# MA374 – Financial Engineering II

LAB 07 Report

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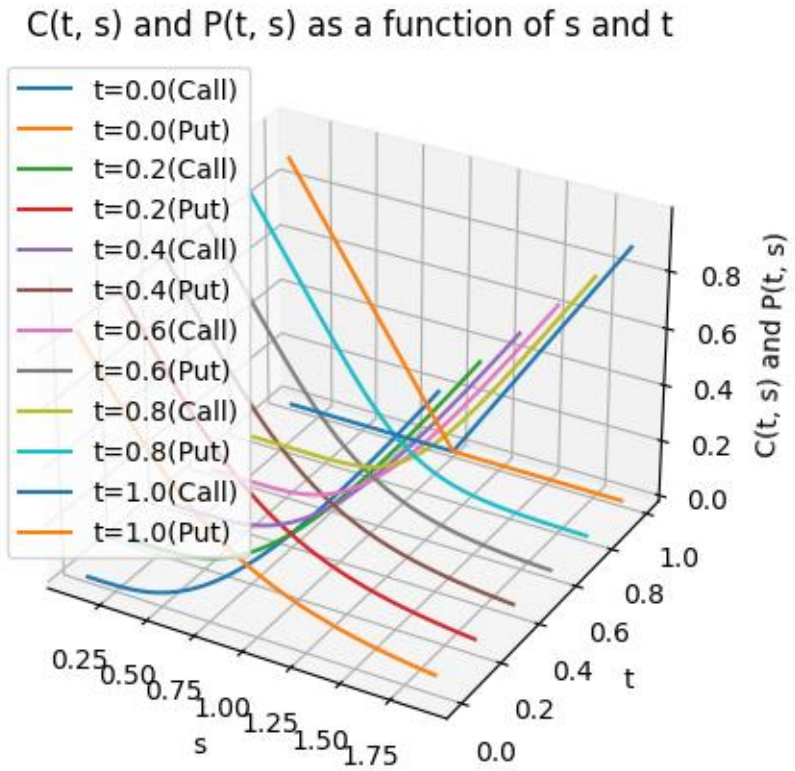
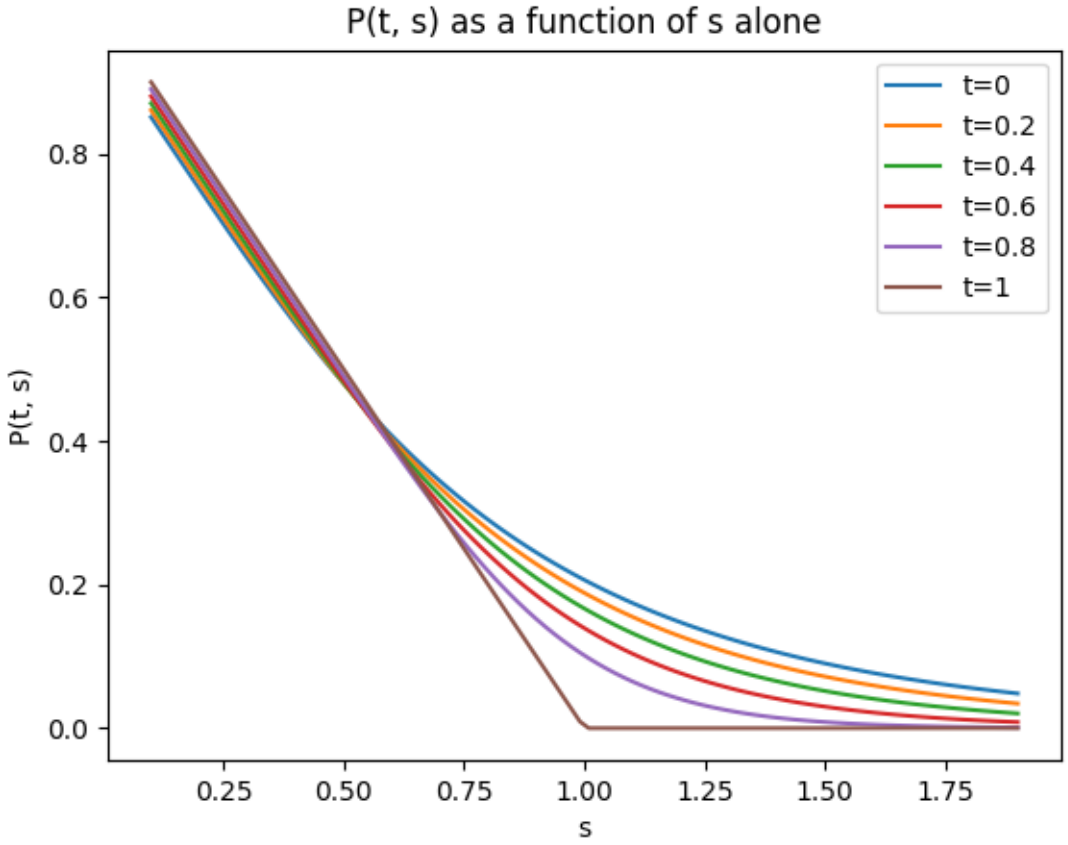
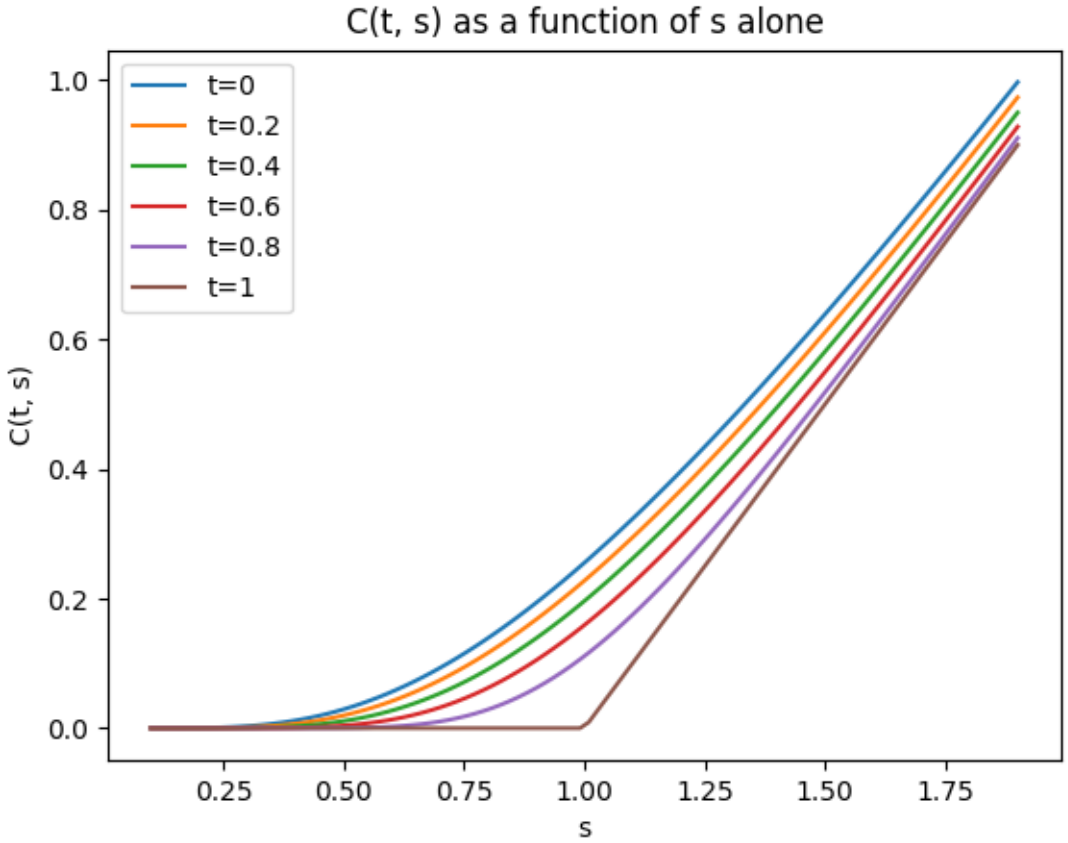
*Question 2*



