

MA 374 – Financial Engineering Lab

Lab – 8

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Roll No - 180123053

1 QUESTION - 1:

The historical volatility from last one month's data:

SI No.	Stocks Name (from bsedata1)	Historical Volatility
1.	WIPRO.BO	0.28602
2.	BAJAJ-AUTO.BO	0.253034
3.	HDFCBANK.BO	0.15554
4.	HEROMOTOCO.BO	0.358761
5.	TCS.BO	0.179806
6.	INFY.BO	0.271099
7.	NESTLEIND.BO	0.236681
8.	MARUTI.BO	0.290557
9.	RELIANCE.BO	0.243351
10.	TATAMOTORS.BO	0.3437
11.	BSE Index	0.158524

SI No.	Stocks Name (from nsedata1)	Historical Volatility
1.	WIPRO.NS	0.259191
2.	BAJAJ-AUTO.NS	0.264682
3.	HDFCBANK.NS	0.166909
4.	HEROMOTOCO.NS	0.35209
5.	TCS.NS	0.18165
6.	INFY.NS	0.276314
7.	NESTLEIND.NS	0.236231
8.	MARUTI.NS	0.294158
9.	RELIANCE.NS	0.238356
10.	TATAMOTORS.NS	0.349414
11.	NSE Index	0.157738

2 QUESTION - 2:

Using the final price of the stock price in the data as S_0 , and taking $r = 0.05$, $t = 0$, σ = from the last 1 month's data and various prices of K , the option prices are computed:

i. For stocks in bsedata1:

***** For stocks - BSE Index *****

Historical volatility for last 1 month = 0.1585237368520172

Strike price (K)	Call Option	Put Option
0.5*S0	18483.7	3.12957e-08
0.6*S0	14965.1	0.000524672
0.7*S0	11446.8	0.283614
0.8*S0	7944.7	16.7657
0.9*S0	4638.31	228.978
1.0*S0	2077.32	1186.59
1.1*S0	675.147	3303.01
1.2*S0	159.014	6305.47
1.3*S0	28.0205	9693.08
1.4*S0	3.85727	13187.5
1.5*S0	0.43296	16702.7

***** For stocks - BAJAJ-AUTO.BO *****

Historical volatility for last 1 month = 0.25303438677643103

Strike price (K)	Call Option	Put Option
0.5*S0	1306.2	0.00213365
0.6*S0	1057.68	0.135382
0.7*S0	811.115	2.2163
0.8*S0	575.412	15.164
0.9*S0	369.624	58.0274
1.0*S0	212.711	149.765
1.1*S0	109.817	295.521
1.2*S0	51.3471	485.702
1.3*S0	22.03	705.036
1.4*S0	8.79227	940.449
1.5*S0	3.30604	1183.61

***** For stocks - HDFCBANK.BO *****

Historical volatility for last 1 month = 0.15553966425159013

Strike price (K)	Call Option	Put Option
0.5*S0	539.271	3.90402e-10
0.6*S0	436.614	9.32441e-06
0.7*S0	333.964	0.00628421
0.8*S0	231.726	0.424805
0.9*S0	134.909	6.26446
1.0*S0	59.755	33.7674
1.1*S0	18.9478	95.6168
1.2*S0	4.28852	183.614
1.3*S0	0.716102	282.698
1.4*S0	0.0923057	384.731
1.5*S0	0.00960726	487.305

***** For stocks - HEROMOTOCO.BO *****

Historical volatility for last 1 month = 0.35876095316560974

Strike price (K)	Call Option	Put Option
0.5*S0	1478.94	0.348222
0.6*S0	1200.6	3.47997
0.7*S0	933.098	17.4437
0.8*S0	690.06	55.8725
0.9*S0	484.931	132.21
1.0*S0	324.707	253.453
1.1*S0	208.244	418.457
1.2*S0	128.704	620.385
1.3*S0	77.1305	850.278
1.4*S0	45.0743	1099.69
1.5*S0	25.8144	1361.9

***** For stocks - INFY.BO *****

Historical volatility for last 1 month = 0.27109896165658304

Strike price (K)	Call Option	Put Option
0.5*S0	315.182	0.0017519
0.6*S0	255.252	0.0695031
0.7*S0	196.028	0.844335
0.8*S0	139.969	4.78336
0.9*S0	91.4716	16.2846
1.0*S0	54.3809	39.1923
1.1*S0	29.5066	74.3163
1.2*S0	14.7442	119.552
1.3*S0	6.86251	171.669
1.4*S0	3.00964	227.814
1.5*S0	1.25698	286.06

***** For stocks - MARUTI.BO *****

Historical volatility for last 1 month = 0.290557237968282

Strike price (K)	Call Option	Put Option
0.5*S0	3761.34	0.0624402
0.6*S0	3046.92	1.63927
0.7*S0	2344.58	15.3031
0.8*S0	1686.57	73.3002
0.9*S0	1121.88	224.616
1.0*S0	688.256	506.998
1.1*S0	391.131	925.879
1.2*S0	207.639	1458.39
1.3*S0	103.986	2070.74
1.4*S0	49.6062	2732.37
1.5*S0	22.7419	3421.51

***** For stocks - NESTLEIND.BO *****

Historical volatility for last 1 month = 0.23668108599521595

Strike price (K)	Call Option	Put Option
0.5*S0	5503.09	0.00236676
0.6*S0	4455.76	0.252398
0.7*S0	3413.67	5.73956
0.8*S0	2408.63	48.2785
0.9*S0	1522.42	209.646
1.0*S0	847.916	582.72
1.1*S0	415.583	1197.96
1.2*S0	180.997	2010.96
1.3*S0	71.1031	2948.64
1.4*S0	25.6038	3950.72
1.5*S0	8.58046	4981.27

***** For stocks - RELIANCE.BO *****

Historical volatility for last 1 month = 0.24335114679176587

Strike price (K)	Call Option	Put Option
0.5*S0	571.507	0.000436405
0.6*S0	462.751	0.0371912
0.7*S0	354.654	0.733932
0.8*S0	250.775	5.64814
0.9*S0	159.565	23.231
1.0*S0	90.1009	62.5597
1.1*S0	45.1471	126.399
1.2*S0	20.2691	210.314
1.3*S0	8.26969	307.108
1.4*S0	3.11262	410.744
1.5*S0	1.09617	517.521

***** For stocks - TATAMOTORS.BO *****

Historical volatility for last 1 month = 0.34369983443720353

Strike price (K)	Call Option	Put Option
0.5*S0	87.5214	0.0128947
0.6*S0	71.0024	0.152189
0.7*S0	55.0417	0.849737
0.8*S0	40.4543	2.92068
0.9*S0	28.1123	7.23692
1.0*S0	18.5098	14.2928
1.1*S0	11.6081	24.0493
1.2*S0	6.97985	36.0794
1.3*S0	4.0514	49.8092
1.4*S0	2.28448	64.7006
1.5*S0	1.25842	80.3328

***** For stocks - TCS.BO *****

Historical volatility for last 1 month = 0.17980621449552703

Strike price (K)	Call Option	Put Option
0.5*S0	920.995	2.15916e-07
0.6*S0	745.673	0.000472052
0.7*S0	570.422	0.0715462
0.8*S0	396.974	1.94602
0.9*S0	236.68	16.9749
1.0*S0	113.916	69.5329
1.1*S0	43.0232	173.962
1.2*S0	12.8239	319.086
1.3*S0	3.09394	484.678
1.4*S0	0.623608	657.53
1.5*S0	0.108311	832.337

***** For stocks - WIPRO.BO *****

Historical volatility for last 1 month = 0.286020315623835

Strike price (K)	Call Option	Put Option
0.5*S0	126.059	0.00165057
0.6*S0	102.108	0.0473642
0.7*S0	78.5324	0.468021
0.8*S0	56.3925	2.32472
0.9*S0	37.3599	7.28866
1.0*S0	22.7595	16.6847
1.1*S0	12.8028	30.7246
1.2*S0	6.7073	48.6256
1.3*S0	3.30597	69.2208
1.4*S0	1.54861	91.46
1.5*S0	0.695791	114.604

ii. For stocks in nsedata1:

***** For stocks - NSE Index *****

Historical volatility for last 1 month = 0.15773797914236246

Strike price (K)	Call Option	Put Option
0.5*S0	5564.02	7.566e-09
0.6*S0	4504.84	0.000138964
0.7*S0	3445.74	0.0795143
0.8*S0	2391.35	4.86593
0.9*S0	1395.09	67.7862
1.0*S0	623.006	354.874
1.1*S0	201.191	992.236
1.2*S0	46.9004	1897.12
1.3*S0	8.15047	2917.55
1.4*S0	1.10311	3969.68
1.5*S0	0.12143	5027.87

***** For stocks - BAJAJ-AUTO.NS *****

Historical volatility for last 1 month = 0.2646819256693275

Strike price (K)	Call Option	Put Option
0.5*S0	1303.29	0.00481208
0.6*S0	1055.41	0.223152
0.7*S0	810.089	2.9938
0.8*S0	577.061	18.0626
0.9*S0	374.851	63.9485
1.0*S0	220.38	157.574
1.1*S0	117.579	302.87
1.2*S0	57.4553	490.842
1.3*S0	26.0227	707.506
1.4*S0	11.0589	940.638
1.5*S0	4.45991	1182.14

***** For stocks - HDFCBANK.NS *****

Historical volatility for last 1 month = 0.16690948948038953

Strike price (K)	Call Option	Put Option
0.5*S0	539.269	7.90216e-09
0.6*S0	436.613	5.41087e-05
0.7*S0	333.973	0.0167329
0.8*S0	232.004	0.703896
0.9*S0	136.55	7.90597
1.0*S0	63.0042	37.0167
1.1*S0	21.8336	98.5024
1.2*S0	5.69501	185.02
1.3*S0	1.15101	283.132
1.4*S0	0.187232	384.825
1.5*S0	0.0254504	487.32

***** For stocks - HEROMOTOCO.NS *****

Historical volatility for last 1 month = 0.35209001941047746

Strike price (K)	Call Option	Put Option
0.5*S0	1475.35	0.284049
0.6*S0	1197.32	3.048
0.7*S0	929.476	16.0003
0.8*S0	685.502	52.8233
0.9*S0	479.375	127.494
1.0*S0	318.652	247.567
1.1*S0	202.394	412.107
1.2*S0	123.618	614.128
1.3*S0	73.0722	844.379
1.4*S0	42.0529	1094.16
1.5*S0	23.6859	1356.59

***** For stocks - INFY.NS *****

Historical volatility for last 1 month = 0.27631403459319387

Strike price (K)	Call Option	Put Option
0.5*S0	314.87	0.00239496
0.6*S0	255.013	0.0843503
0.7*S0	195.94	0.94987
0.8*S0	140.179	5.12803
0.9*S0	92.0529	16.9404
1.0*S0	55.2083	40.0347
1.1*S0	30.3499	75.1152
1.2*S0	15.4292	120.133
1.3*S0	7.33334	171.976
1.4*S0	3.29467	227.877
1.5*S0	1.41338	285.934

***** For stocks - MARUTI.NS *****

Historical volatility for last 1 month = 0.29415801174853756

Strike price (K)	Call Option	Put Option
0.5*S0	3758.8	0.0748089
0.6*S0	3045.04	1.83532
0.7*S0	2344.09	16.4067
0.8*S0	1688.61	76.4359
0.9*S0	1126.81	230.155
1.0*S0	695.054	513.92
1.1*S0	398.111	932.494
1.2*S0	213.5	1463.4
1.3*S0	108.233	2073.65
1.4*S0	52.3563	2733.29
1.5*S0	24.3748	3420.83

***** For stocks - NESTLEIND.NS *****

Historical volatility for last 1 month = 0.23623130253003924

Strike price (K)	Call Option	Put Option
0.5*S0	5514.25	0.00227782
0.6*S0	4464.79	0.246782
0.7*S0	3420.51	5.66814
0.8*S0	2413.12	47.9769
0.9*S0	1524.57	209.131
1.0*S0	848.307	582.573
1.1*S0	415.135	1199.1
1.2*S0	180.419	2014.09
1.3*S0	70.6879	2954.06
1.4*S0	25.3752	3958.45
1.5*S0	8.47426	4991.25

***** For stocks - RELIANCE.NS *****

Historical volatility for last 1 month = 0.2383561661853663

Strike price (K)	Call Option	Put Option
0.5*S0	565.984	0.000282341
0.6*S0	458.27	0.0284114
0.7*S0	351.123	0.622801
0.8*S0	247.878	5.11963
0.9*S0	156.939	21.9224
1.0*S0	87.7149	60.4399
1.1*S0	43.2356	123.702
1.2*S0	18.9782	207.187
1.3*S0	7.52859	303.479
1.4*S0	2.74219	406.434
1.5*S0	0.93084	512.365

***** For stocks - TATAMOTORS.NS *****

Historical volatility for last 1 month = 0.3494139705247439

Strike price (K)	Call Option	Put Option
0.5*S0	87.5497	0.0155051
0.6*S0	71.0424	0.171385
0.7*S0	55.1249	0.917135
0.8*S0	40.6108	3.06613
0.9*S0	28.3428	7.46133
1.0*S0	18.7838	14.5655
1.1*S0	11.8832	24.3281
1.2*S0	7.22253	36.3306
1.3*S0	4.24512	50.0163
1.4*S0	2.42755	64.8619
1.5*S0	1.35785	80.4554

***** For stocks - TCS.NS *****

Historical volatility for last 1 month = 0.18165036953378483

Strike price (K)	Call Option	Put Option
0.5*S0	921.145	3.06824e-07
0.6*S0	745.795	0.000580947
0.7*S0	570.524	0.0804772
0.8*S0	397.164	2.0715
0.9*S0	237.239	17.4974
1.0*S0	114.839	70.4485
1.1*S0	43.8612	174.822
1.2*S0	13.2993	319.611
1.3*S0	3.28172	484.944
1.4*S0	0.679659	657.693
1.5*S0	0.121759	832.486

***** For stocks - WIPRO.NS *****

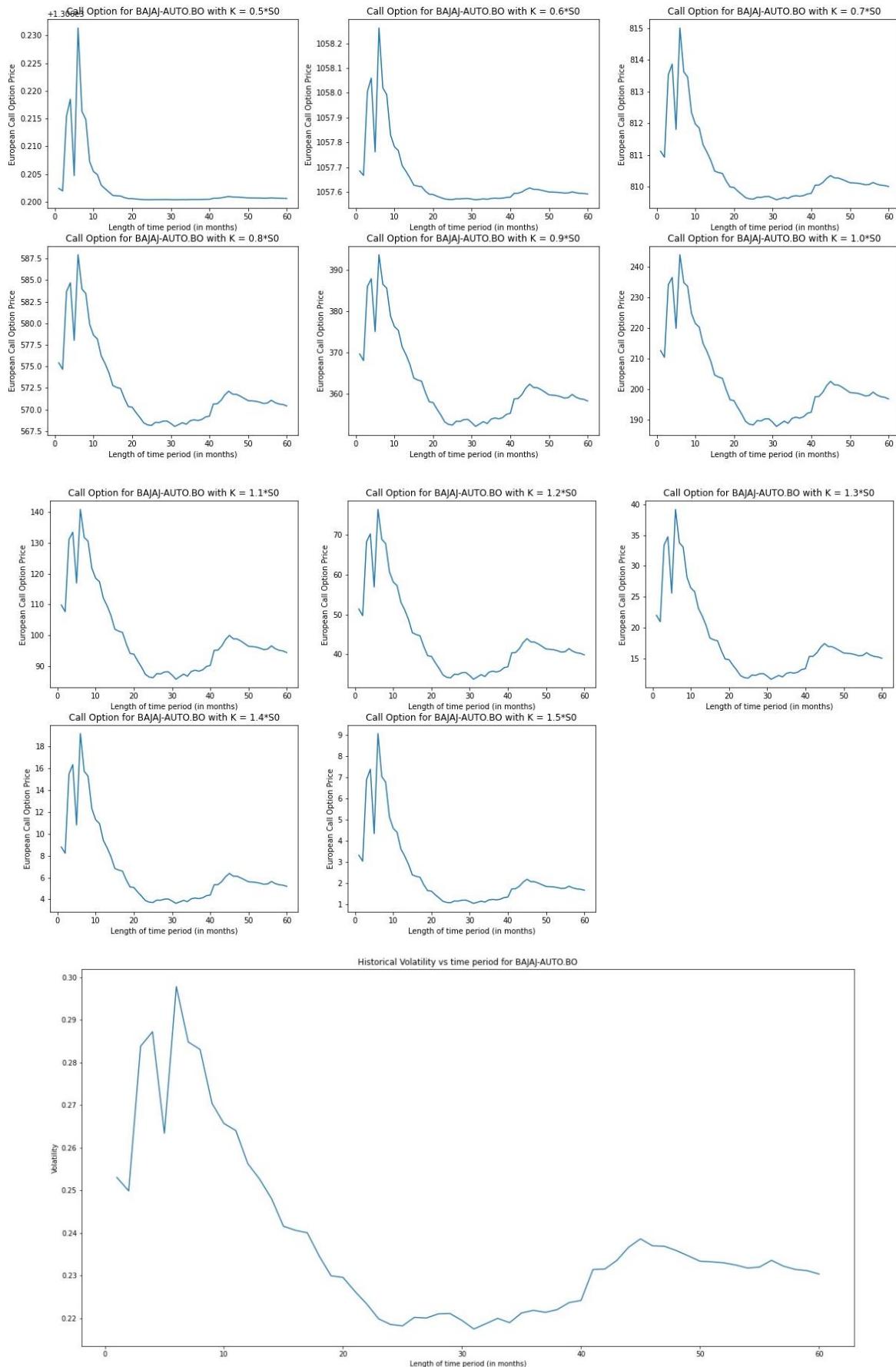
Historical volatility for last 1 month = 0.25919139780584455

Strike price (K)	Call Option	Put Option
0.5*S0	125.677	0.000319881
0.6*S0	101.77	0.0171081
0.7*S0	78.0797	0.251291
0.8*S0	55.51	1.60559
0.9*S0	35.8703	5.88991
1.0*S0	20.8811	14.8247
1.1*S0	10.9736	28.8412
1.2*S0	5.25512	47.0468
1.3*S0	2.322	68.0377
1.4*S0	0.958924	90.5986
1.5*S0	0.374579	113.938

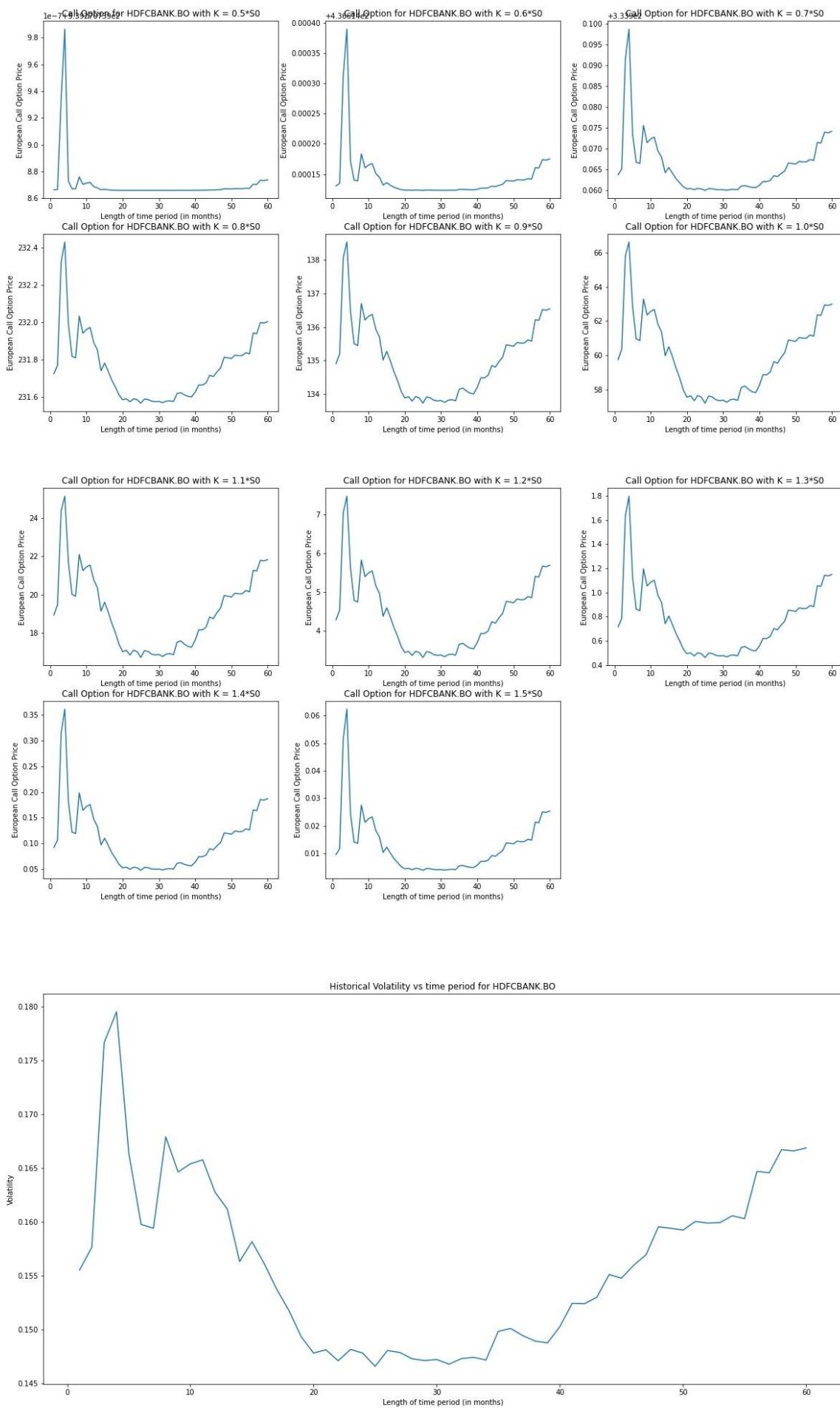
3 QUESTION – 3 :

i. Plots for Call Option and Volatility - stocks in bsedata1:

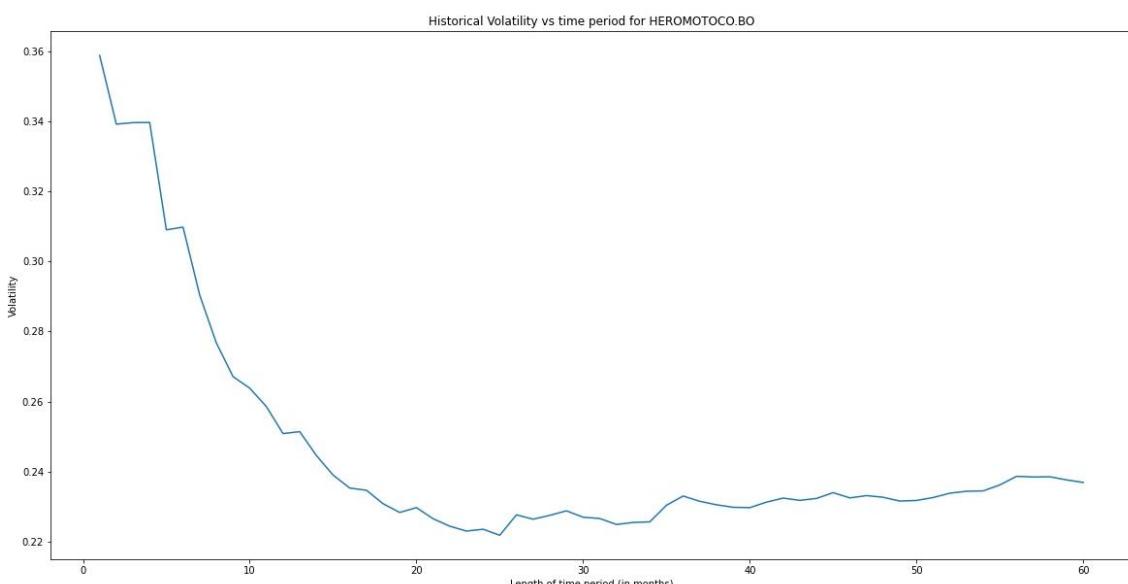
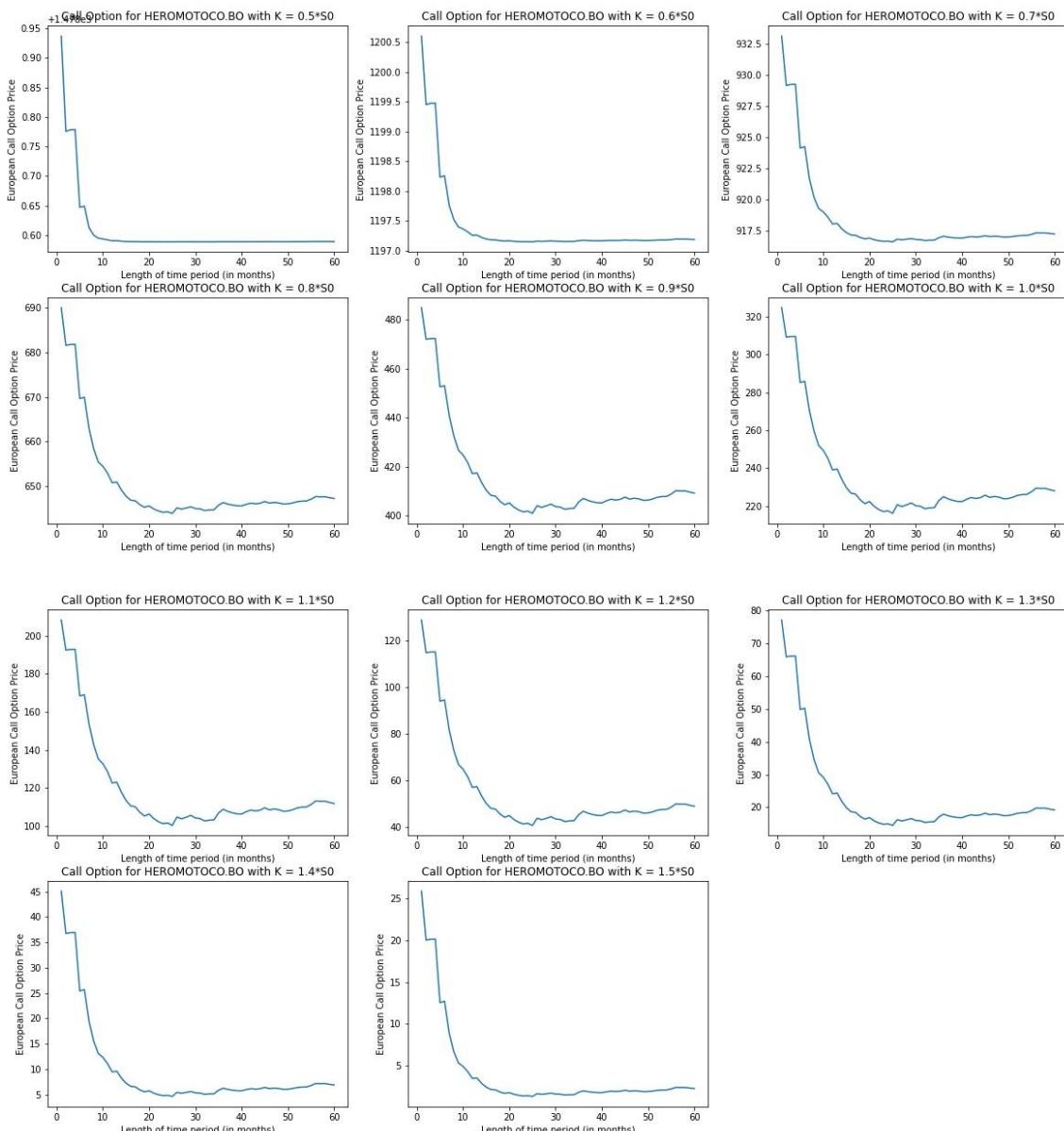
i) BAJA-AUTO.BO



