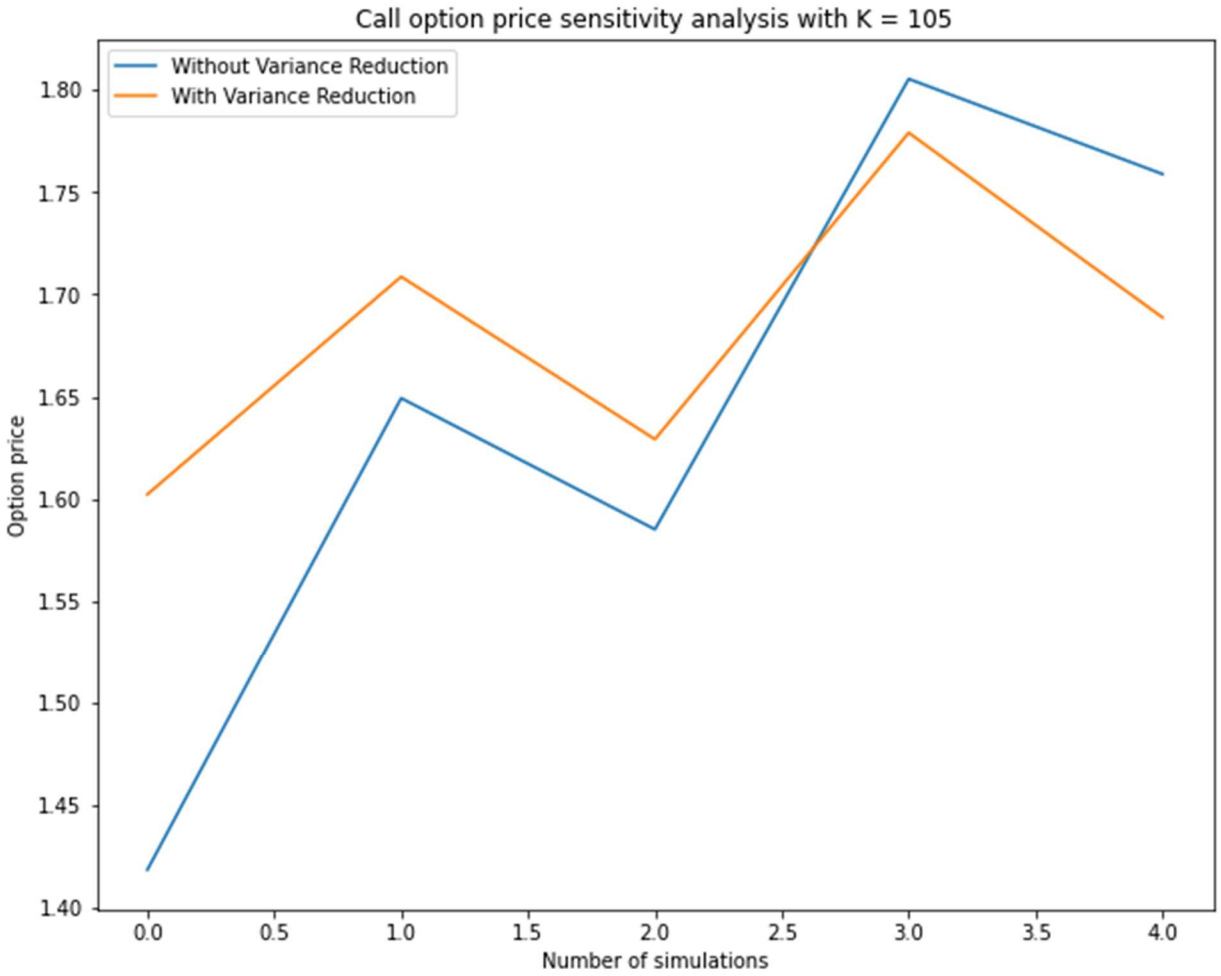
Question 2.

- In this question, we employ the variance reduction techniques and repeat the above exercise.
- We most definitely observe a reduction in variance as we note down the variance for call and put option prices for K = 90, 105 and 110.