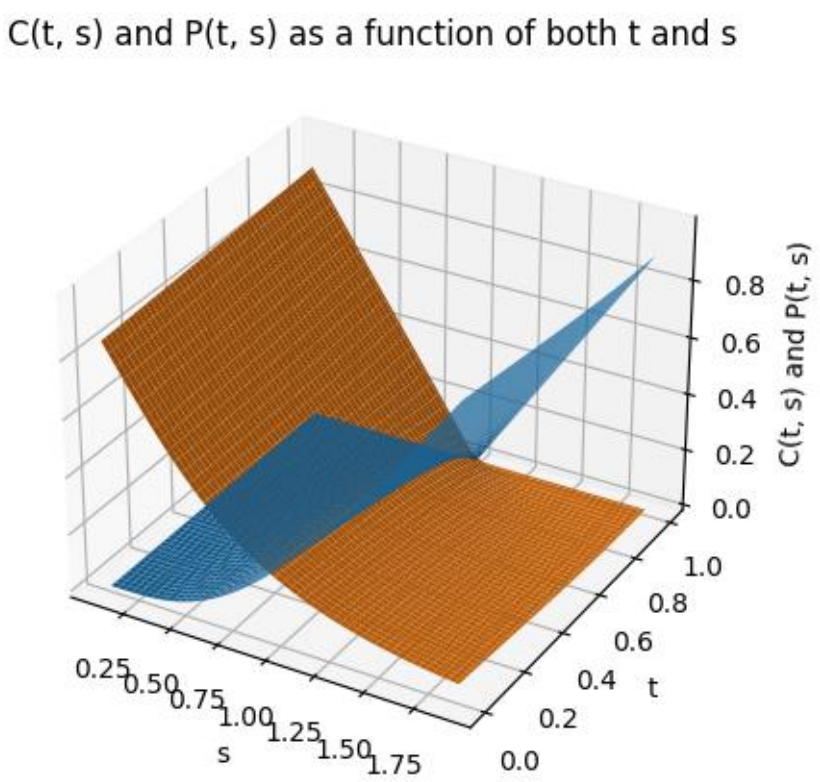



Observation -

1. All the curves are smooth except the final time curve. This makes sense because at final time the exact value is known and given by $(S(T) - K)^+$ and $(K - S(T))^+$ for call and put options respectively.
2. The value for call is more at earlier time as expected but surprisingly put doesn't follow that trend for low stock price.

