

# Financial Engineering Lab    MA – 374    Lab – 8

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*Note on computing the historical volatility: Assume that you have daily data of stock prices and that there are 252 trading days, by convention, in a year. If the daily returns of a stock have a standard deviation  $\sigma_d$  then the annualized volatility is given by  $\sigma_a = \sigma_d\sqrt{252}$ . In our labs, the volatility should always be expressed in annualized terms, just like any other rates (e.g.  $r$ ).*

## Question 1:

1. Consider the data in databases “bsedata1” and “nsedata1” that you have already obtained. Now for each of the stocks and for each of the market indices do the following :

The stocks used are as follows:

10 stocks included in BSE (SENSEX) index:

- RELIANCE.BO: Reliance Industries Limited
- TCS.BO: Tata Consultancy Services Limited
- HDFCBANK.BO: HDFC Bank Limited
- HINDUNILVR.BO: Hindustan Unilever Limited
- INFY.BO: Infosys Limited
- KOTAKBANK.BO: Kotak Mahindra Bank Limited
- ICICIBANK.BO: ICICI Bank Limited
- LT.BO: Larsen & Toubro Limited
- AXISBANK.BO: Axis Bank Limited
- SBIN.BO: State Bank of India

10 stocks included in NSE (NIFTY) index:

- TCS.NS: Tata Consultancy Services Limited
- HINDUNILVR.NS: Hindustan Unilever Limited
- INFY.NS: Infosys Limited
- KOTAKBANK.NS: Kotak Mahindra Bank Limited
- ICICIBANK.NS: ICICI Bank Limited
- LT.NS: Larsen & Toubro Limited
- SBIN.NS: State Bank of India
- RELIANCE.NS: Reliance Industries Limited

- ITC.NS: ITC Limited
- ONGC.NS: Oil and Natural Gas Corporation Limited

10 stocks not included in BSE (SENSEX) index:

- GOOGL: Alphabet Inc. (Google)
- AAPL: Apple Inc.
- AMZN: Amazon.com Inc.
- MSFT: Microsoft Corporation
- NVDA: NVIDIA Corporation
- ADBE: Adobe Inc.
- NFLX: Netflix Inc.
- TSLA: Tesla Inc.
- ORCL: Oracle Corporation
- CSCO: Cisco Systems Inc.

10 stocks not included in NSE (NIFTY) index:

- NKE: NIKE Inc.
- BIDU: Baidu Inc.
- NVDA: NVIDIA Corporation
- KO: The Coca-Cola Company
- PYPL: PayPal Holdings Inc.
- SNAP: Snap Inc.
- MCD: McDonald's Corporation
- WMT: Walmart Inc.
- BABA: Alibaba Group Holding Limited
- PEP: PepsiCo Inc.

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stocksInBSEIndex = ['RELIANCE.BO', 'TCS.BO', 'HDFCBANK.BO', 'HINDUNILVR.BO', 'INFY.BO', 'KOTAKBANK.BO', 'ICICIBANK.BO', 'LT.BO', 'AXISBANK.BO', 'SBIN.BO']
stocksNotInBSEIndex = ['GOOGL', 'AAPL', 'AMZN', 'MSFT', 'NVDA', 'ADBE', 'NFLX', 'TSLA', 'ORCL', 'CSCO']
stocksInNSEIndex = ['RELIANCE.NS', 'TCS.NS', 'HINDUNILVR.NS', 'INFY.NS', 'KOTAKBANK.NS', 'ICICIBANK.NS', 'LT.NS', 'SBIN.NS', 'ITC.NS', 'ONGC.NS']
stocksNotInNSEIndex = ['NKE', 'BIDU', 'NVDA', 'KO', 'PYPL', 'SNAP', 'MCD', 'WMT', 'BABA', 'PEP']
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(a)

**(a) Estimate the historical volatility from last one month's data.**

The historical volatility from last one month's data is as follows:

**Historical Volatility from last one month's data for BSE**

Serial No.	Stock's Name	Historical Volatility
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1	RELIANCE.BO	0.132343
2	TCS.BO	0.238266
3	HDFCBANK.BO	0.156845
4	HINDUNILVR.BO	0.13054
5	INFY.BO	0.280073
6	KOTAKBANK.BO	0.174408
7	ICICIBANK.BO	0.225815
8	LT.BO	0.213195
9	AXISBANK.BO	0.155186
10	SBIN.BO	0.256764
11	GOOGL	0.403539
12	AAPL	0.16104
13	AMZN	0.41373
14	MSFT	0.242392
15	NVDA	0.397011
16	ADBE	0.293939
17	NFLX	0.642432
18	TSLA	0.503911
19	ORCL	0.271368
20	CSCO	0.131839
21	Sensex	0.0883676

Historical Volatility from last one month's data for NSE		
Serial No.	Stock's Name	Historical Volatility
1	RELIANCE.NS	0.13163
2	TCS.NS	0.238461
3	HINDUNILVR.NS	0.133966
4	INFY.NS	0.280114
5	KOTAKBANK.NS	0.17538
6	ICICIBANK.NS	0.226342
7	LT.NS	0.216888
8	SBIN.NS	0.254489
9	ITC.NS	0.170274
10	ONGC.NS	0.236406
11	NKE	0.247592
12	BIDU	0.336942
13	NVDA	0.283575
14	KO	0.0750131
15	PYPL	0.363634
16	SNAP	0.332614
17	MCD	0.109492
18	WMT	0.311877
19	BABA	0.4002
20	PEP	0.0858441
21	Nifty	0.102617

(b)

- (b) Using the final value of the stock price in your data set as  $S_0$  and taking  $r = 5\%$ ,  $K = S_0$  compute the BSM price of six month European call and put options. Repeat this for  $K = A \times S_0$  (for  $A = 0.5 : 0.1 : 1.5$ ) also.

Using the final value of the stock price in my data set as  $S_0$  and taking  $r = 5\%$ ,  $K = A * S_0$ , (for  $A = 0.5 : 0.1 : 1.5$ ), the computed BSM price of six-

month European call and put options for each of the stocks are as follows:

(i) For the stocks in bsedata1.csv:

Strike price (K)	Price of Call Option	Price of Put Option
0.5*S0	1324.34	1.77358e-13
0.6*S0	1072.23	1.57276e-07
0.7*S0	820.13	0.00100421
0.8*S0	568.291	0.264788
0.9*S0	324.355	8.43181
1.0*S0	130.562	66.7415
1.1*S0	32.7669	221.05
1.2*S0	5.00595	445.392
1.3*S0	0.486814	692.976
1.4*S0	0.0322524	944.624
1.5*S0	0.00155805	1196.7

Strike price (K)	Price of Call Option	Price of Put Option
0.5*S0	1944.32	0.000962298
0.6*S0	1574.3	0.0971334
0.7*S0	1206.21	2.13341
0.8*S0	851.507	17.5588
0.9*S0	539.066	75.2434
1.0*S0	301.233	207.536
1.1*S0	148.436	424.864
1.2*S0	65.1285	711.681
1.3*S0	25.8229	1042.5
1.4*S0	9.3999	1396.2
1.5*S0	3.18864	1760.12

For the Stock: HDFCBANK.BO

Historical Volatility from last one month's data = 0.1568449376043027

Strike price (K)	Price of Call Option	Price of Put Option
0.5*S0	875.931	9.24828e-10
0.6*S0	709.187	1.8874e-05
0.7*S0	542.455	0.0115326
0.8*S0	376.434	0.734502
0.9*S0	219.424	10.4687
1.0*S0	97.6644	55.453
1.1*S0	31.3084	155.841
1.2*S0	7.21235	298.489
1.3*S0	1.23345	459.254
1.4*S0	0.163702	624.928
1.5*S0	0.0176196	791.526

For the Stock: HINDUNILVR.BO

Historical Volatility from last one month's data = 0.1305397341961312

Strike price (K)	Price of Call Option	Price of Put Option
0.5*S0	1364.55	7.74208e-14
0.6*S0	1104.8	9.87861e-08
0.7*S0	845.037	0.000790756
0.8*S0	585.516	0.23897
0.9*S0	333.731	8.21384
1.0*S0	133.238	67.4796
1.1*S0	32.7093	226.71
1.2*S0	4.80859	458.569
1.3*S0	0.443168	713.962
1.4*S0	0.0274702	973.306
1.5*S0	0.00122869	1233.04

For the Stock: INFY.BO

Historical Volatility from last one month's data = 0.280072856404496

Strike price (K)	Price of Call Option	Price of Put Option
0.5*S0	790.479	0.00746481
0.6*S0	640.238	0.242258
0.7*S0	492.11	2.58943
0.8*S0	352.567	13.5228
0.9*S0	232.322	43.7533
1.0*S0	140.195	102.102
1.1*S0	77.775	190.158
1.2*S0	40.0139	302.872
1.3*S0	19.2954	432.629
1.4*S0	8.81433	572.624
1.5*S0	3.85165	718.137

For the Stock: KOTAKBANK.BO

Historical Volatility from last one month's data = 0.17440830649514977

Strike price (K)	Price of Call Option	Price of Put Option
0.5*S0	977.606	7.71027e-08
0.6*S0	791.507	0.000263652
0.7*S0	605.461	0.0528497
0.8*S0	421.015	1.70589
0.9*S0	249.648	16.438
1.0*S0	118.111	70.9995
1.1*S0	43.1021	182.09
1.2*S0	12.1871	337.274
1.3*S0	2.74228	513.928
1.4*S0	0.508086	697.792
1.5*S0	0.0801544	883.463

For the Stock: ICICIBANK.BO

Historical Volatility from last one month's data = 0.22581531771495017

Strike price (K)	Price of Call Option	Price of Put Option
0.5*S0	510.526	7.78376e-05
0.6*S0	413.354	0.0124833
0.7*S0	316.524	0.367258
0.8*S0	222.601	3.62881
0.9*S0	139.161	17.3738
1.0*S0	75.6906	51.0882
1.1*S0	35.6795	108.262
1.2*S0	14.7186	184.486
1.3*S0	5.40133	272.353
1.4*S0	1.79547	365.932
1.5*S0	0.549979	461.871

For the Stock: LT.BO

Historical Volatility from last one month's data = 0.2131954841177526

Strike price (K)	Price of Call Option	Price of Put Option
0.5*S0	1807.07	6.84458e-05
0.6*S0	1463.09	0.0190879
0.7*S0	1119.87	0.795618
0.8*S0	784.841	9.76431
0.9*S0	484.336	53.2557
1.0*S0	255.712	168.629
1.1*S0	114.591	371.504
1.2*S0	43.9976	644.908
1.3*S0	14.7418	959.649
1.4*S0	4.40098	1293.3
1.5*S0	1.19422	1634.09

For the Stock: AXISBANK.BO

Historical Volatility from last one month's data = 0.15518640303416592

Strike price (K)	Price of Call Option	Price of Put Option
0.5*S0	565.091	3.68795e-10
0.6*S0	457.519	9.19766e-06
0.7*S0	349.954	0.00636809
0.8*S0	242.813	0.437583
0.9*S0	141.317	6.51355
1.0*S0	62.5105	35.2785
1.1*S0	19.7624	100.102
1.2*S0	4.45127	192.363
1.3*S0	0.738416	296.222
1.4*S0	0.0944212	403.15
1.5*S0	0.00973723	510.637

For the Stock: SBIN.BO

Historical Volatility from last one month's data = 0.25676445960303385

Strike price (K)	Price of Call Option	Price of Put Option
0.5*S0	328.901	0.000705301
0.6*S0	266.33	0.0402921
0.7*S0	204.297	0.617119
0.8*S0	145.118	4.04861
0.9*S0	93.5563	15.0965
1.0*S0	54.2184	38.3686
1.1*S0	28.2975	75.0577
1.2*S0	13.4264	122.797
1.3*S0	5.8654	177.846
1.4*S0	2.3905	236.981
1.5*S0	0.920145	298.12

For the Stock: GOOGL

Historical Volatility from last one month's data = 0.403539081932373

Strike price (K)	Price of Call Option	Price of Put Option
0.5*S0	63.8132	0.046783
0.6*S0	51.9433	0.315579
0.7*S0	40.713	1.22398
0.8*S0	30.6597	3.30933
0.9*S0	22.2114	6.99977
1.0*S0	15.5354	12.4625
1.1*S0	10.5403	19.6061
1.2*S0	6.97122	28.1757
1.3*S0	4.51547	37.8587
1.4*S0	2.87627	48.3582
1.5*S0	1.80816	59.4288

For the Stock: AAPL

Historical Volatility from last one month's data = 0.16104049009339377

Strike price (K)	Price of Call Option	Price of Put Option
0.5*S0	87.0214	2.91312e-10
0.6*S0	70.4558	3.6786e-06
0.7*S0	53.8919	0.00166645
0.8*S0	37.4132	0.0884678
0.9*S0	21.8952	1.136
1.0*S0	9.89607	5.70247
1.1*S0	3.28134	15.6533
1.2*S0	0.798039	29.7356
1.3*S0	0.14684	45.6499
1.4*S0	0.0213084	62.09
1.5*S0	0.00254101	78.6368

For the Stock: AMZN

Historical Volatility from last one month's data = 0.4137296008344152

Strike price (K)	Price of Call Option	Price of Put Option
0.5*S0	68.0552	0.0619036
0.6*S0	55.4382	0.388246
0.7*S0	43.5421	1.43548
0.8*S0	32.9226	3.75932
0.9*S0	24.0032	7.78324
1.0*S0	16.9367	13.66
1.1*S0	11.6186	21.2854
1.2*S0	7.78548	30.3955
1.3*S0	5.11814	40.6715
1.4*S0	3.31368	51.8104
1.5*S0	2.11992	63.56

For the Stock: MSFT

Historical Volatility from last one month's data = 0.24239169262637383

Strike price (K)	Price of Call Option	Price of Put Option
0.5*S0	172.151	0.000121359
0.6*S0	139.39	0.0106695
0.7*S0	106.824	0.214742
0.8*S0	75.5111	1.67317
0.9*S0	48.001	6.93405
1.0*S0	27.0519	18.7559
1.1*S0	13.513	37.988
1.2*S0	6.04109	63.287
1.3*S0	2.45176	92.4686
1.4*S0	0.917151	123.705
1.5*S0	0.320772	155.879

For the Stock: NVDA  
Historical Volatility from last one month's data = 0.3970112504817291

Strike price (K)	Price of Call Option	Price of Put Option
0.5*S0	211.002	0.133742
0.6*S0	171.675	0.947931
0.7*S0	134.383	3.79779
0.8*S0	100.936	10.4923
0.9*S0	72.8181	22.5151
1.0*S0	50.6356	40.4738
1.1*S0	34.102	64.0814
1.2*S0	22.3574	92.478
1.3*S0	14.3377	124.599
1.4*S0	9.03294	159.436
1.5*S0	5.61167	196.156

For the Stock: ADBE  
Historical Volatility from last one month's data = 0.29393896519124474

Strike price (K)	Price of Call Option	Price of Put Option
0.5*S0	269.98	0.00531518
0.6*S0	218.713	0.130929
0.7*S0	168.363	1.17347
0.8*S0	121.272	5.47607
0.9*S0	80.9094	16.5063
1.0*S0	49.8914	36.8812
1.1*S0	28.5632	66.946
1.2*S0	15.3086	105.084
1.3*S0	7.75495	148.924
1.4*S0	3.74823	196.31
1.5*S0	1.74341	245.698

For the Stock: NFLX

Historical Volatility from last one month's data = 0.642431821258583

Strike price (K)	Price of Call Option	Price of Put Option
0.5*S0	213.206	3.10306
0.6*S0	178.3	8.19352
0.7*S0	147.075	16.9633
0.8*S0	119.972	29.8556
0.9*S0	97.0166	46.8962
1.0*S0	77.9445	67.8196
1.1*S0	62.3285	92.1991
1.2*S0	49.6817	119.548
1.3*S0	39.5218	149.383
1.4*S0	31.4067	181.264
1.5*S0	24.9508	214.803

For the Stock: TSLA

Historical Volatility from last one month's data = 0.5039111742064276

Strike price (K)	Price of Call Option	Price of Put Option
0.5*S0	101.511	0.395034
0.6*S0	83.4129	1.54519
0.7*S0	66.7956	4.17661
0.8*S0	52.2202	8.8499
0.9*S0	39.9754	15.8539
1.0*S0	30.0662	25.1933
1.1*S0	22.2907	36.6666
1.2*S0	16.3389	49.9635
1.3*S0	11.8714	64.7447
1.4*S0	8.56841	80.6904
1.5*S0	6.15471	97.5255

For the Stock: ORCL

Historical Volatility from last one month's data = 0.271368485427559

Strike price (K)	Price of Call Option	Price of Put Option
0.5*S0	51.8791	0.000293193
0.6*S0	42.0147	0.0115586
0.7*S0	32.2672	0.139852
0.8*S0	23.0419	0.790275
0.9*S0	15.062	2.68615
1.0*S0	8.95863	6.45857
1.1*S0	4.86422	12.2399
1.2*S0	2.43282	19.6843
1.3*S0	1.13358	28.2608
1.4*S0	0.497784	37.5008
1.5*S0	0.208196	47.0869

For the Stock: CSCO

Historical Volatility from last one month's data = 0.13183915298581889

Strike price (K)	Price of Call Option	Price of Put Option
0.5*S0	26.2176	2.77197e-15
0.6*S0	21.2268	2.71691e-09
0.7*S0	16.236	1.84609e-05
0.8*S0	11.2502	0.00505389
0.9*S0	6.41863	0.164355
1.0*S0	2.57779	1.31435
1.1*S0	0.643016	4.37042
1.2*S0	0.0972009	8.81544
1.3*S0	0.00931375	13.7184
1.4*S0	0.000605854	18.7005
1.5*S0	2.8654e-05	23.6908