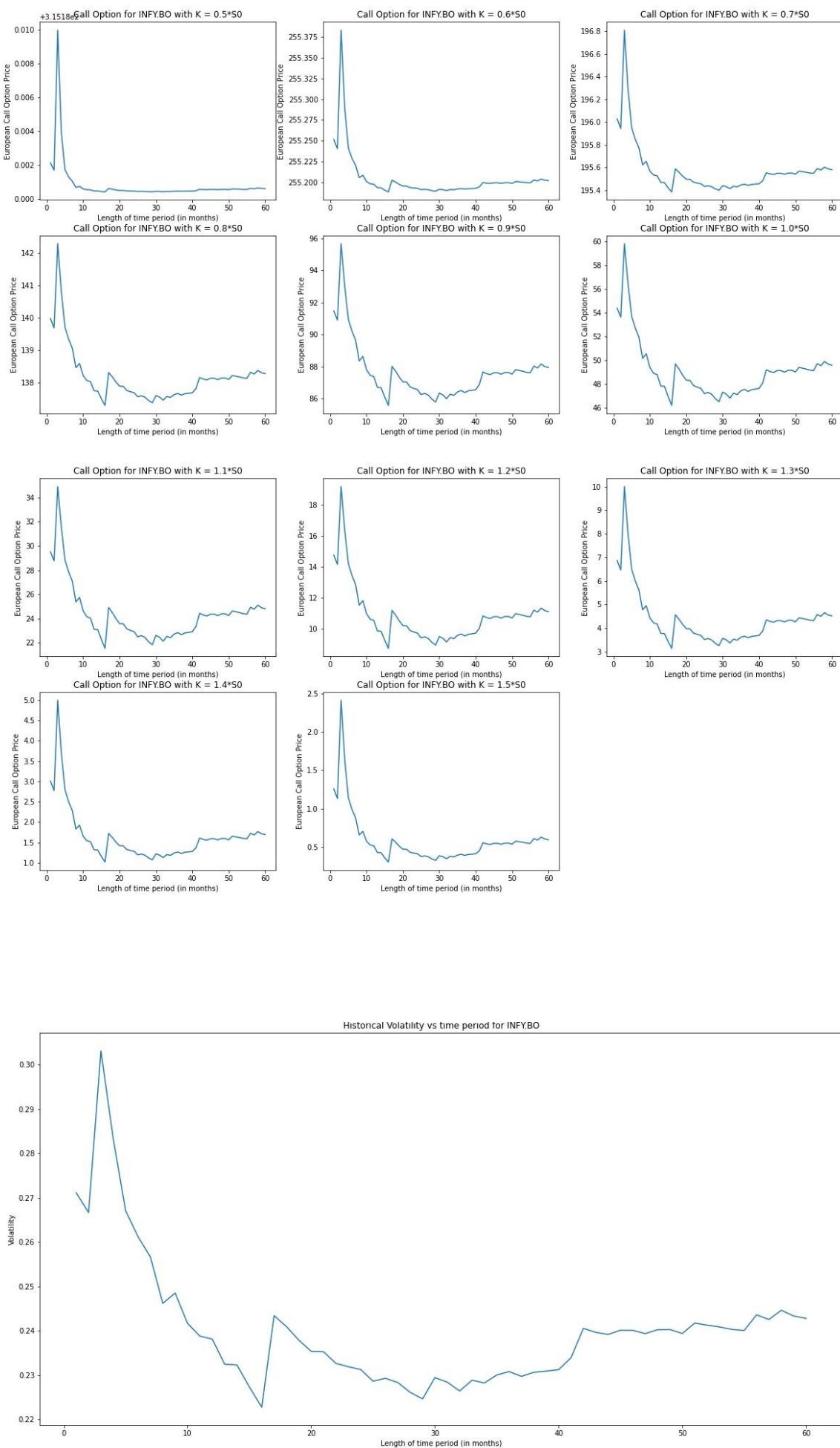
ii) HDFCBANK.BO



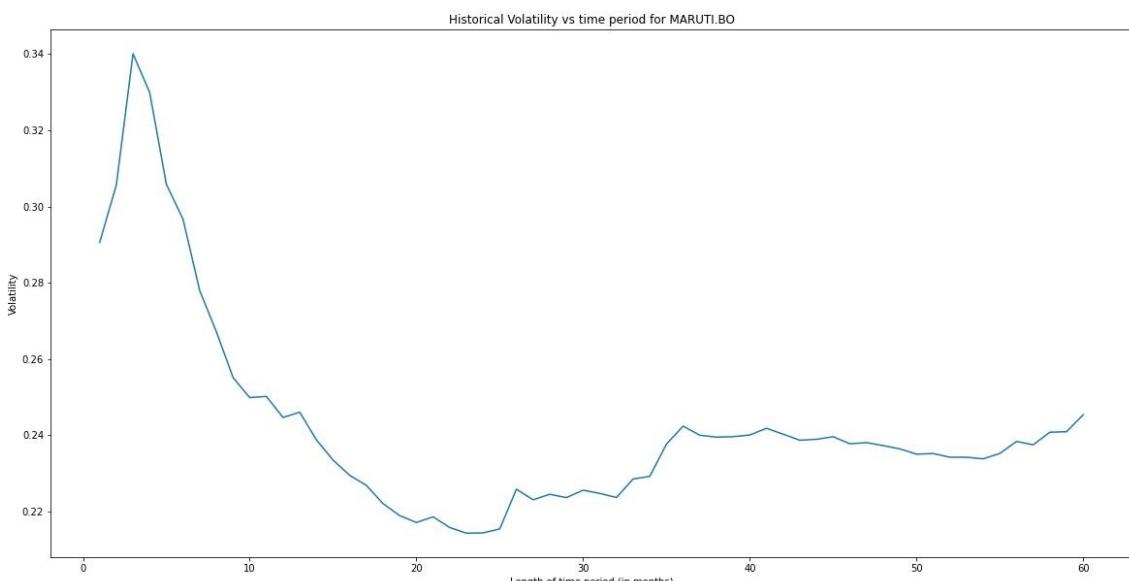
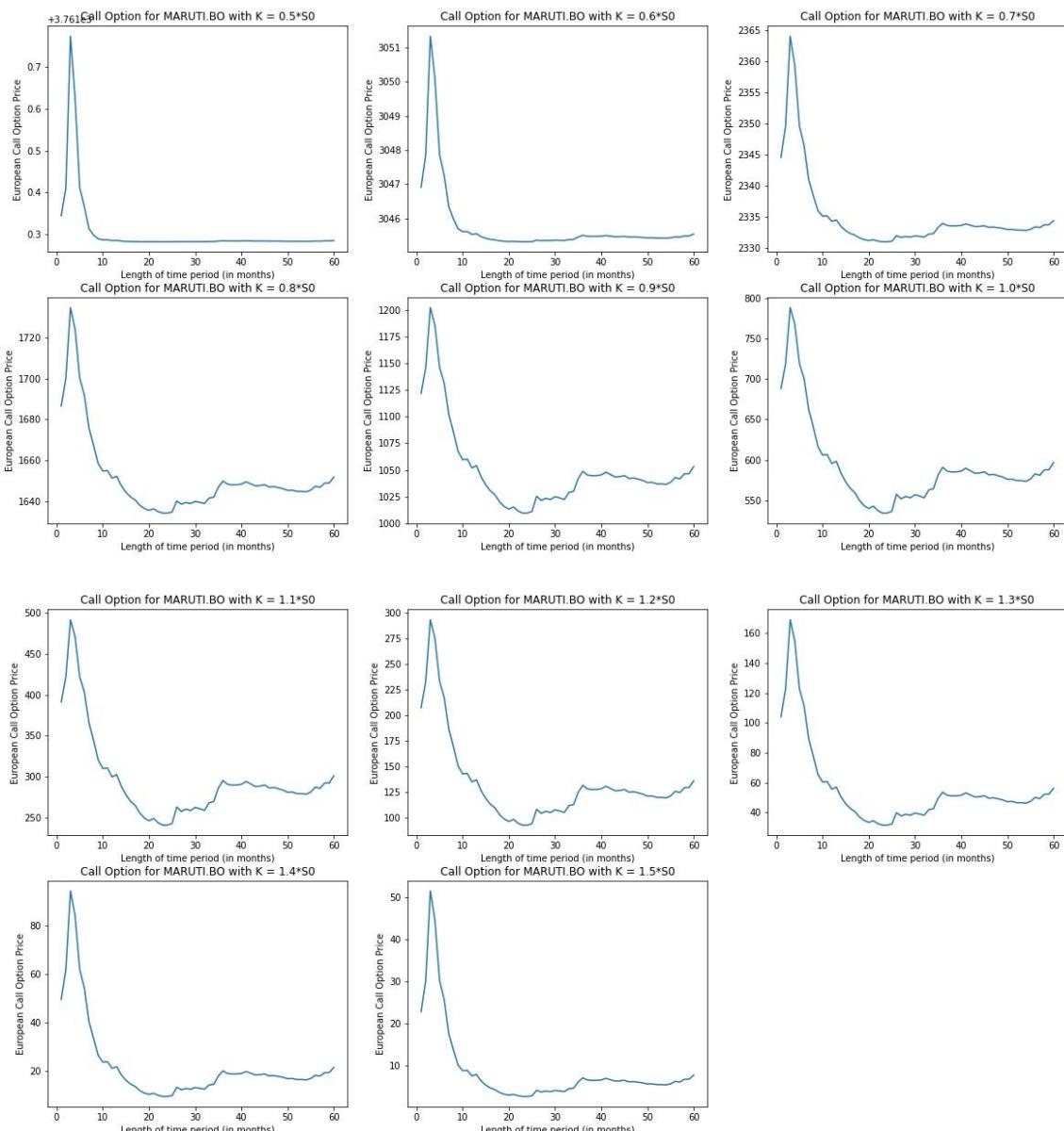
iii) HEROMOTOCO.BO



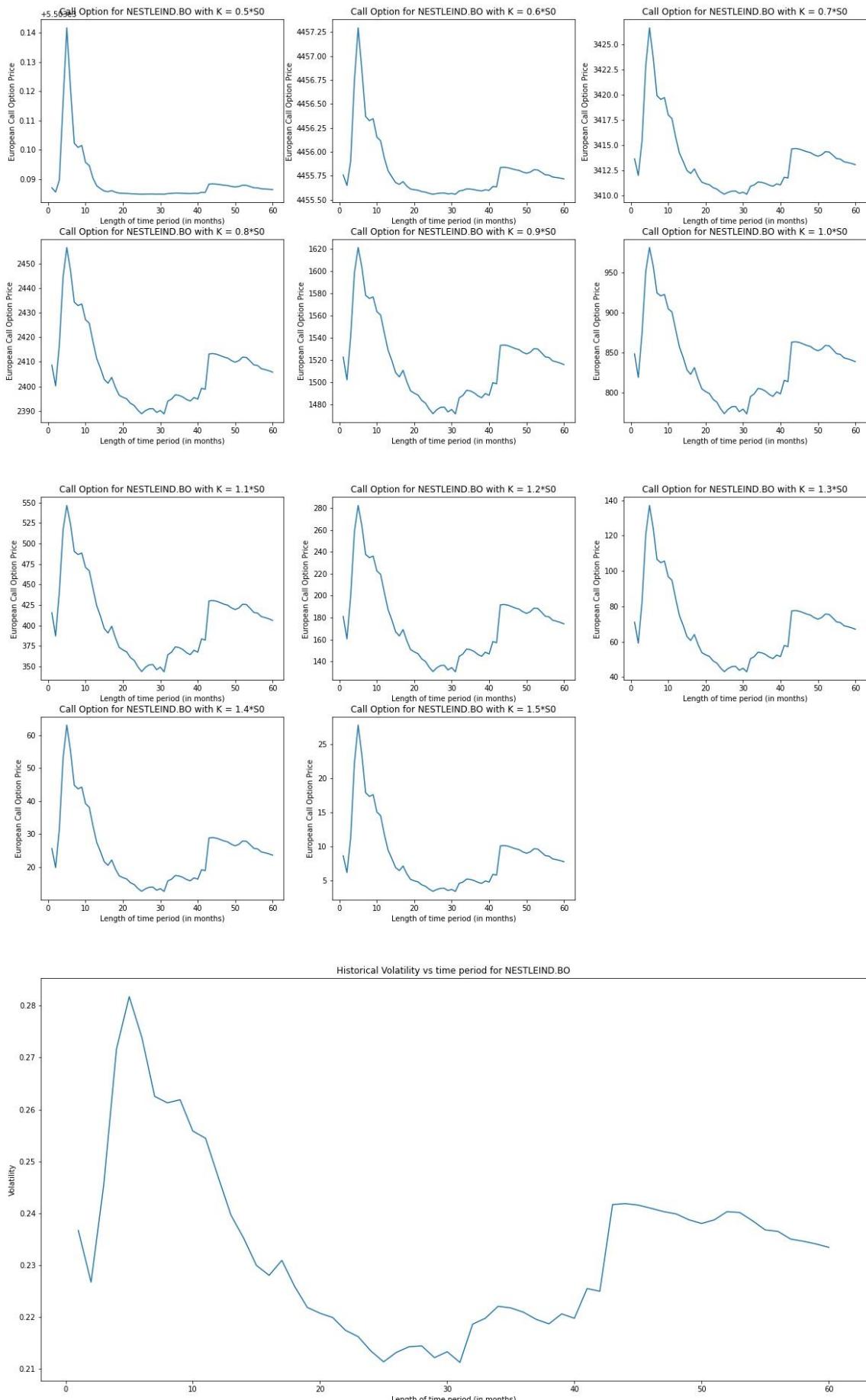
iv) INFY.BO



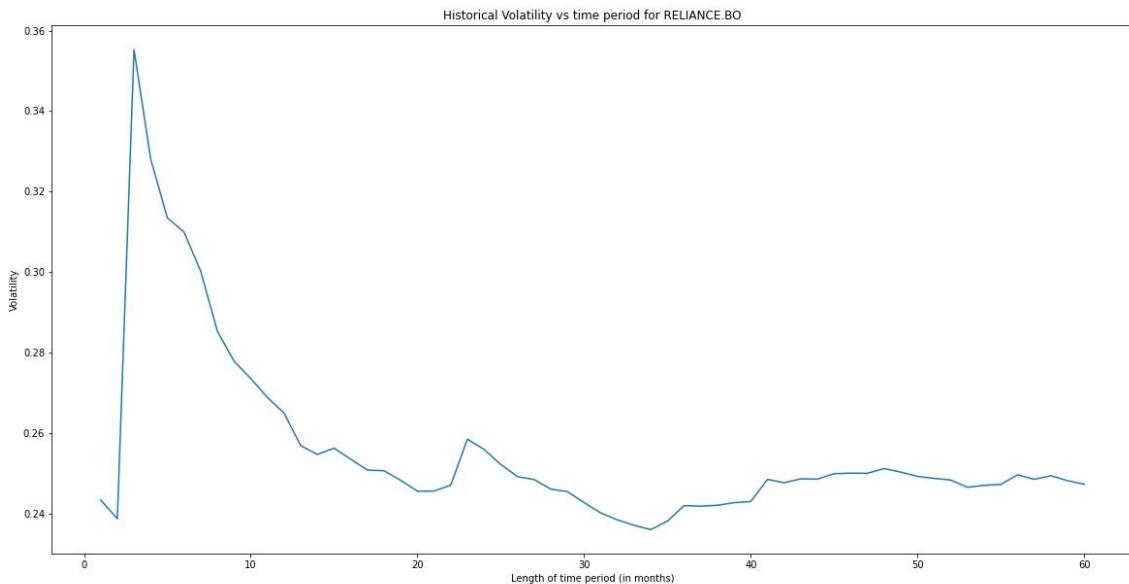
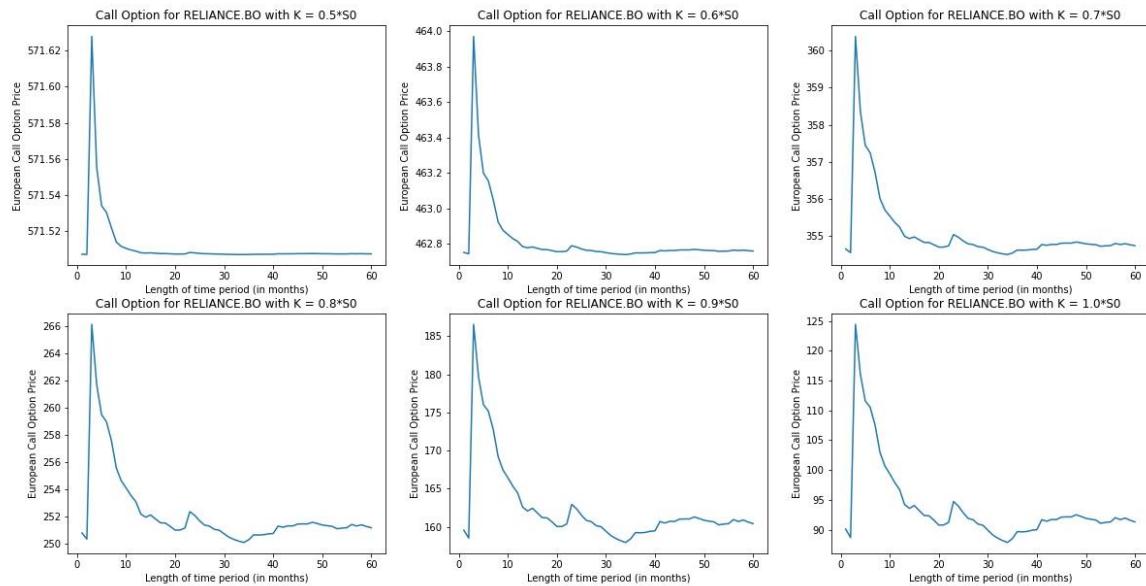
v) MARUTI.BO



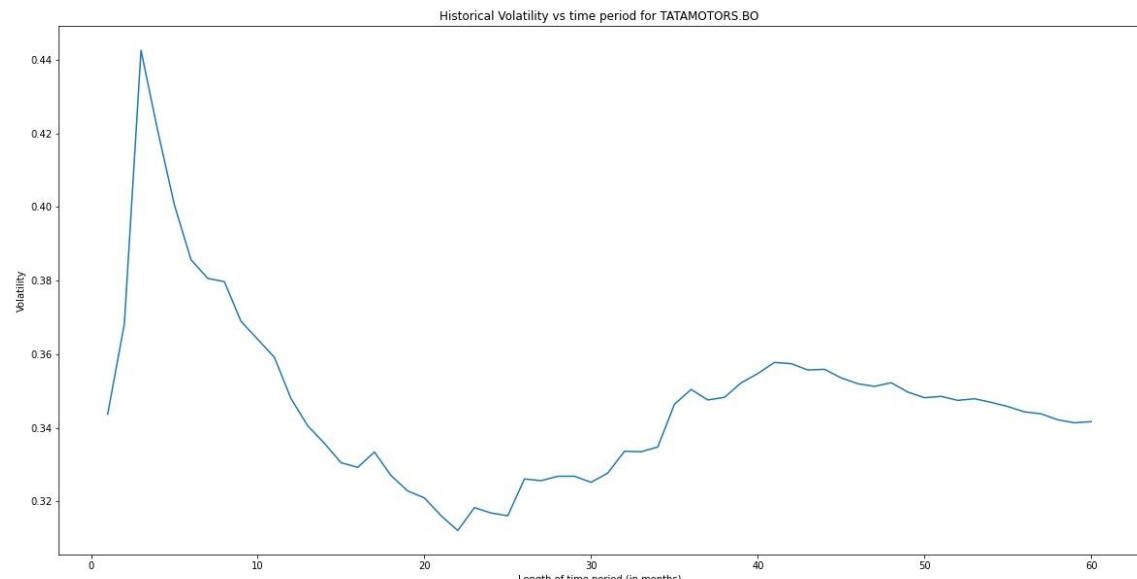
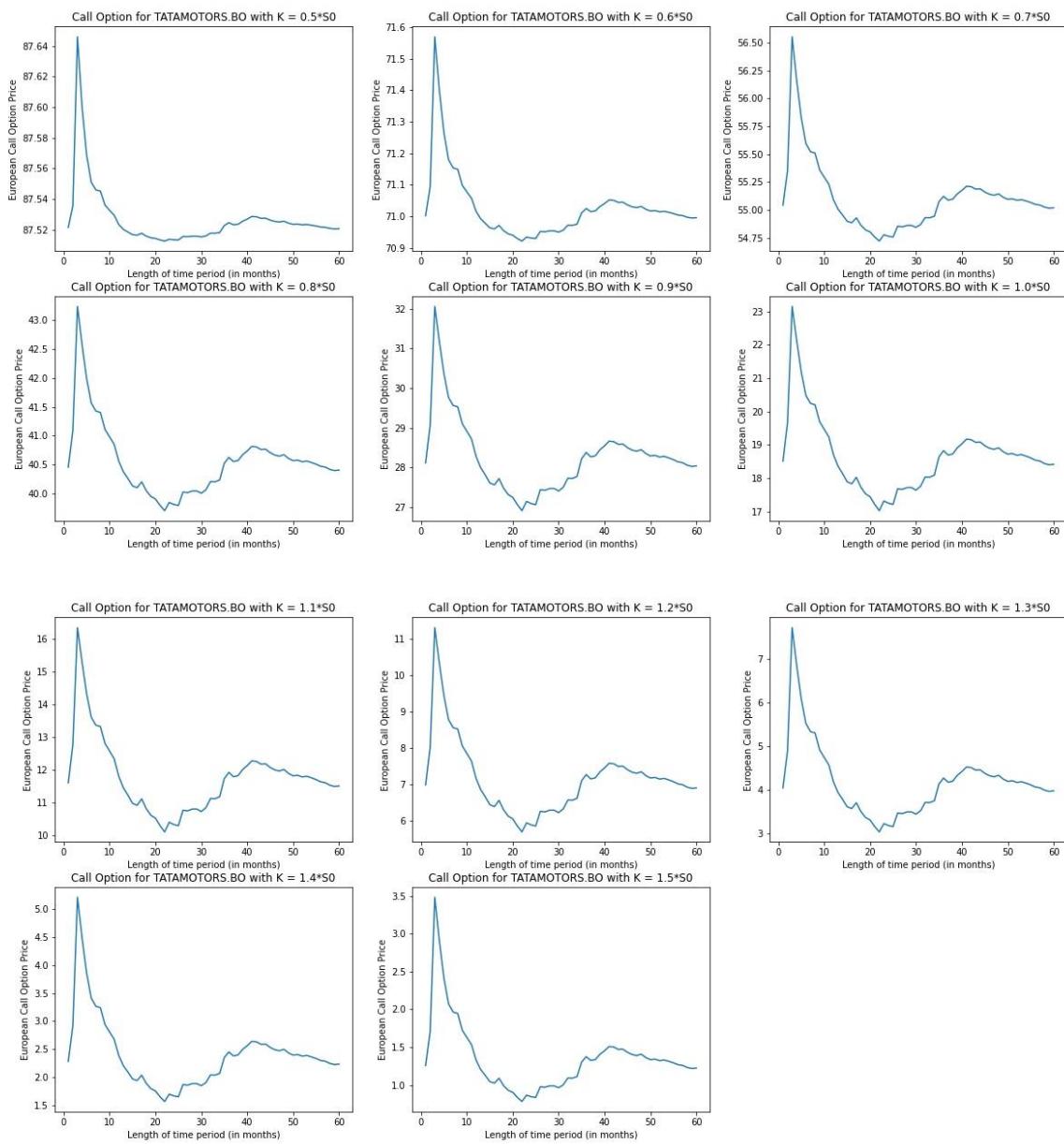
vi) NESTLEIND.BO