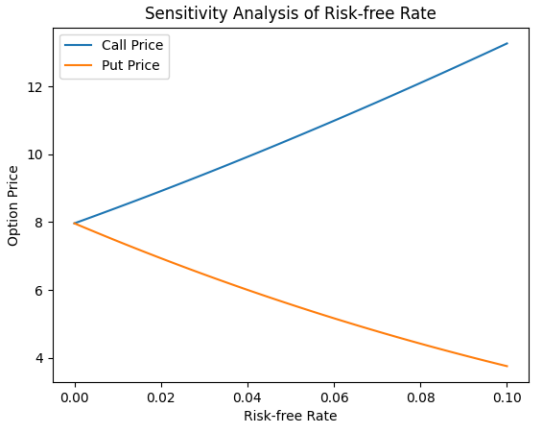
## *Question 3*

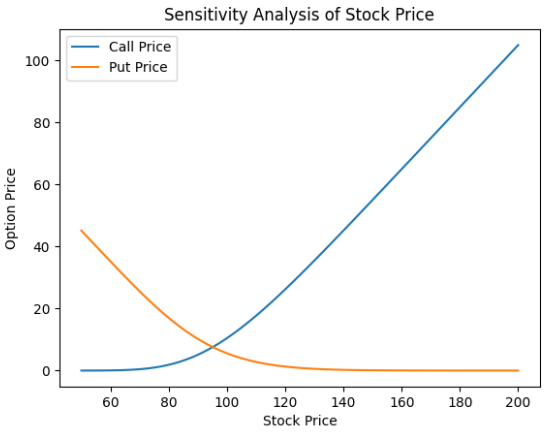


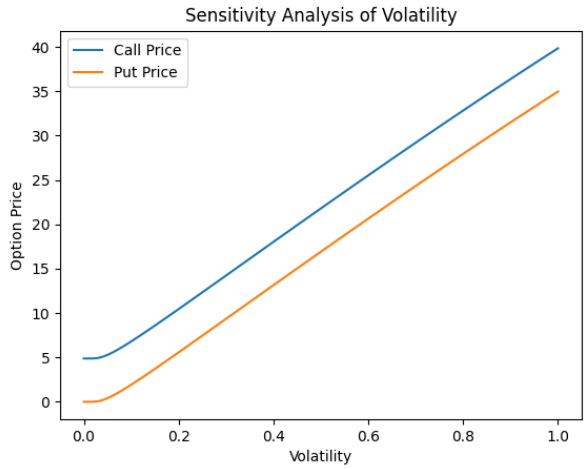

## *Question 4*

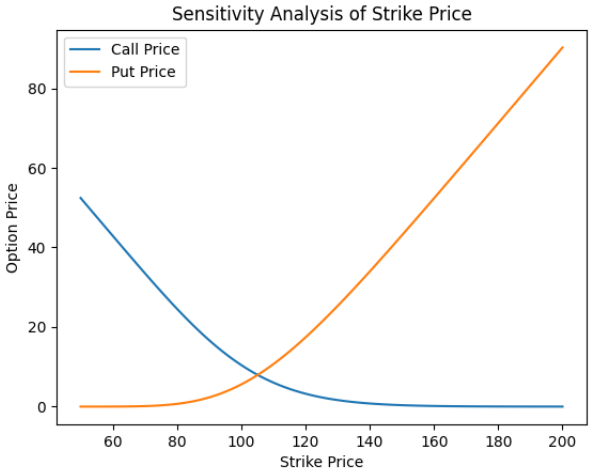
Sensitivity analysis was done on the following parameters with default values given as –

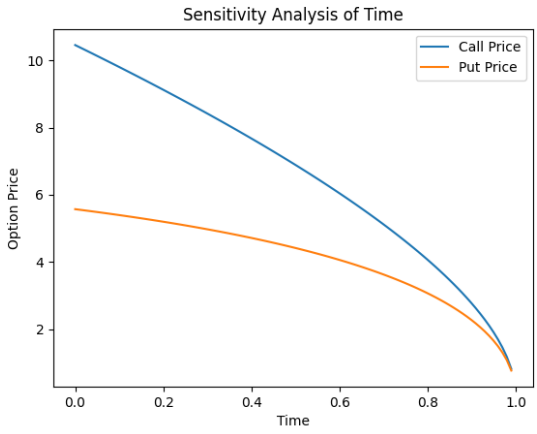
```
'S': 'Stock Price' = 100,
'K': 'Strike Price'= 100,
'r': 'Risk-free Rate'= 0.05,
't': 'Time' = 0,
'sigma': 'Volatility' = 0.2,
```


Sensitivity Analysis of Risk-free Rate
Call Price
Put Price
Option Price
Risk-free Rate
0.00
0.02
0.04
0.06
0.08
0.10
4
6
8
10
12

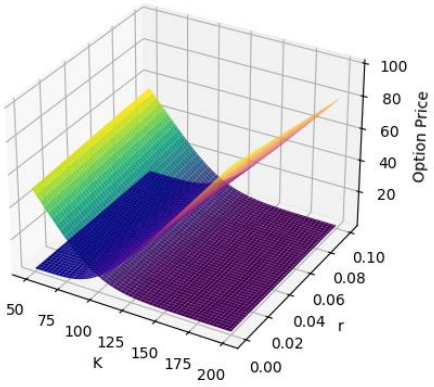

Sensitivity Analysis of Stock Price
Call Price
Put Price
Option Price
Stock Price
60
80
100
120
140
160
180
200
0
20
40
60
80
100


Sensitivity Analysis of Volatility
Call Price
Put Price
Option Price
Volatility
0.0
0.2
0.4
0.6
0.8
1.0
0
5
10
15
20
25
30
35
40

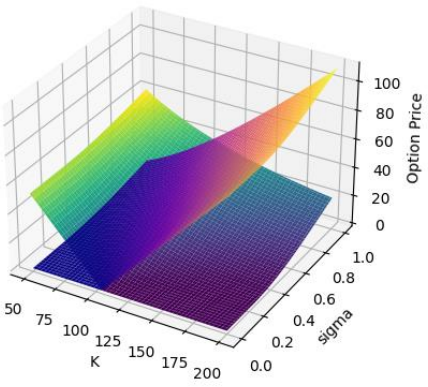

Sensitivity Analysis of Strike Price
Call Price
Put Price
Option Price
Strike Price
60
80
100
120
140
160
180
200
0
20
40
60
80


Sensitivity Analysis of Time
Call Price
Put Price
Option Price
Time
0.0
0.2
0.4
0.6
0.8
1.0
2
4
6
8
10