Strike price (K)	Price of Call Option	Price of Put Option
0.5*S0	35774.8	1.86641e-28
0.6*S0	28964.6	1.87454e-15
0.7*S0	22154.5	2.83007e-07
0.8*S0	15344.4	0.0312573
0.9*S0	8561.61	27.4508
1.0*S0	2716.56	992.56
1.1*S0	294.853	5381.01
1.2*S0	8.94911	11905.3
1.3*S0	0.0840571	18706.6
1.4*S0	0.000295656	25516.6
1.5*S0	4.68969e-07	32326.8

(ii) For the stocks in nsedata1.csv:

Strike price (K)	Price of Call Option	Price of Put Option
0.5*S0	1324.39	1.2684e-13
0.6*S0	1072.27	1.2964e-07
0.7*S0	820.162	0.00090411
0.8*S0	568.3	0.251428
0.9*S0	324.184	8.24885
1.0*S0	130.072	66.2497
1.1*S0	32.3635	220.654
1.2*S0	4.87056	445.273
1.3*S0	0.463817	692.979
1.4*S0	0.0299406	944.658
1.5*S0	0.00140355	1196.74

For the Stock: TCS.NS

Historical Volatility from last one month's data = 0.23846072979679792

Strike price (K)	Price of Call Option	Price of Put Option
0.5*S0	1934.57	0.000973943
0.6*S0	1566.4	0.0976551
0.7*S0	1200.17	2.13584
0.8*S0	847.295	17.5324
0.9*S0	536.504	75.0092
1.0*S0	299.923	206.696
1.1*S0	147.887	422.927
1.2*S0	64.9462	708.254
1.3*S0	25.7795	1037.36
1.4*S0	9.39648	1389.24
1.5*S0	3.19218	1751.3

For the Stock: HINDUNILVR.NS

Historical Volatility from last one month's data = 0.13396562889318941

Strike price (K)	Price of Call Option	Price of Put Option
0.5*S0	1364.86	3.84875e-13
0.6*S0	1105.04	2.4904e-07
0.7*S0	845.228	0.00130732
0.8*S0	585.715	0.306287
0.9*S0	334.718	9.12756
1.0*S0	135.719	69.9454
1.1*S0	34.7245	228.769
1.2*S0	5.48549	459.348
1.3*S0	0.558897	714.239
1.4*S0	0.0392273	973.537
1.5*S0	0.00202573	1233.32

For the Stock: INFY.NS

Historical Volatility from last one month's data = 0.2801138361592228

Strike price (K)	Price of Call Option	Price of Put Option
0.5*S0	790.505	0.00748236
0.6*S0	640.259	0.242615
0.7*S0	492.128	2.5918
0.8*S0	352.586	13.5304
0.9*S0	232.343	43.7682
1.0*S0	140.217	102.122
1.1*S0	77.7948	190.181
1.2*S0	40.0292	302.896
1.3*S0	19.3058	432.653
1.4*S0	8.82063	572.649
1.5*S0	3.85516	718.164

For the Stock: KOTAKBANK.NS

Historical Volatility from last one month's data = 0.17538040117543216

Strike price (K)	Price of Call Option	Price of Put Option
0.5*S0	977.606	9.44809e-08
0.6*S0	791.507	0.000297169
0.7*S0	605.464	0.0565369
0.8*S0	421.076	1.76751
0.9*S0	249.929	16.7187
1.0*S0	118.616	71.5049
1.1*S0	43.5623	182.55
1.2*S0	12.4387	337.525
1.3*S0	2.8355	514.021
1.4*S0	0.533677	697.818
1.5*S0	0.0857171	883.469

For the Stock: ICICIBANK.NS

Historical Volatility from last one month's data = 0.2263415778739383

Strike price (K)	Price of Call Option	Price of Put Option
0.5*S0	510.603	8.21212e-05
0.6*S0	413.417	0.0128952
0.7*S0	316.579	0.374361
0.8*S0	222.673	3.66841
0.9*S0	139.281	17.4755
1.0*S0	75.8459	51.2397
1.1*S0	35.8236	108.417
1.2*S0	14.8191	184.612
1.3*S0	5.4573	272.449
1.4*S0	1.82156	366.013
1.5*S0	0.560567	461.951

For the Stock: LT.NS

Historical Volatility from last one month's data = 0.21688808526378467

Strike price (K)	Price of Call Option	Price of Put Option
0.5*S0	1806.53	0.000105284
0.6*S0	1462.66	0.0247266
0.7*S0	1119.67	0.925057
0.8*S0	785.461	10.6156
0.9*S0	486.567	55.6158
1.0*S0	259.204	172.147
1.1*S0	117.965	374.802
1.2*S0	46.3044	647.036
1.3*S0	15.9568	960.582
1.4*S0	4.92483	1293.44
1.5*S0	1.38751	1633.8

For the Stock: SBIN.NS

Historical Volatility from last one month's data = 0.2544891969238904

Strike price (K)	Price of Call Option	Price of Put Option
0.5*S0	328.952	0.000598283
0.6*S0	266.368	0.036419
0.7*S0	204.292	0.580725
0.8*S0	145	3.90796
0.9*S0	93.2744	14.8024
1.0*S0	53.8254	37.9731
1.1*S0	27.9078	74.6753
1.2*S0	13.1245	122.512
1.3*S0	5.67119	177.678
1.4*S0	2.28221	236.909
1.5*S0	0.866115	298.113

For the Stock: ITC.NS

Historical Volatility from last one month's data = 0.17027431371321686

Strike price (K)	Price of Call Option	Price of Put Option
0.5*S0	233.328	7.46939e-09
0.6*S0	188.911	3.70332e-05
0.7*S0	144.504	0.00936207
0.8*S0	100.426	0.34824
0.9*S0	59.3039	3.64304
1.0*S0	27.6772	16.433
1.1*S0	9.82242	42.995
1.2*S0	2.6595	80.2488
1.3*S0	0.564949	122.571
1.4*S0	0.097624	166.52
1.5*S0	0.0142207	210.854

For the Stock: ONGC.NS

Historical Volatility from last one month's data = 0.23640644285174725

Strike price (K)	Price of Call Option	Price of Put Option
0.5*S0	103.541	4.34487e-05
0.6*S0	83.8354	0.00467835
0.7*S0	64.2275	0.107036
0.8*S0	45.314	0.903779
0.9*S0	28.6337	3.93372
1.0*S0	15.9384	10.9487
1.1*S0	7.80442	22.525
1.2*S0	3.39463	37.8255
1.3*S0	1.33139	55.4725
1.4*S0	0.478517	74.3299
1.5*S0	0.160022	93.7216

For the Stock: NKE

Historical Volatility from last one month's data = 0.2475922282363823

Strike price (K)	Price of Call Option	Price of Put Option
0.5*S0	55.1272	5.93245e-05
0.6*S0	44.6375	0.00442439
0.7*S0	34.2192	0.0802408
0.8*S0	24.2304	0.585587
0.9*S0	15.4822	2.33147
1.0*S0	8.81642	6.15982
1.1*S0	4.47723	12.3147
1.2*S0	2.04715	20.3788
1.3*S0	0.854377	29.6801
1.4*S0	0.330195	39.6501
1.5*S0	0.119777	49.9338

For the Stock: BIDU

Historical Volatility from last one month's data = 0.33694171259197464

Strike price (K)	Price of Call Option	Price of Put Option
0.5*S0	63.5382	0.00745155
0.6*S0	51.5324	0.095436
0.7*S0	39.9049	0.561779
0.8*S0	29.2478	1.99858
0.9*S0	20.2195	5.06409
1.0*S0	13.2075	10.1459
1.1*S0	8.1945	17.2268
1.2*S0	4.8623	25.9884
1.3*S0	2.77883	35.9988
1.4*S0	1.53985	46.8537
1.5*S0	0.832268	58.2399

For the Stock: NVDA

Historical Volatility from last one month's data = 0.28357506452559667

Strike price (K)	Price of Call Option	Price of Put Option
0.5*S0	247.147	0.00283548
0.6*S0	200.183	0.0855105
0.7*S0	153.922	0.872189
0.8*S0	110.424	4.42088
0.9*S0	72.9951	14.0383
1.0*S0	44.297	32.3871
1.1*S0	24.7782	59.915
1.2*S0	12.8861	95.0697
1.3*S0	6.29546	135.526
1.4*S0	2.91918	179.196
1.5*S0	1.29693	224.621

For the Stock: KO

Historical Volatility from last one month's data = 0.07501310124136261

Strike price (K)	Price of Call Option	Price of Put Option
0.5*S0	29.7151	7.20694e-43
0.6*S0	24.0585	6.19348e-25
0.7*S0	18.4018	1.05861e-13
0.8*S0	12.7452	7.76709e-07
0.9*S0	7.09518	0.00657893
1.0*S0	2.06013	0.628147
1.1*S0	0.137333	4.36197
1.2*S0	0.00143316	9.88269
1.3*S0	2.71606e-06	15.5379
1.4*S0	1.24912e-09	21.1945
1.5*S0	1.8366e-13	26.8511

For the Stock: PYPL

Historical Volatility from last one month's data = 0.363634477858598

Strike price (K)	Price of Call Option	Price of Put Option
0.5*S0	28.899	0.00783518
0.6*S0	23.4659	0.0745112
0.7*S0	18.2532	0.361645
0.8*S0	13.5259	1.1341
0.9*S0	9.53864	2.64659
1.0*S0	6.42024	5.02796
1.1*S0	4.1457	8.2532
1.2*S0	2.58365	12.1909
1.3*S0	1.56332	16.6704
1.4*S0	0.923452	21.5303
1.5*S0	0.53507	26.6417

For the Stock: SNAP

Historical Volatility from last one month's data = 0.3326136625703096

Strike price (K)	Price of Call Option	Price of Put Option
0.5*S0	6.49719	0.000654206
0.6*S0	5.26869	0.00885149
0.7*S0	4.07713	0.053984
0.8*S0	2.98299	0.196532
0.9*S0	2.05523	0.505468
1.0*S0	1.33548	1.02241
1.1*S0	0.822718	1.74634
1.2*S0	0.483873	2.64419
1.3*S0	0.273687	3.6707
1.4*S0	0.149904	4.78361
1.5*S0	0.0799957	5.95039

For the Stock: MCD

Historical Volatility from last one month's data = 0.1094918832029283

Strike price (K)	Price of Call Option	Price of Put Option
0.5*S0	143.539	1.40808e-20
0.6*S0	116.215	5.17542e-12
0.7*S0	88.8904	1.39208e-06
0.8*S0	61.5695	0.00348098
0.9*S0	34.628	0.386395
1.0*S0	12.4444	5.52717
1.1*S0	2.2219	22.6291
1.2*S0	0.182691	47.9143
1.3*S0	0.00737824	75.0634
1.4*S0	0.000163384	102.381
1.5*S0	2.21335e-06	129.705

For the Stock: WMT

Historical Volatility from last one month's data = 0.31187650004739825

Strike price (K)	Price of Call Option	Price of Put Option
0.5*S0	80.0267	0.00358952
0.6*S0	64.855	0.0651887
0.7*S0	50.037	0.480549
0.8*S0	36.3009	1.97784
0.9*S0	24.594	5.50427
1.0*S0	15.5591	11.7027
1.1*S0	9.23759	20.6146
1.2*S0	5.18662	31.797
1.3*S0	2.77731	44.621
1.4*S0	1.4299	58.507
1.5*S0	0.71301	73.0235

For the Stock: BABA

Historical Volatility from last one month's data = 0.40020009681800267

Strike price (K)	Price of Call Option	Price of Put Option
0.5*S0	39.2219	0.026712
0.6*S0	31.9187	0.184753
0.7*S0	25.0011	0.728425
0.8*S0	18.8025	1.99111
0.9*S0	13.5925	4.24238
1.0*S0	9.47895	7.59012
1.1*S0	6.40715	11.9796
1.2*S0	4.21878	17.2525
1.3*S0	2.71885	23.2138
1.4*S0	1.72224	29.6785
1.5*S0	1.07621	36.4938

For the Stock: PEP

Historical Volatility from last one month's data = 0.08584409757527374

Strike price (K)	Price of Call Option	Price of Put Option
0.5*S0	85.5853	7.97086e-33
0.6*S0	69.2931	4.59537e-19
0.7*S0	53.0009	2.04755e-10
0.8*S0	36.7088	4.3162e-05
0.9*S0	20.4704	0.0538109
1.0*S0	6.39083	2.26644
1.1*S0	0.641222	12.809
1.2*S0	0.016479	28.4765
1.3*S0	0.00012087	44.7523
1.4*S0	3.10708e-07	61.0444
1.5*S0	3.41704e-10	77.3365

For the Stock: Nifty

Historical Volatility from last one month's data = 0.10261698744451399

Strike price (K)	Price of Call Option	Price of Put Option
0.5*S0	11134	2.33533e-21
0.6*S0	9014.49	1.20725e-11
0.7*S0	6895.01	1.67232e-05
0.8*S0	4775.63	0.111684
0.9*S0	2677.3	21.2627
1.0*S0	925.937	389.387
1.1*S0	144.248	1727.18
1.2*S0	9.11946	3711.54
1.3*S0	0.25183	5822.16
1.4*S0	0.00345889	7941.39
1.5*S0	2.68756e-05	10060.9

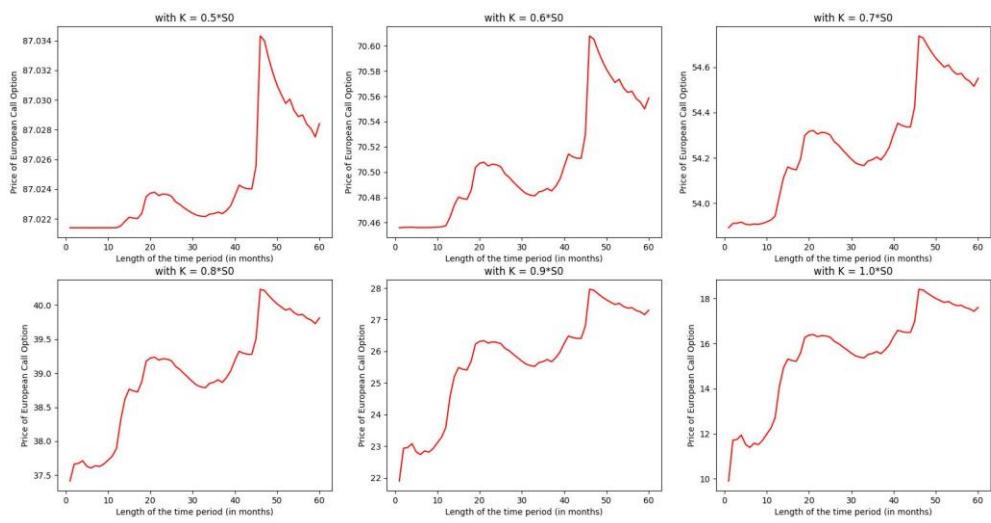
(c)

- (c) Now estimating the historical volatility by extending the data period backwards by one month at a time, repeat part (b) above. Plot the volatility and the option prices against the corresponding length of the period considered.

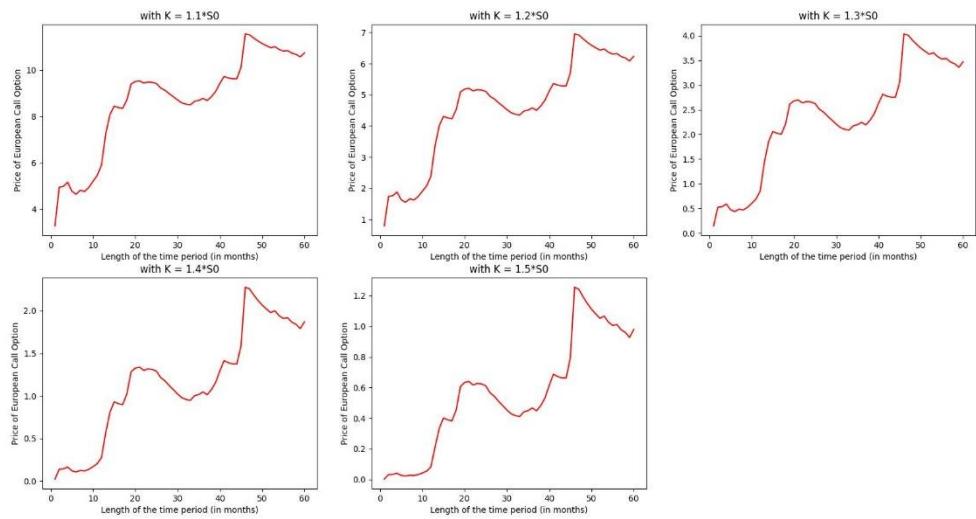
Put all your observations in the report, with appropriate tables and figures.