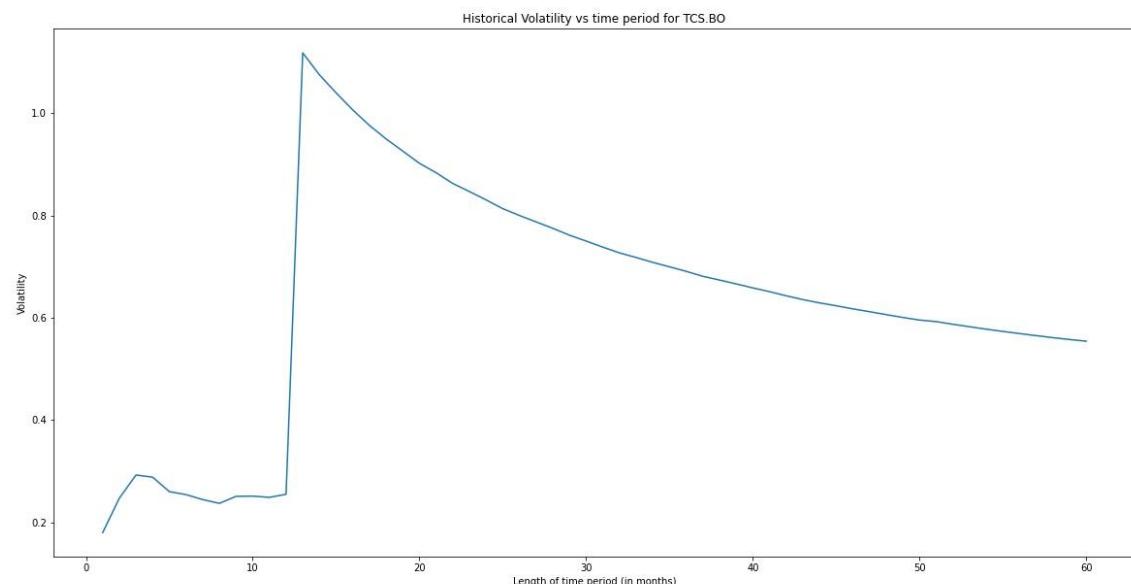
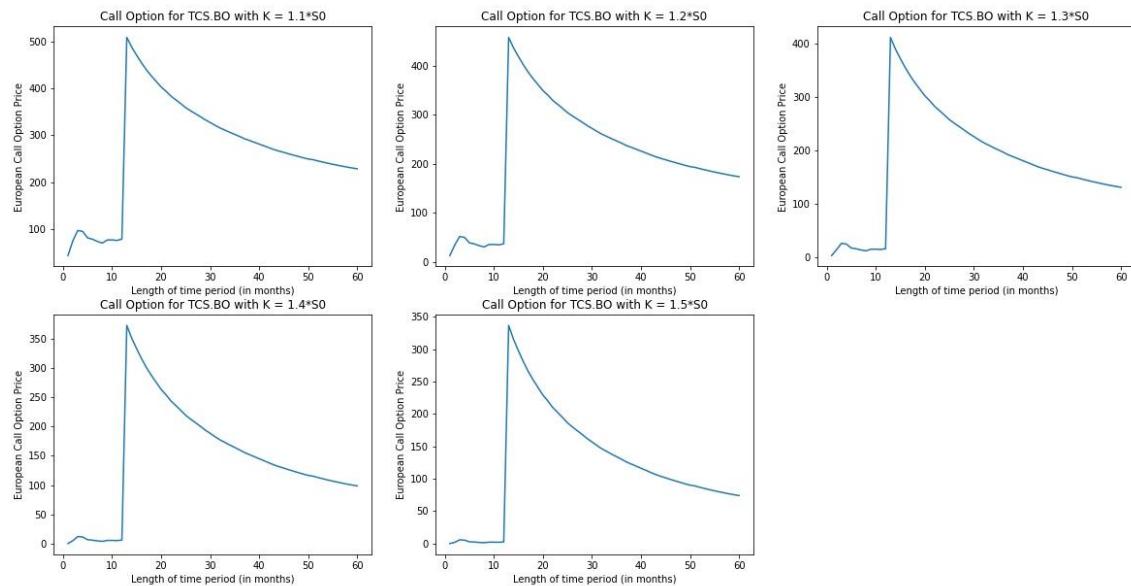
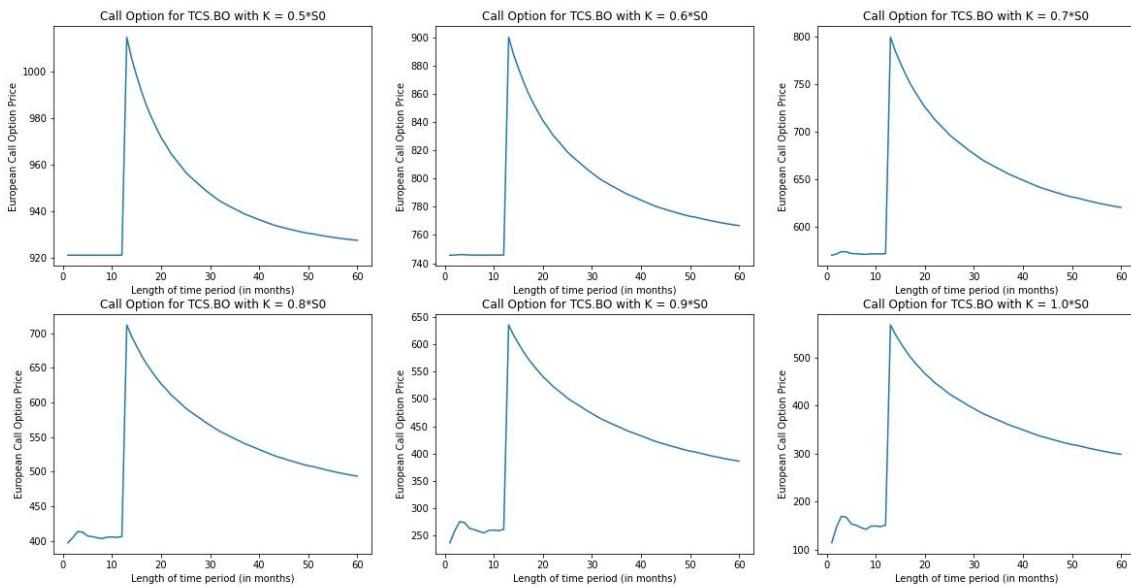
vii) RELIANCE.BO



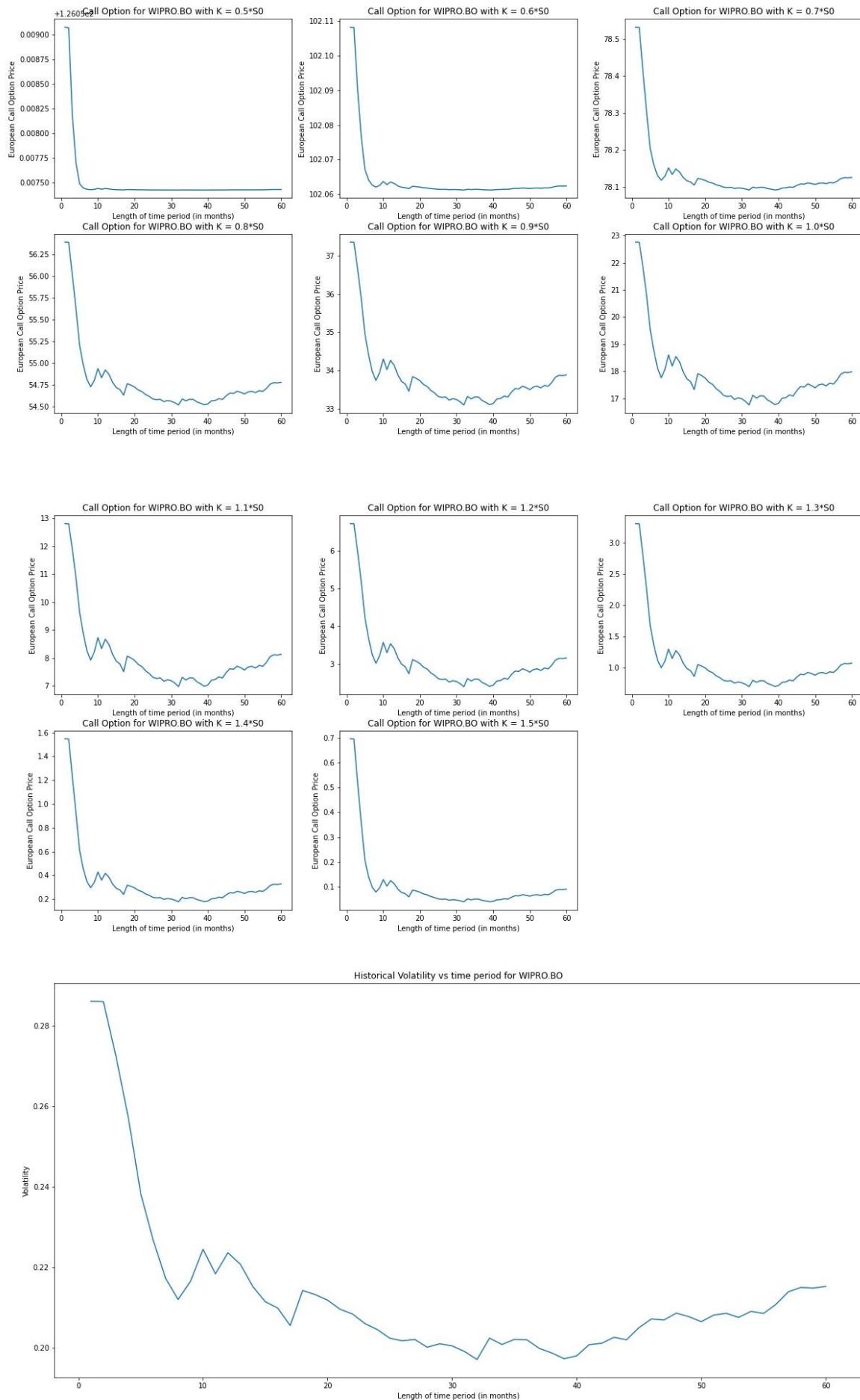
viii) TATAMOTORS.BO



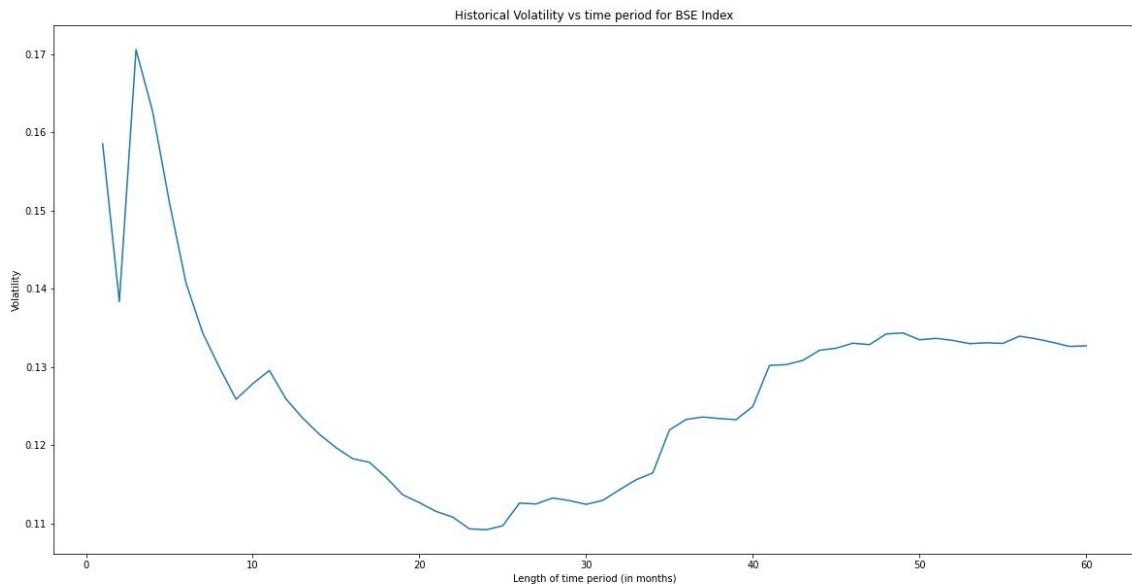
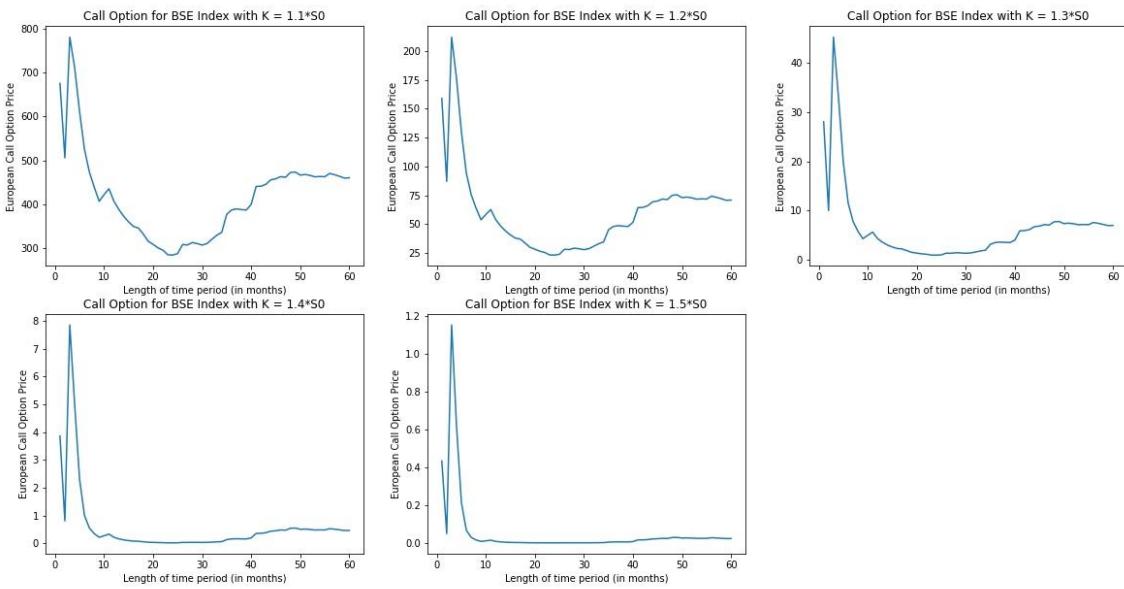
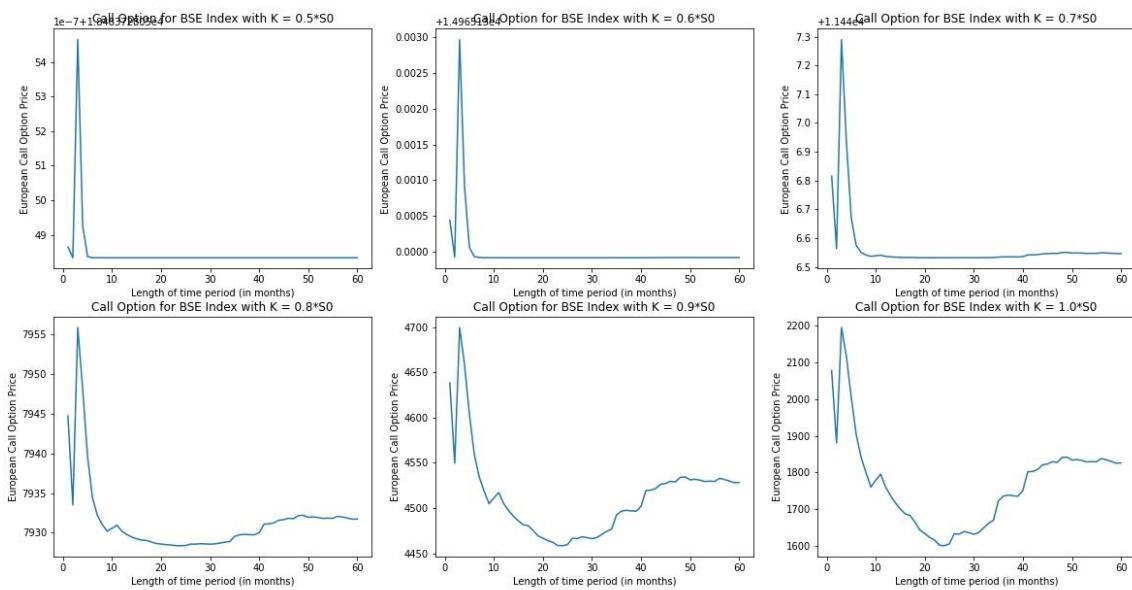
ix) TCS.BO



x) WIPRO.BO

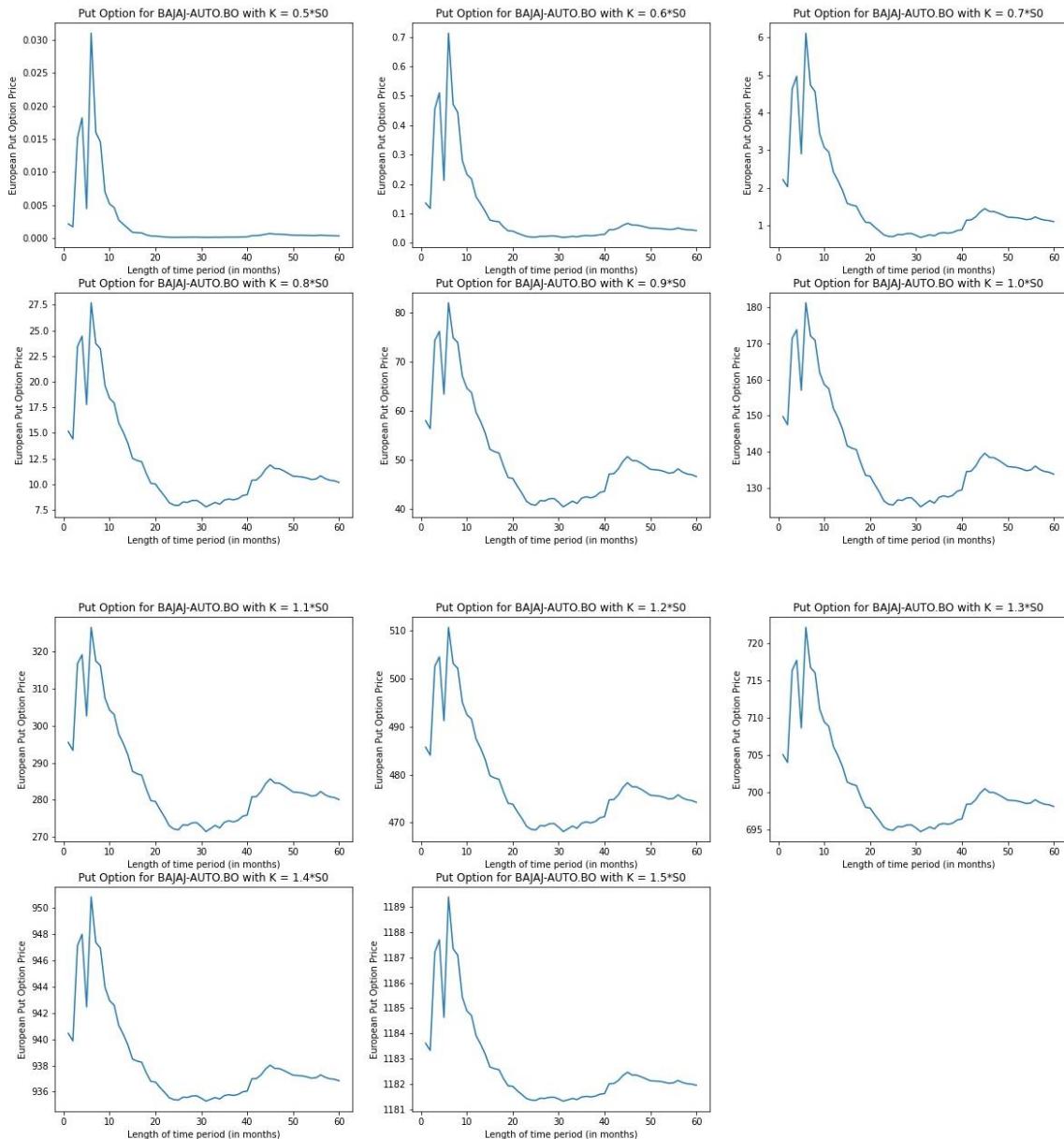


xi) BSE Index

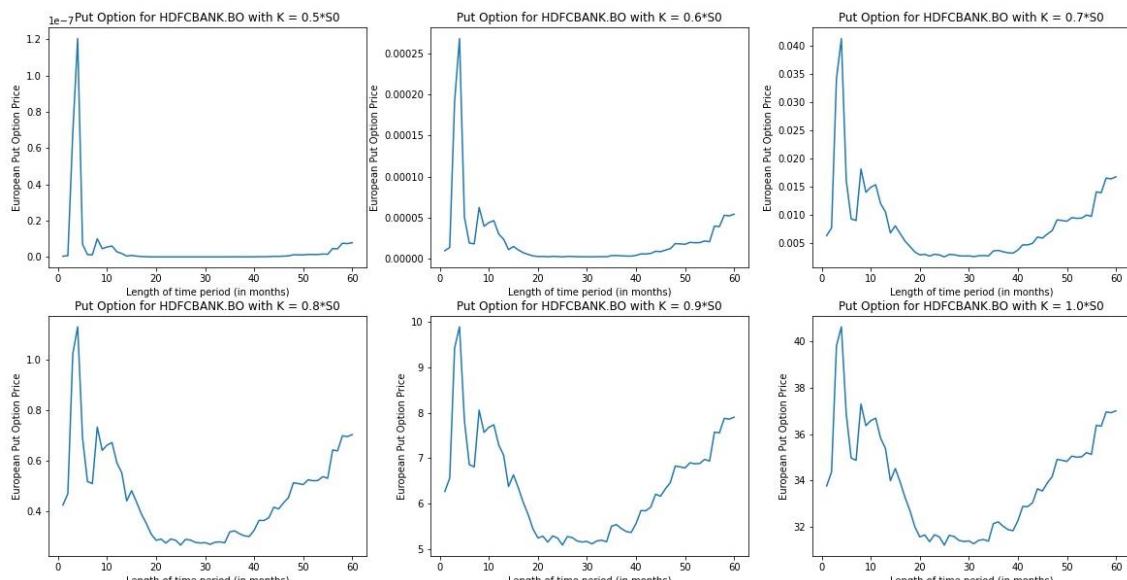


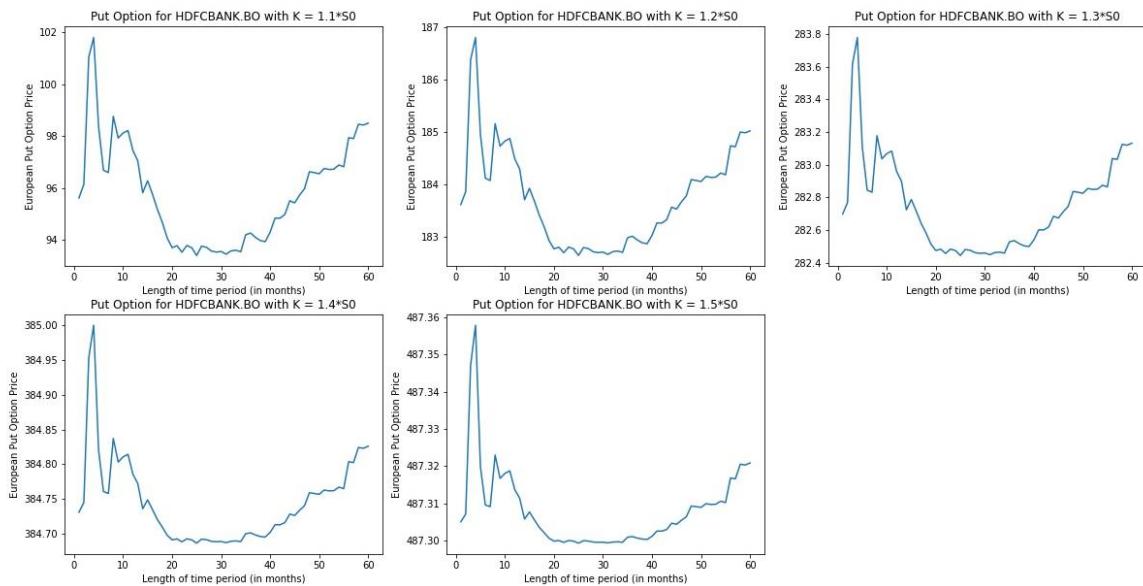
ii. Plots for Put Option - stocks in nsedata1:

i) BAJA-AUTO.BO

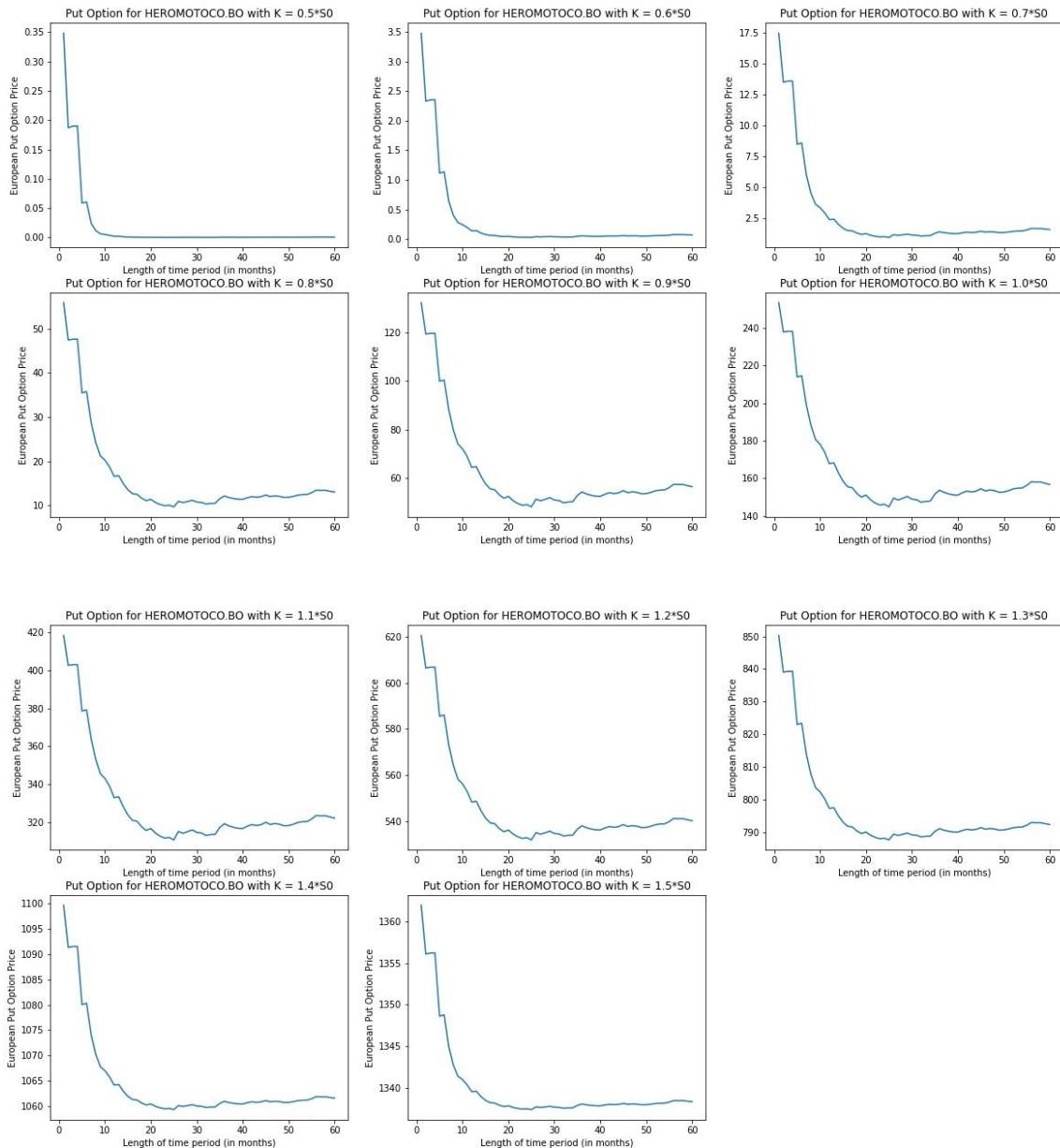


ii) HDFCBANK.BO

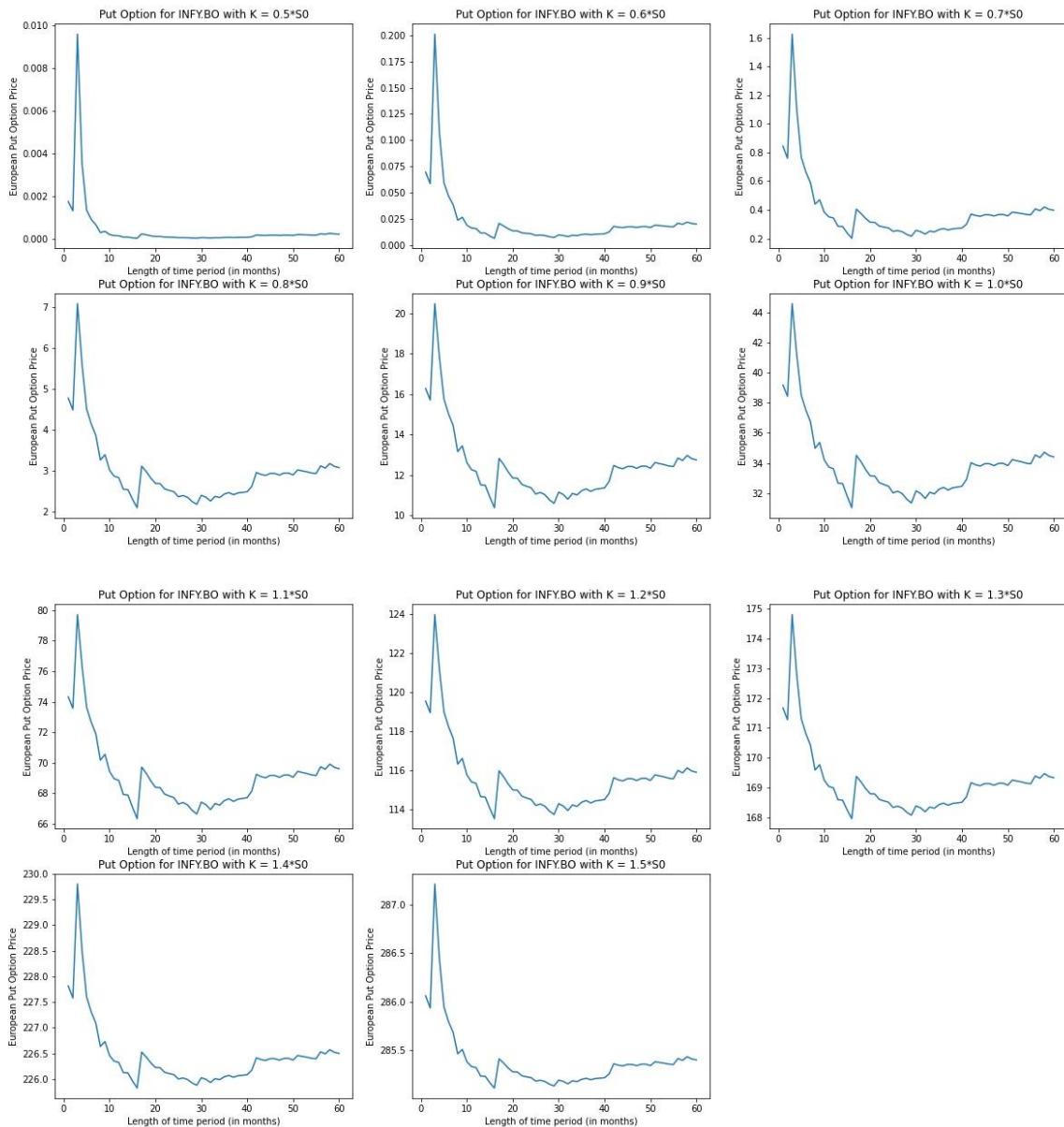




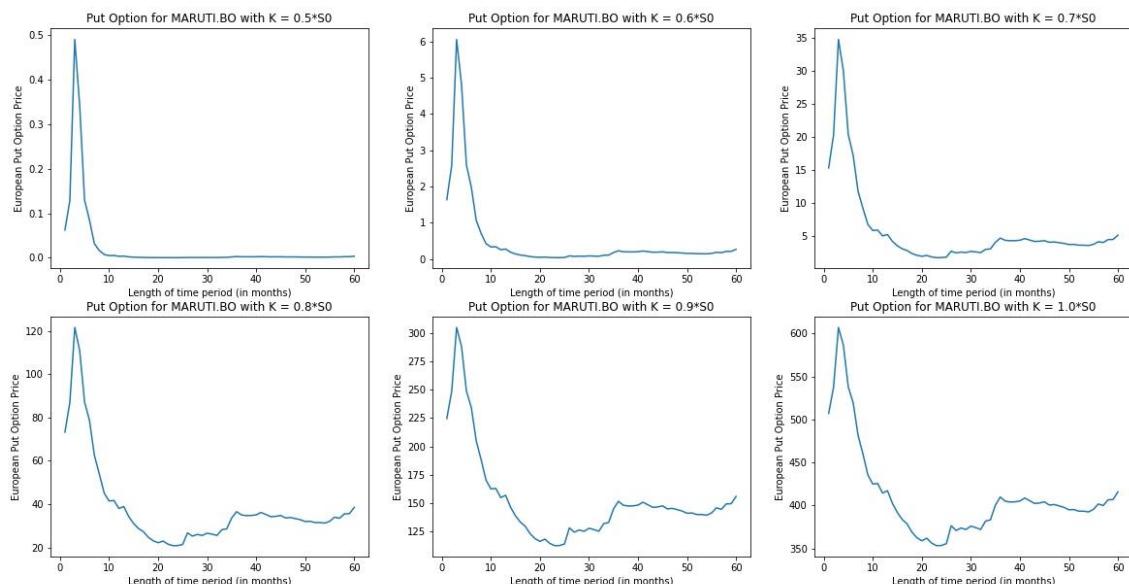
iii) HEROMOTOCO.BO

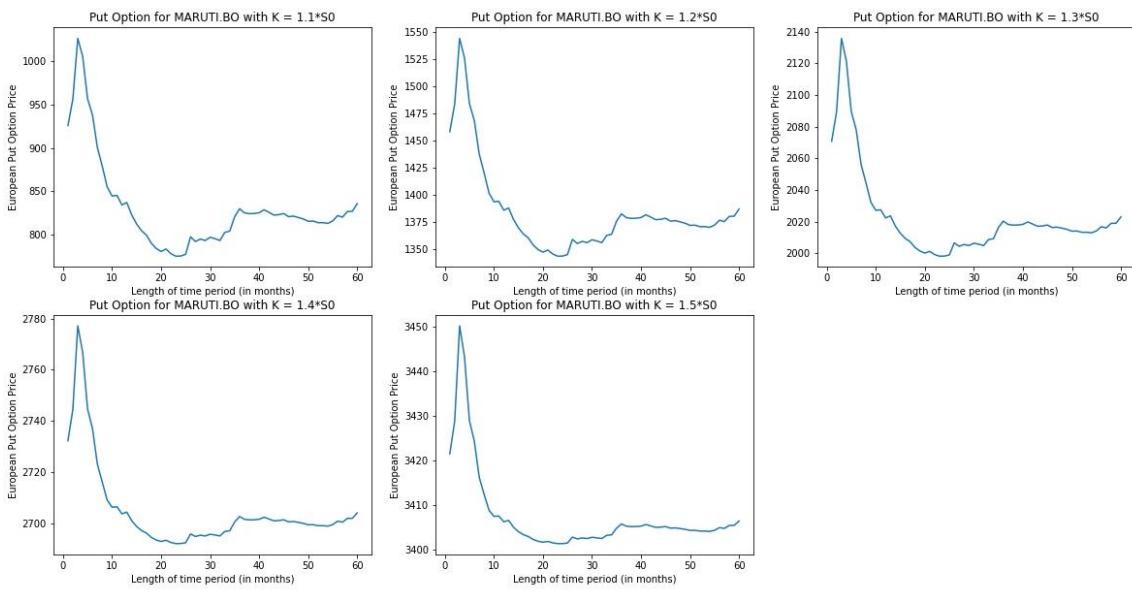


iv) INFY.BO

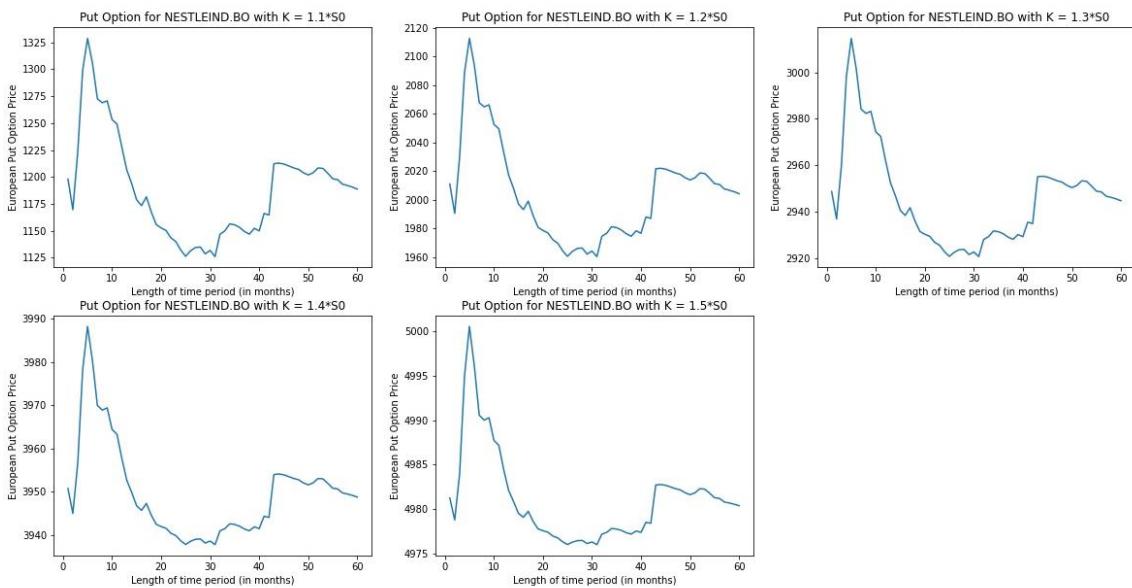
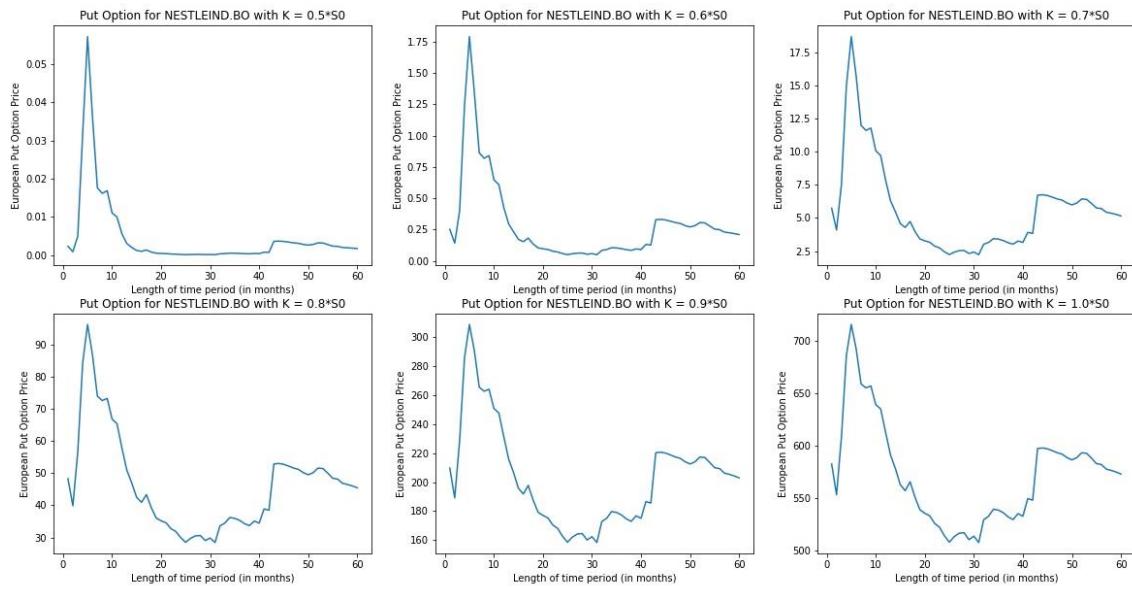