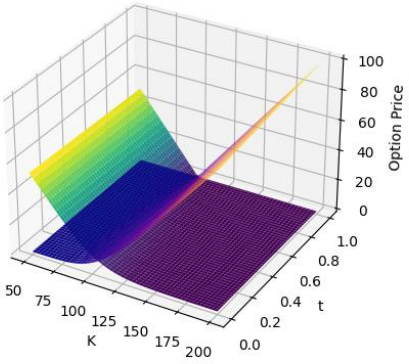
Sensitivity Analysis of K and r



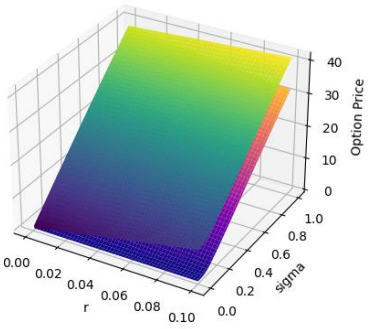

Sensitivity Analysis of K and sigma



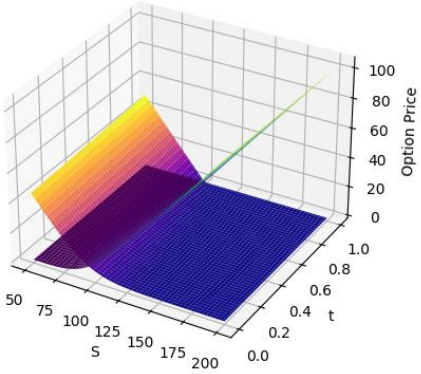

Sensitivity Analysis of K and t



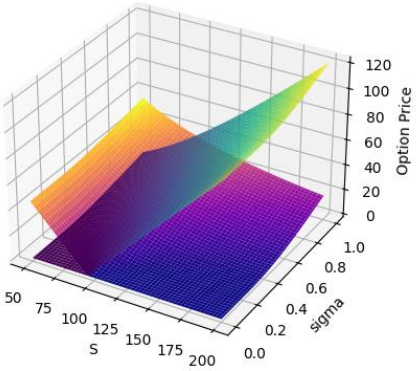

Sensitivity Analysis of r and sigma

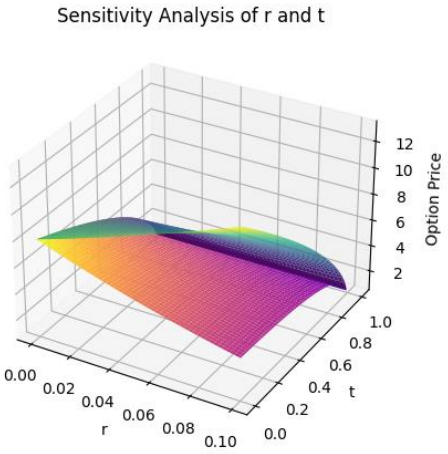


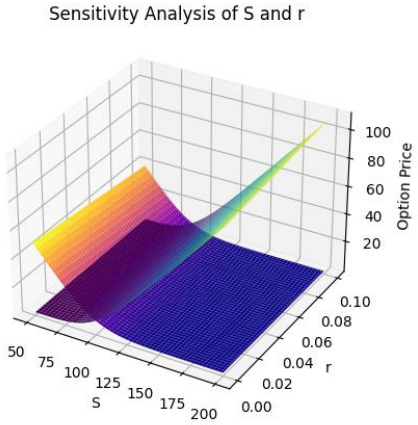

Sensitivity Analysis of S and t

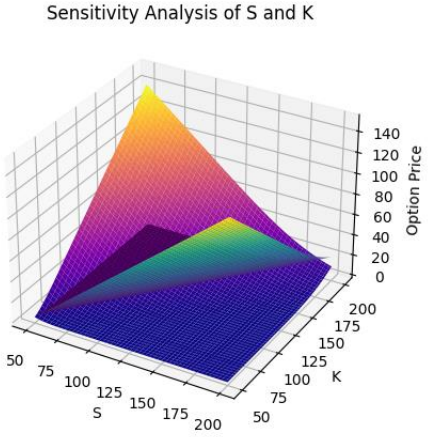


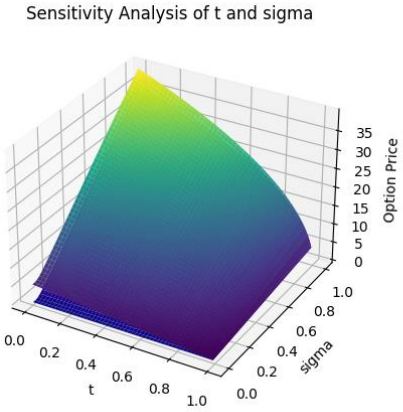

Sensitivity Analysis of S and sigma






Sensitivity Analysis of Stock Price

| Stock Price | Call Price | Put Price |
|---|---|---|
| 56.0606 | 0.0185102 | 39.0808 |
| 57.5758 | 0.0286071 | 37.5758 |
| 62.1212 | 0.0910336 | 33.0928 |
| 59.0909 | 0.0430805 | 36.0751 |
| 53.0303 | 0.00711217 | 42.0998 |
| 51.5152 | 0.00420411 | 43.612 |
| 54.5455 | 0.0116476 | 40.5891 |
| 63.6364 | 0.128142 | 31.6147 |
| 60.6061 | 0.0633312 | 34.5802 |
| 50 | 0.00239942 | 45.1253 |

Sensitivity Analysis of Time

| Time | Call Price | Put Price |
|---|---|---|
| 0 | 10.4506 | 5.57353 |
| 0.0808081 | 9.92515 | 5.43321 |
| 0.0606061 | 10.0579 | 5.46952 |
| 0.010101 | 10.3857 | 5.55668 |
| 0.0505051 | 10.1239 | 5.48736 |
| 0.030303 | 10.2552 | 5.52242 |
| 0.0909091 | 9.85842 | 5.41473 |
| 0.0707071 | 9.99164 | 5.45147 |
| 0.020202 | 10.3206 | 5.53965 |
| 0.040404 | 10.1897 | 5.50499 |

Sensitivity Analysis of Strike Price

| Strike Price | Call Price | Put Price |
|---|---|---|
| 53.0303 | 49.5571 | 0.00112687 |
| 63.6364 | 39.4973 | 0.0301141 |
| 51.5152 | 50.9979 | 0.000624476 |
| 57.5758 | 45.2377 | 0.00542954 |
| 56.0606 | 46.6768 | 0.00331485 |
| 59.0909 | 43.7996 | 0.00864882 |
| 50 | 52.4389 | 0.000333342 |
| 62.1212 | 40.9288 | 0.0203348 |
| 54.5455 | 48.1167 | 0.0019641 |
| 60.6061 | 42.3632 | 0.0134235 |

Sensitivity Analysis of Risk-free Rate

| Risk-free Rate | Call Price | Put Price |
|---|---|---|
| 0.0030303 | 8.10571 | 7.80314 |
| 0.00707071 | 8.29474 | 7.59016 |
| 0 | 7.96557 | 7.96557 |
| 0.00909091 | 8.39017 | 7.4852 |
| 0.0020202 | 8.05884 | 7.85703 |
| 0.0010101 | 8.01213 | 7.91117 |
| 0.00606061 | 8.24725 | 7.64302 |
| 0.0040404 | 8.15274 | 7.74951 |
| 0.00505051 | 8.19992 | 7.69614 |
| 0.00808081 | 8.34238 | 7.53755 |

Sensitivity Analysis of Volatility

| Volatility | Call Price | Put Price |
|---|---|---|
| 0 | 4.87706 | 0 |
| 0.0606061 | 5.55664 | 0.67958 |
| 0.040404 | 5.08163 | 0.204577 |
| 0.020202 | 4.88132 | 0.00426551 |
| 0.0909091 | 6.49702 | 1.61996 |
| 0.0707071 | 5.85016 | 0.973106 |
| 0.010101 | 4.87706 | 6.87804e-08 |
| 0.0808081 | 6.16578 | 1.28872 |
| 0.030303 | 4.93804 | 0.0609871 |
| 0.0505051 | 5.29524 | 0.418186 |