For the stocks in bsedata1.csv,

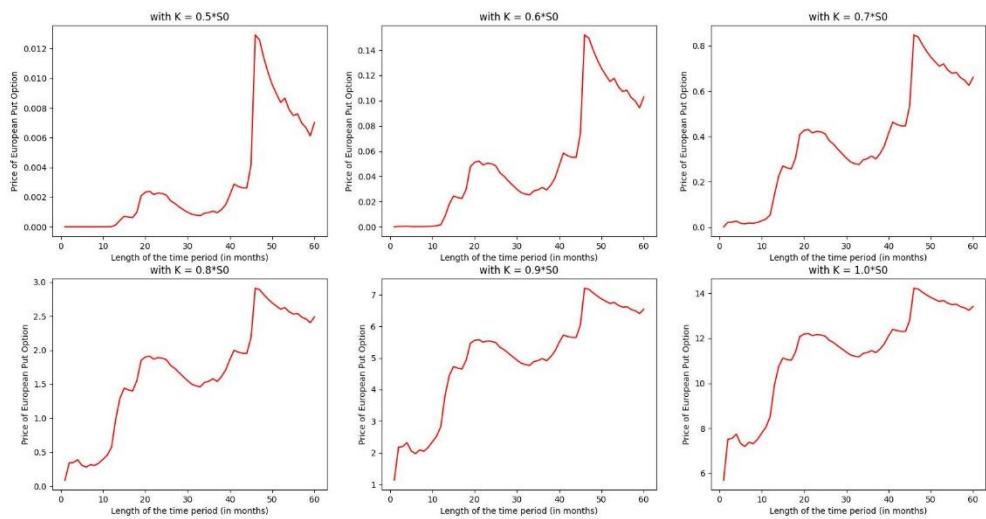
Prices of European Call Option for the stock: AAPL



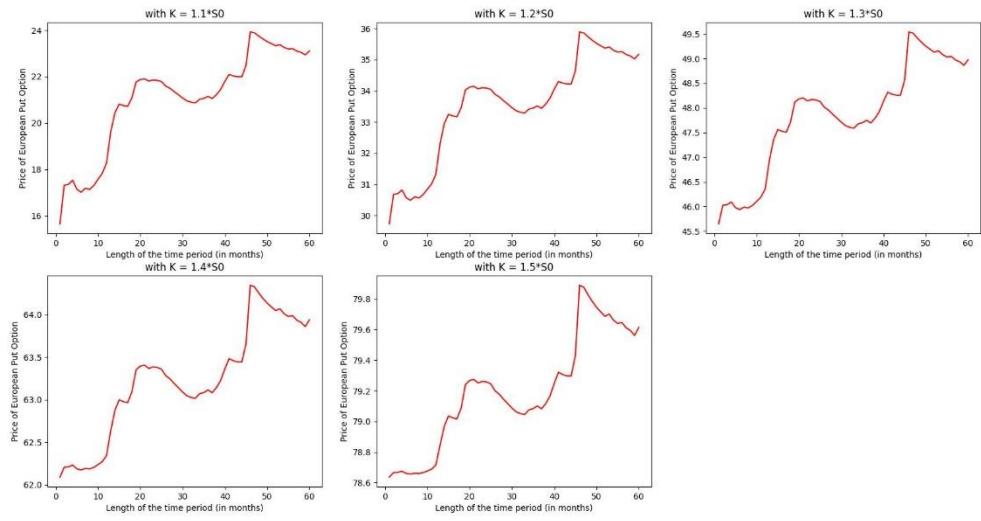
Prices of European Call Option for the stock: AAPL



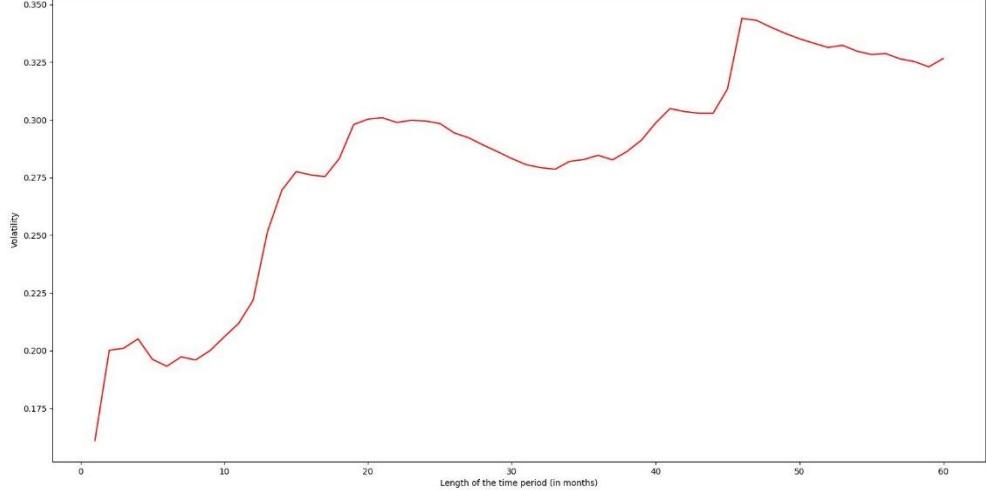
Prices of European Put Option for the stock AAPL



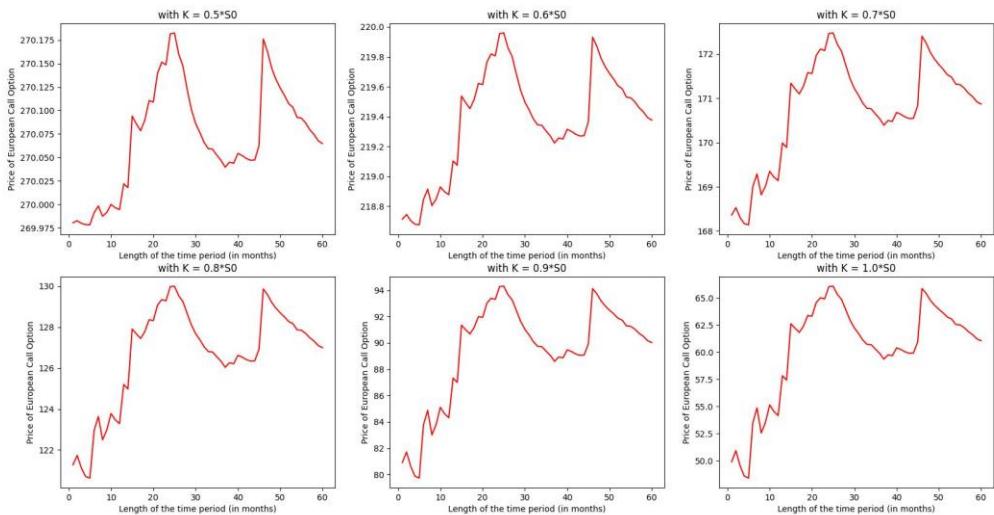
Prices of European Put Option for the stock AAPL



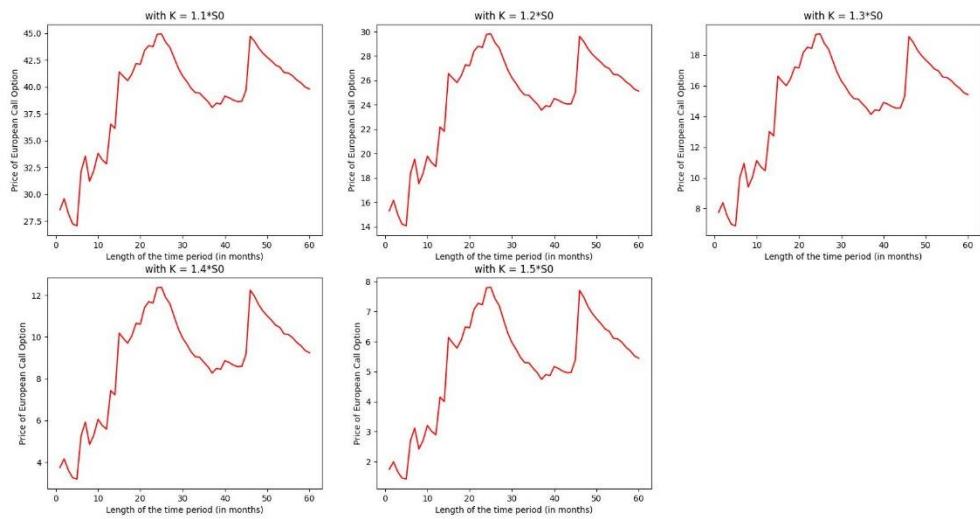
Historical Volatility versus time period for the stock: AAPL



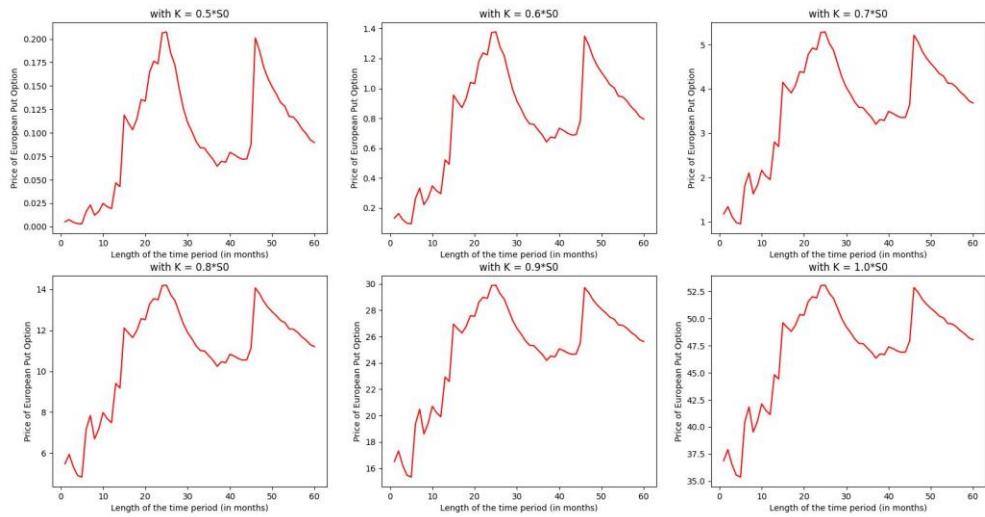
Prices of European Call Option for the stock: ADBE



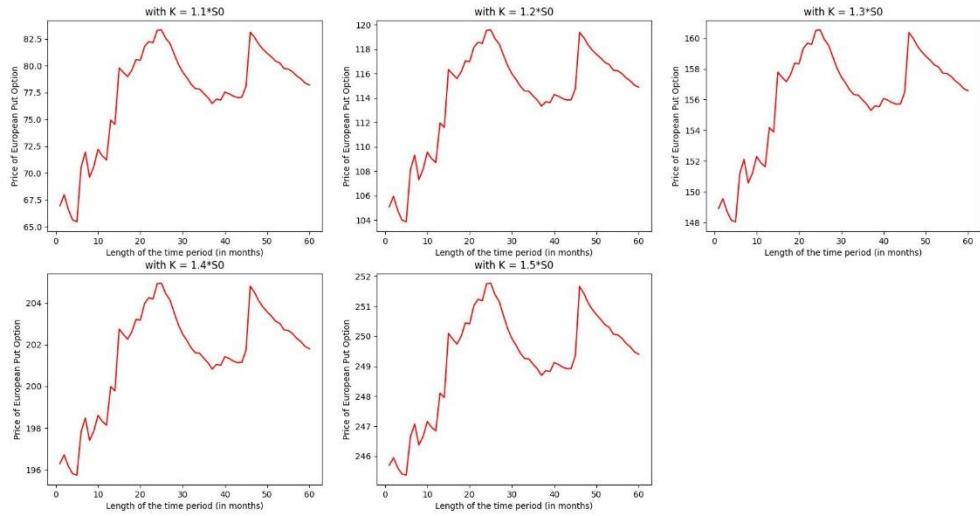
Prices of European Call Option for the stock: ADBE

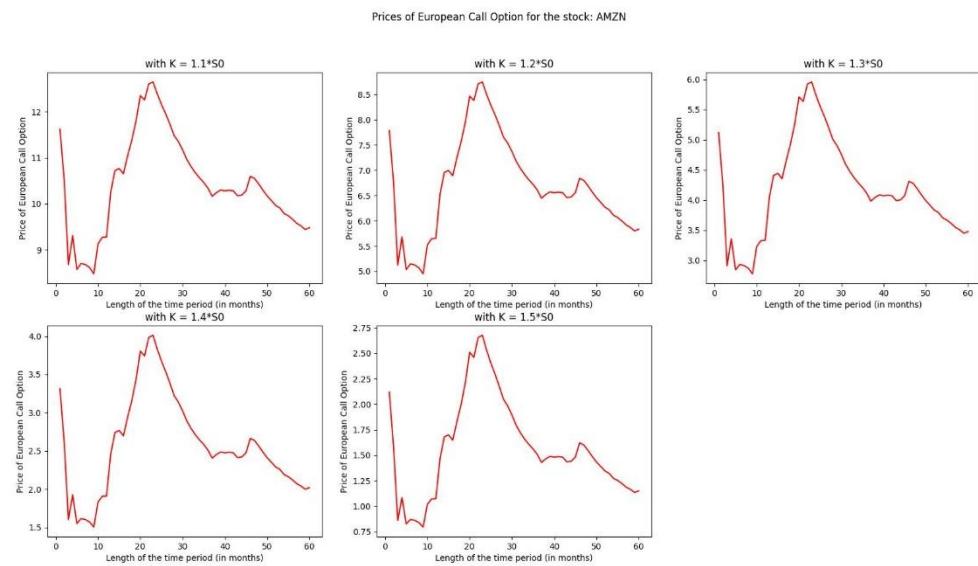
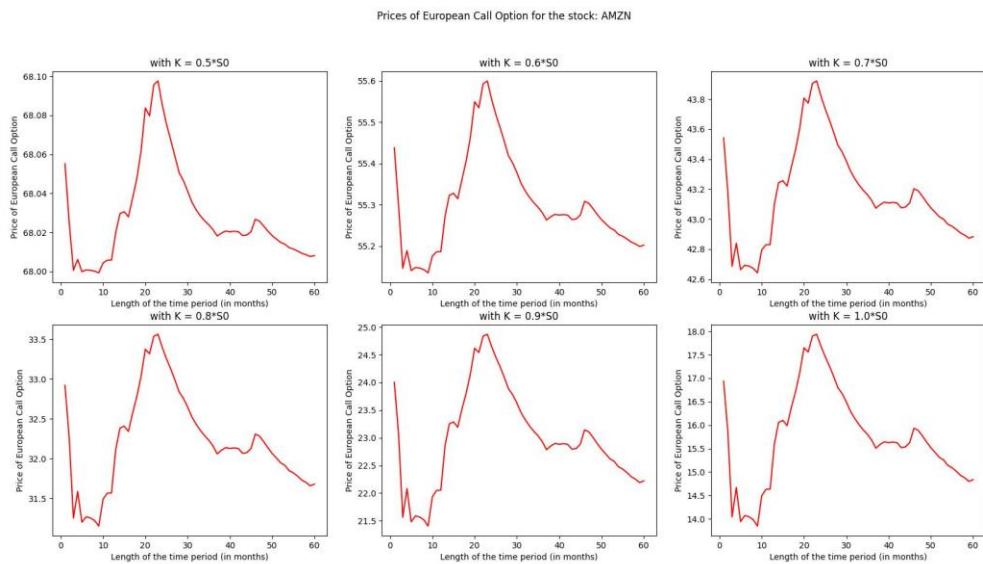
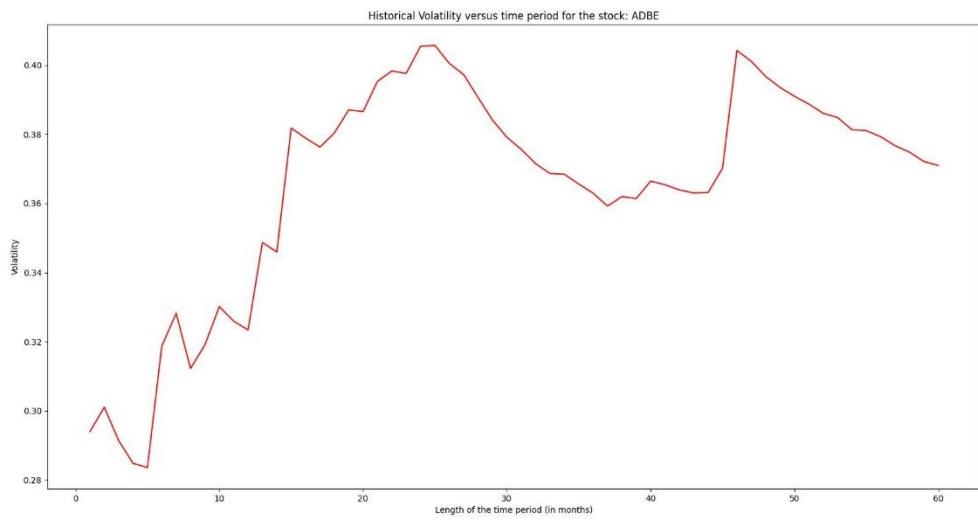