v) MARUTI.BO

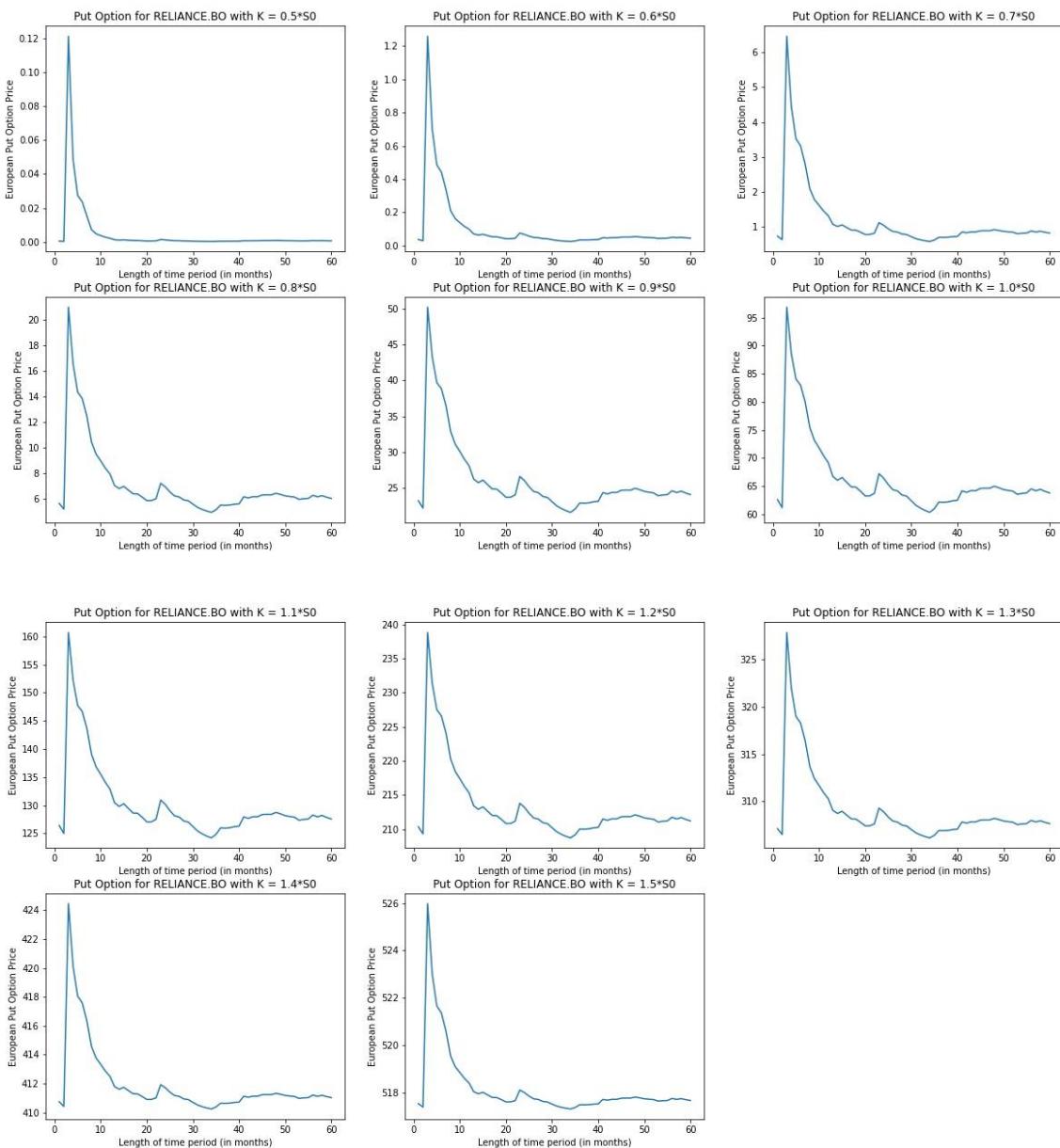




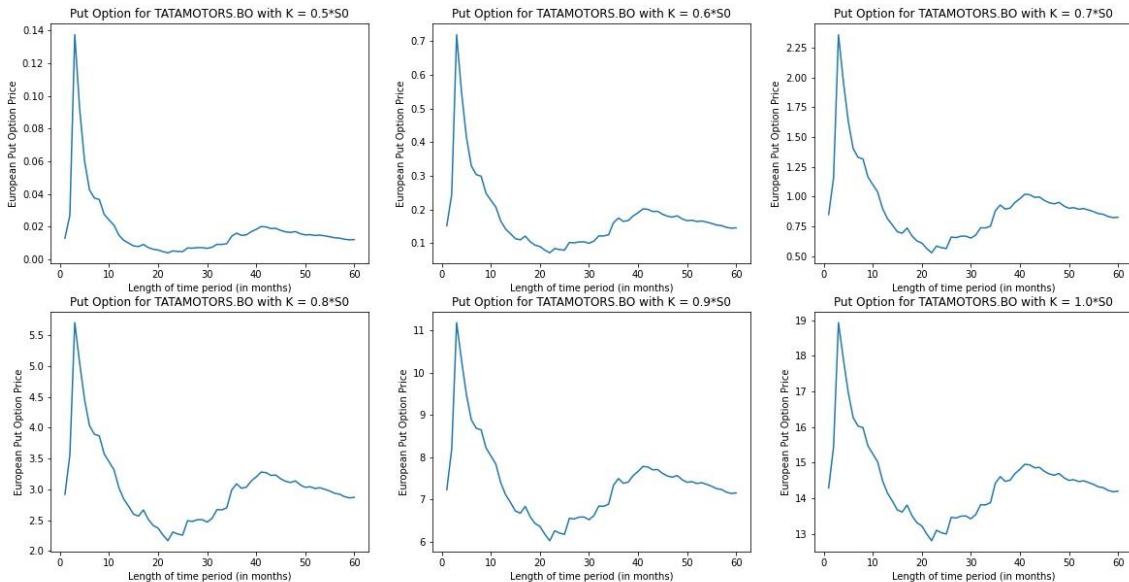
vi) NESTLEIND.BO

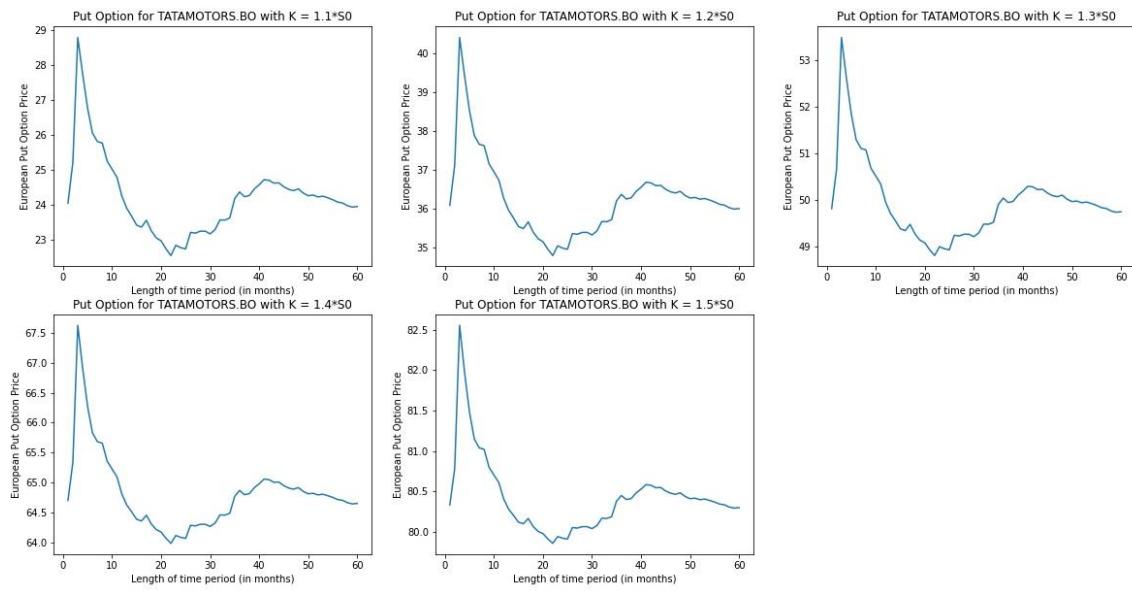


vii) RELIANCE.BO

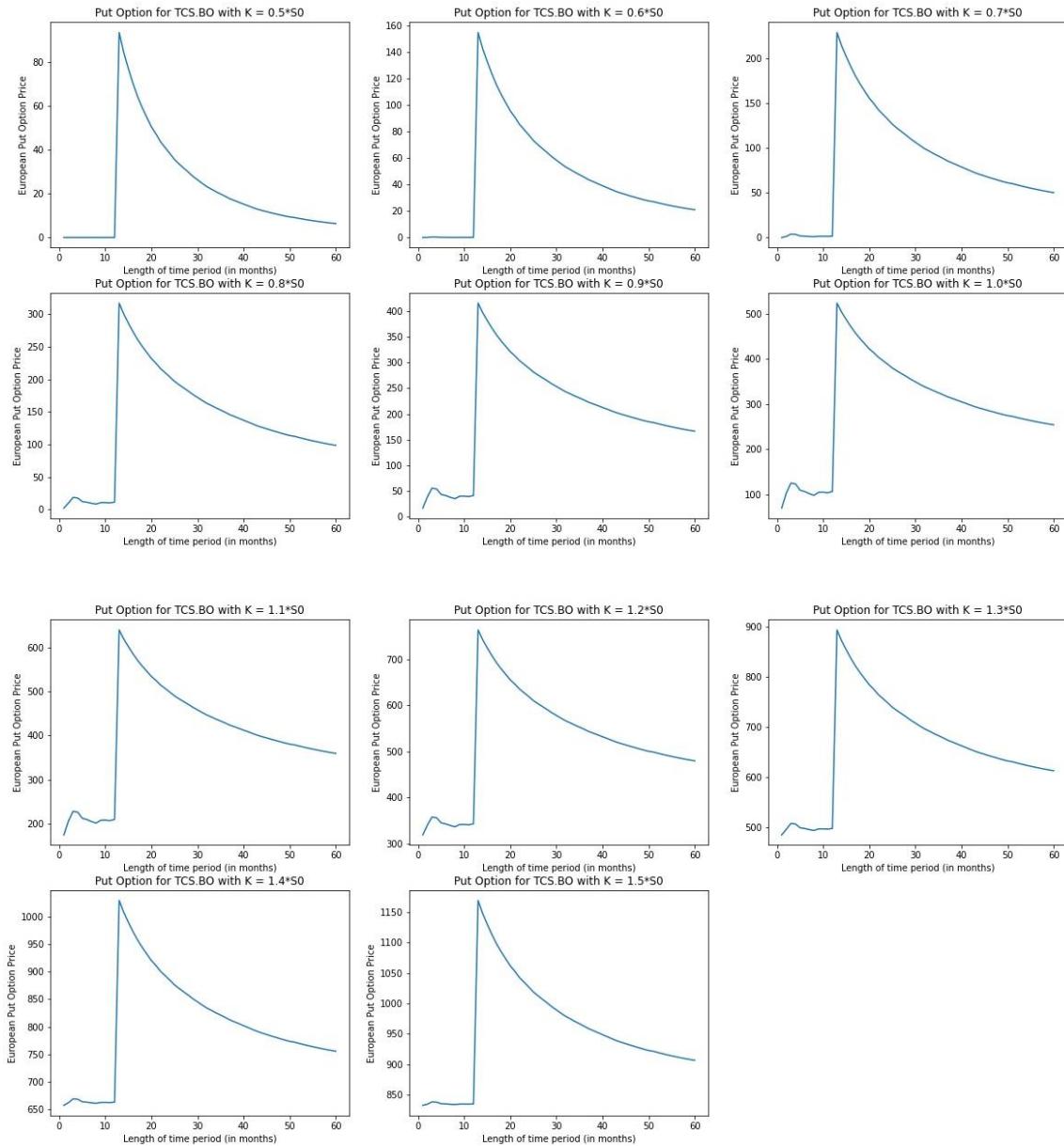


viii) TATAMOTORS.BO

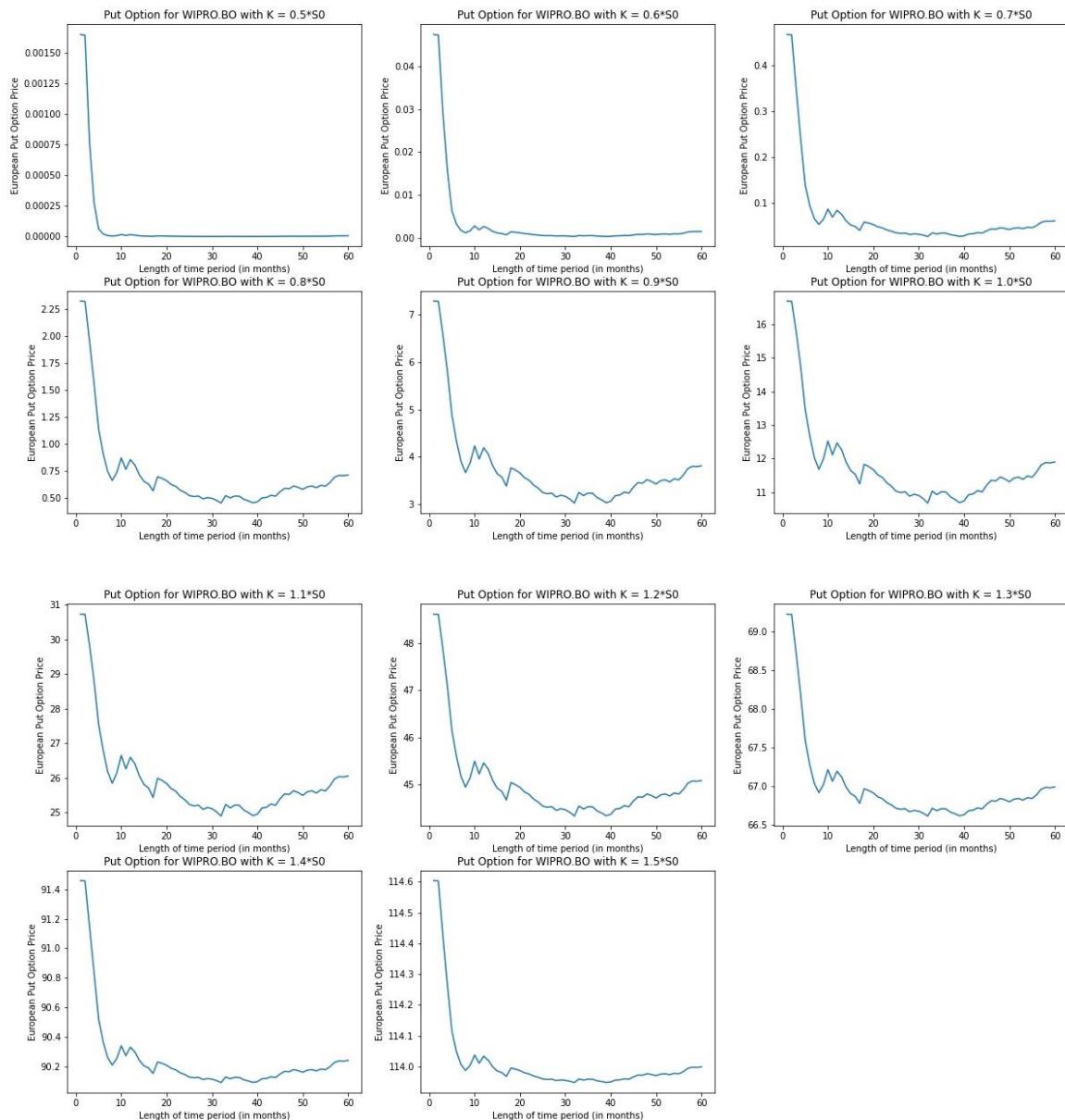




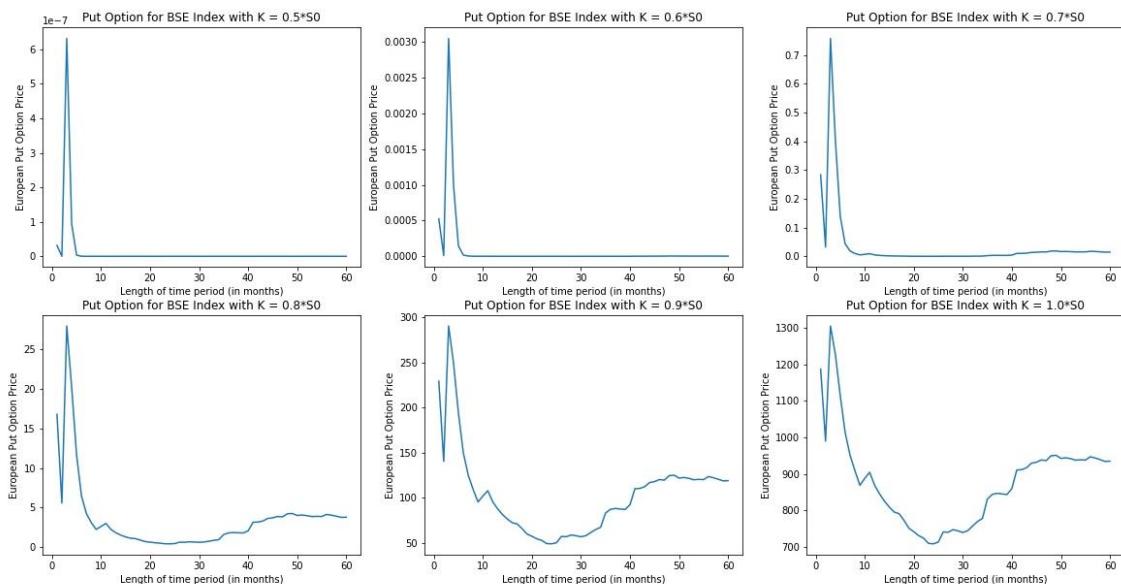
ix) TCS.BO

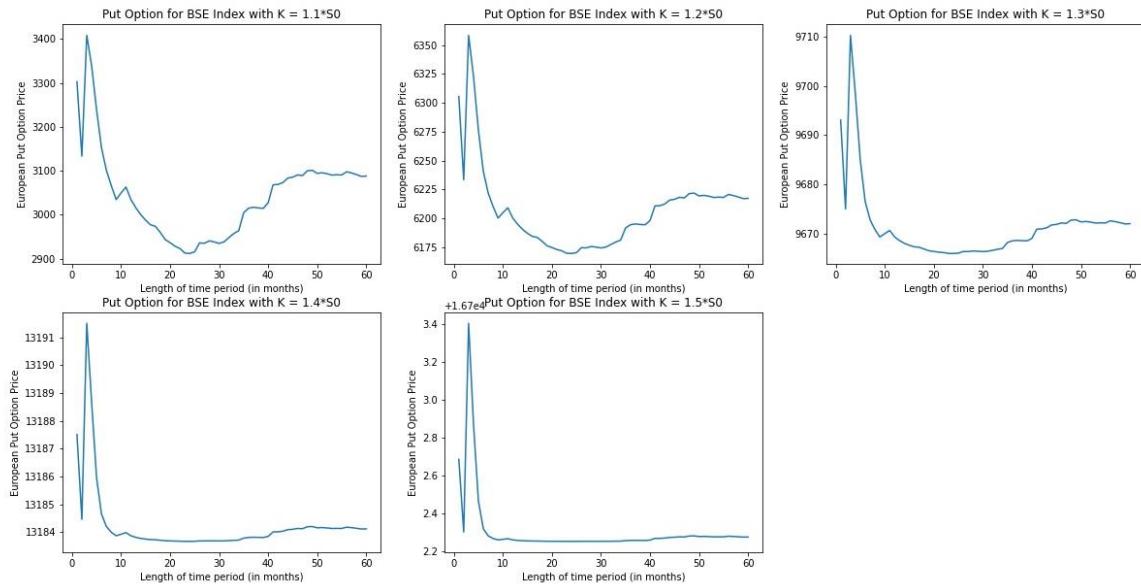


x) WIPRO.BO



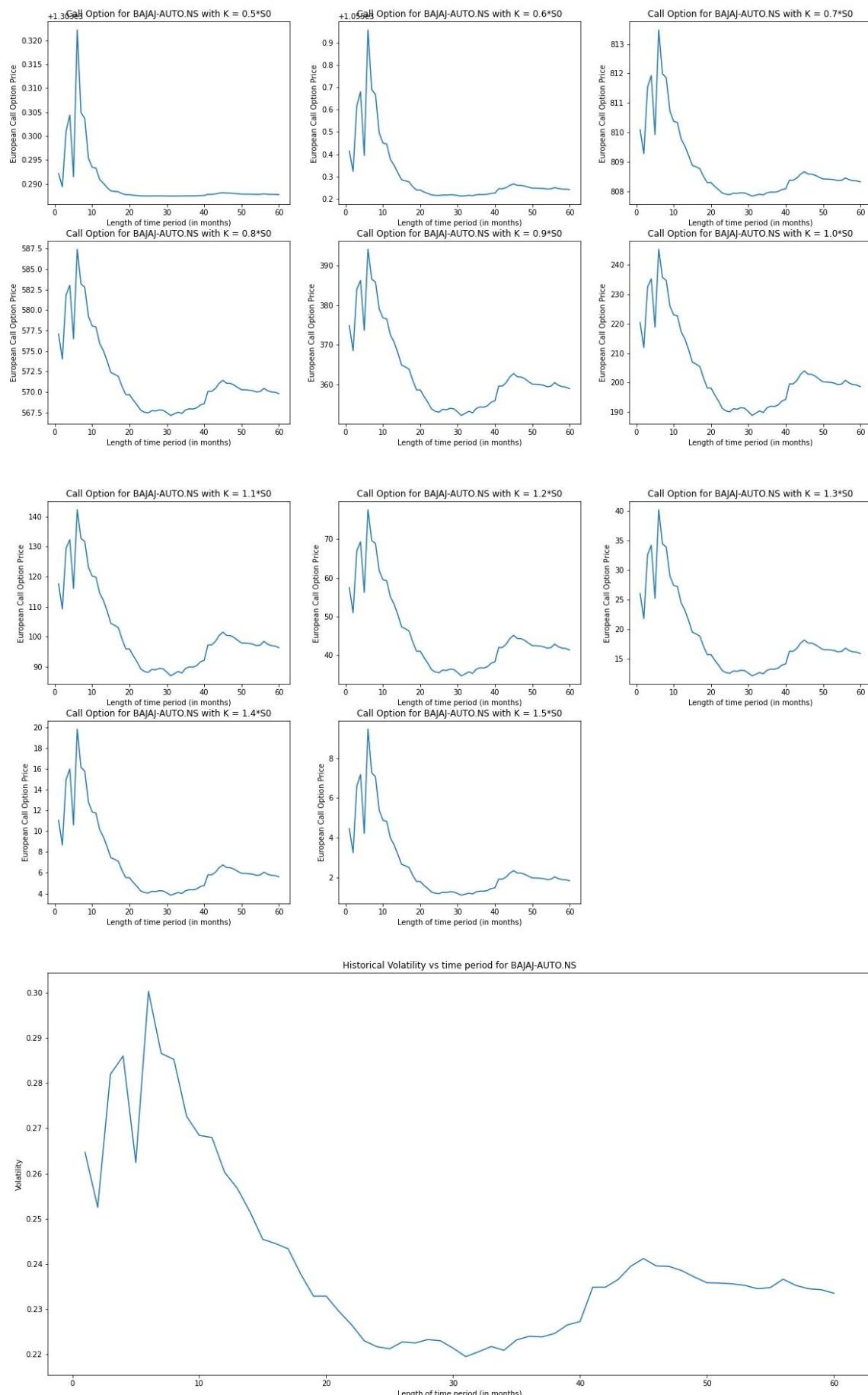
xi) BSE Index



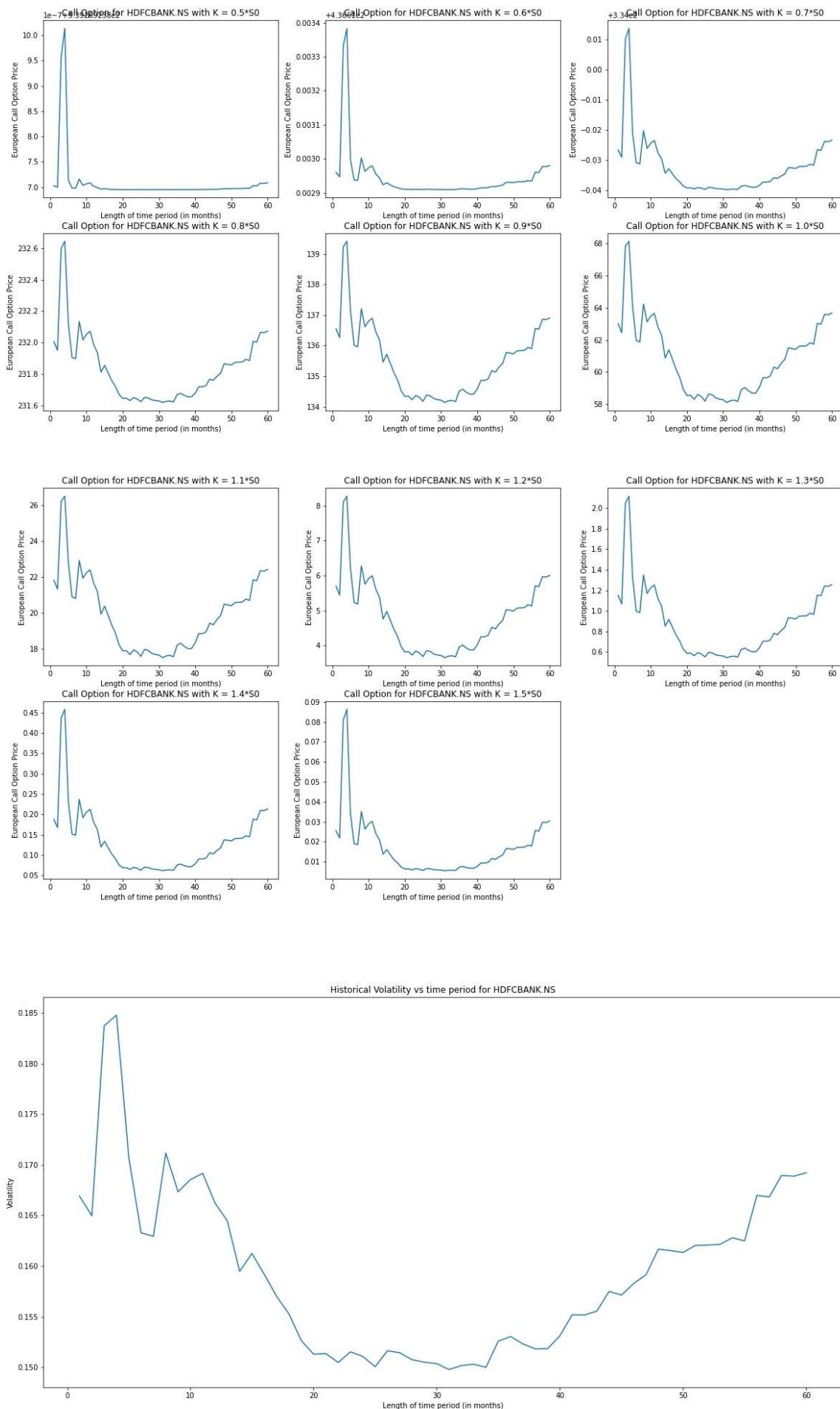


iii. Plots for Call Option and Volatility - stocks in nsedata1:

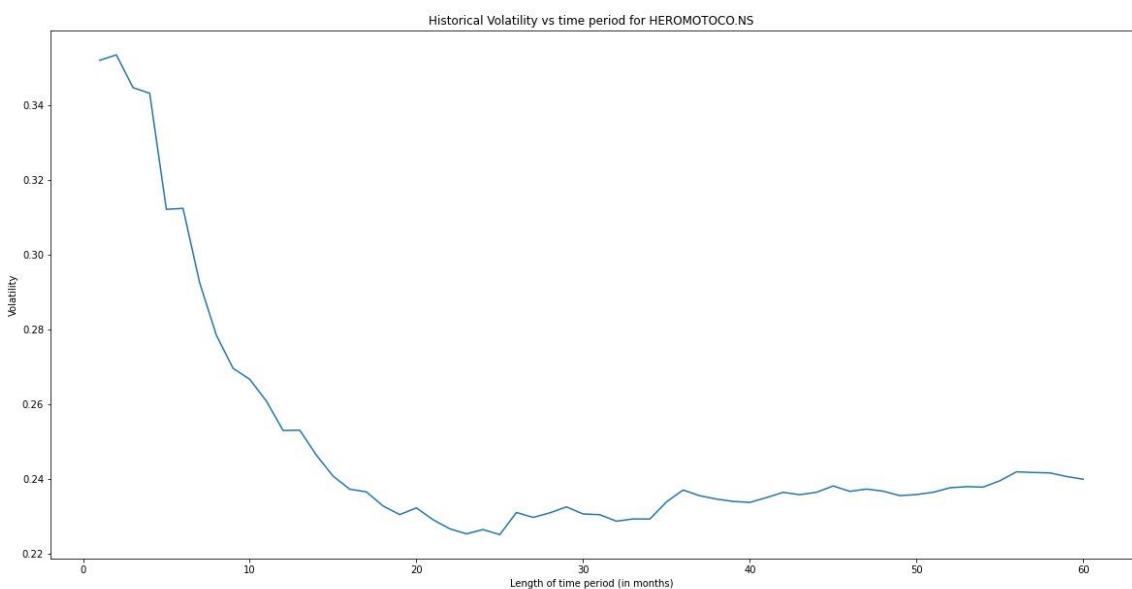
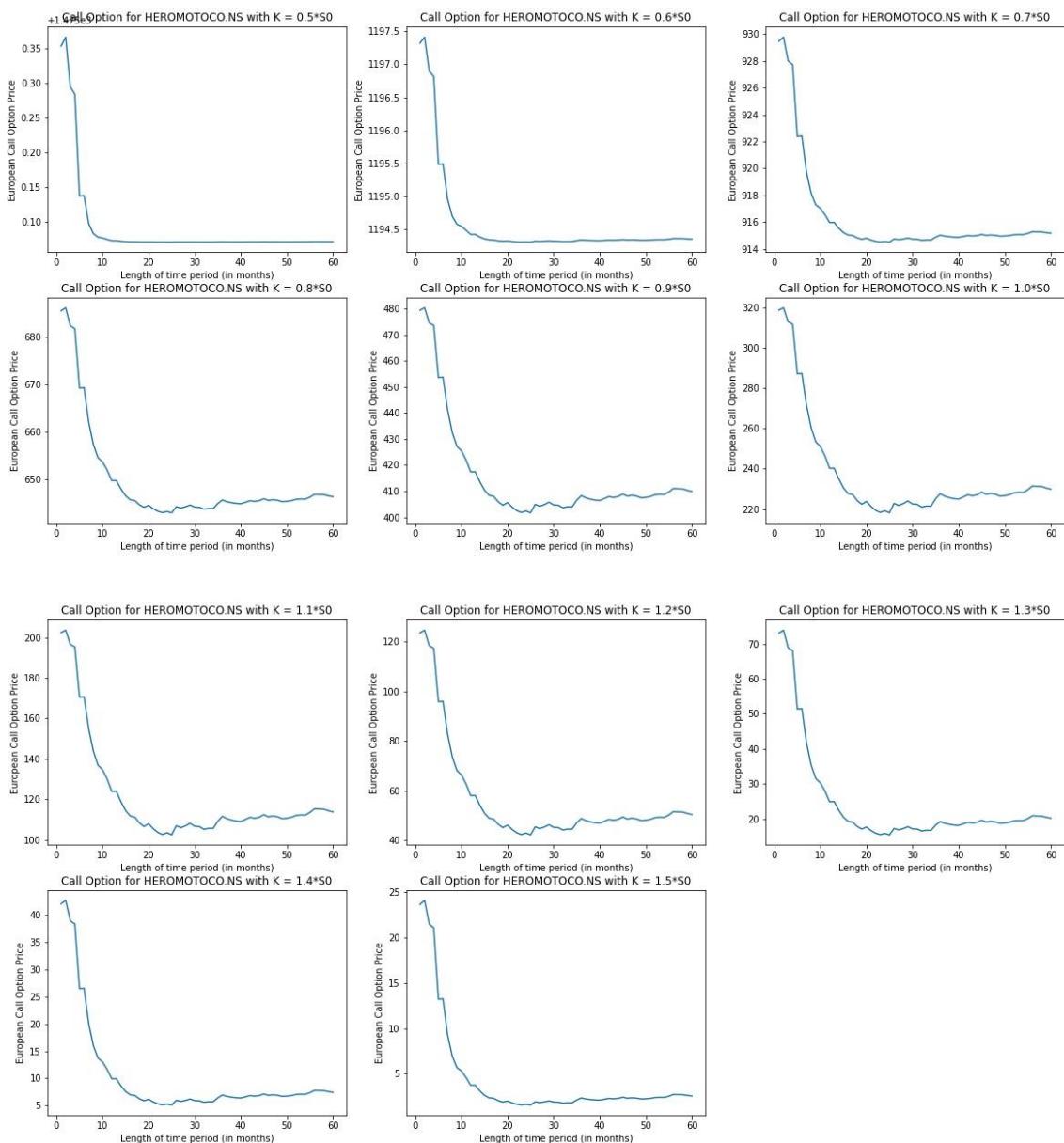
i) BAJAJ-AUTO.NS



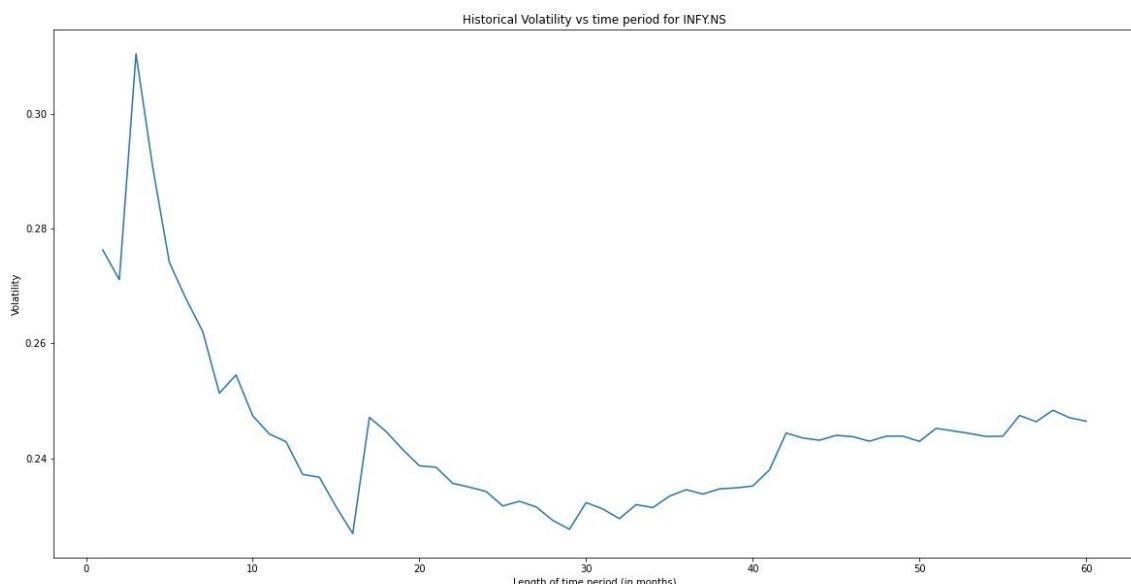
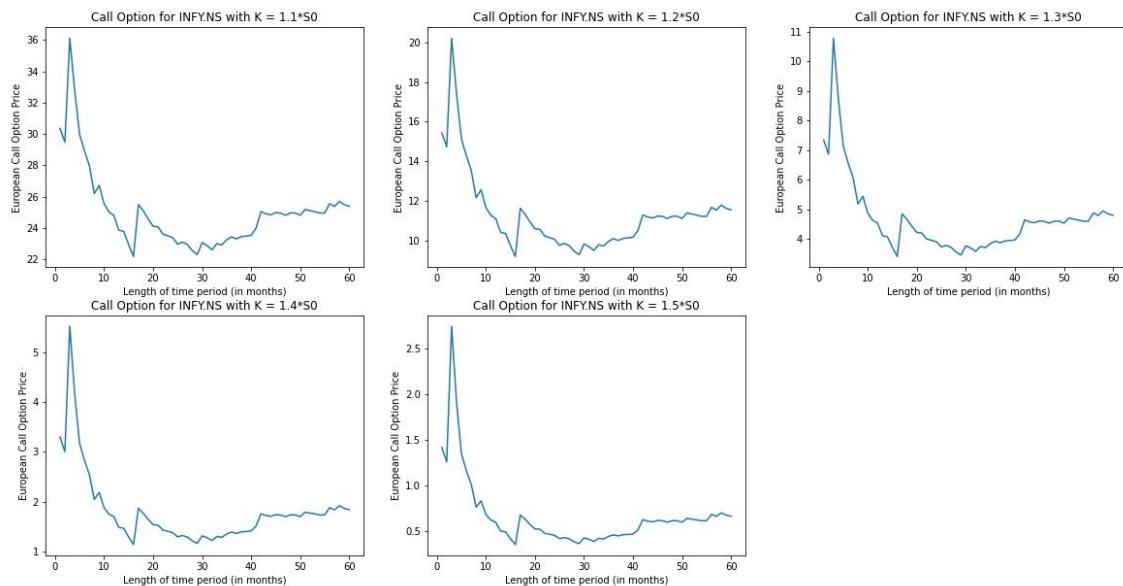
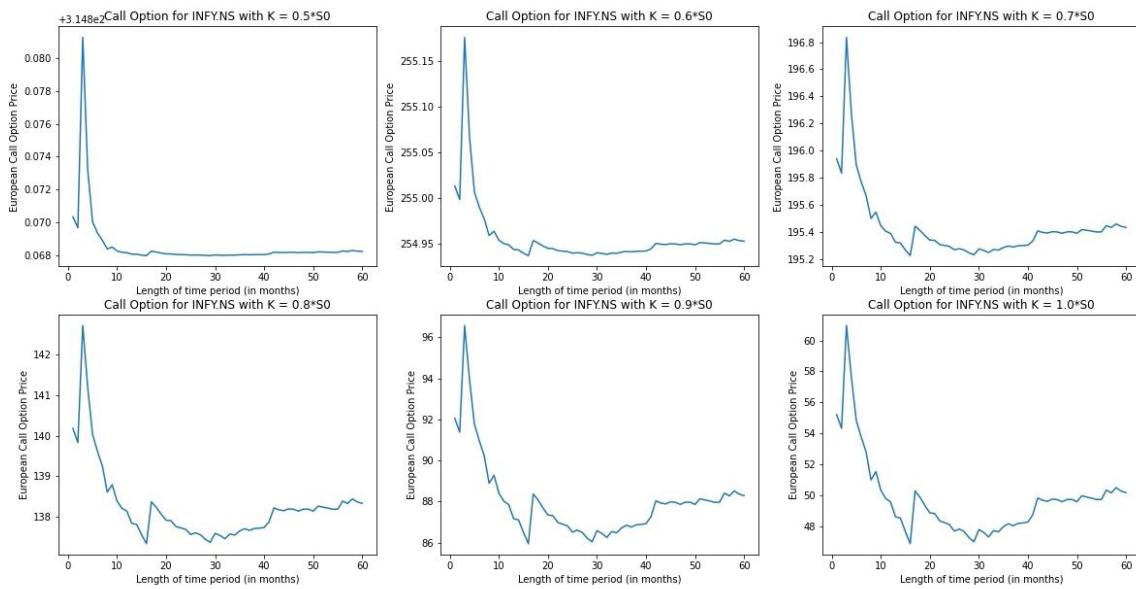
ii) HDFCBANK.NS