Sensitivity Analysis of S and K

| S | K | Call Price | Put Price |
|---|---|---|---|
| 54.5455 | 57.5758 | 7.7795 | 2.08898 |
| 53.0303 | 60.6061 | 11.2339 | 1.07181 |
| 57.5758 | 54.5455 | 4.24346 | 4.46576 |
| 60.6061 | 53.0303 | 2.47563 | 7.0956 |
| 59.0909 | 59.0909 | 6.17534 | 3.29345 |
| 51.5152 | 56.0606 | 8.6215 | 1.56362 |
| 56.0606 | 62.1212 | 10.266 | 1.4713 |
| 50 | 63.6364 | 16.43 | 0.355093 |
| 62.1212 | 51.5152 | 1.60967 | 9.18604 |
| 63.6364 | 50 | 0.993387 | 11.5262 |

Sensitivity Analysis of S and t

| S | t | Call Price | Put Price |
|---|---|---|---|
| 51.5152 | 0.040404 | 0.0174948 | 39.1279 |
| 57.5758 | 0.030303 | 0.00850198 | 40.8265 |
| 63.6364 | 0.0909091 | 0.0877255 | 32.0077 |
| 62.1212 | 0.020202 | 0.0040721 | 42.4818 |
| 53.0303 | 0.0606061 | 0.0390411 | 36.1672 |
| 59.0909 | 0.0505051 | 0.0205728 | 37.8564 |
| 50 | 0.0808081 | 0.0910336 | 33.0928 |
| 54.5455 | 0.010101 | 0.00339344 | 43.7554 |
| 56.0606 | 0 | 0.00175989 | 45.3171 |
| 60.6061 | 0.0707071 | 0.0452881 | 34.8991 |

Sensitivity Analysis of S and r

| S | r | Call Price | Put Price |
|---|---|---|---|
| 54.5455 | 0.00707071 | 0.0321293 | 39.1235 |
| 56.0606 | 0.00909091 | 0.0691707 | 36.0296 |
| 63.6364 | 0.0040404 | 0.00959841 | 43.044 |
| 50 | 0.00505051 | 0.0131299 | 42.4374 |
| 57.5758 | 0.0010101 | 0.00187578 | 47.9829 |
| 59.0909 | 0 | 0.00105929 | 49.3968 |
| 53.0303 | 0.0030303 | 0.00522009 | 45.2579 |
| 62.1212 | 0.00606061 | 0.023038 | 40.1273 |
| 51.5152 | 0.00808081 | 0.0459638 | 37.8238 |
| 60.6061 | 0.0020202 | 0.0033856 | 46.2685 |

Sensitivity Analysis of S and sigma

| S | sigma | Call Price | Put Price |
|---|---|---|---|
| 53.0303 | 0 | 4.52196e-224 | 45.1229 |
| 57.5758 | 0.030303 | 5.46711e-29 | 40.5775 |
| 56.0606 | 0.0909091 | 3.94075e-24 | 31.4866 |
| 60.6061 | 0.0505051 | 4.4058e-13 | 37.5472 |
| 51.5152 | 0.0606061 | 0 | 36.032 |
| 50 | 0.0808081 | 0 | 33.0017 |
| 63.6364 | 0.020202 | 6.23175e-11 | 42.0926 |
| 54.5455 | 0.040404 | 2.23341e-69 | 39.0623 |
| 59.0909 | 0.0707071 | 3.06043e-14 | 34.5169 |
| 62.1212 | 0.010101 | 1.15739e-14 | 43.6078 |

Sensitivity Analysis of K and r

| K | r | Call Price | Put Price |
|---|---|---|---|
| 59.0909 | 0.00808081 | 38.2954 | 0.0412228 |
| 63.6364 | 0.00606061 | 41.4613 | 0.0174752 |
| 57.5758 | 0.00909091 | 36.7448 | 0.0606038 |
| 53.0303 | 0.0020202 | 47.0796 | 0.00287226 |
| 51.5152 | 0 | 50.0514 | 0.000924016 |
| 60.6061 | 0.00707071 | 39.8484 | 0.0274026 |
| 54.5455 | 0.0040404 | 44.1168 | 0.00782237 |
| 56.0606 | 0.0030303 | 45.6792 | 0.00468095 |
| 50 | 0.00505051 | 42.4374 | 0.0131299 |
| 62.1212 | 0.0010101 | 48.9009 | 0.00145745 |

Sensitivity Analysis of K and sigma

| K | sigma | Call Price | Put Price |
|---|---|---|---|
| 59.0909 | 0.0808081 | 40.9085 | 1.03181e-18 |
| 63.6364 | 0.0606061 | 43.791 | 1.20241e-10 |
| 57.5758 | 0.020202 | 49.556 | 1.04766e-42 |
| 53.0303 | 0.040404 | 46.6735 | 2.82904e-214 |
| 62.1212 | 0.0505051 | 45.2322 | 3.60253e-14 |
| 51.5152 | 0.010101 | 50.9973 | 0 |
| 50 | 0.0707071 | 42.3497 | 0 |
| 54.5455 | 0.030303 | 48.1148 | 2.89043e-105 |
| 56.0606 | 0 | 52.4385 | 1.12765e-76 |
| 60.6061 | 0.0909091 | 39.4672 | 4.67234e-13 |

Sensitivity Analysis of K and t

| K | t | Call Price | Put Price |
|---|---|---|---|
| 62.1212 | 0 | 52.2462 | 0.000177922 |
| 59.0909 | 0.040404 | 46.514 | 0.00235769 |
| 51.5152 | 0.020202 | 49.5316 | 0.00105807 |
| 54.5455 | 0.0606061 | 43.7133 | 0.00750531 |
| 53.0303 | 0.0707071 | 42.3038 | 0.0123097 |
| 63.6364 | 0.0505051 | 44.9861 | 0.00333413 |
| 60.6061 | 0.0808081 | 40.7144 | 0.0151569 |
| 50 | 0.030303 | 48.1167 | 0.0019641 |
| 57.5758 | 0.010101 | 50.8738 | 0.000438699 |
| 56.0606 | 0.0909091 | 39.3707 | 0.0259025 |