Prices of European Put Option for the stock ADBE

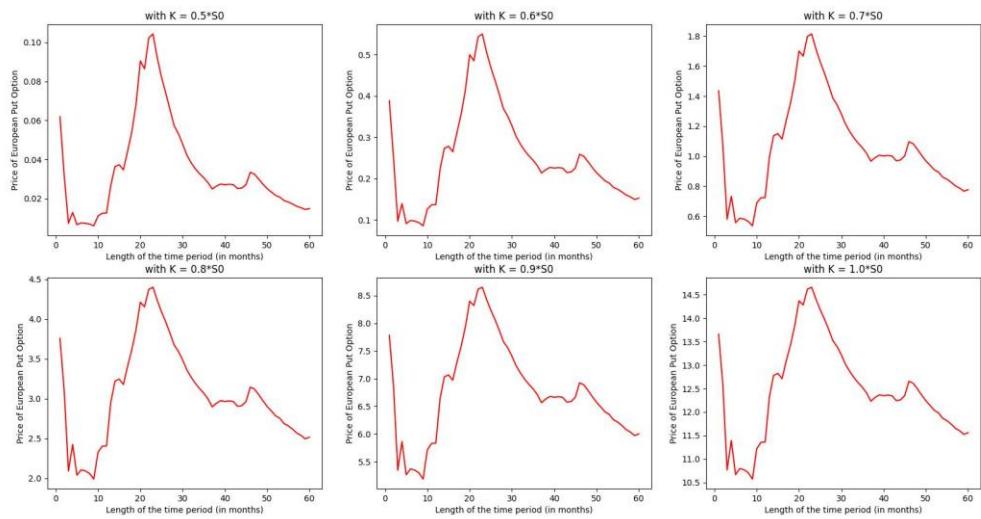


Prices of European Put Option for the stock ADBE

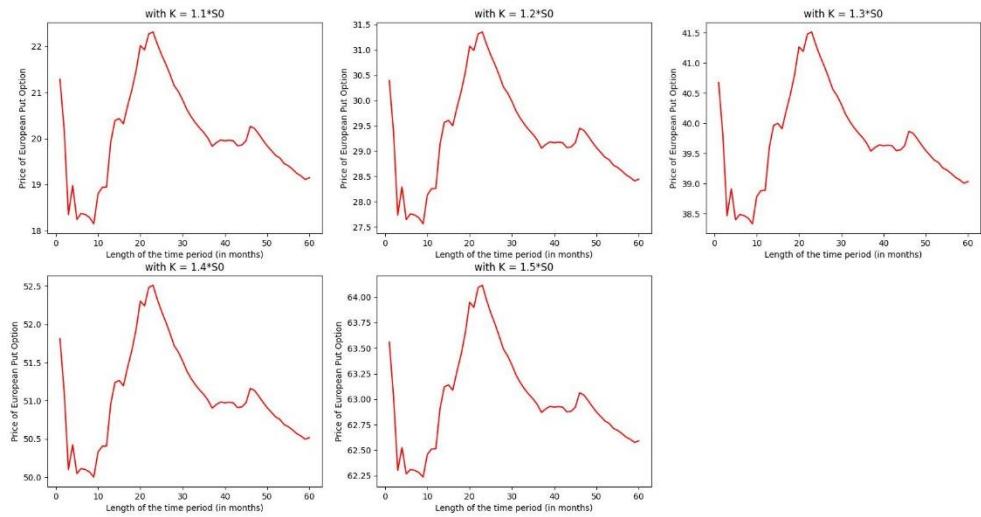




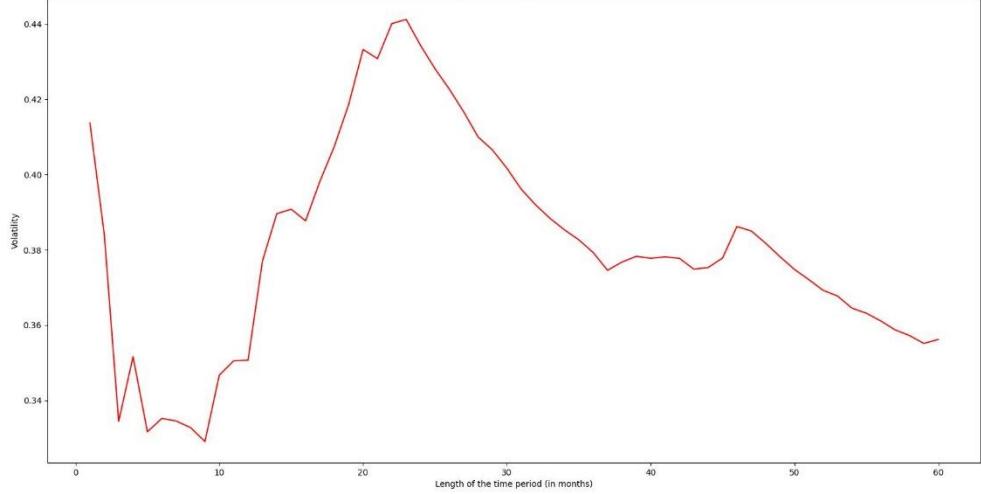
Prices of European Put Option for the stock AMZN



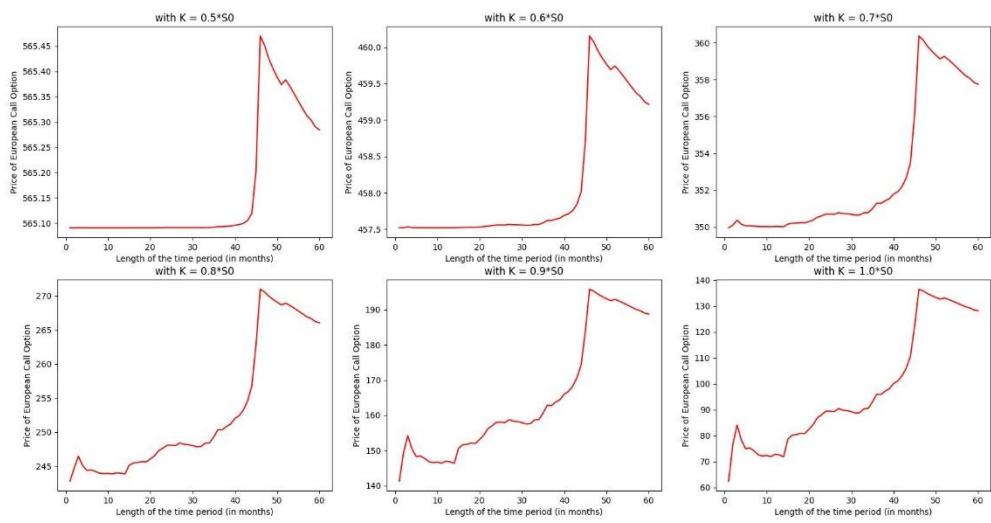
Prices of European Put Option for the stock AMZN



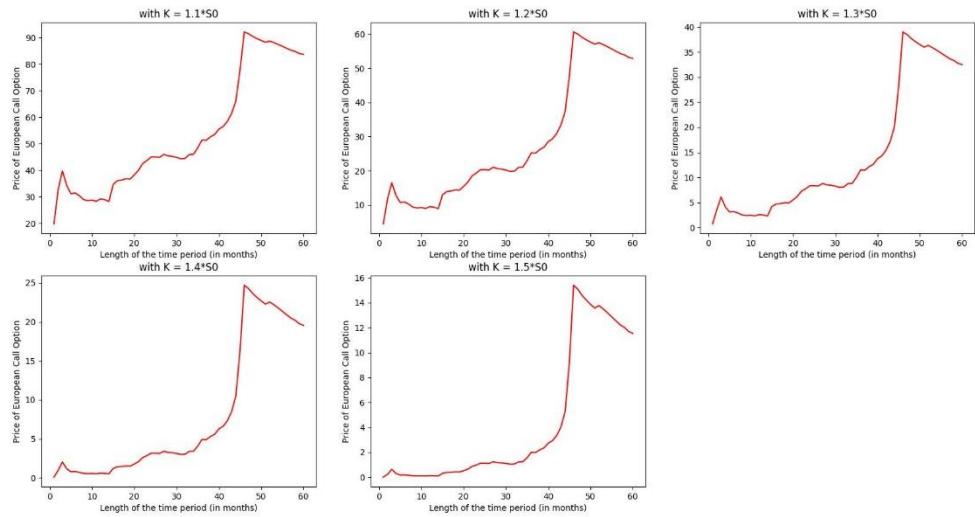
Historical Volatility versus time period for the stock: AMZN



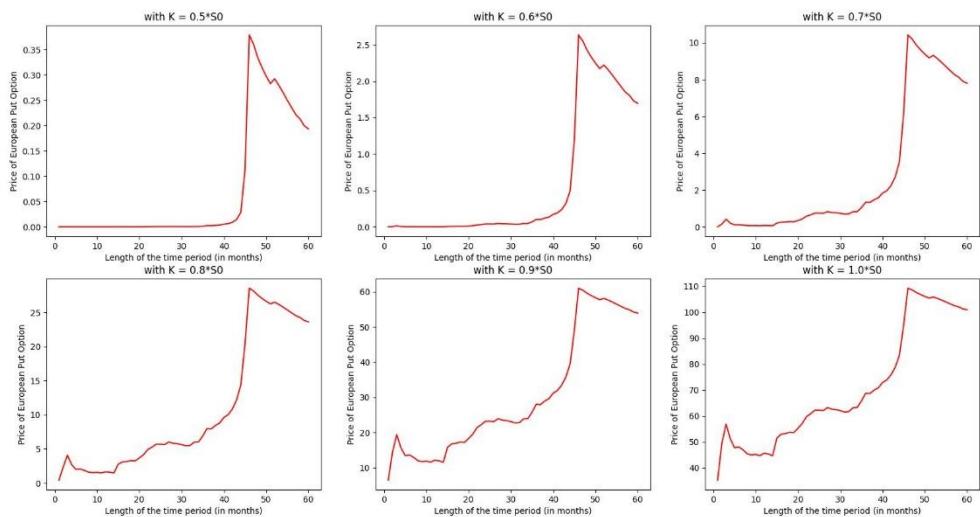
Prices of European Call Option for the stock: AXISBANK.BO



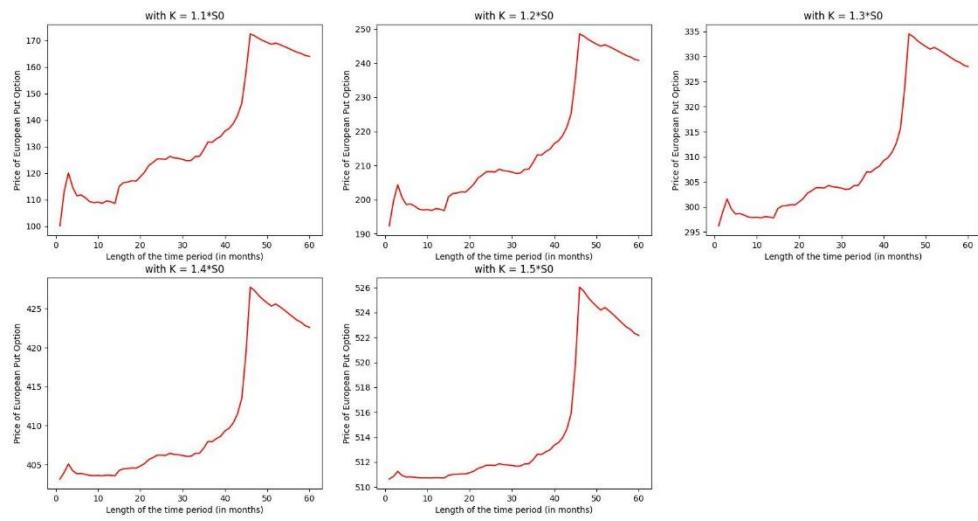
Prices of European Call Option for the stock: AXISBANK.BO



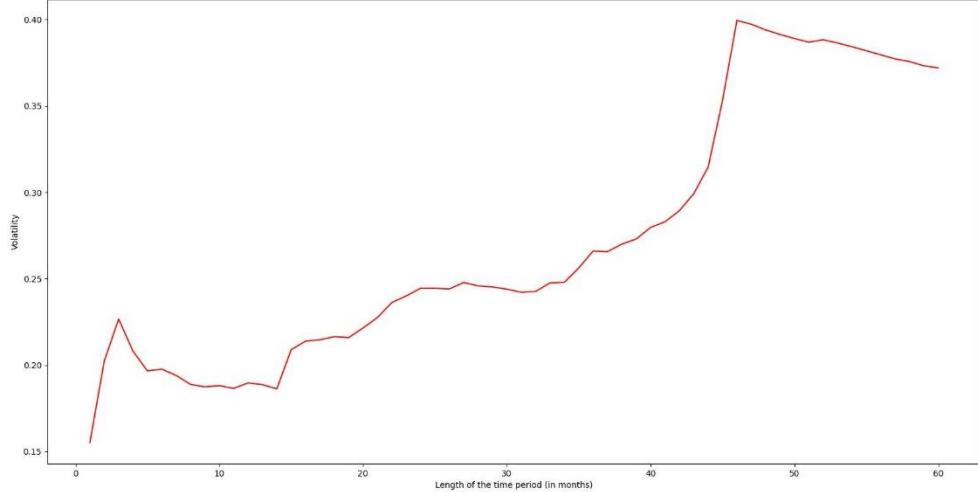
Prices of European Put Option for the stock AXISBANK.BO



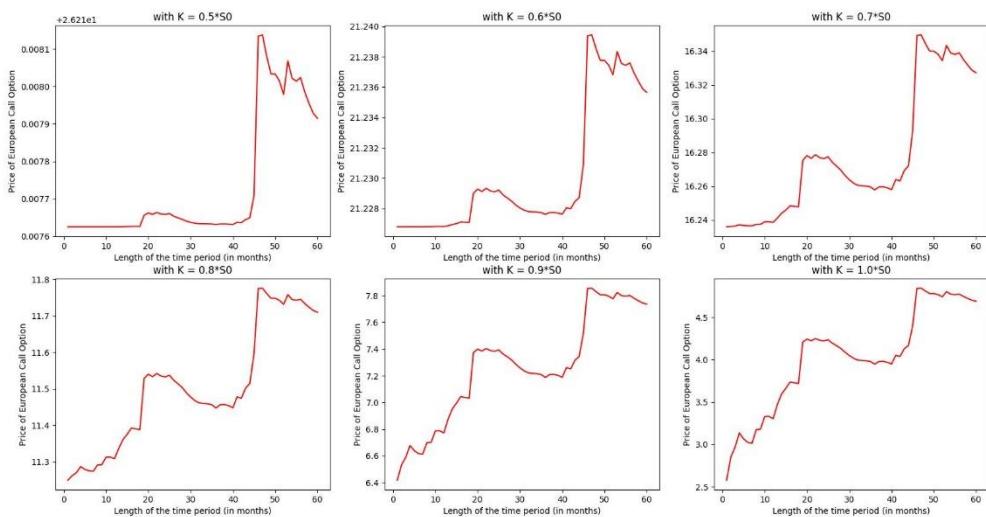
Prices of European Put Option for the stock AXISBANK.BO



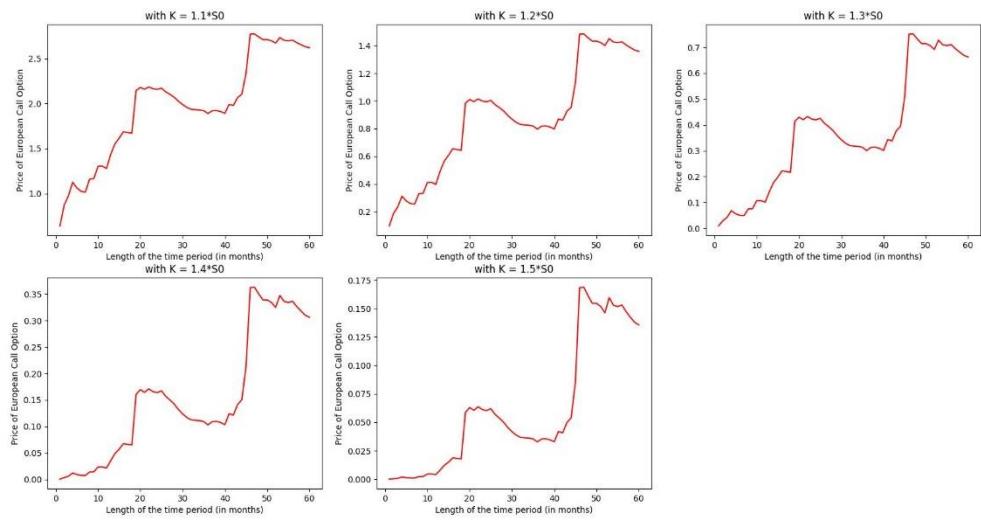
Historical Volatility versus time period for the stock: AXISBANK.BO



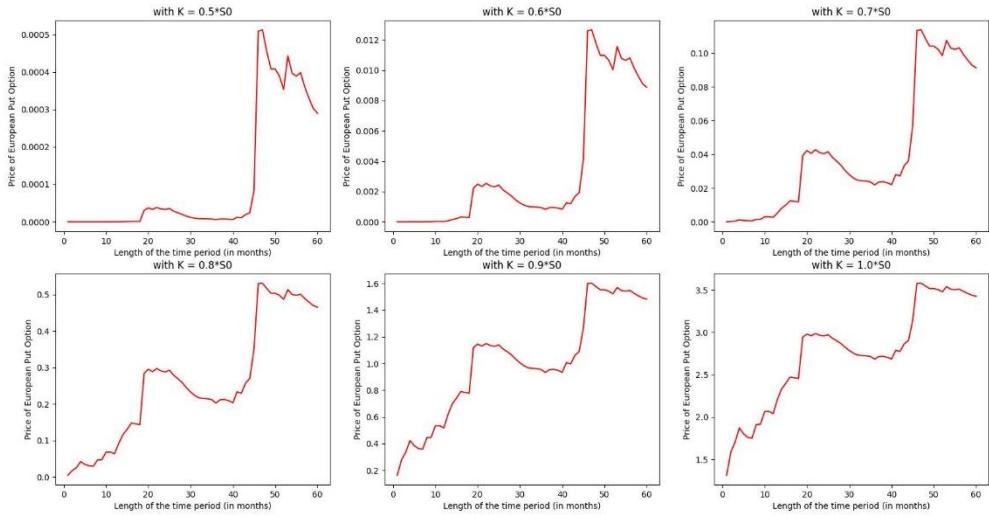
Prices of European Call Option for the stock: CSCCO