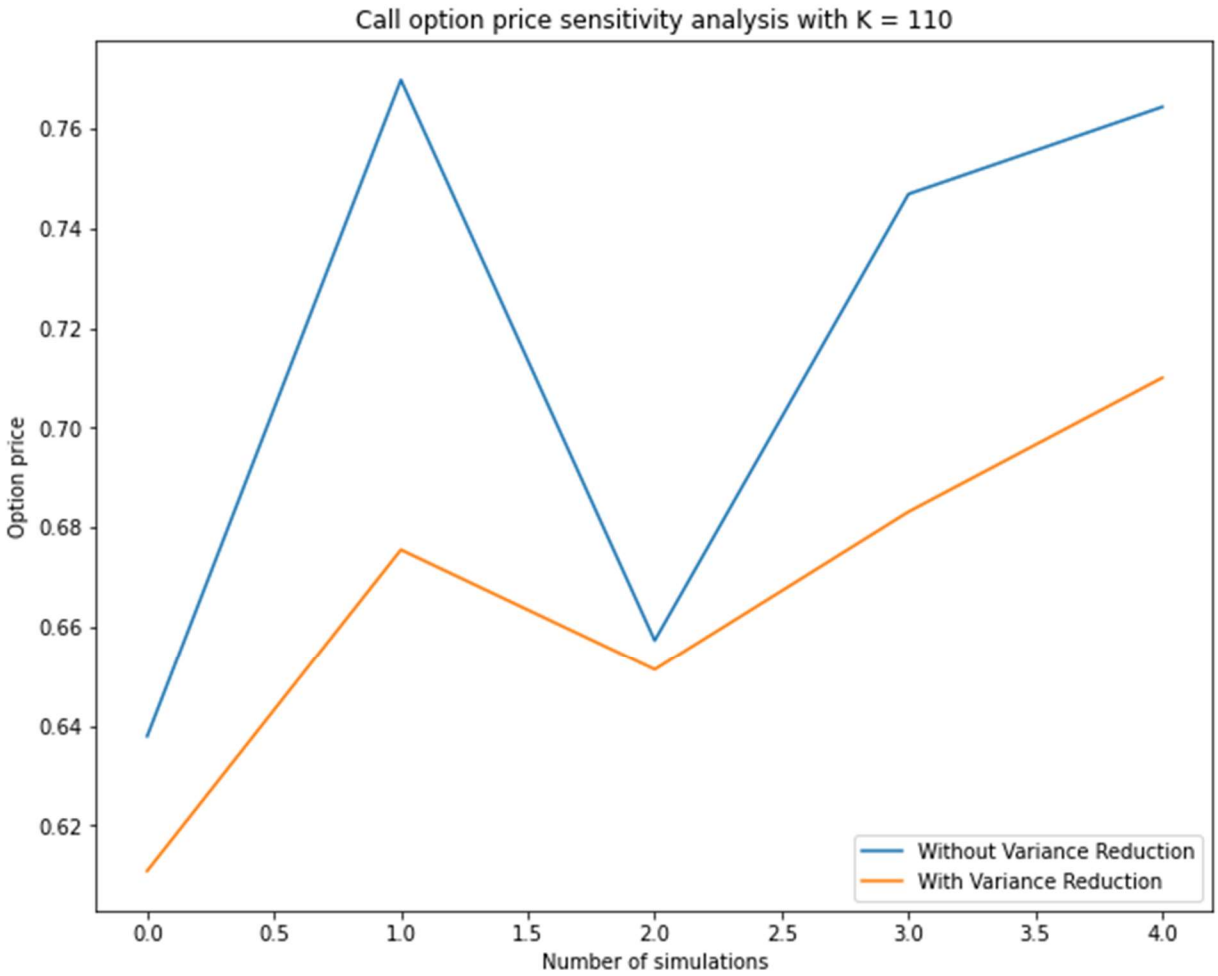
```
Variance of Call option price without variance reduction
for K = 90 is 0.02995
Variance of Call option price with variance reduction for K
= 90 is 0.00106
```



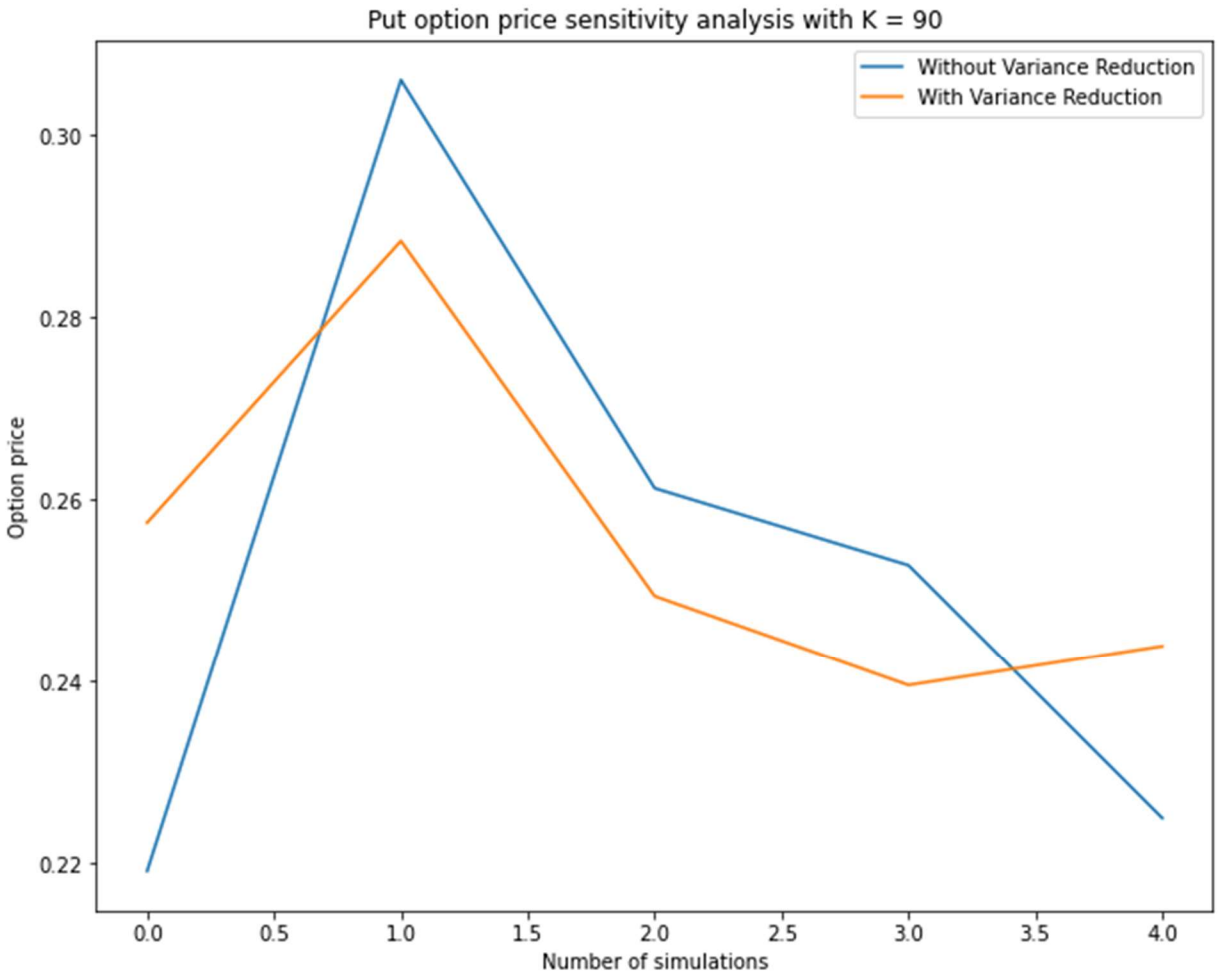
```
Variance of Call option price without variance reduction
for K = 105 is 0.01869