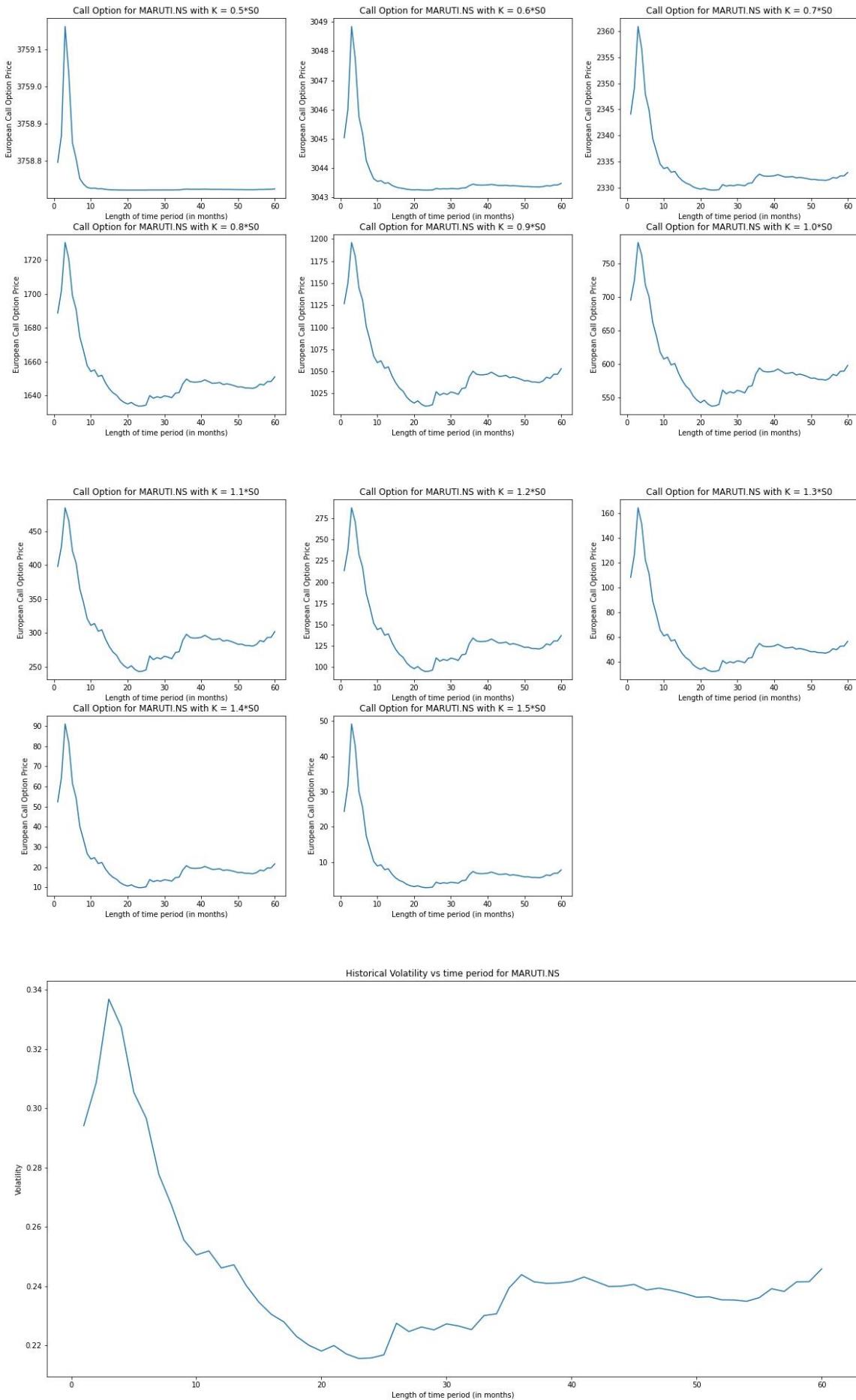
iii) HEROMOTOCO.NS



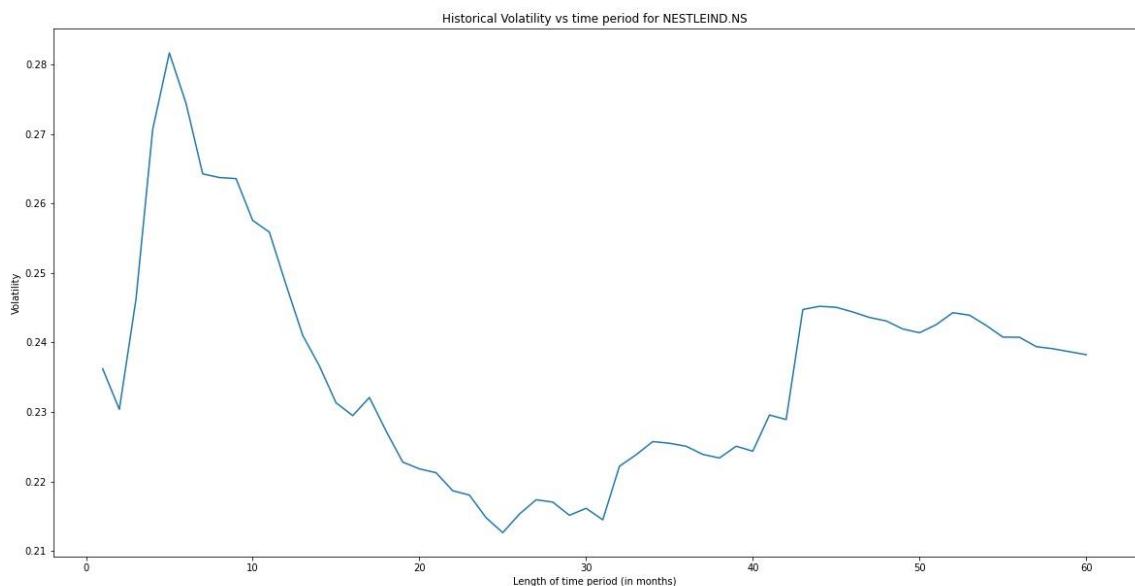
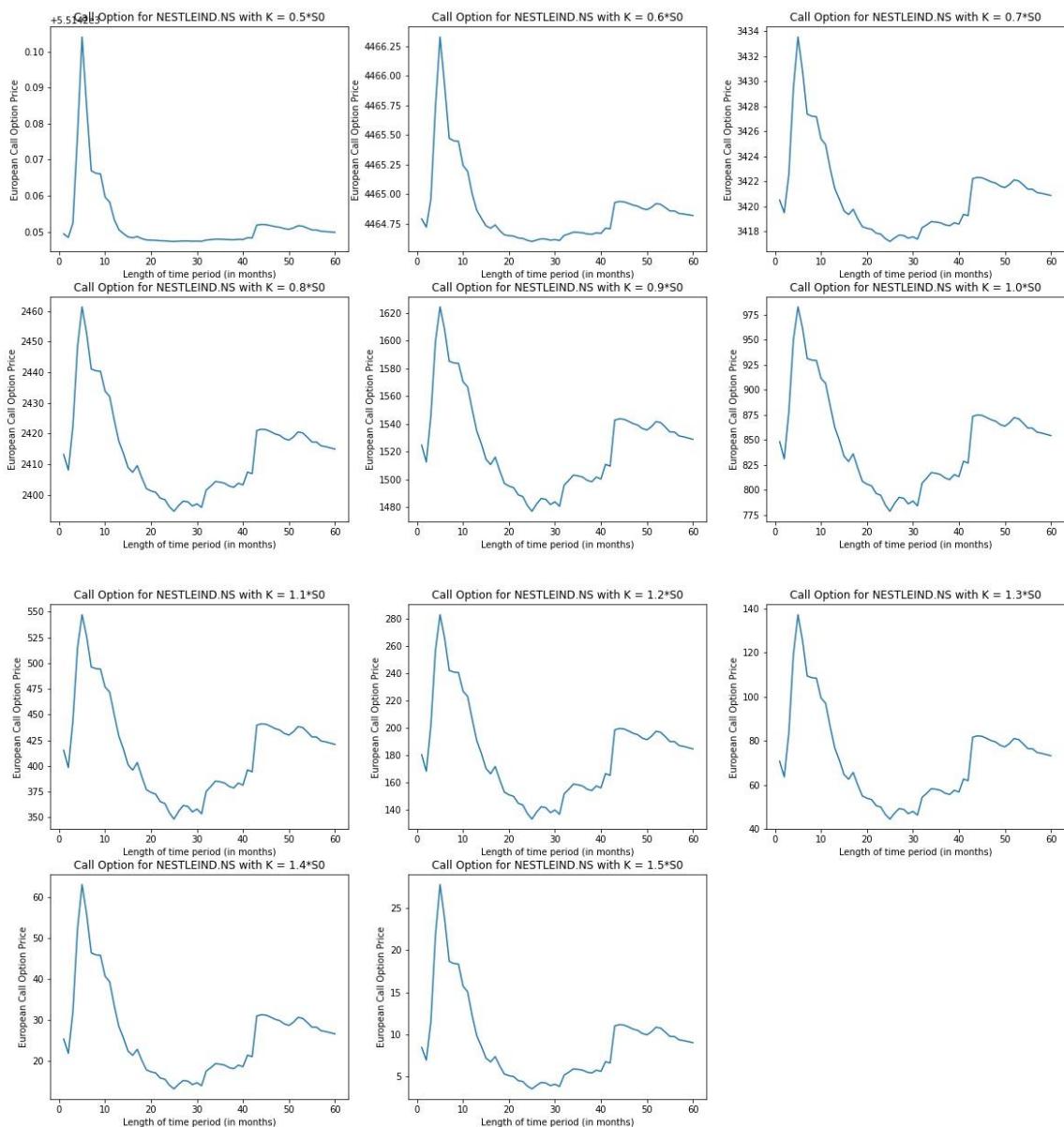
iv) INFY.NS



v) MARUTI.NS

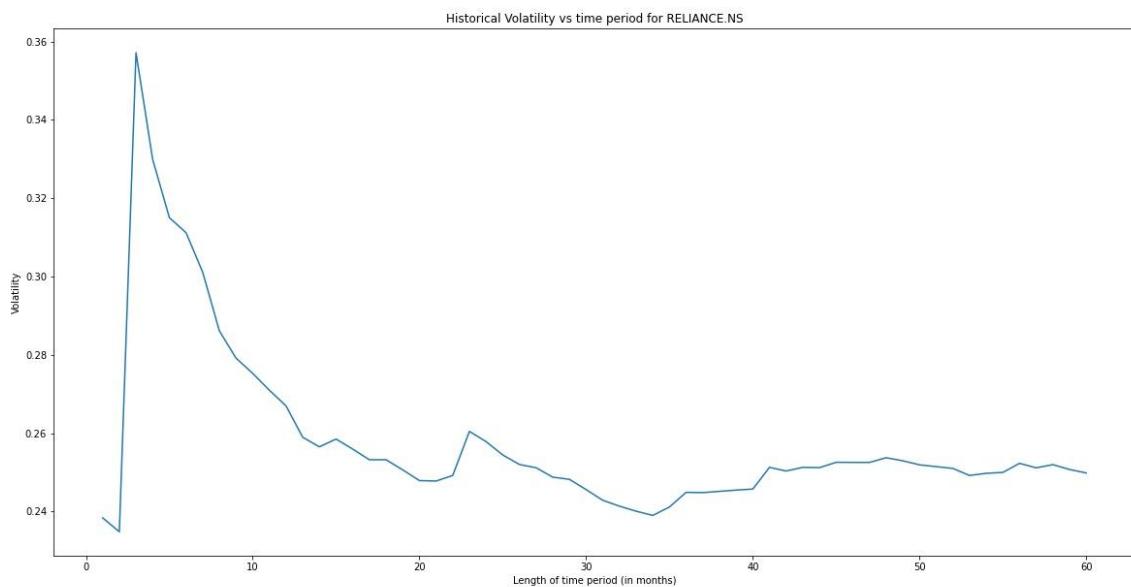
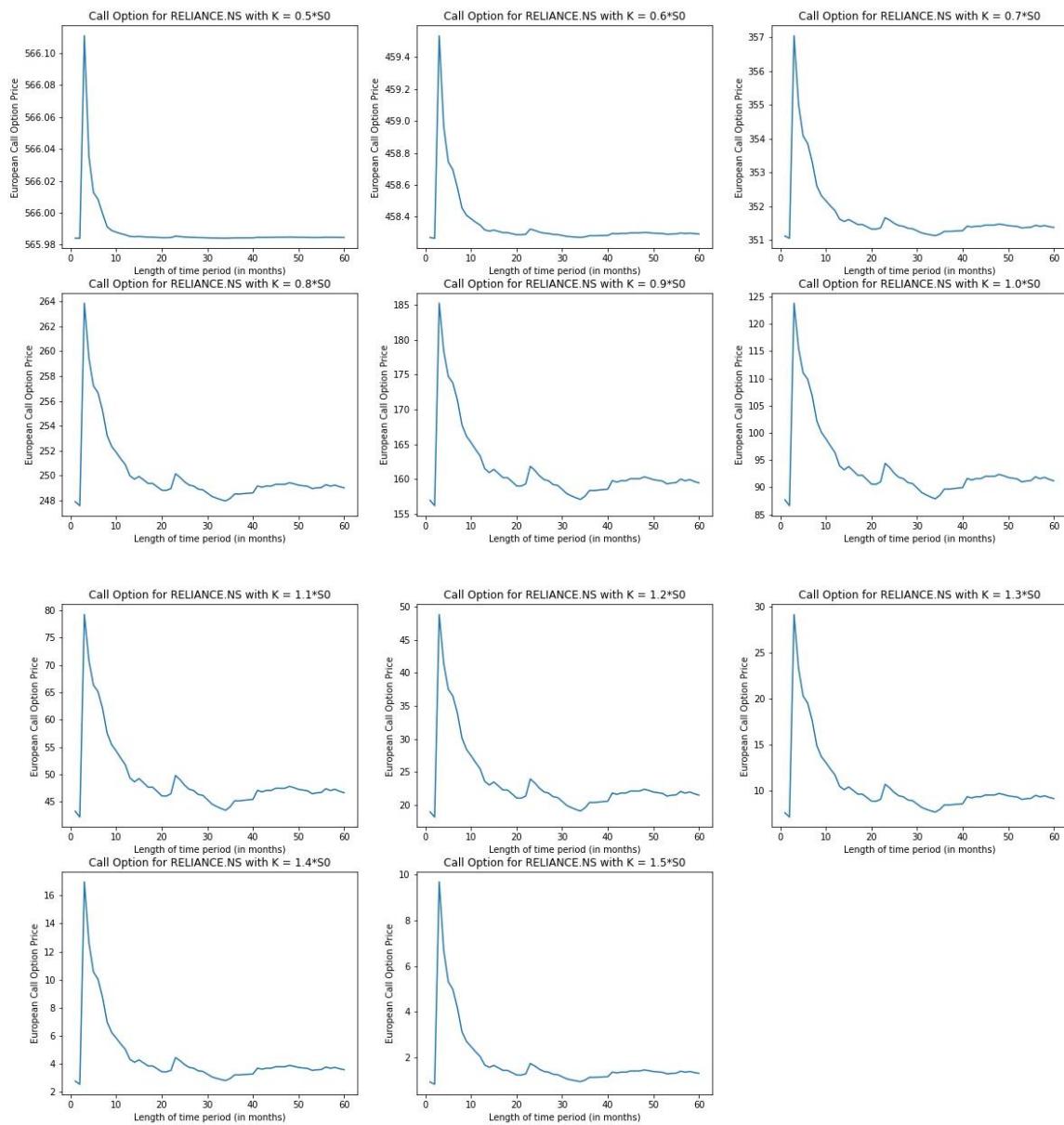


vi) NESTLEIND.NS



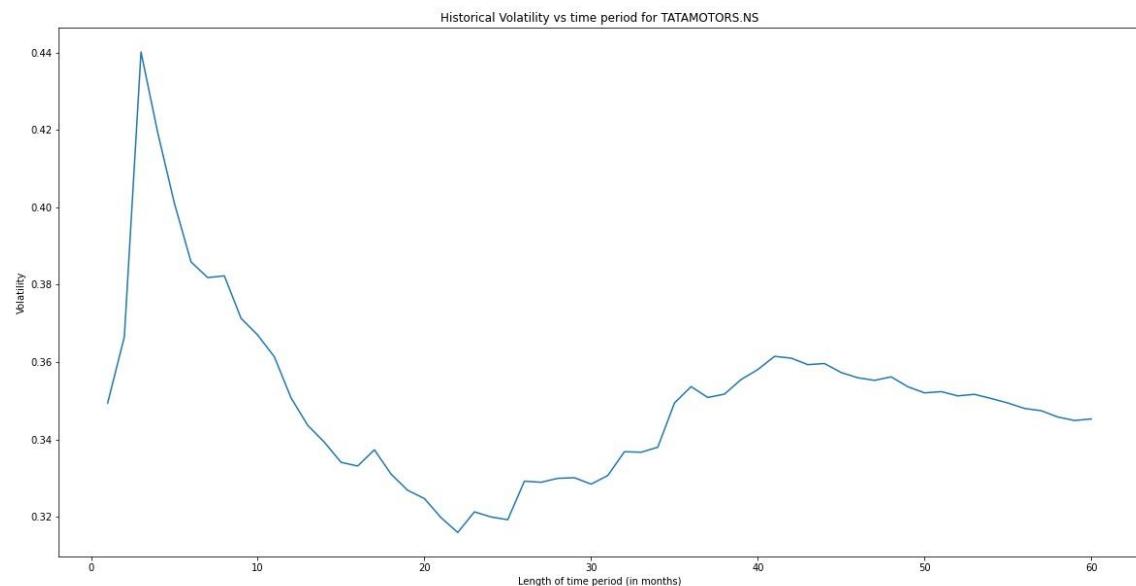
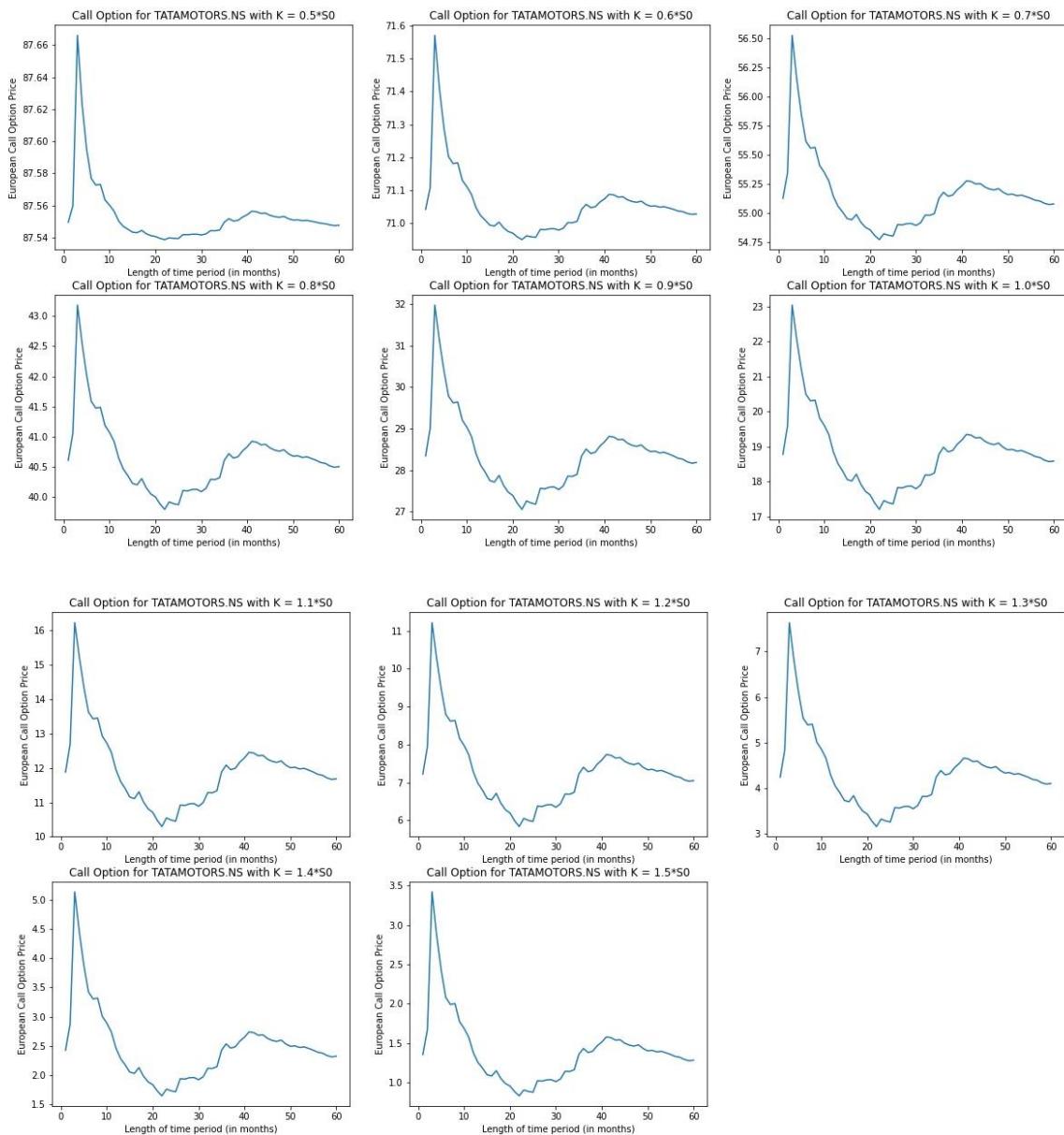
vii)

RELIANCE.NS

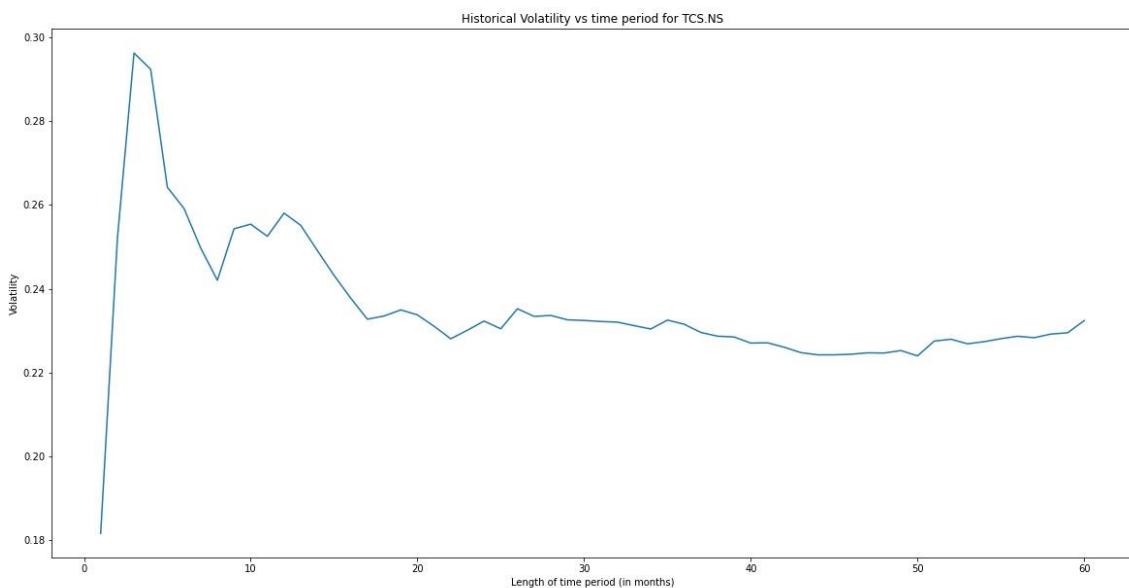
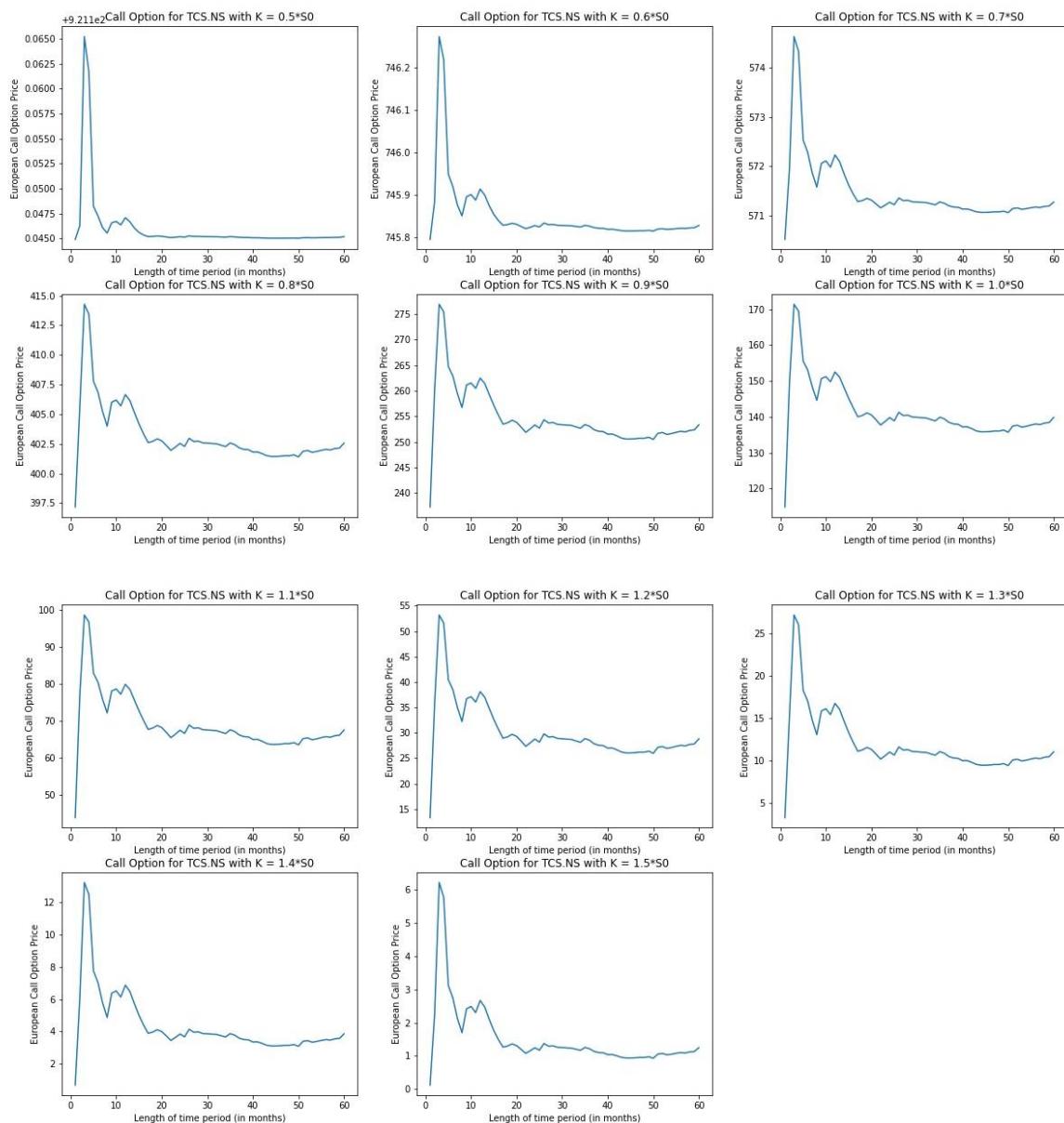


viii)

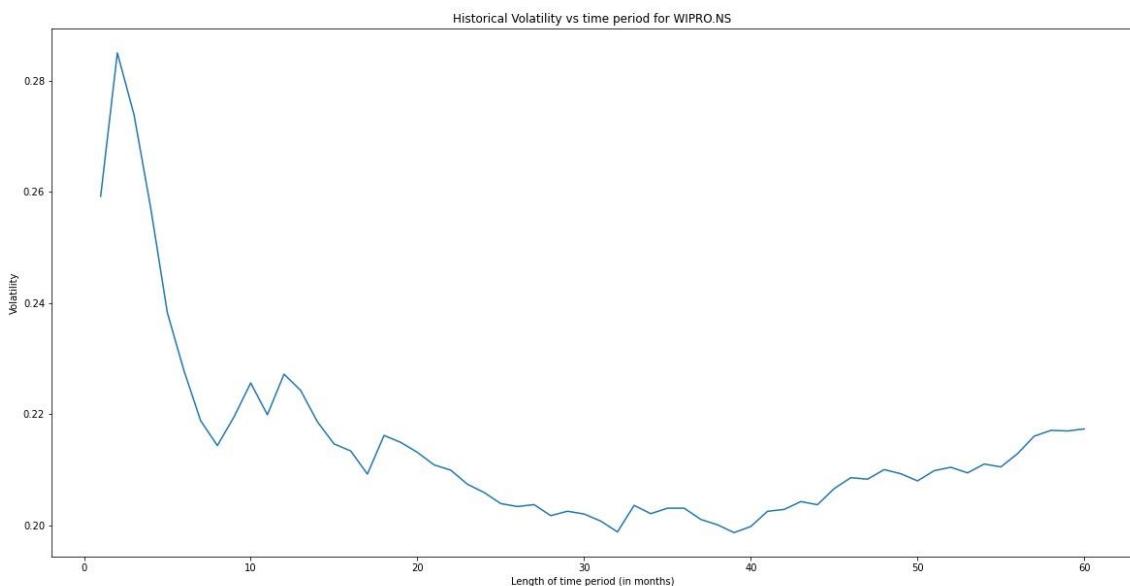
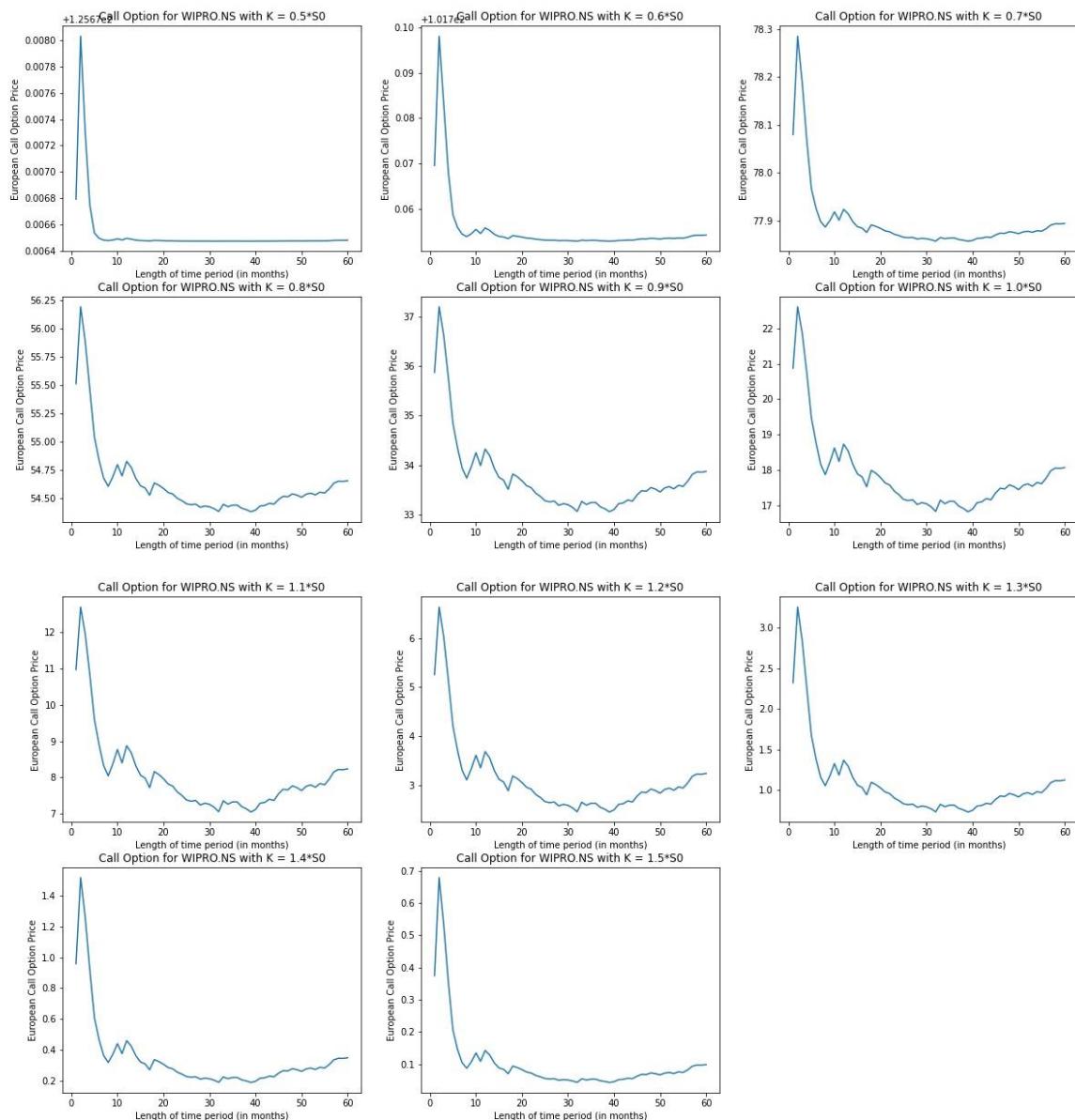
TATAMOTORS.NS