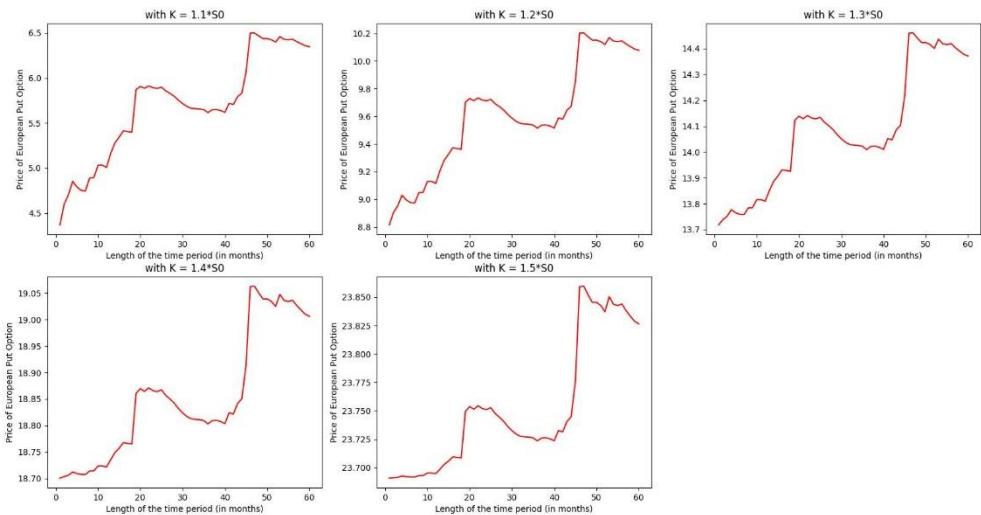
Prices of European Call Option for the stock: CSCO

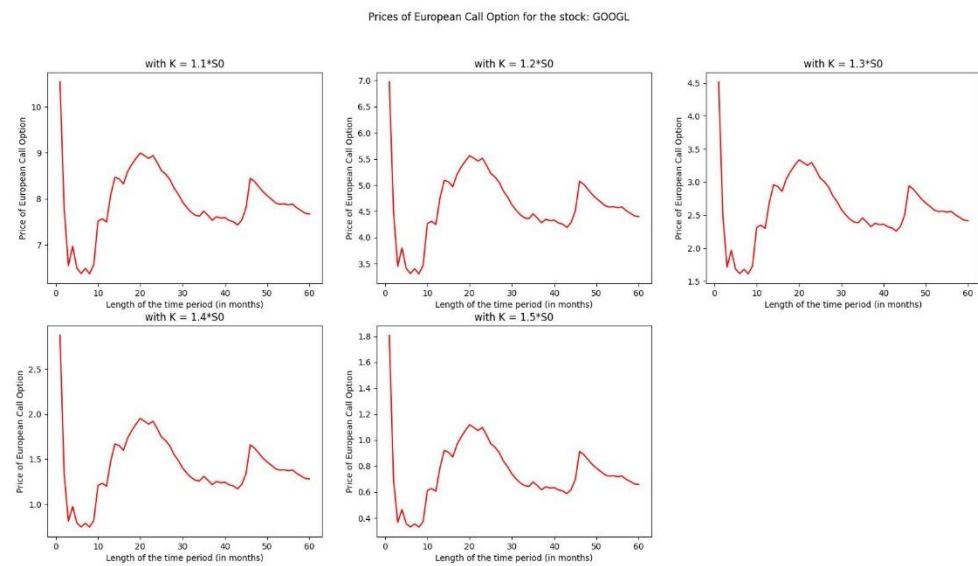
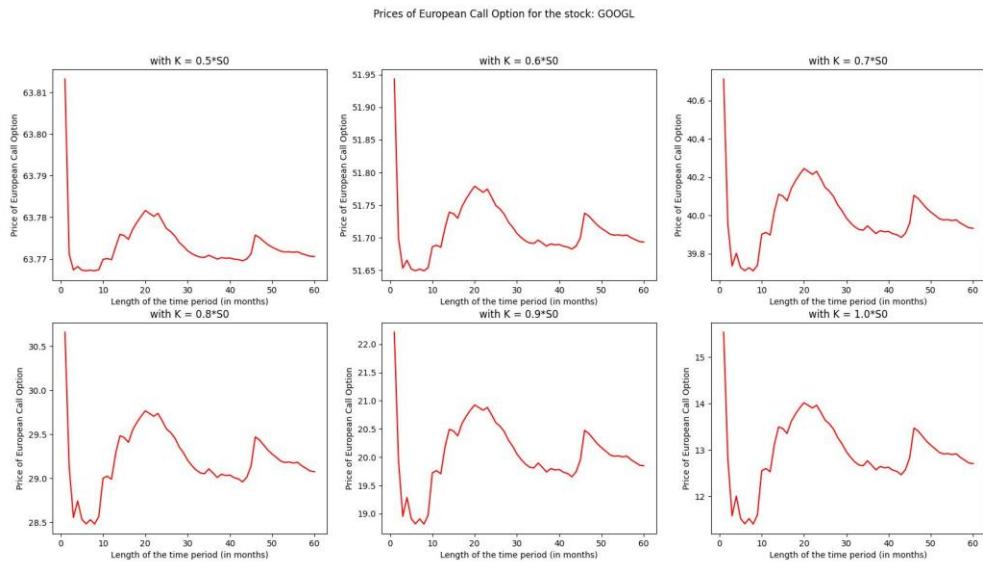
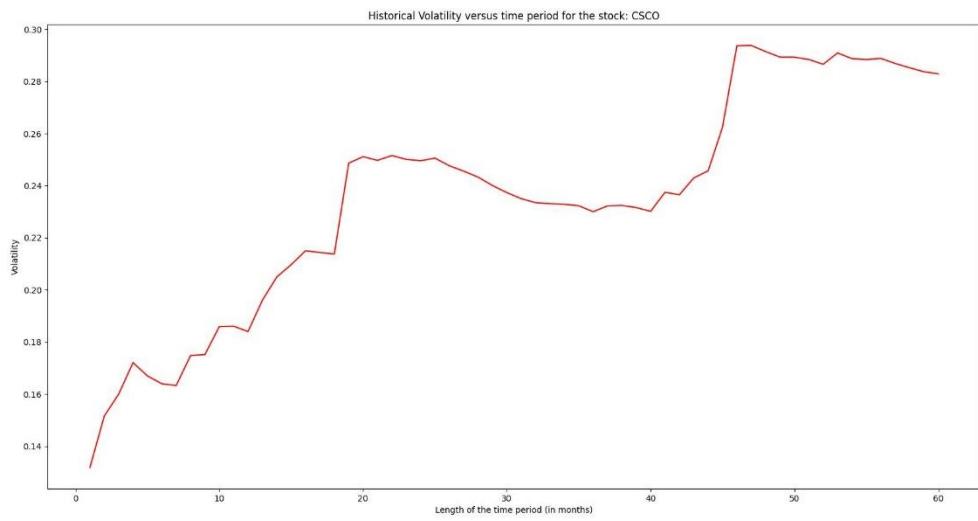


Prices of European Put Option for the stock CSCO

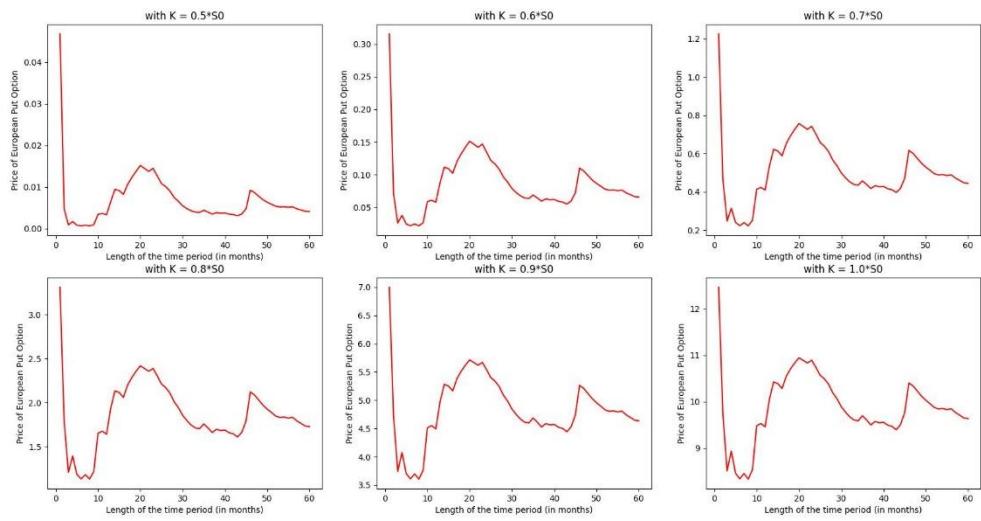


Prices of European Put Option for the stock CSCO

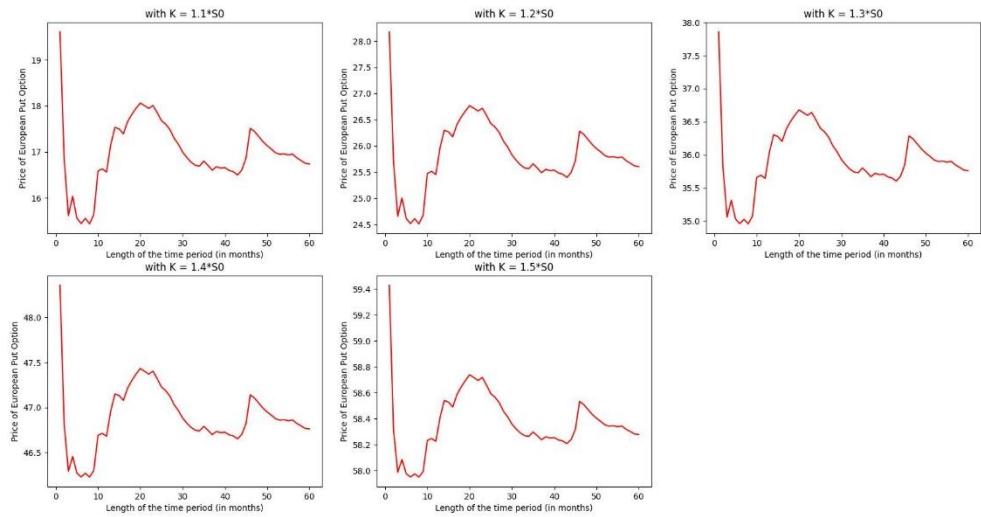




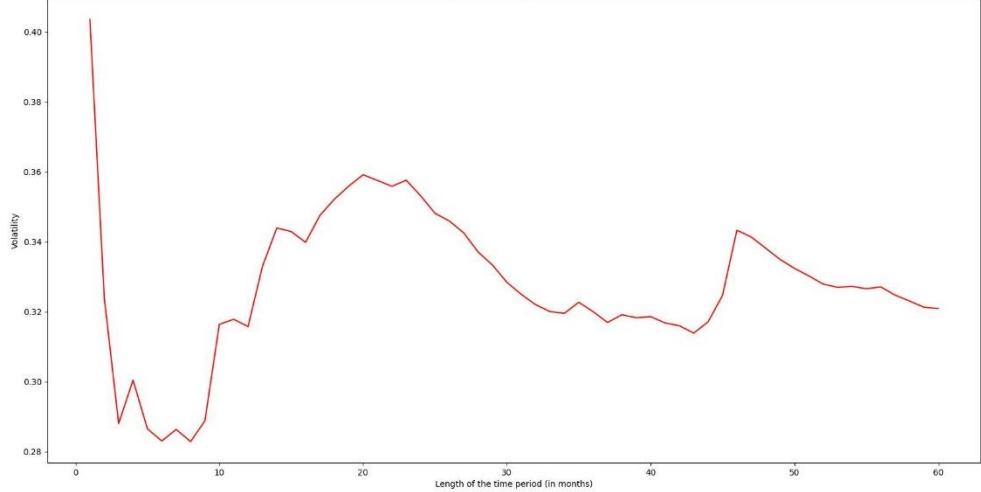
Prices of European Put Option for the stock GOOGL



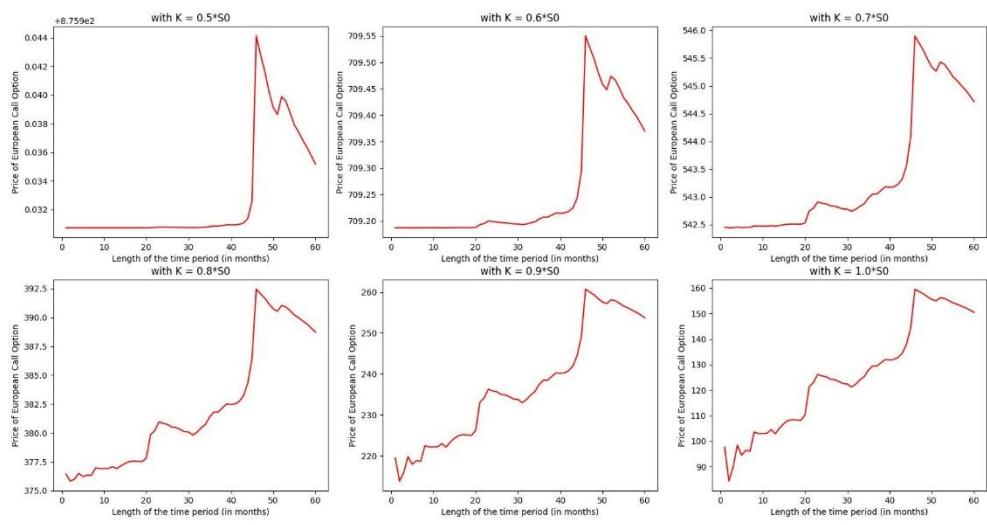
Prices of European Put Option for the stock GOOGL



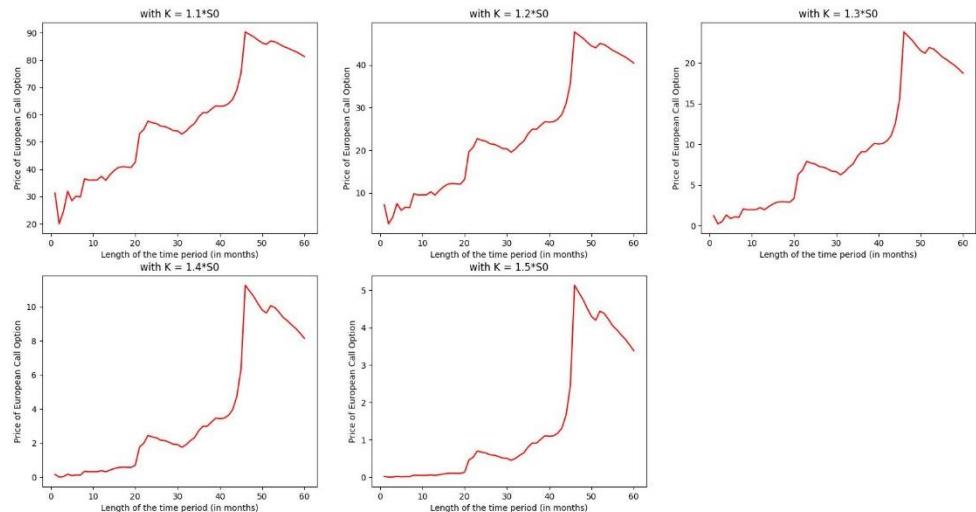
Historical Volatility versus time period for the stock: GOOGL



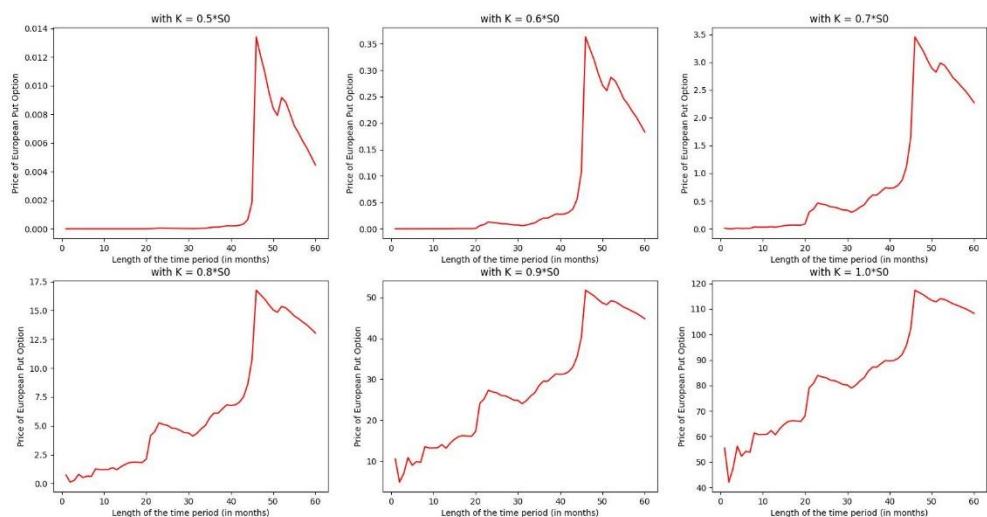
Prices of European Call Option for the stock: HDFCBANK.BO



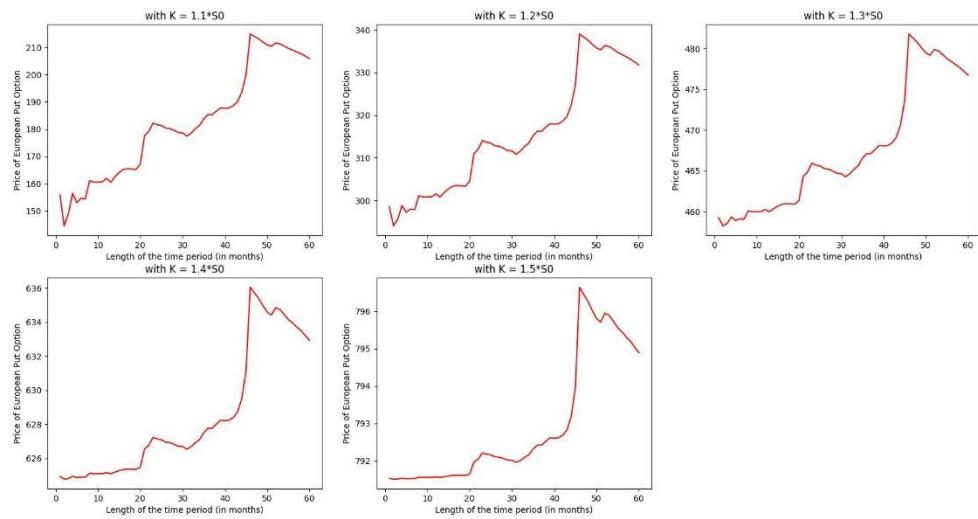
Prices of European Call Option for the stock: HDFCBANK.BO