Sensitivity Analysis of r and t

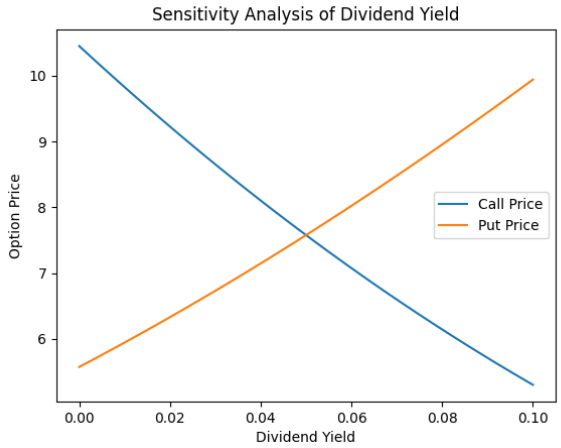
| r | t | Call Price | Put Price |
|---|---|---|---|
| 0.00606061 | 0.0808081 | 8.07599 | 7.31976 |
| 0 | 0 | 7.96557 | 7.96557 |
| 0.0020202 | 0.020202 | 7.97643 | 7.77869 |
| 0.00808081 | 0.0909091 | 8.02947 | 7.19732 |
| 0.00707071 | 0.0707071 | 7.98644 | 7.33152 |
| 0.0010101 | 0.010101 | 7.97148 | 7.87154 |
| 0.00505051 | 0.030303 | 7.89581 | 7.6085 |
| 0.0030303 | 0.040404 | 8.02607 | 7.63504 |
| 0.00909091 | 0.0505051 | 7.80985 | 7.35177 |
| 0.0040404 | 0.0606061 | 8.07425 | 7.49436 |

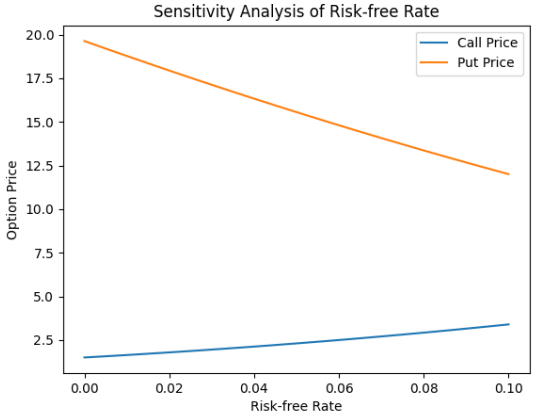
Few Observations –

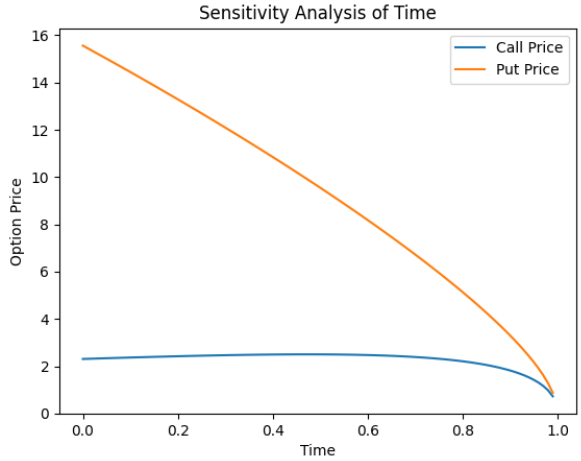
- The impact of volatility is more pronounced at lower stock prices. This is because the option is already in-the-money at these lower prices, so a further increase in volatility makes the option even more valuable.
- At very high stock prices, the impact of volatility on the option price diminishes. This is because at high stock prices, the option is far out-of-the-money, so the probability of it becoming valuable is low regardless of the volatility.
- Volatility increases the price almost linearly for both the options.

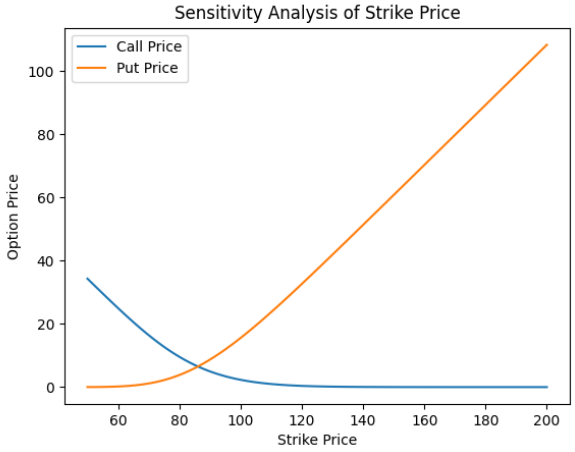
## *Question 5*

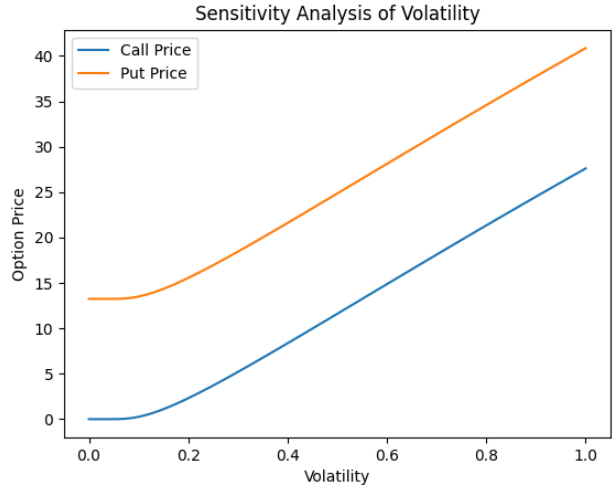
Now we change the dividend to 0.2 from 0.0