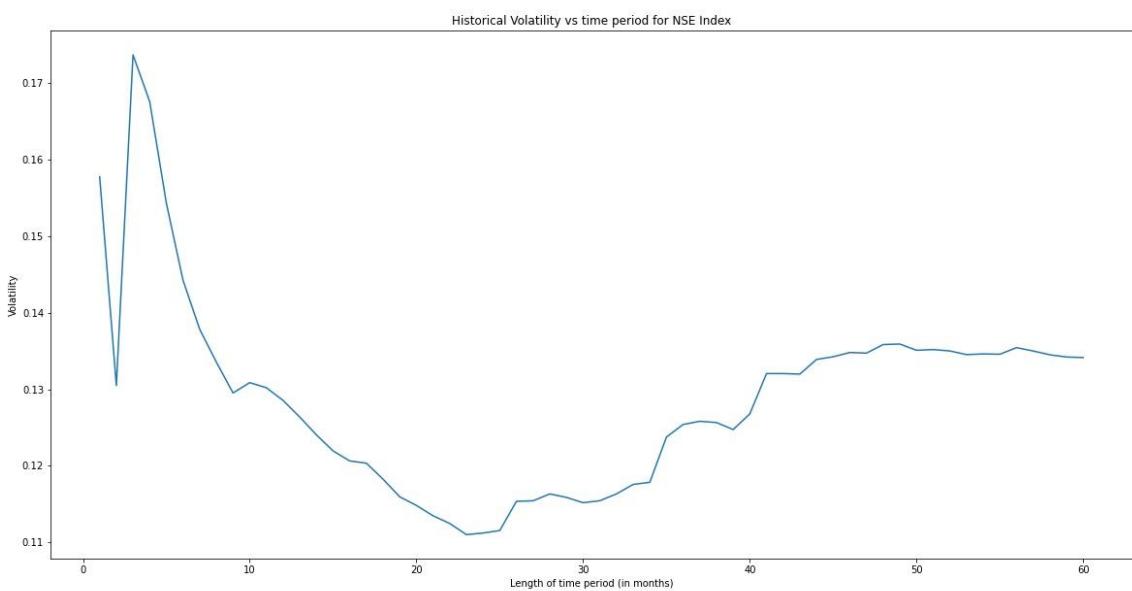
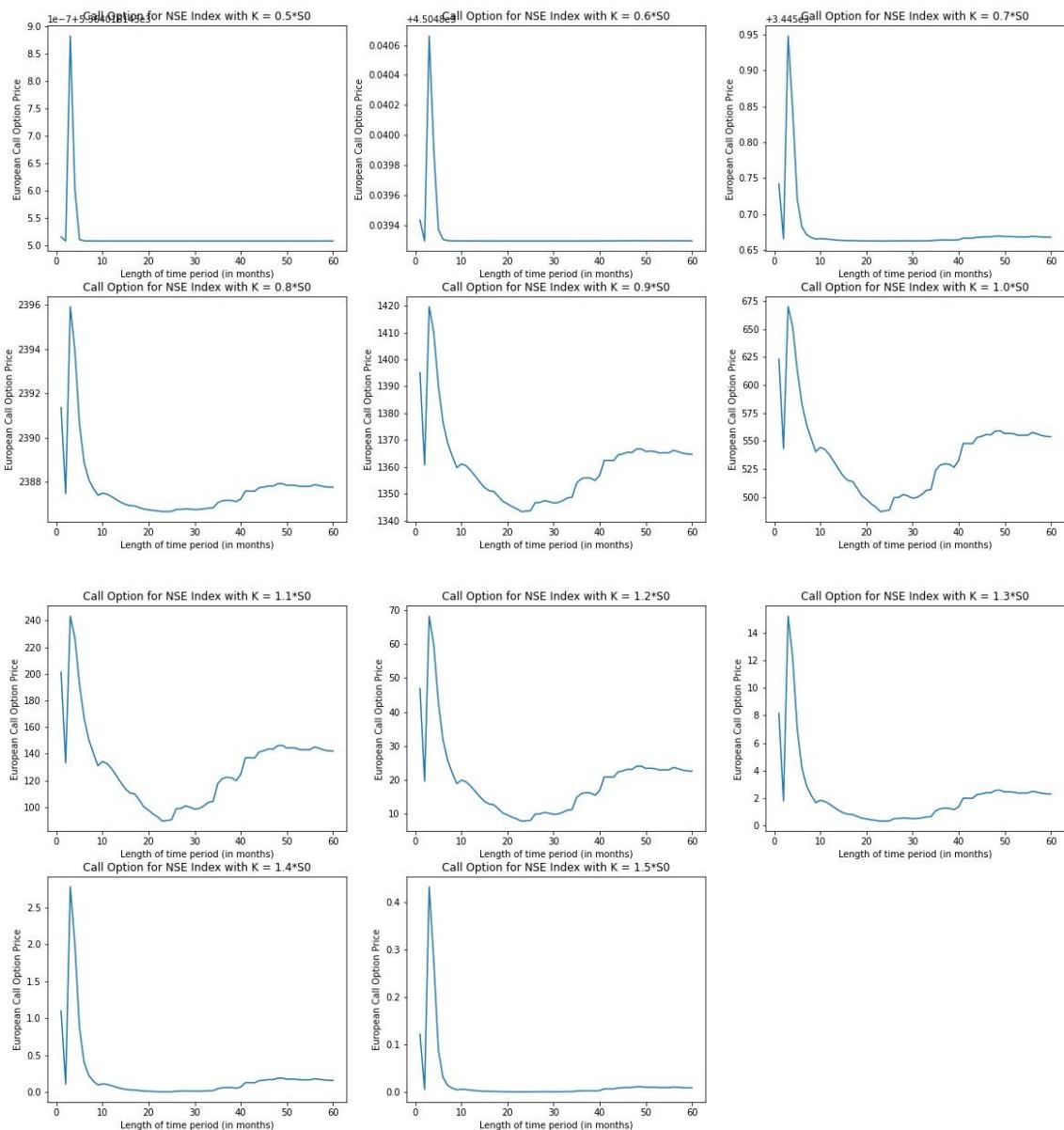
ix) TCS.NS



x) WIPRO.NS

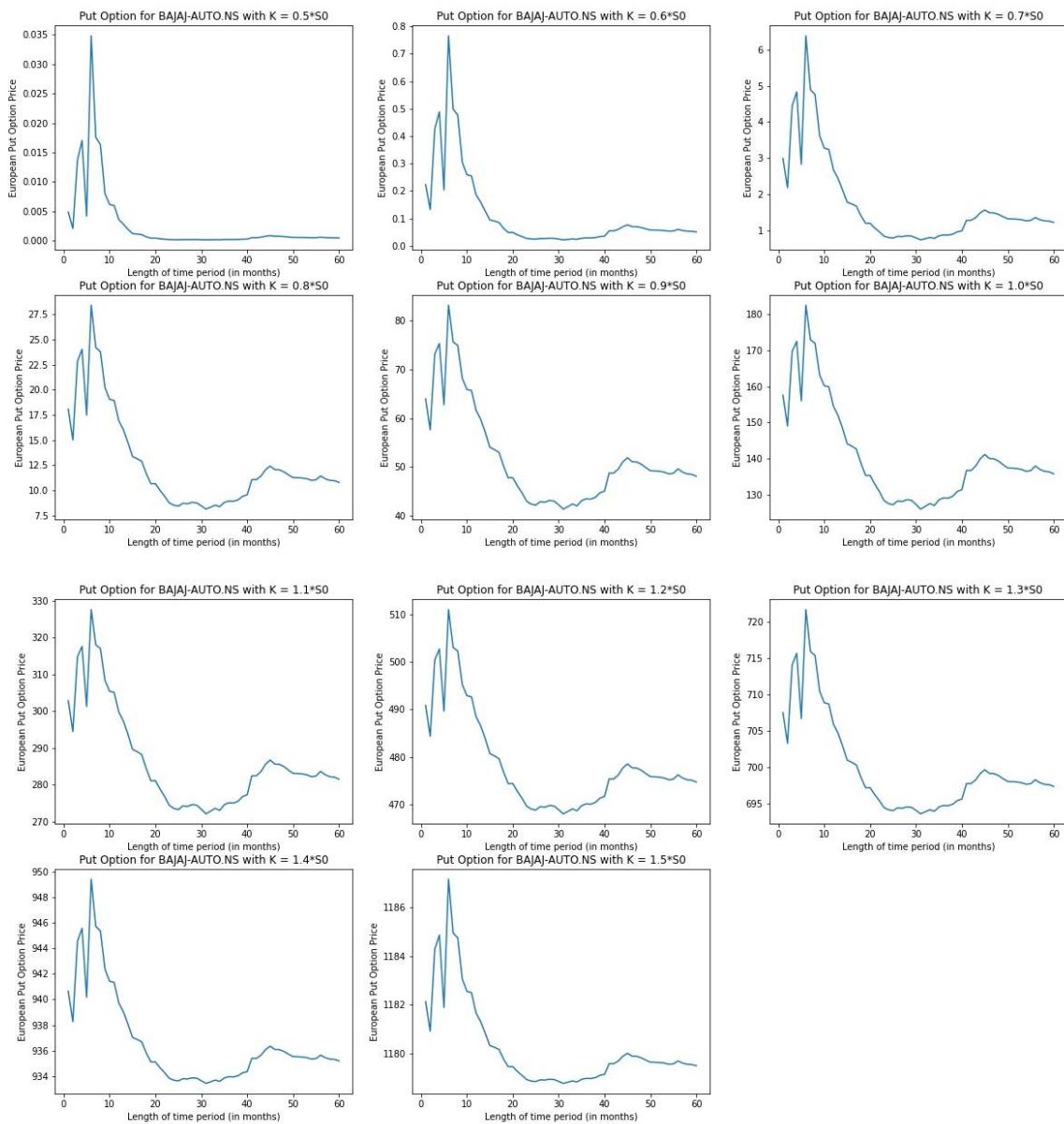


xi) NSE Index

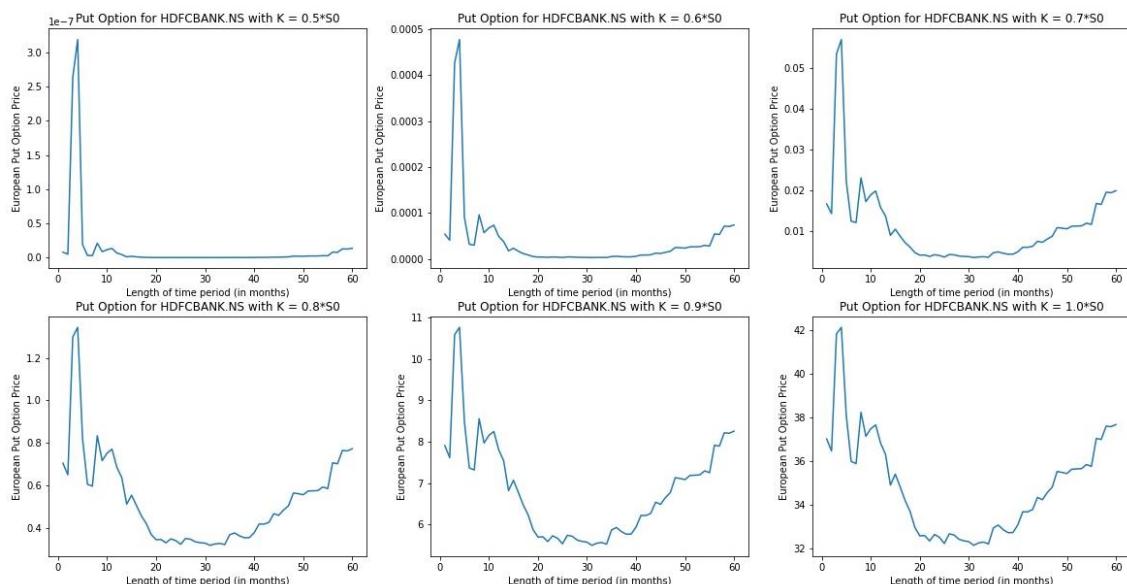


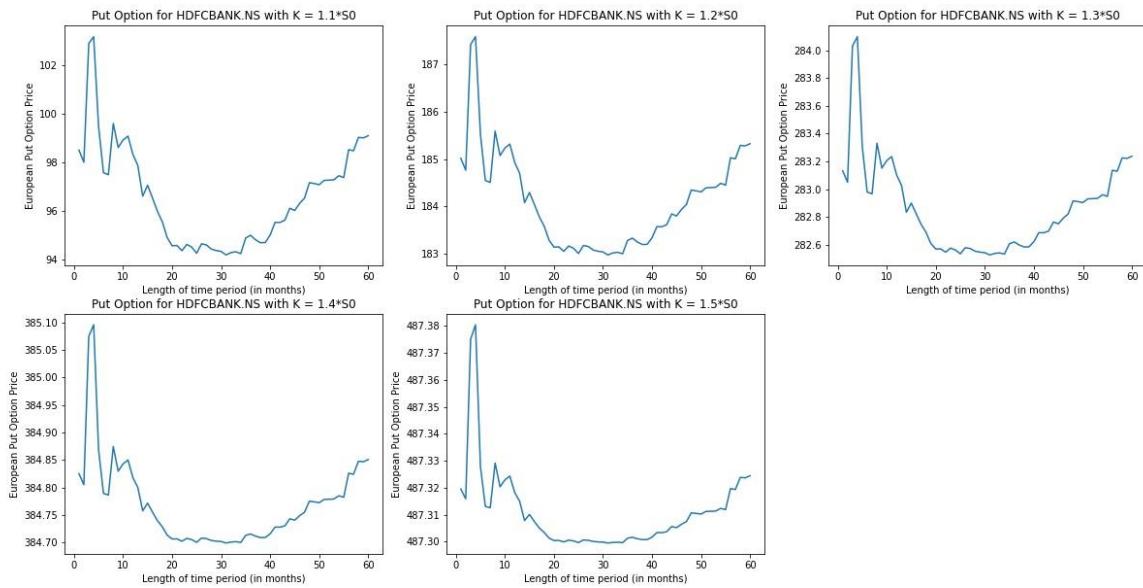
iv. Plots for Put Option - stocks in nsedata1:

i) BAJAJ-AUTO.NS

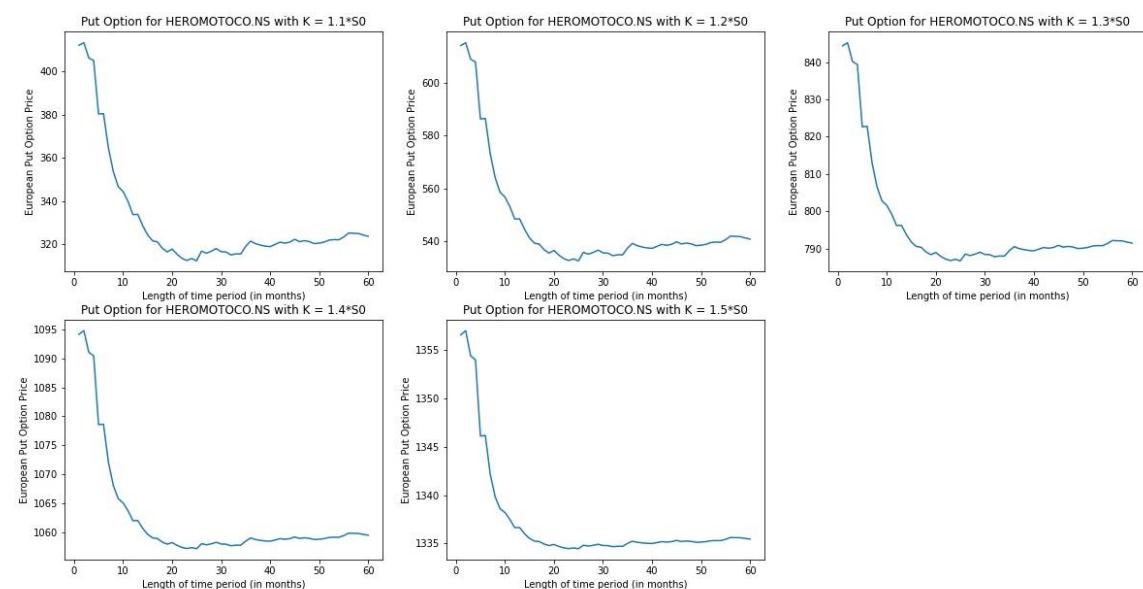
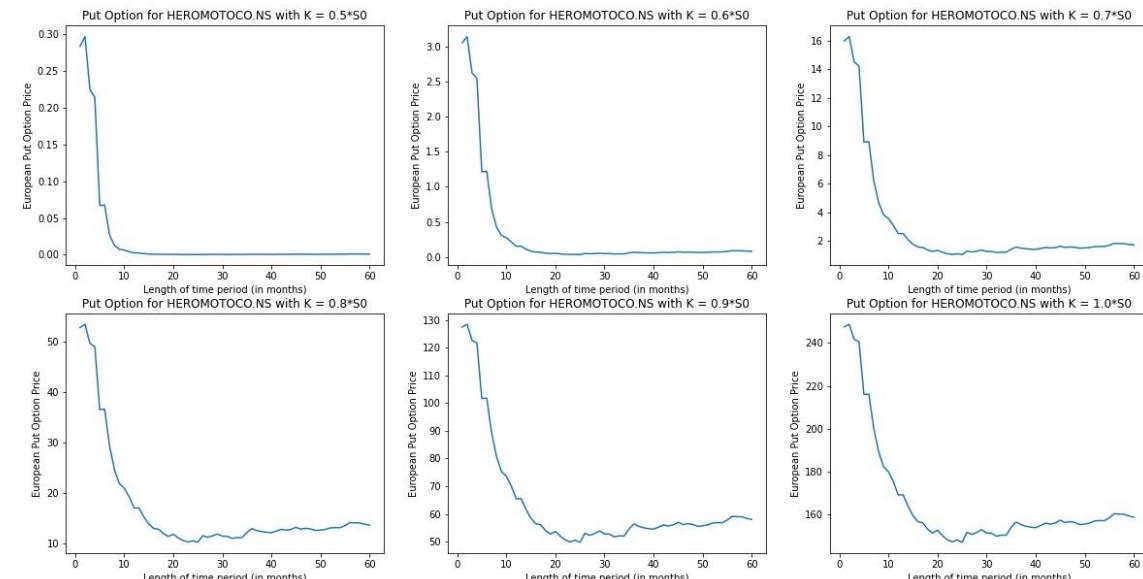