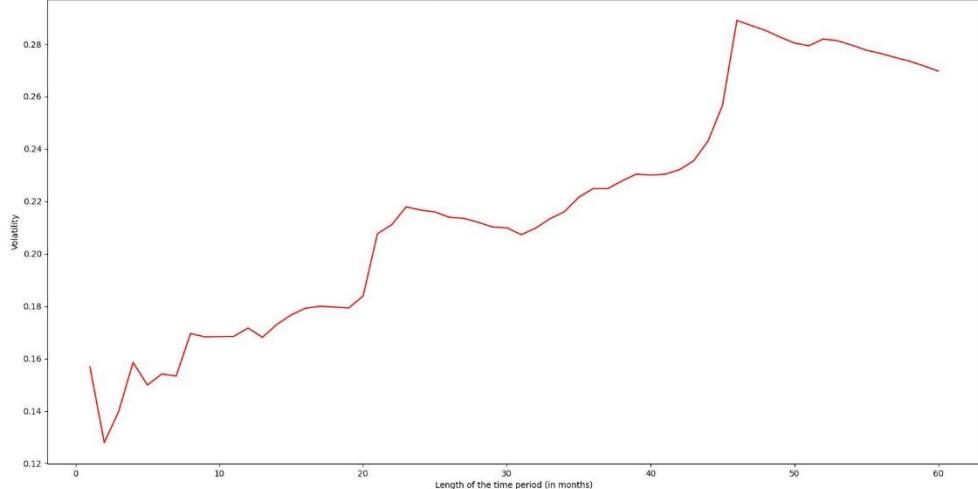
Prices of European Put Option for the stock HDFCBANK.BO



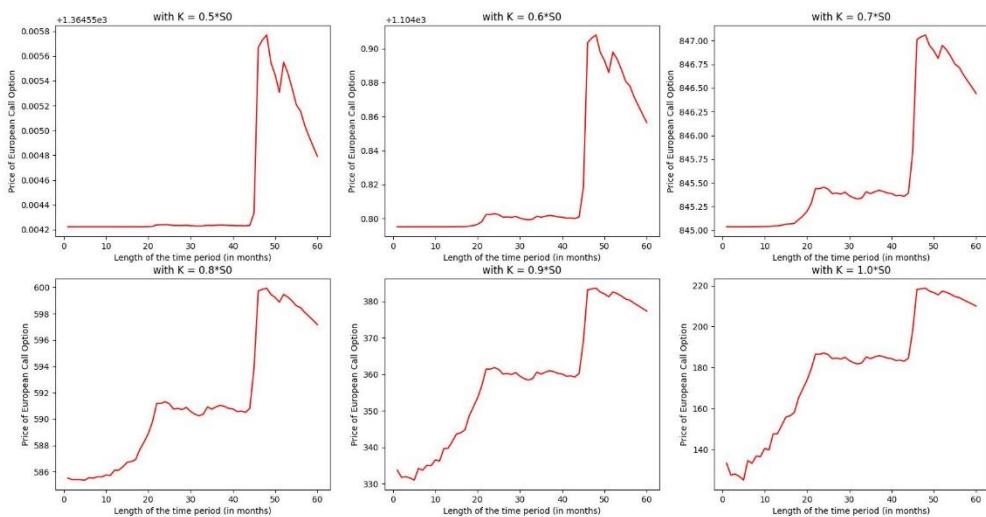
Prices of European Put Option for the stock HDFCBANK.BO



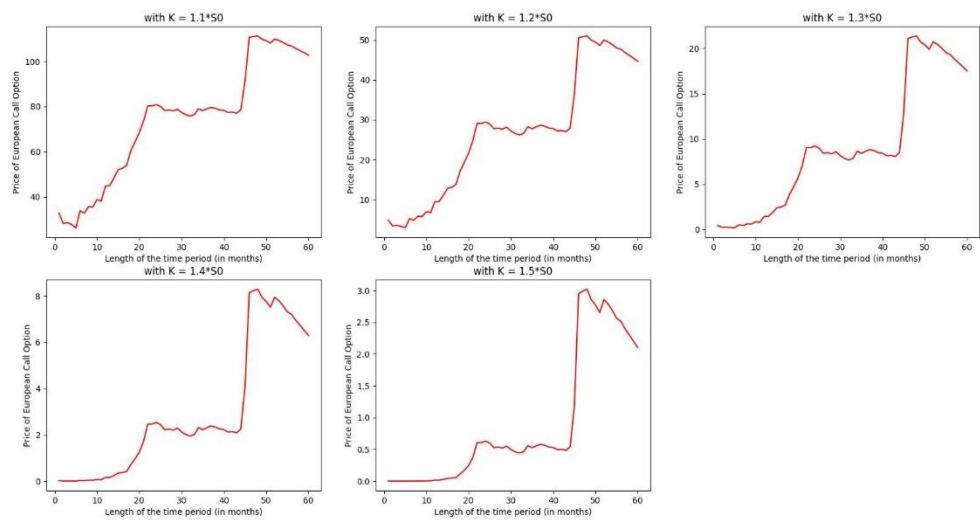
Historical Volatility versus time period for the stock: HDFCBANK.BO



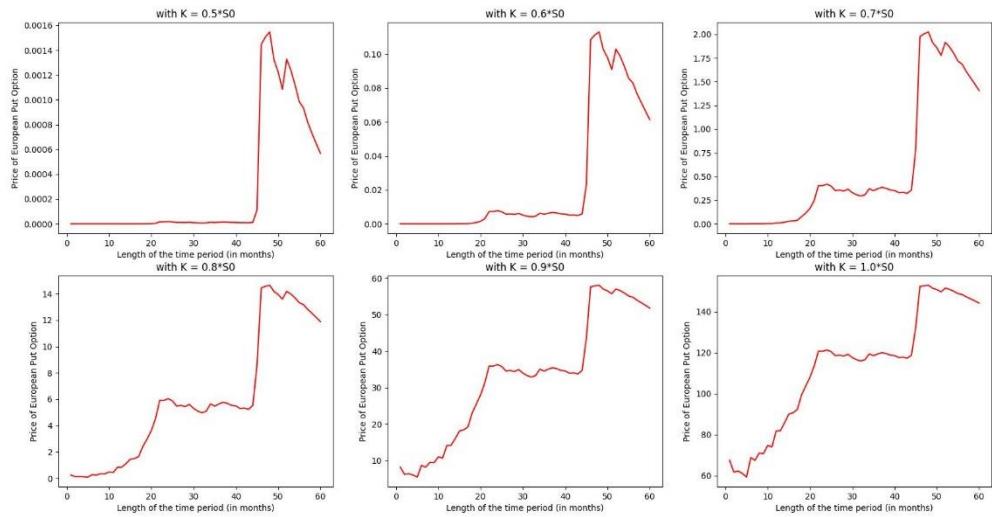
Prices of European Call Option for the stock: HINDUNILVR.BO



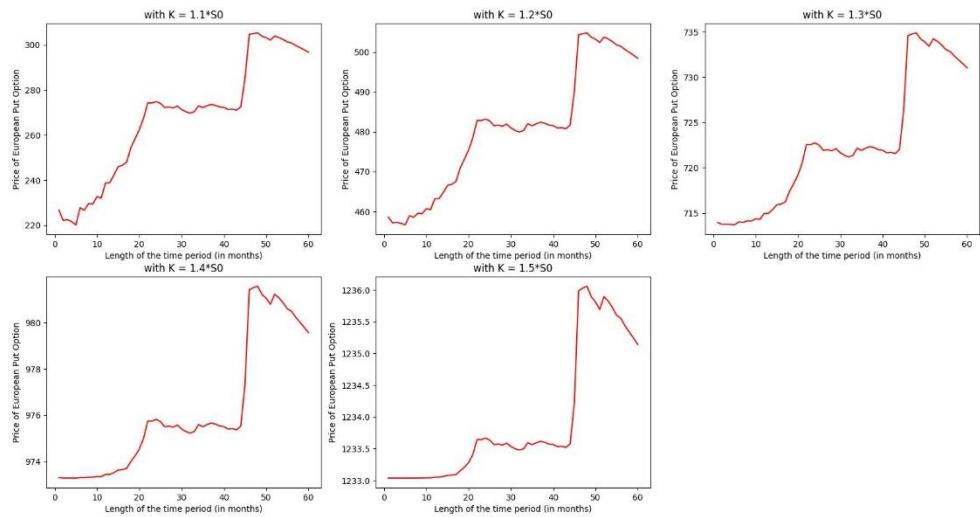
Prices of European Call Option for the stock: HINDUNILVR.BO

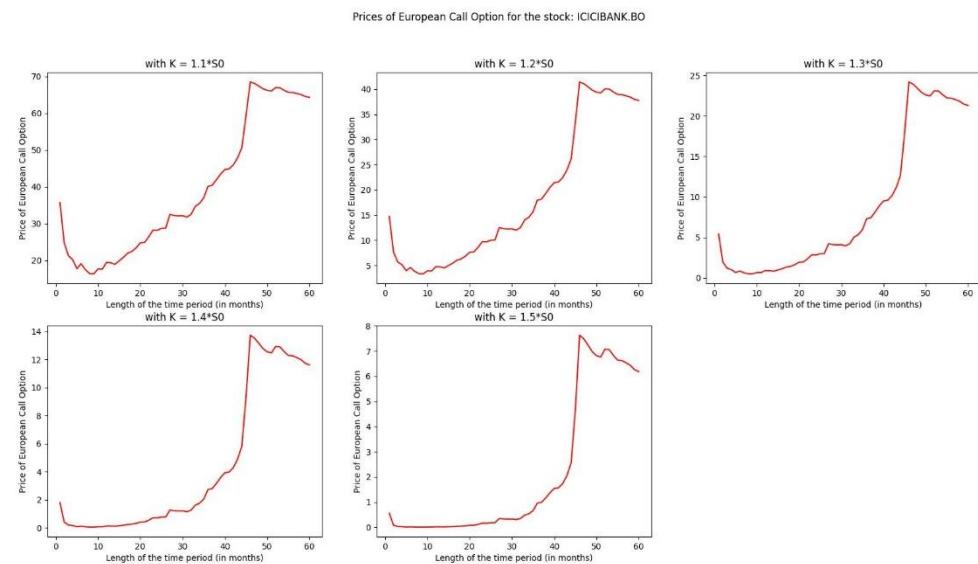
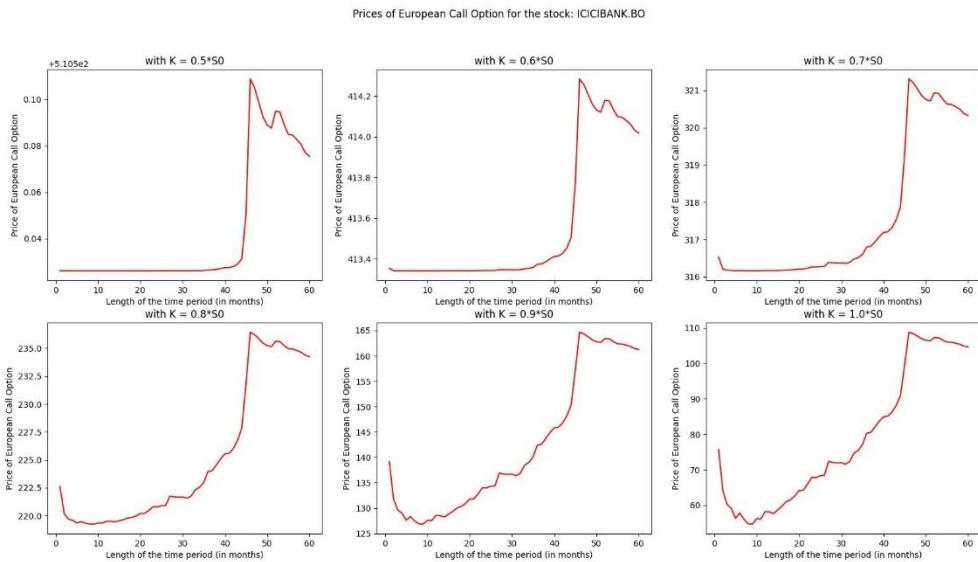
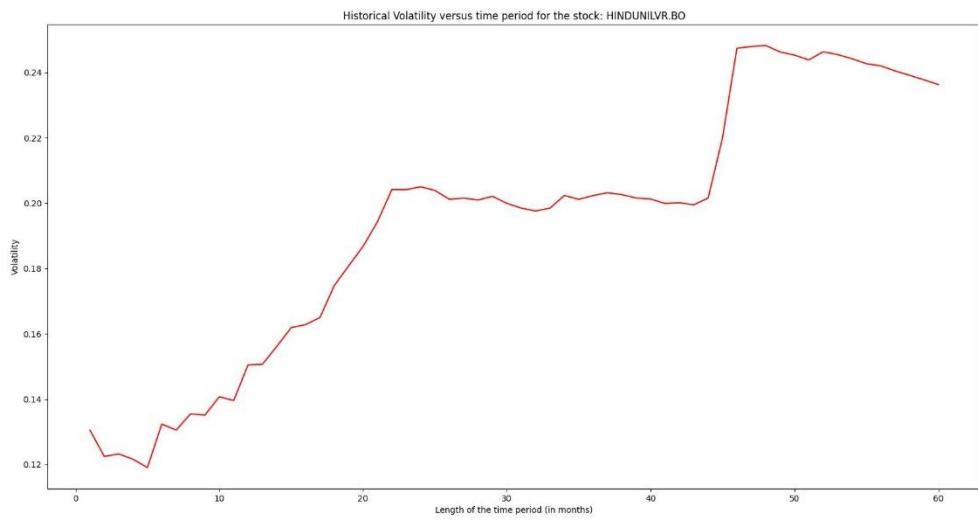


Prices of European Put Option for the stock HINDUNILVR.BO

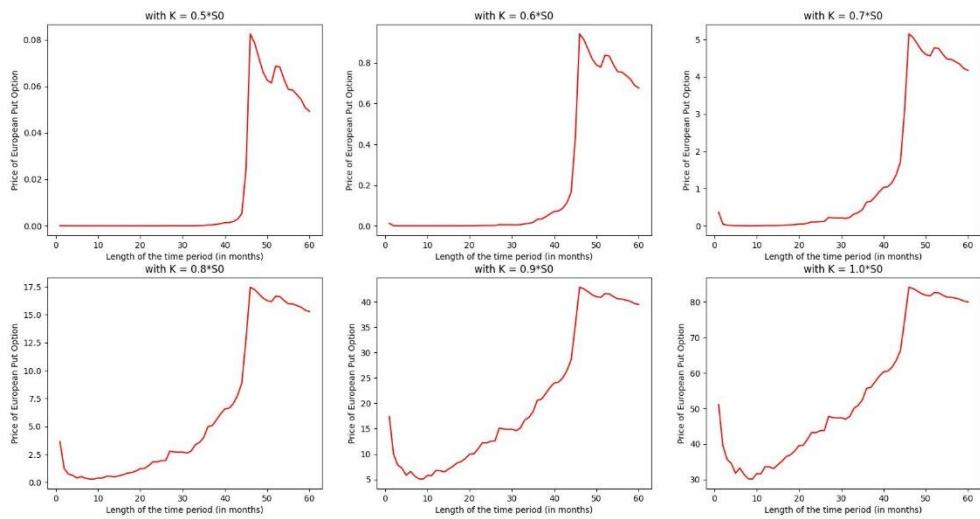


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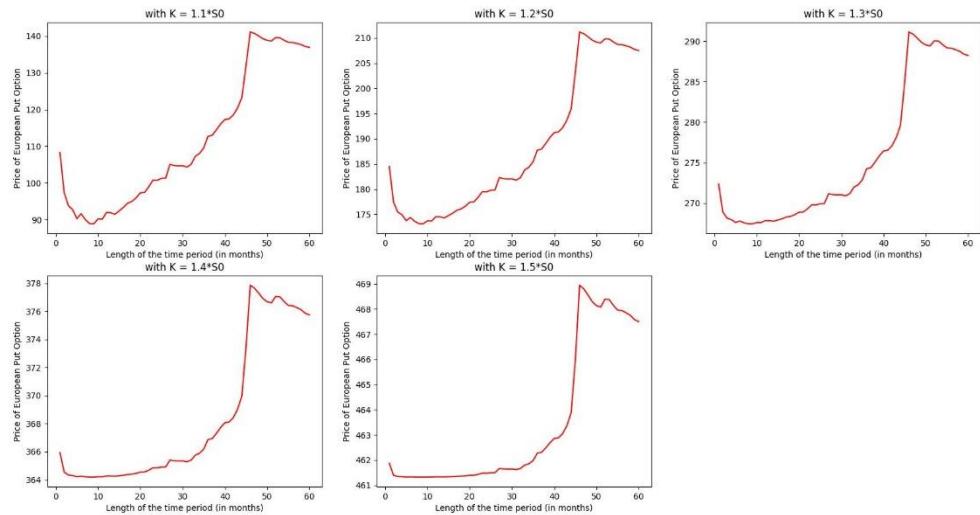