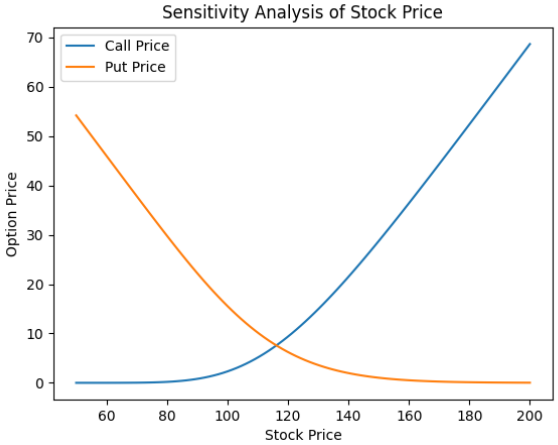


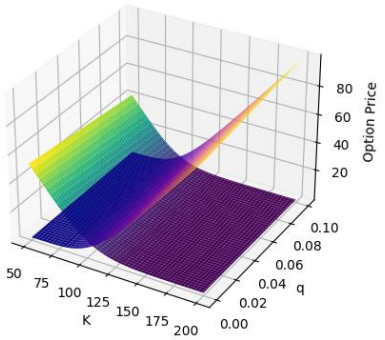



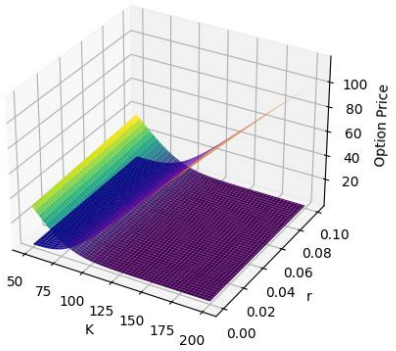



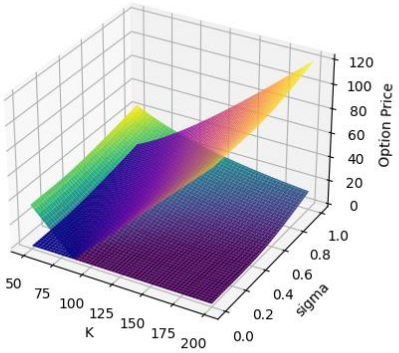
Sensitivity Analysis of K and q



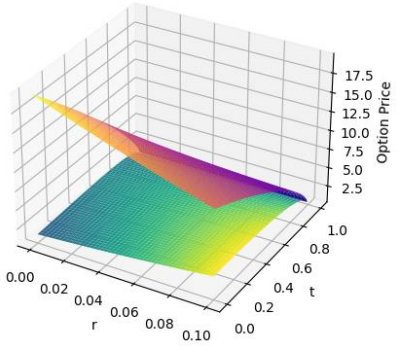

Sensitivity Analysis of K and r



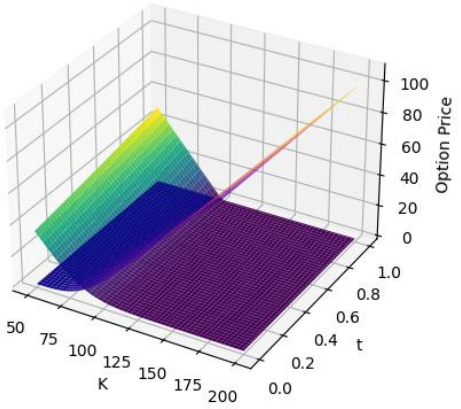

Sensitivity Analysis of K and sigma



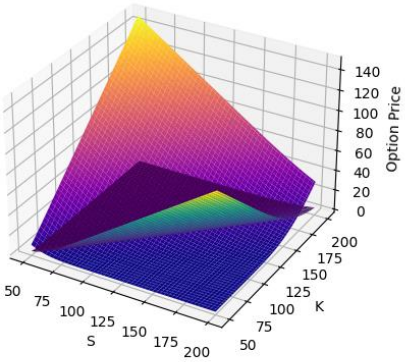

Sensitivity Analysis of r and t



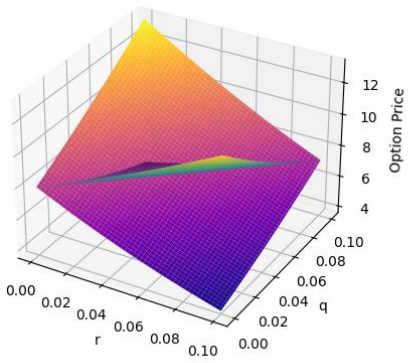

Sensitivity Analysis of K and t



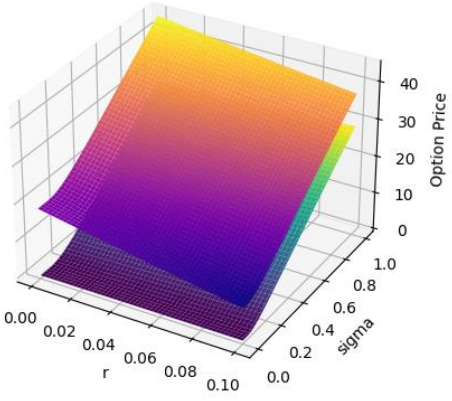

Sensitivity Analysis of S and K



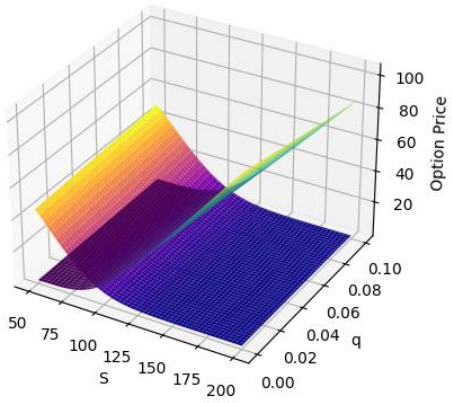

Sensitivity Analysis of r and q



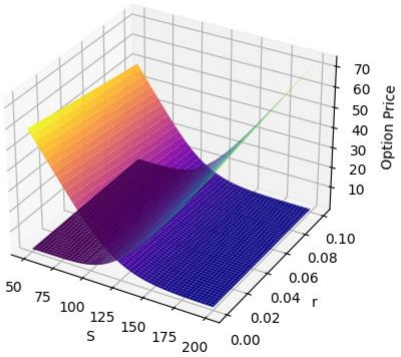

Sensitivity Analysis of r and sigma



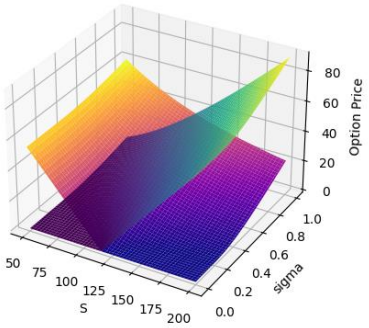
Sensitivity Analysis of S and q



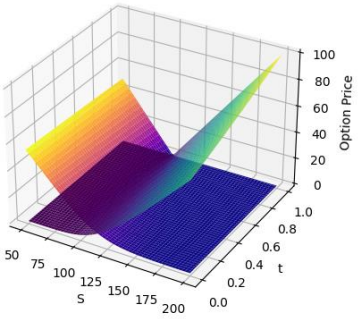

Sensitivity Analysis of S and r



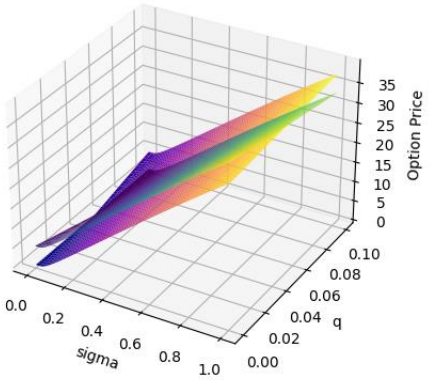

Sensitivity Analysis of S and sigma



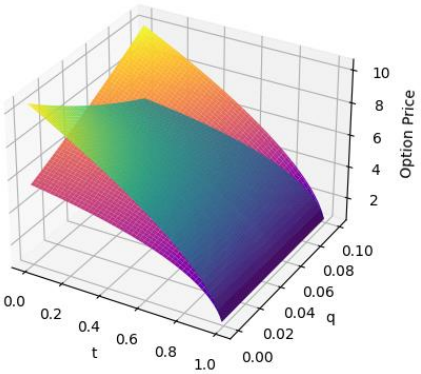

Sensitivity Analysis of S and t



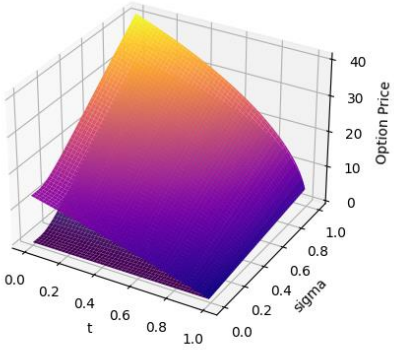

Sensitivity Analysis of sigma and q




Sensitivity Analysis of t and q




Sensitivity Analysis of t and sigma



Sensitivity Analysis of Dividend Yield

| Dividend Yield | Call Price | Put Price |
|---|---|---|
| 0.0030303 | 10.2588 | 5.68427 |
| 0.0010101 | 10.3864 | 5.61029 |
| 0.00707071 | 10.0066 | 5.83409 |
| 0 | 10.4506 | 5.57353 |
| 0.0020202 | 10.3224 | 5.6472 |
| 0.00808081 | 9.94417 | 5.87193 |
| 0.0040404 | 10.1953 | 5.7215 |
| 0.00606061 | 10.0692 | 5.79641 |
| 0.00505051 | 10.1322 | 5.75887 |
| 0.00909091 | 9.88202 | 5.90993 |

Sensitivity Analysis of S and q

| S | q | Call Price | Put Price |
|---|---|---|---|
| 60.6061 | 0 | 0.00209487 | 45.4773 |
| 50 | 0.00808081 | 0.0910336 | 33.0928 |
| 63.6364 | 0.0010101 | 0.00355148 | 44.0775 |
| 51.5152 | 0.00707071 | 0.0623812 | 34.6405 |
| 59.0909 | 0.00909091 | 0.117716 | 31.9888 |
| 54.5455 | 0.0040404 | 0.0175998 | 39.2496 |
| 53.0303 | 0.00606061 | 0.0417518 | 36.193 |
| 57.5758 | 0.0030303 | 0.0106753 | 40.863 |
| 62.1212 | 0.0020202 | 0.00615401 | 42.5256 |
| 56.0606 | 0.00505051 | 0.0268075 | 37.8062 |