Variance of Call option price with variance reduction for K
= 105 is 0.00387
```



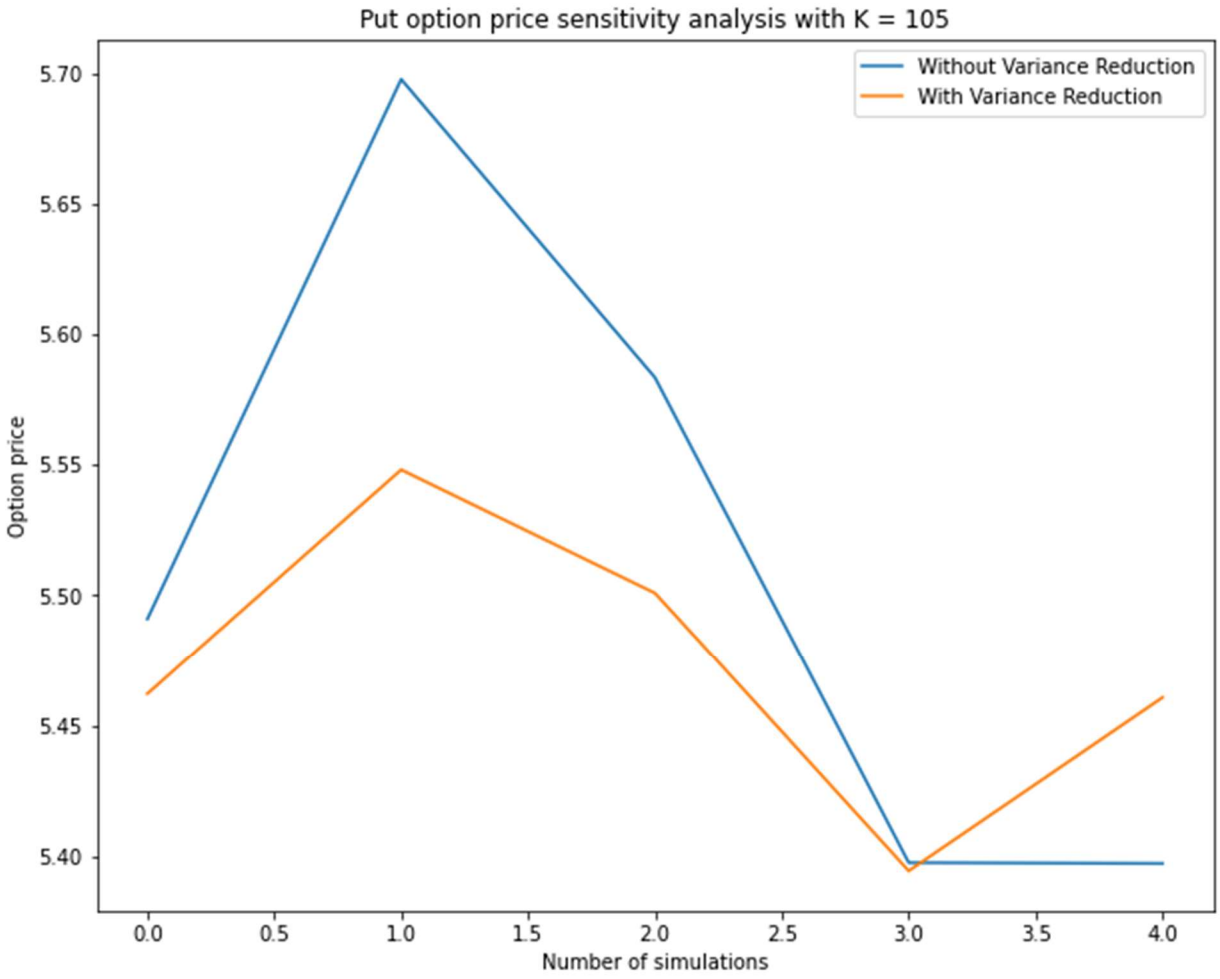
```
Variance of Call option price without variance reduction
for K = 110 is 0.00314
Variance of Call option price with variance reduction for K
= 110 is 0.00111
```



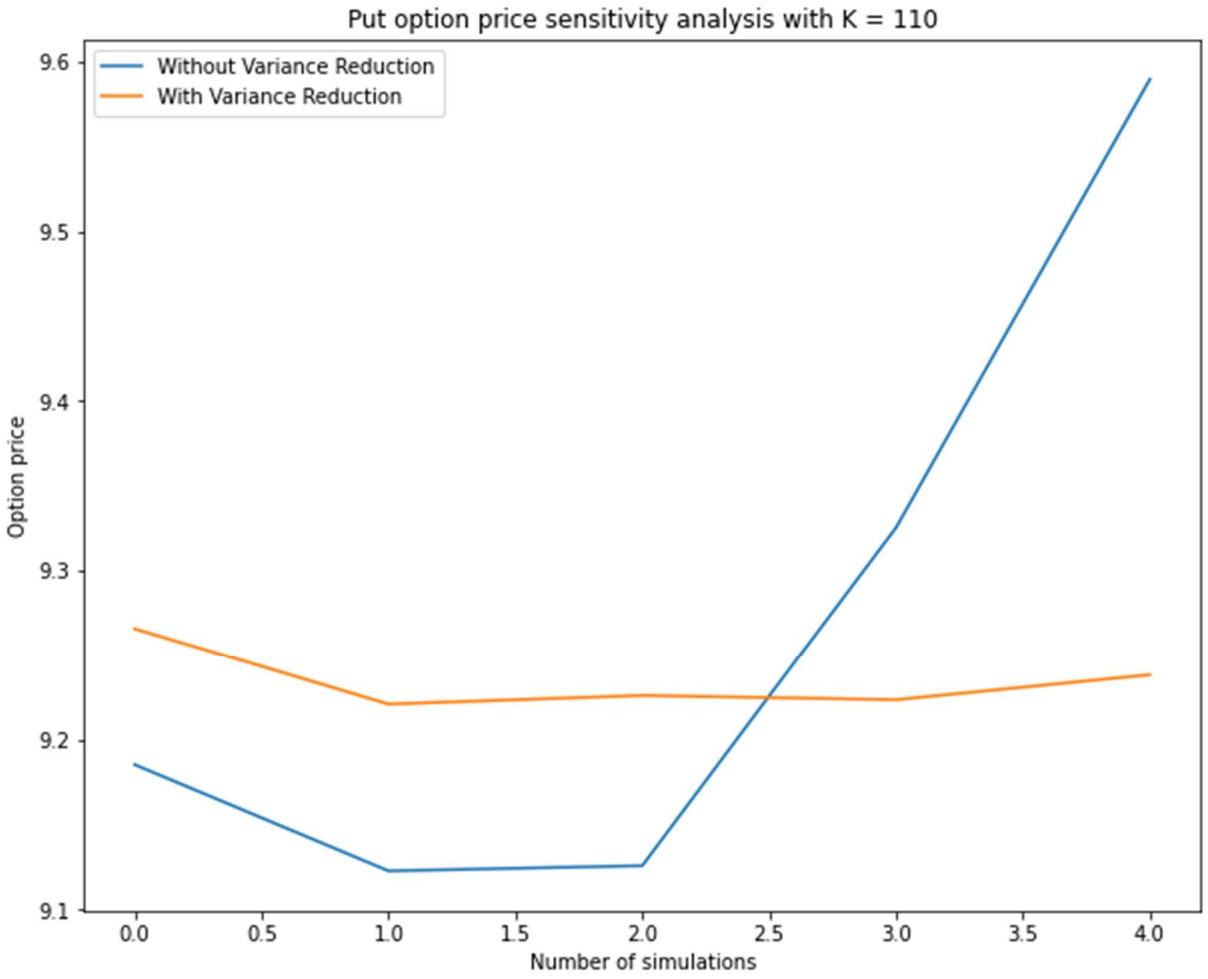
```
Variance of Put option price without variance reduction for
K = 90 is 0.00096
Variance of Put option price with variance reduction for K
= 90 is 0.0003
```



```
Variance of Put option price without variance reduction for
K = 155 is 0.01324
Variance of Put option price with variance reduction for K
= 105 is 0.00257
```



```
Variance of Put option price without variance reduction for
K = 110 is 0.03098
Variance of Put option price with variance reduction for K
= 110 is 0.00027
```



- As is clearly seen in each case, using variance reduction techniques has helped us reduce the variance in the respective option prices.