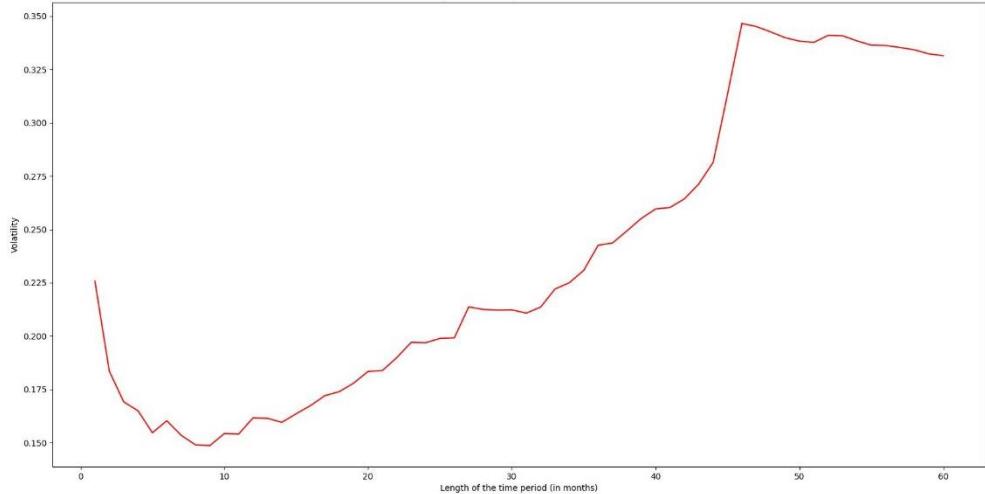
Prices of European Put Option for the stock ICICIBANK.BO



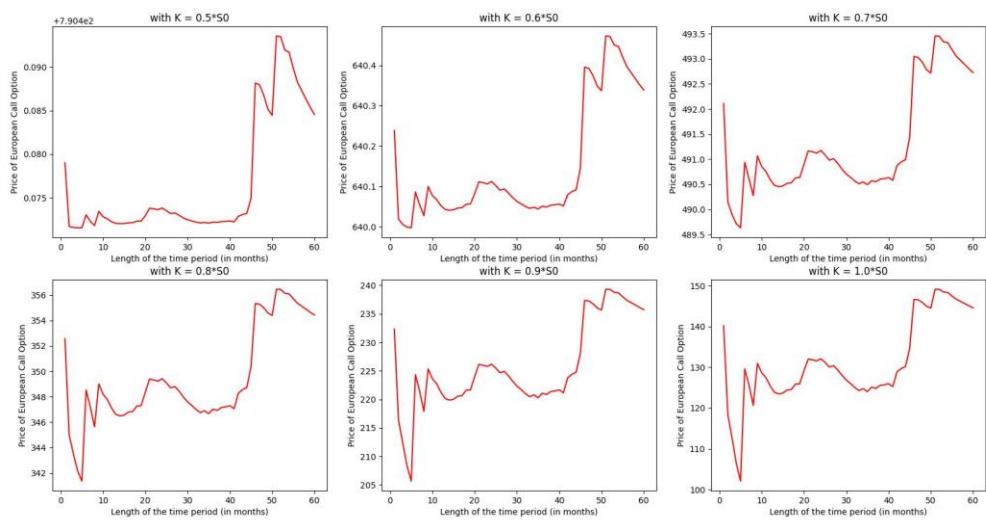
Prices of European Put Option for the stock ICICIBANK.BO



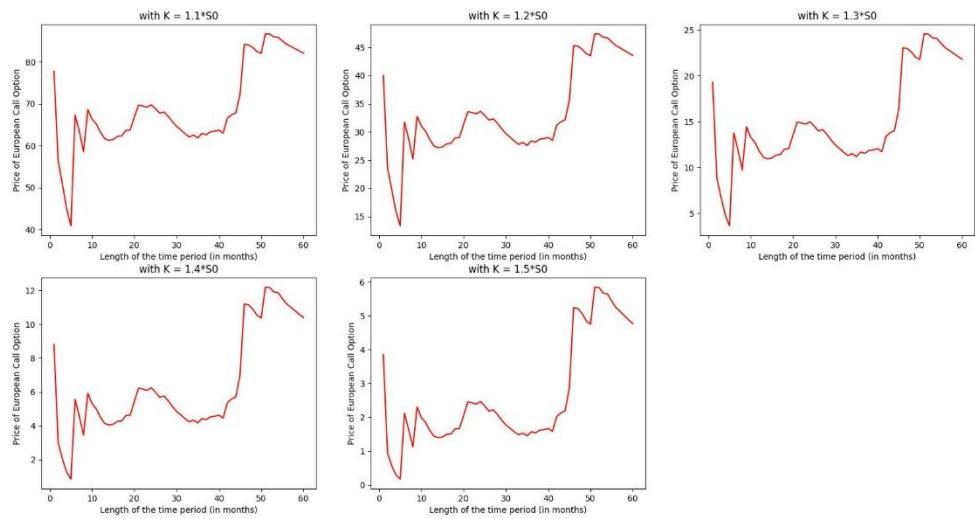
Historical Volatility versus time period for the stock: ICICIBANK.BO



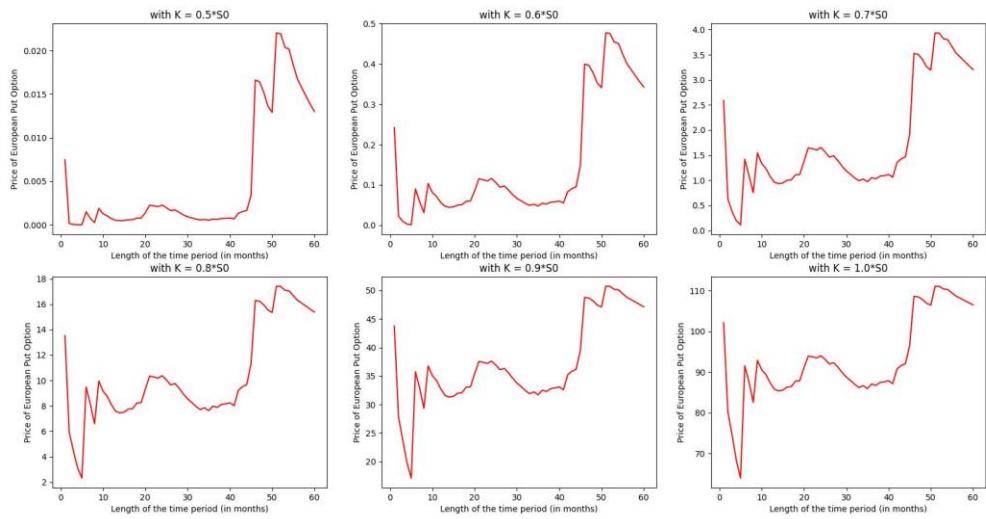
Prices of European Call Option for the stock: INFY.BO



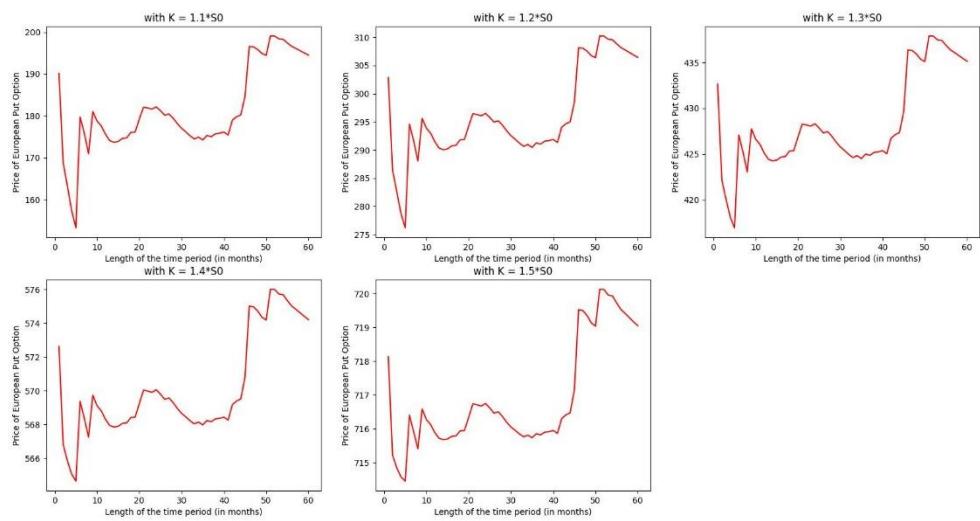
Prices of European Call Option for the stock: INFY.BO



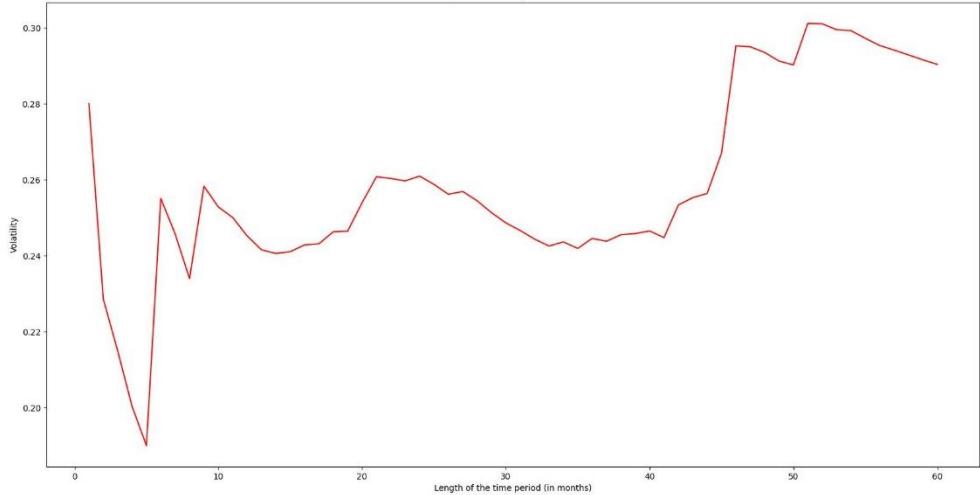
Prices of European Put Option for the stock INFY.BO



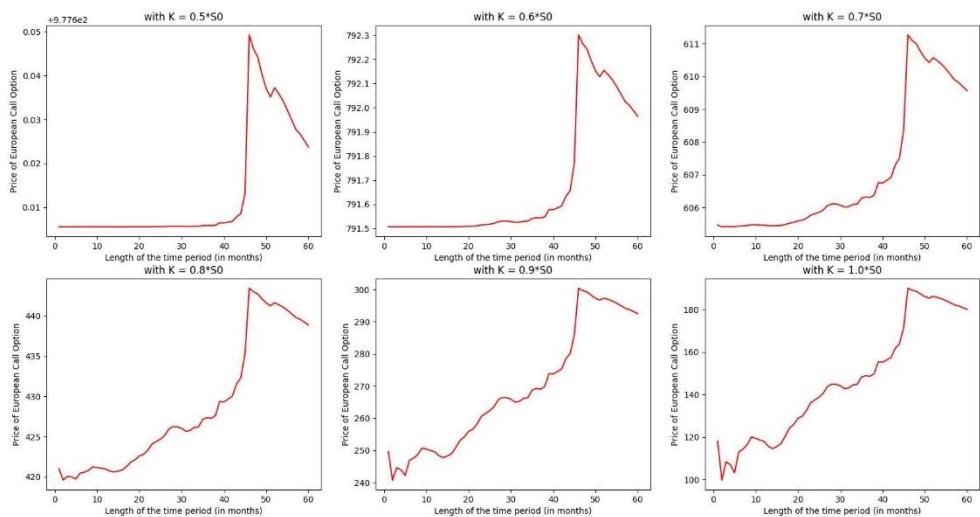
Prices of European Put Option for the stock INFYBO



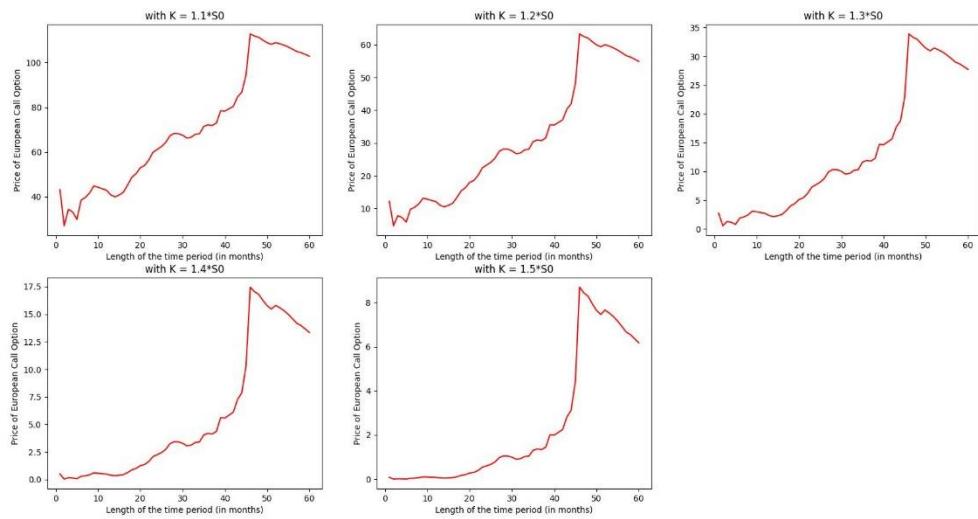
Historical Volatility versus time period for the stock: INFYBO



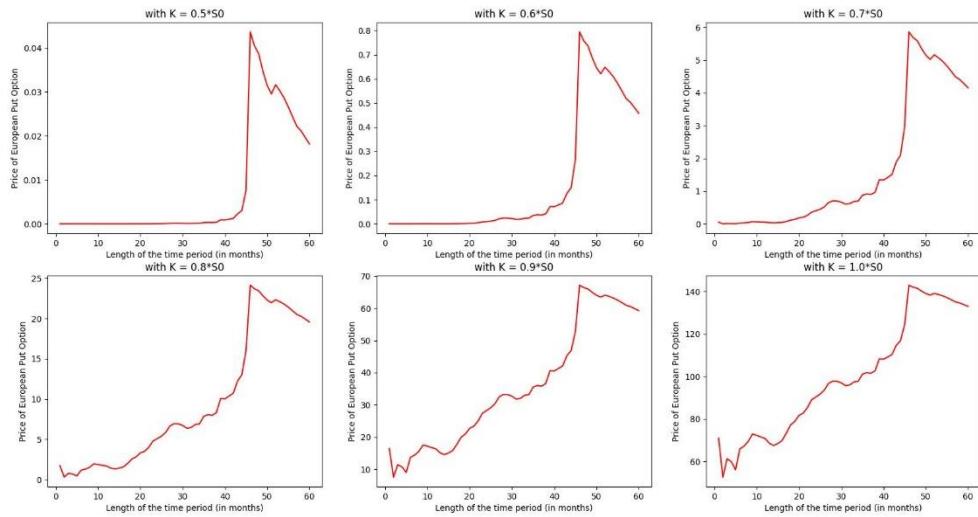
Prices of European Call Option for the stock: KOTAKBANK.BO



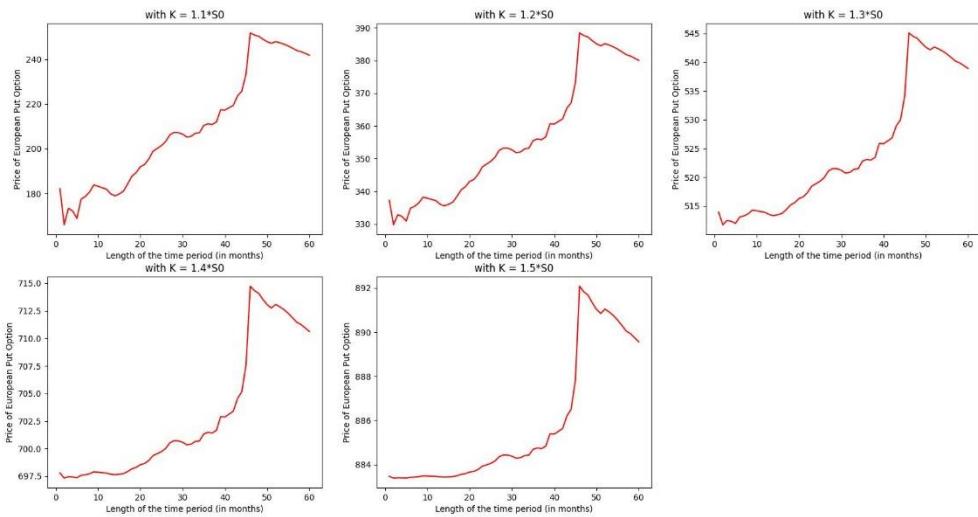
Prices of European Call Option for the stock: KOTAKBANK.BO