ii) HDFCBANK.NS

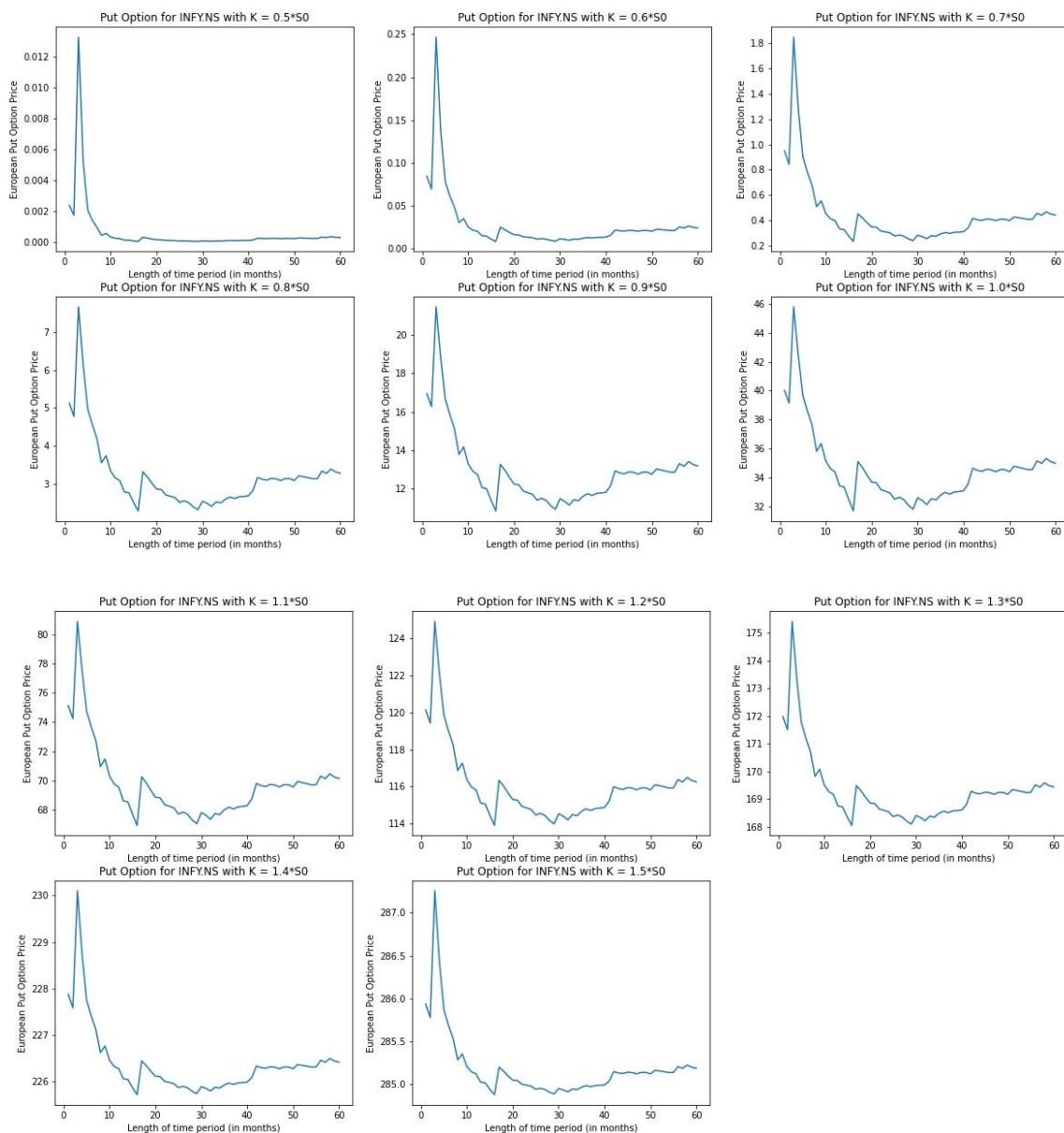




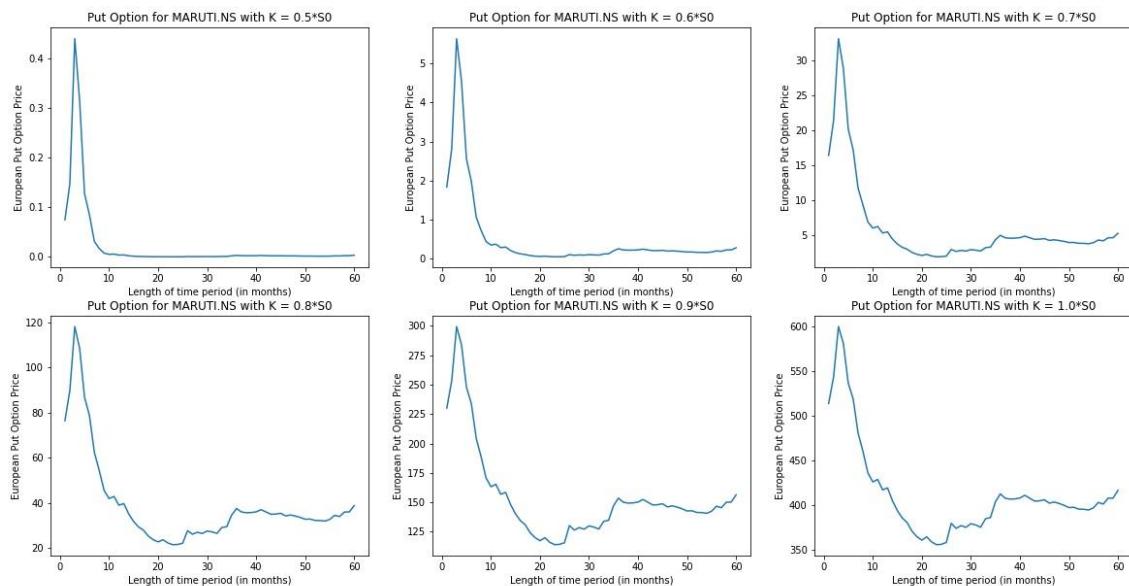
iii) HEROMOTOCO.NS

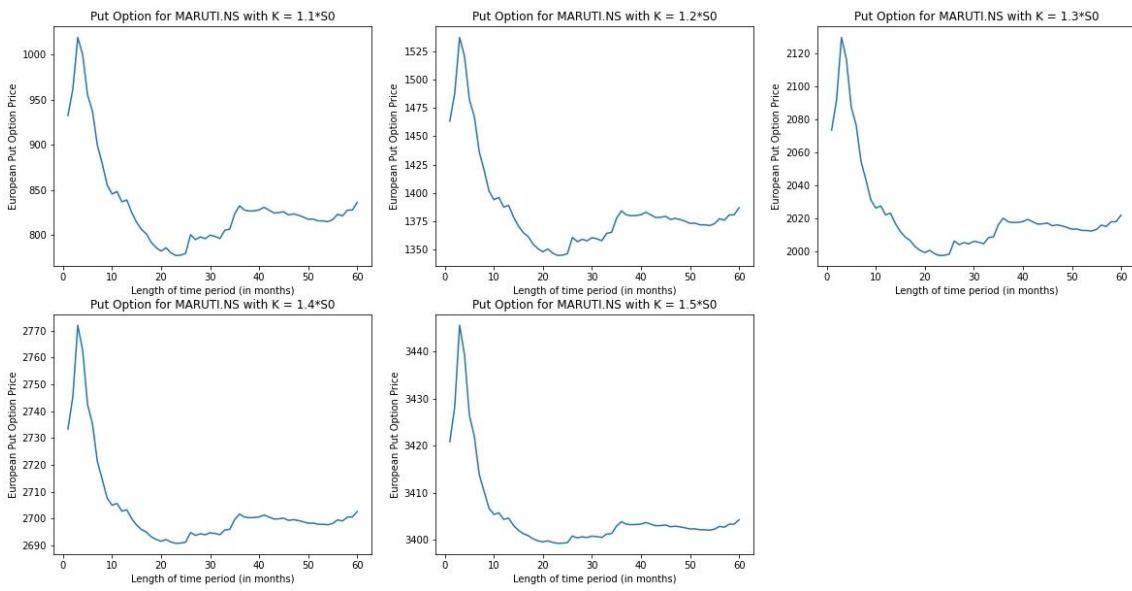


iv) INFY.NS

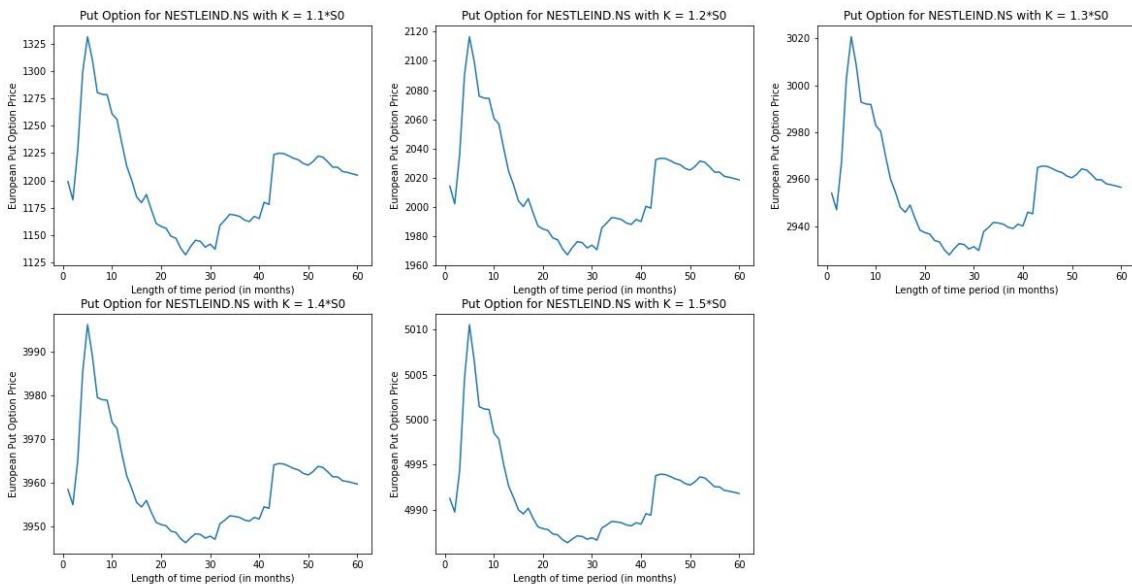
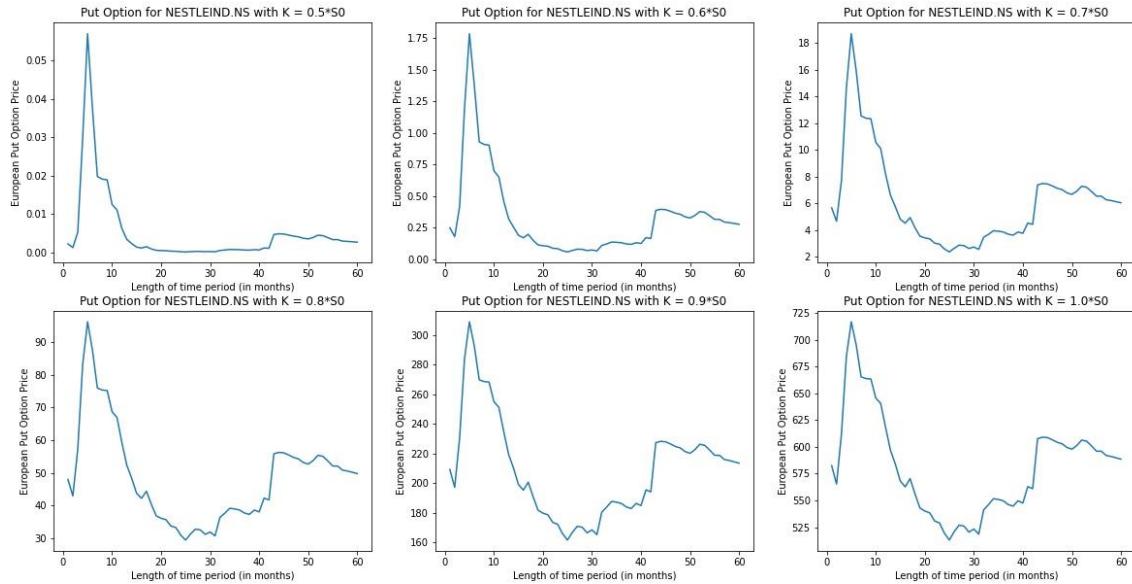


v) MARUTI.NS



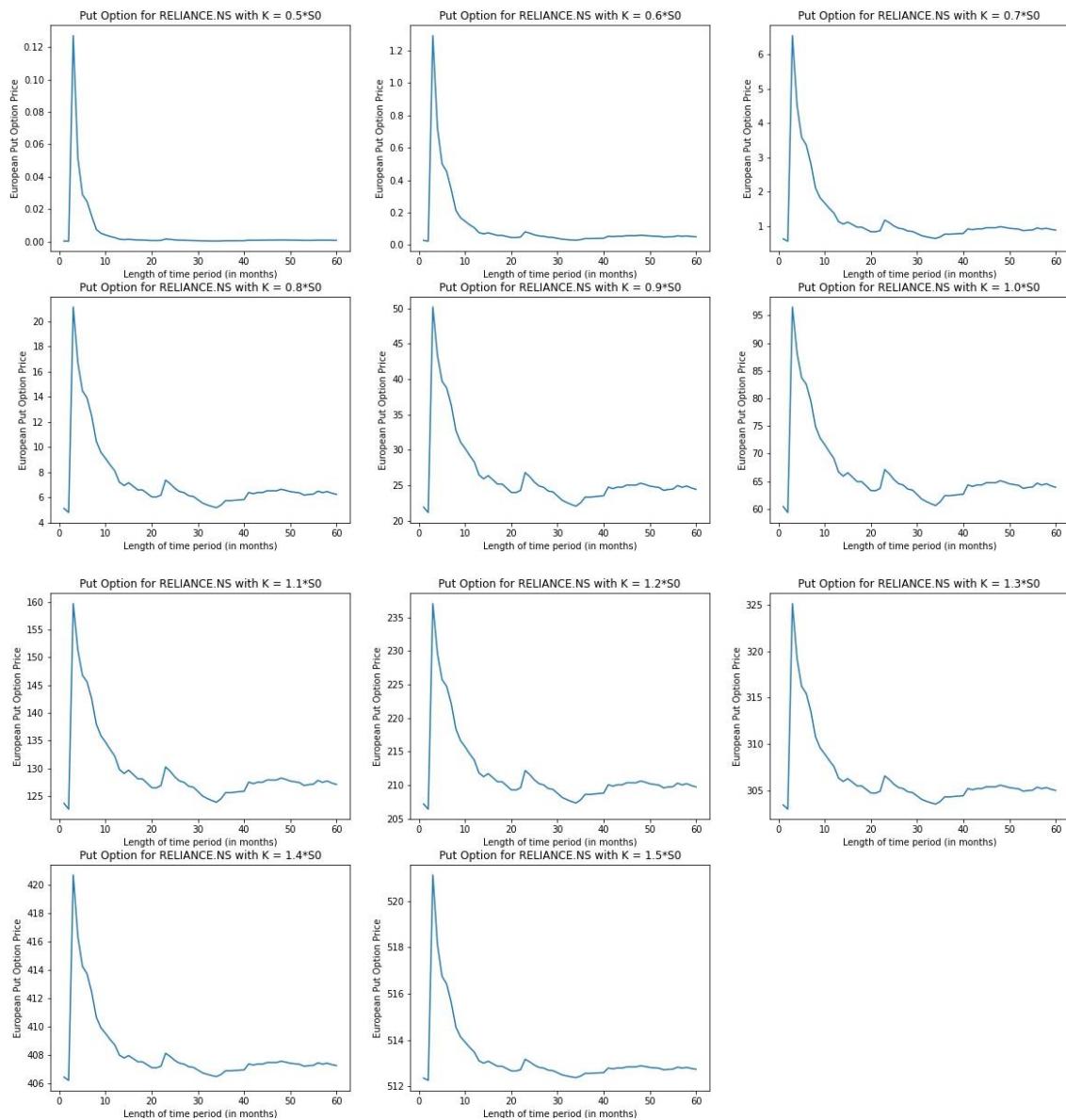


vi) NESTLEIND.NS



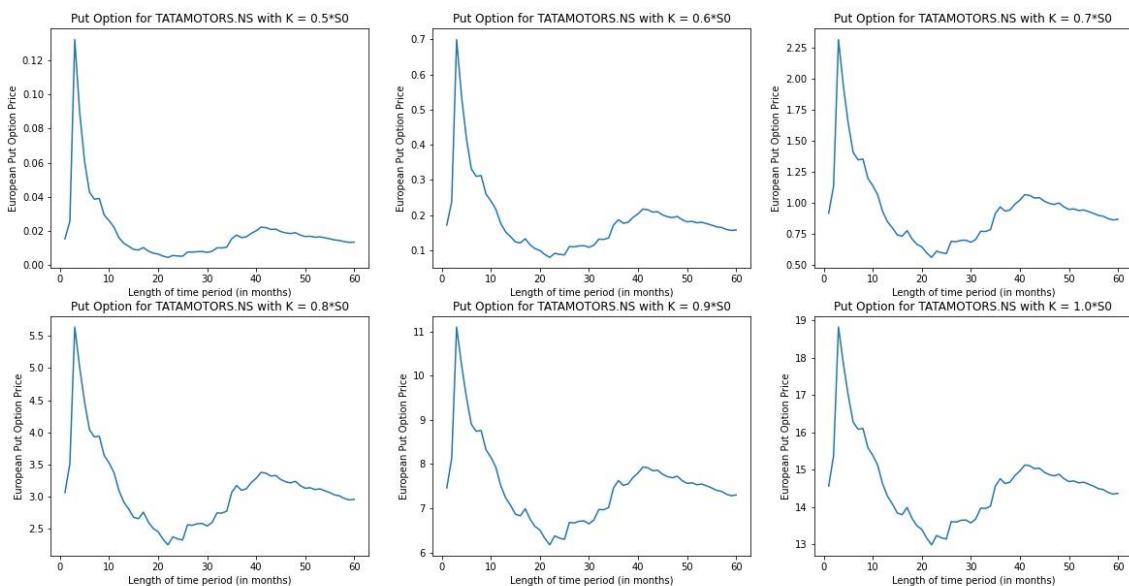
vii)

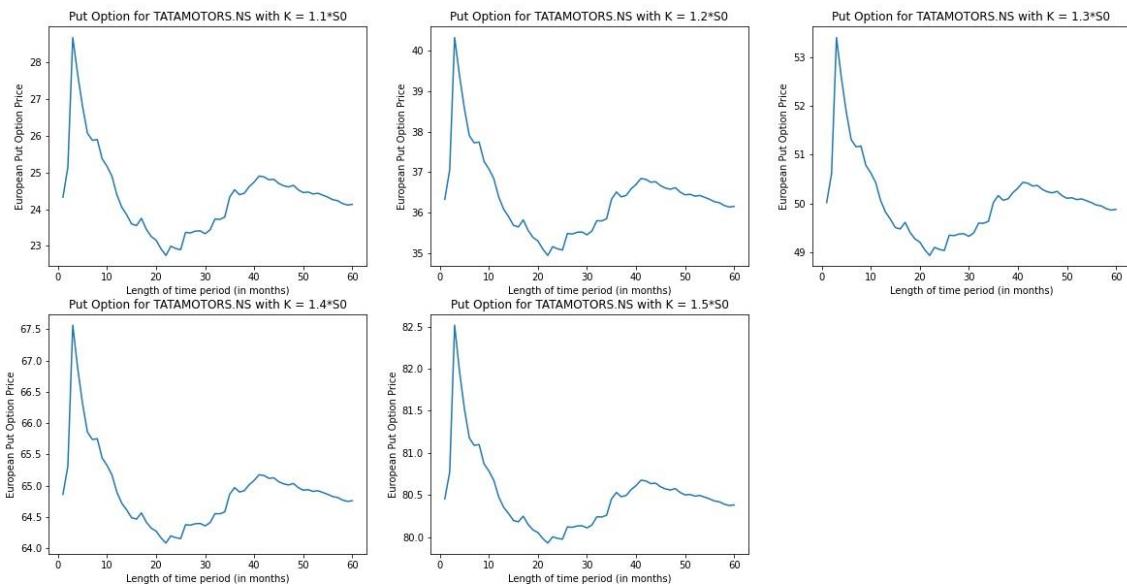
RELIANCE.NS



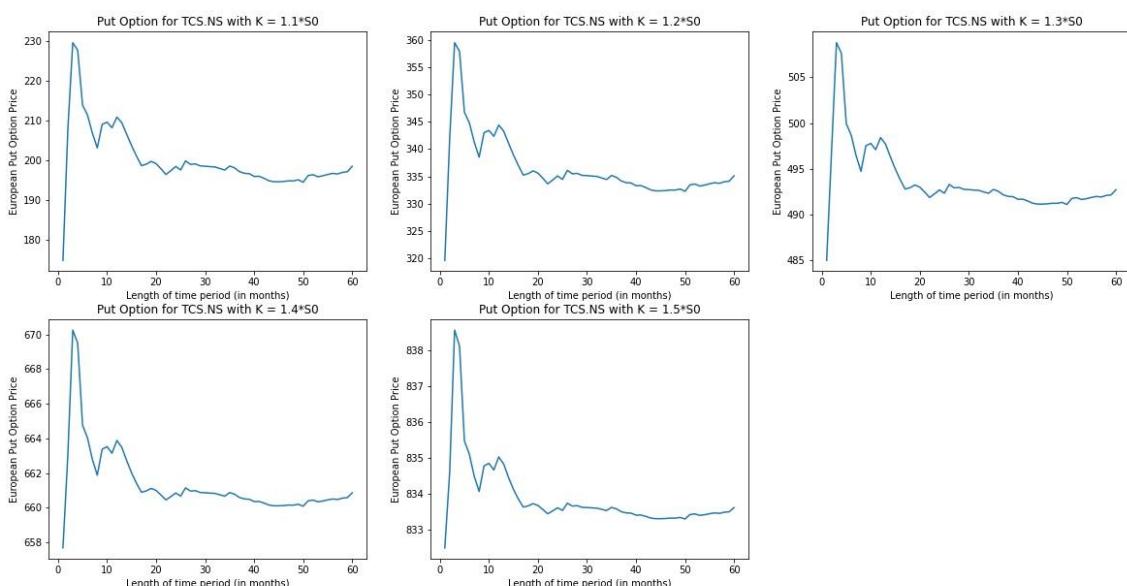
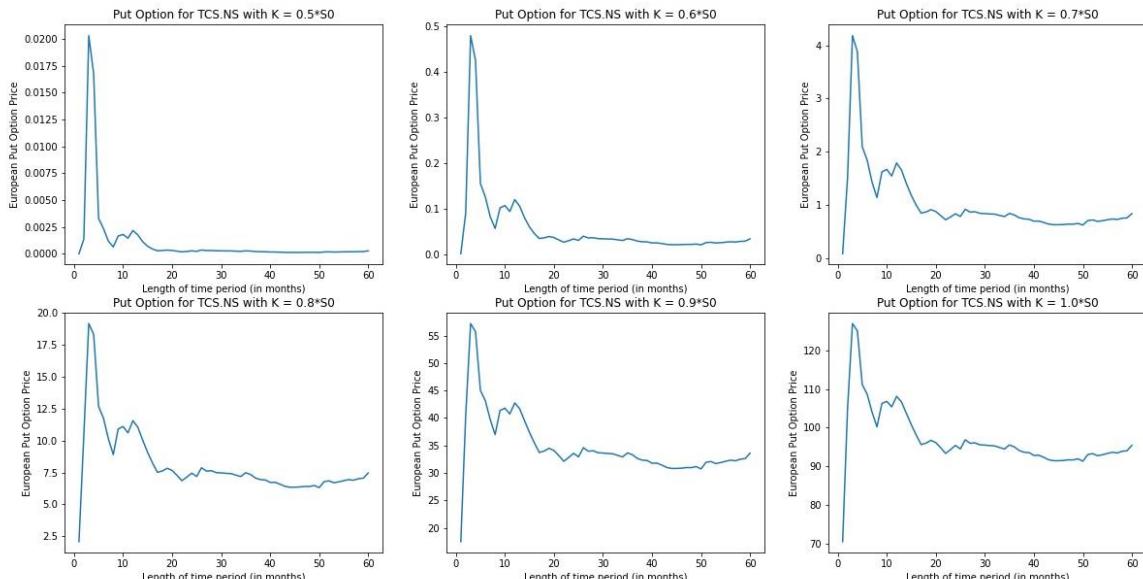
viii)

TATAMOTORS.NS

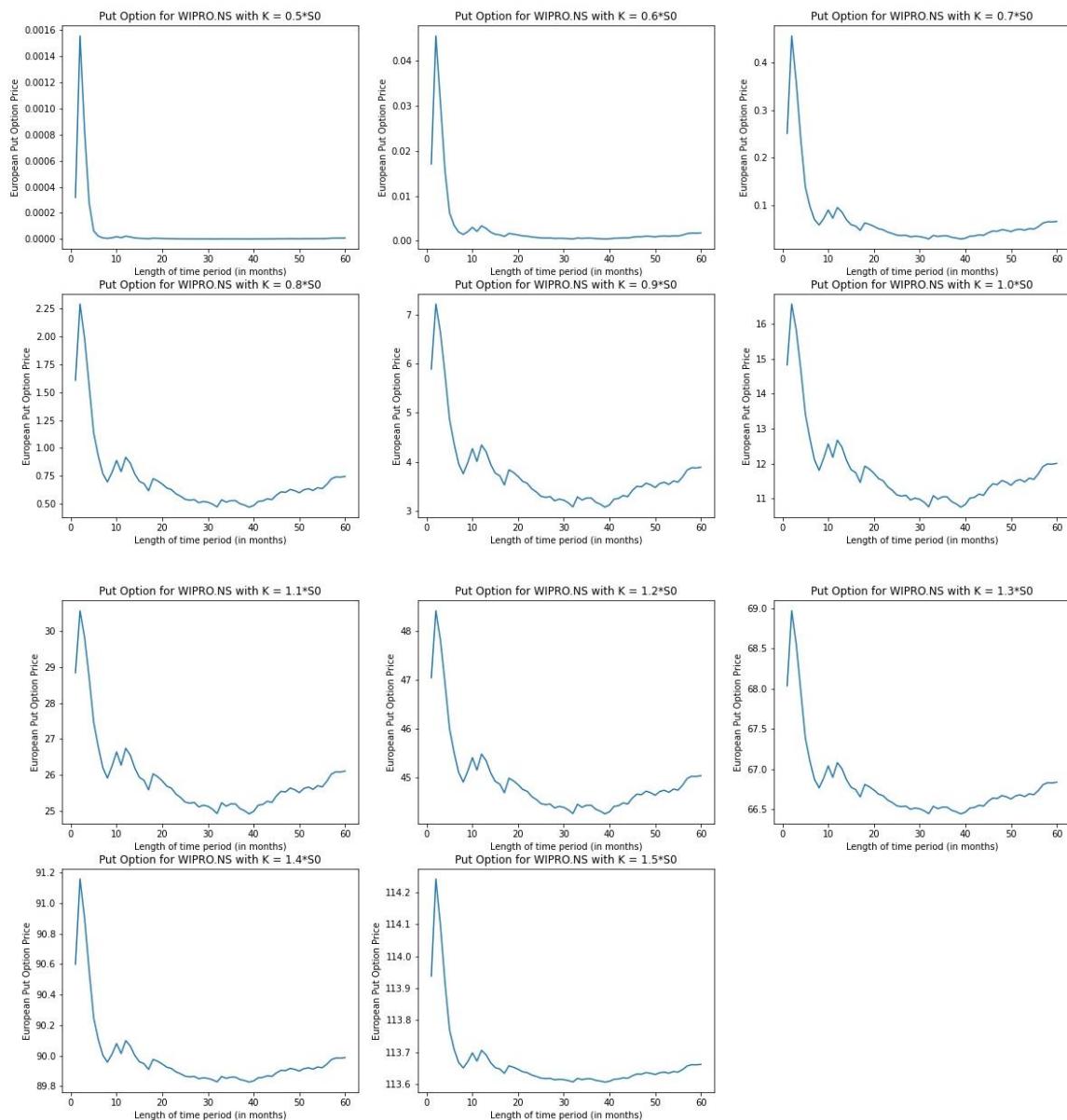




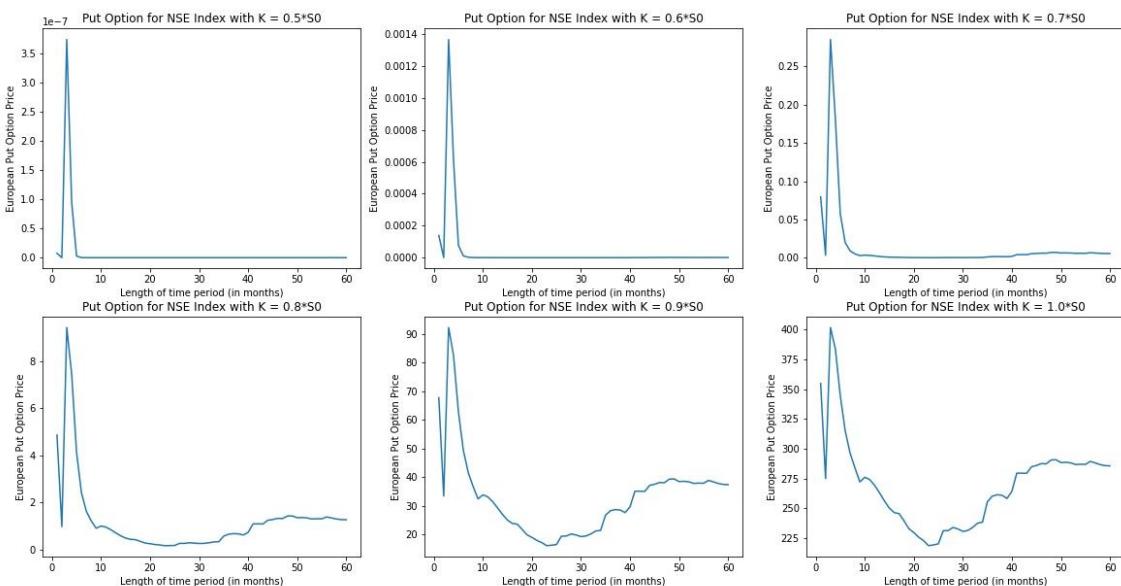
ix) TCS.NS

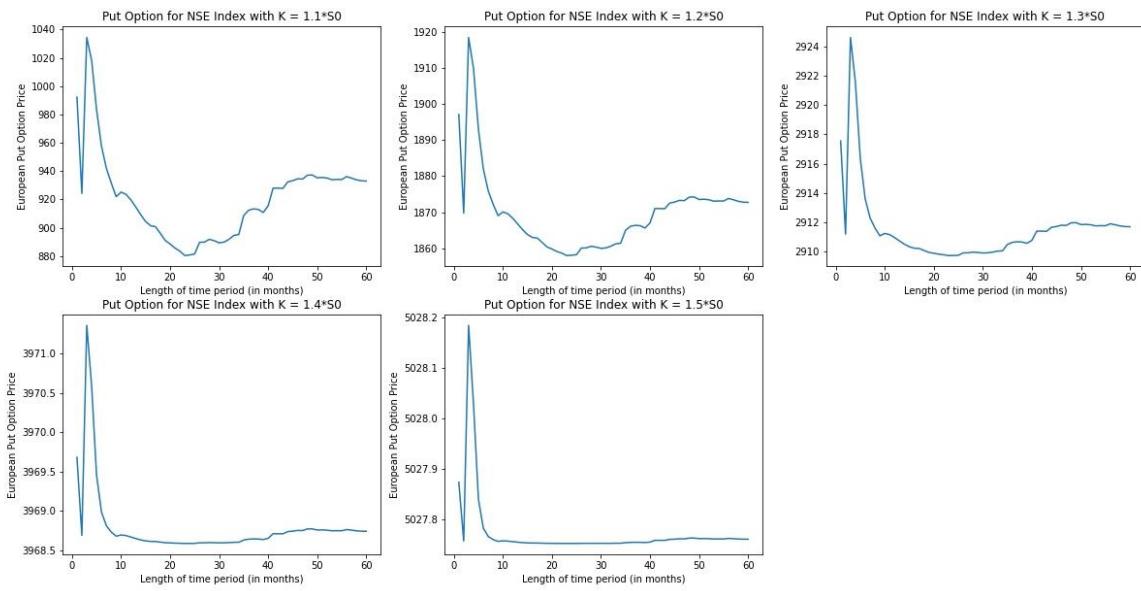


x) WIPRO.NS



xi) NSE Index





4 QUESTION – 4 :

The collected data is in the file **NIFTYoptiondata.csv**. The option prices are collected for the time period from 1st Jan 2014 to 31st Dec 2018, with varying strike prices and maturities.

Theory Involved & Formulae used:

- The price of European Call and Put Option given by BSM framework obtained after solving Black-Scholes-Merton PDE is:

$$C(x, t) = xN(d_1) - Ke^{-r(T-t)}N(d_2)$$

$$P(x, t) = Ke^{-r(T-t)}N(-d_2) - xN(-d_1)$$

where,

$$d_1 = \frac{\log\left(\frac{x}{K}\right) + (r + \frac{1}{2}\sigma^2)(T-t)}{\sigma\sqrt{T-t}}$$

$$d_2 = \frac{\log\left(\frac{x}{K}\right) + (r - \frac{1}{2}\sigma^2)(T-t)}{\sigma\sqrt{T-t}}$$

$$N(x) = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^x e^{-\frac{1}{2}y^2} dy$$

- Put-Call Parity for European Options on a stock that pays no Dividends:

$$C^E - P^E = S(0) - Ke^{-rT}$$

where,

C^E = European call option

P^E = European put option

K = Strike price

T = exercise time