Sensitivity Analysis of t and q

| t | q | Call Price | Put Price |
|---|---|---|---|
| 0.0909091 | 0.00707071 | 9.46686 | 5.76794 |
| 0.0707071 | 0.00505051 | 9.70439 | 5.73696 |
| 0.020202 | 0.0040404 | 10.0672 | 5.5762 |
| 0.010101 | 0 | 10.3864 | 5.61029 |
| 0 | 0.00808081 | 9.92515 | 5.43321 |
| 0.0505051 | 0.0010101 | 10.0708 | 5.74049 |
| 0.030303 | 0.0030303 | 10.0698 | 5.63039 |
| 0.0606061 | 0.00606061 | 9.7018 | 5.68114 |
| 0.040404 | 0.00909091 | 9.62852 | 5.55146 |
| 0.0808081 | 0.0020202 | 9.82535 | 5.83305 |

Sensitivity Analysis of sigma and q

| sigma | q | Call Price | Put Price |
|---|---|---|---|
| 0.0808081 | 0.00707071 | 5.24385 | 1.17162 |
| 0.0505051 | 0.0030303 | 4.46301 | 0.0897259 |
| 0.0606061 | 0.00606061 | 5.07954 | 0.806712 |
| 0.040404 | 0.00505051 | 4.95846 | 0.484628 |
| 0.020202 | 0.0010101 | 4.67524 | 1.95219e-07 |
| 0.0707071 | 0 | 4.17248 | 0 |
| 0.030303 | 0.00909091 | 6.27958 | 1.7051 |
| 0 | 0.00808081 | 6.16578 | 1.28872 |
| 0.010101 | 0.0040404 | 4.99143 | 0.215333 |
| 0.0909091 | 0.0020202 | 3.98766 | 0.0155699 |

Sensitivity Analysis of r and q

| r | q | Call Price | Put Price |
|---|---|---|---|
| 0.00505051 | 0.00606061 | 7.97176 | 7.87131 |
| 0 | 0 | 7.96557 | 7.96557 |
| 0.00606061 | 0.00909091 | 8.05674 | 7.75599 |
| 0.00909091 | 0.00808081 | 7.8475 | 7.94764 |
| 0.00707071 | 0.0040404 | 7.77168 | 8.07303 |
| 0.00808081 | 0.00707071 | 7.85543 | 7.95568 |
| 0.0030303 | 0.0020202 | 7.8952 | 7.99596 |
| 0.0010101 | 0.00505051 | 8.14451 | 7.74169 |
| 0.0020202 | 0.0010101 | 7.90318 | 8.00404 |
| 0.0040404 | 0.0030303 | 7.88723 | 7.98788 |

Sensitivity Analysis of K and q

| K | q | Call Price | Put Price |
|---|---|---|---|
| 62.1212 | 0.0010101 | 50.1932 | 0.00073164 |
| 53.0303 | 0.00606061 | 43.5981 | 0.00894408 |
| 57.5758 | 0 | 51.9351 | 0.000369348 |
| 56.0606 | 0.00909091 | 39.096 | 0.0319948 |
| 50 | 0.00505051 | 45.2377 | 0.00542954 |
| 60.6061 | 0.0030303 | 47.4124 | 0.00223586 |
| 51.5152 | 0.00808081 | 40.8282 | 0.0206566 |
| 54.5455 | 0.0020202 | 49.2546 | 0.00119367 |
| 59.0909 | 0.00707071 | 41.7603 | 0.0147923 |
| 63.6364 | 0.0040404 | 45.7724 | 0.00389346 |