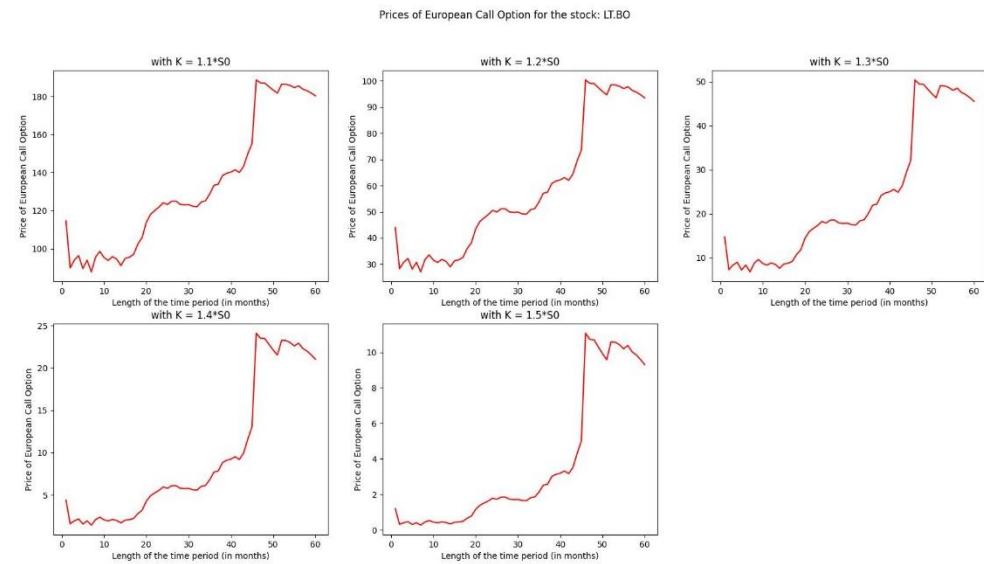
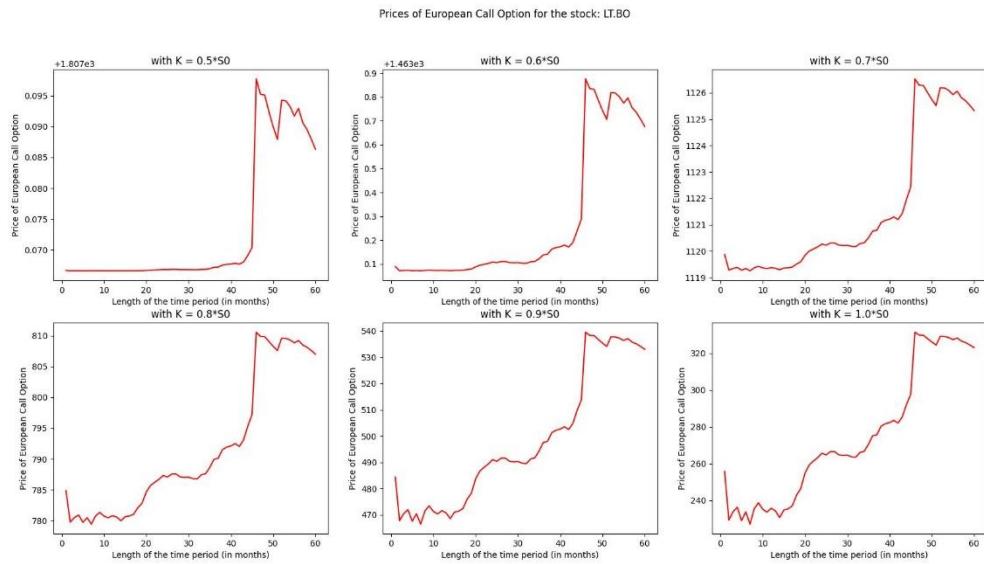
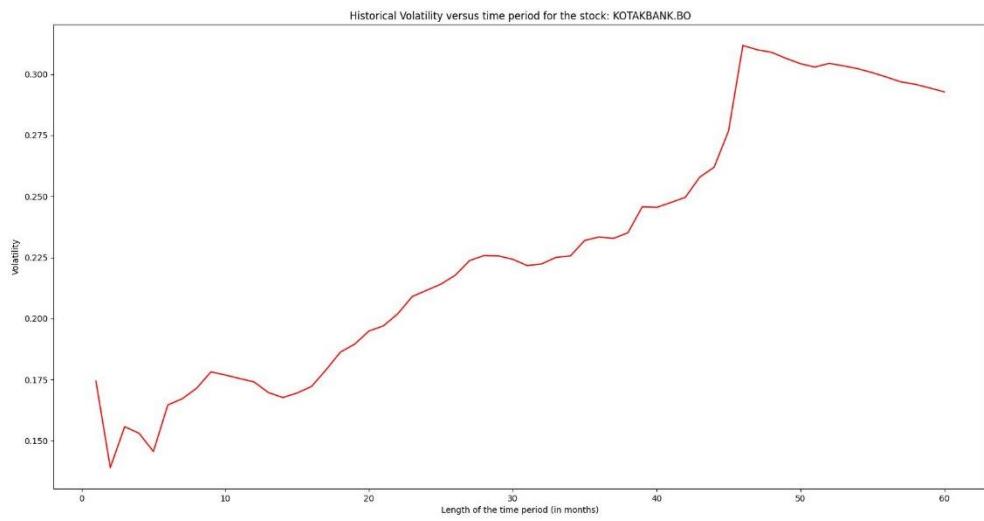


Prices of European Put Option for the stock KOTAKBANK.BO

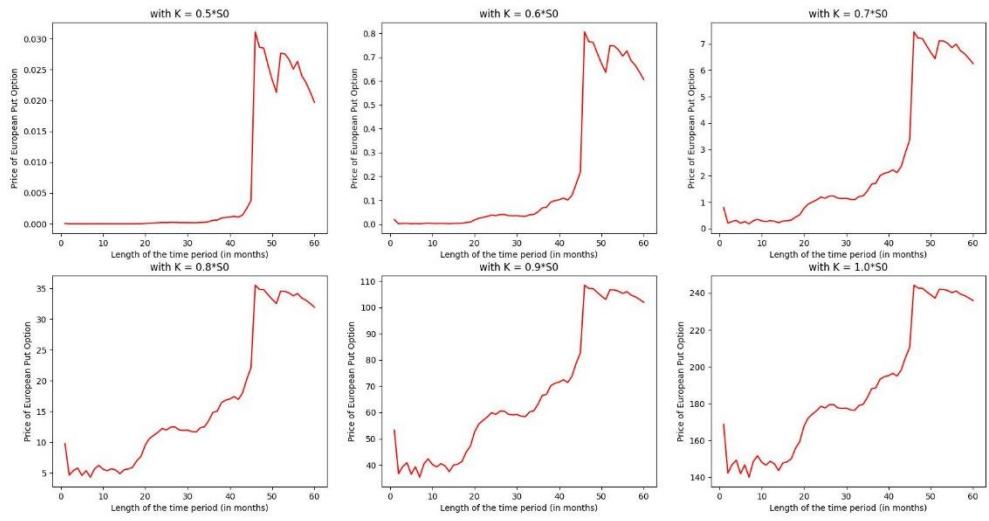


Prices of European Put Option for the stock KOTAKBANK.BO

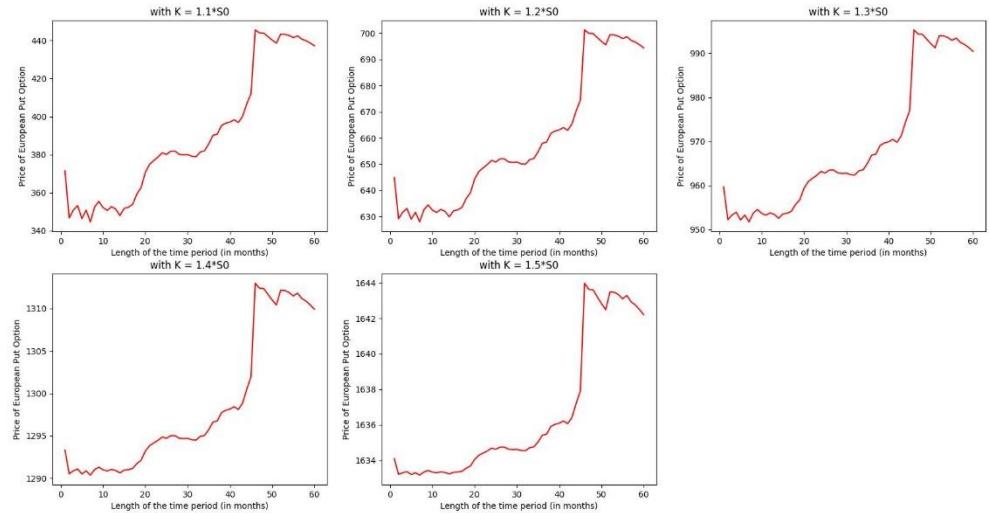




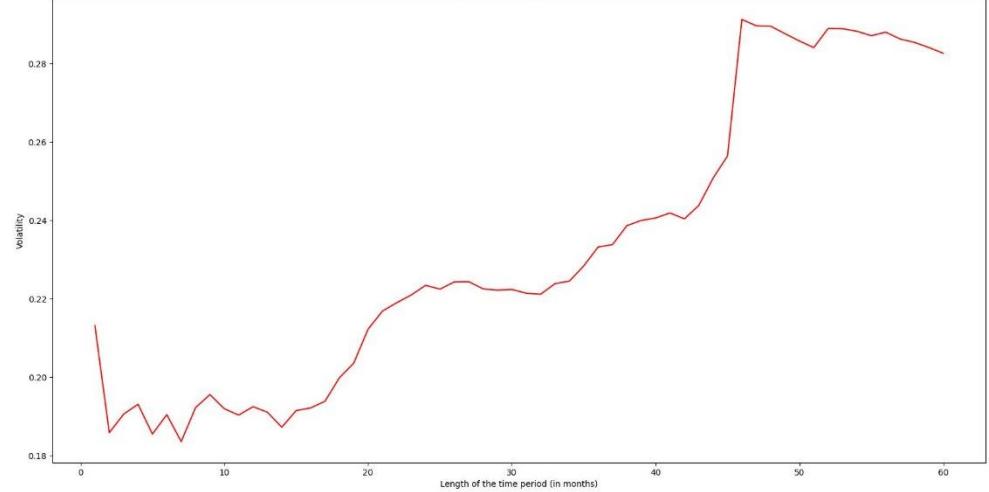
Prices of European Put Option for the stock LT.BO



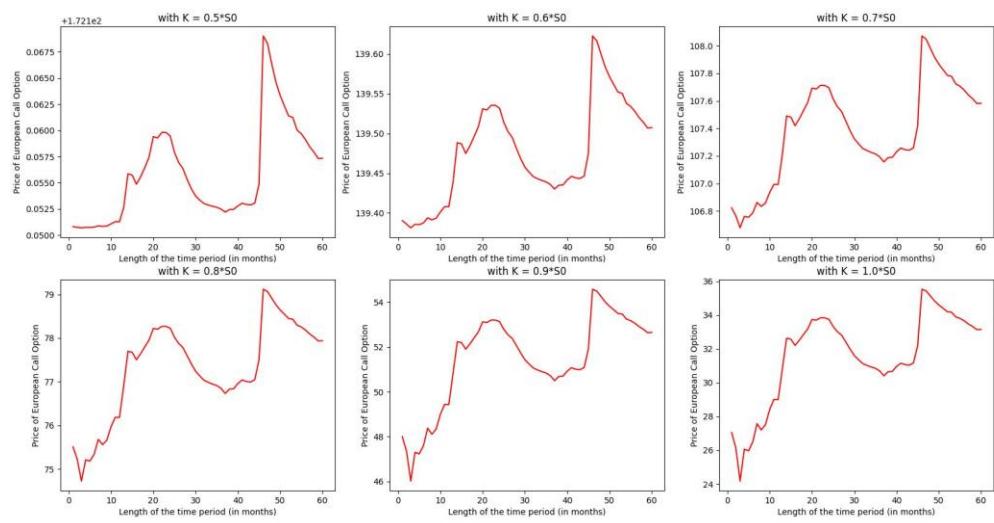
Prices of European Put Option for the stock LT.BO



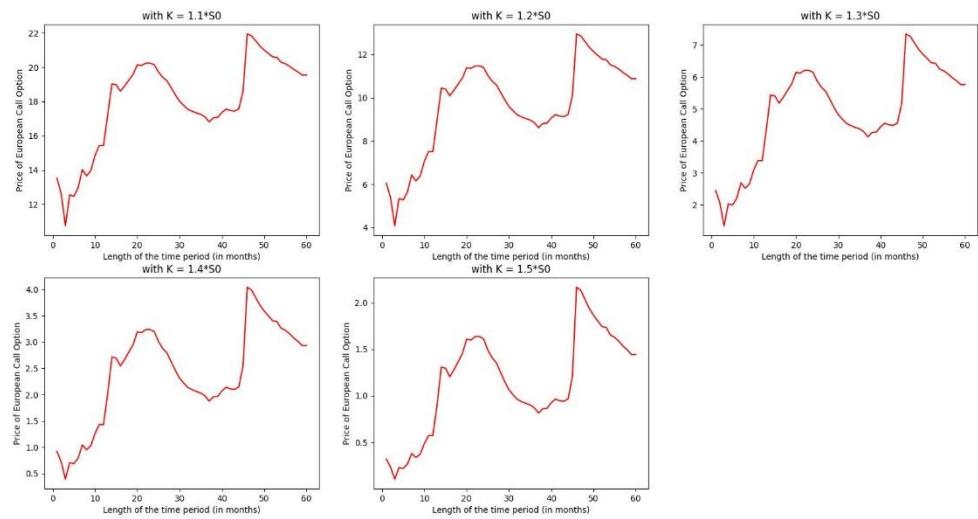
Historical Volatility versus time period for the stock: LT.BO



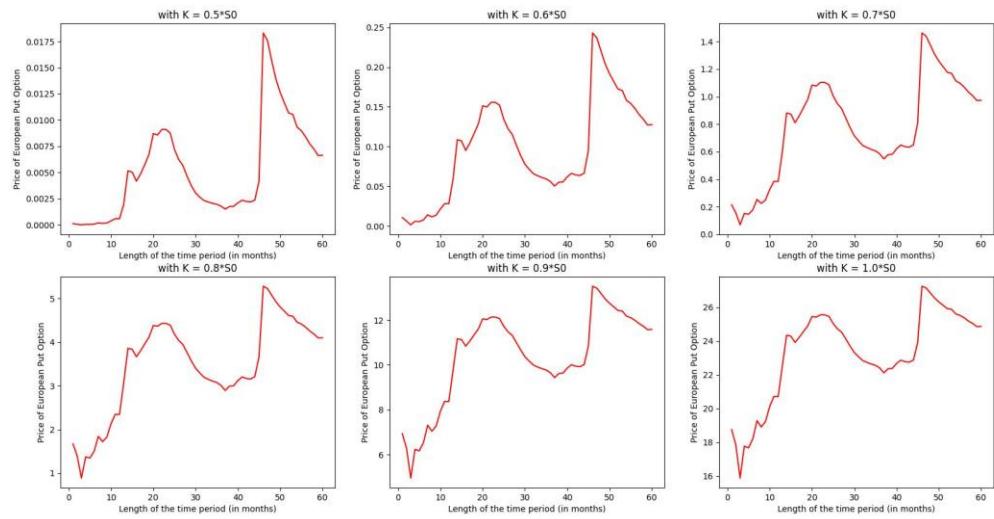
Prices of European Call Option for the stock: MSFT



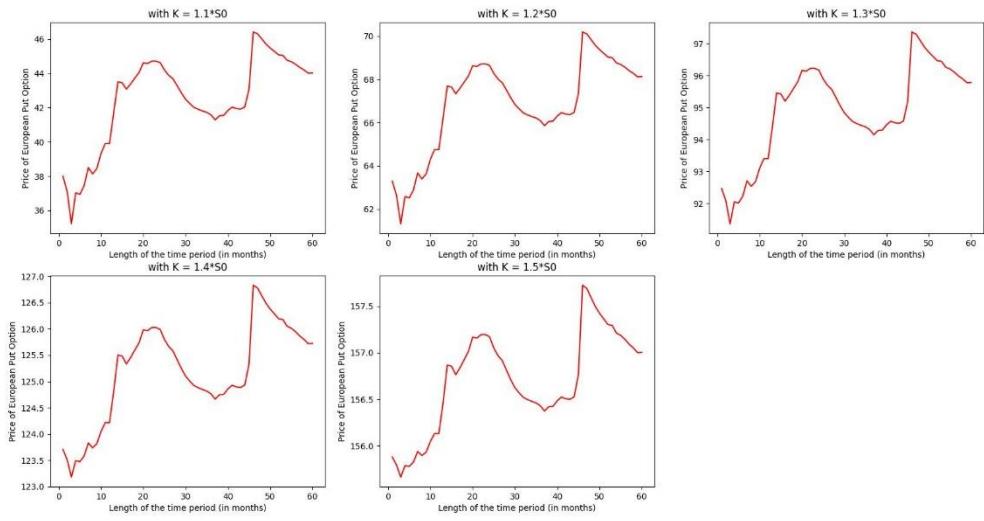
Prices of European Call Option for the stock: MSFT



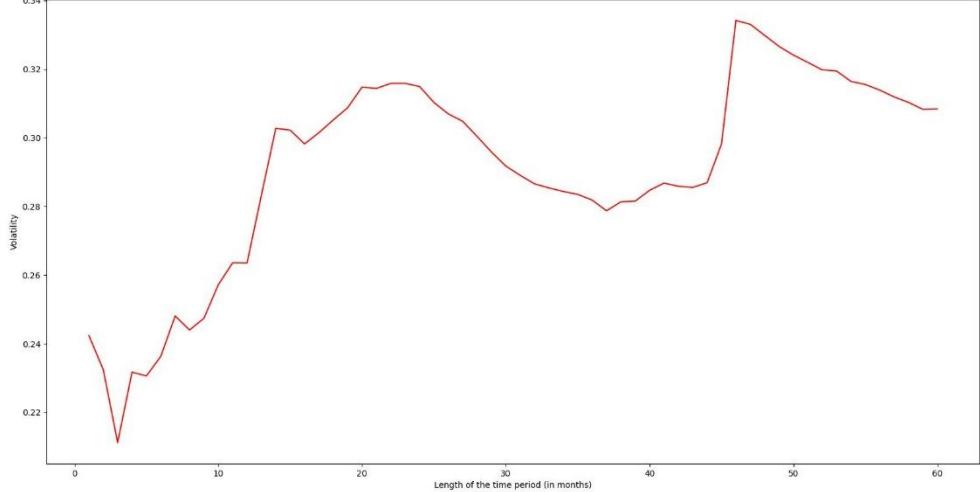
Prices of European Put Option for the stock MSFT



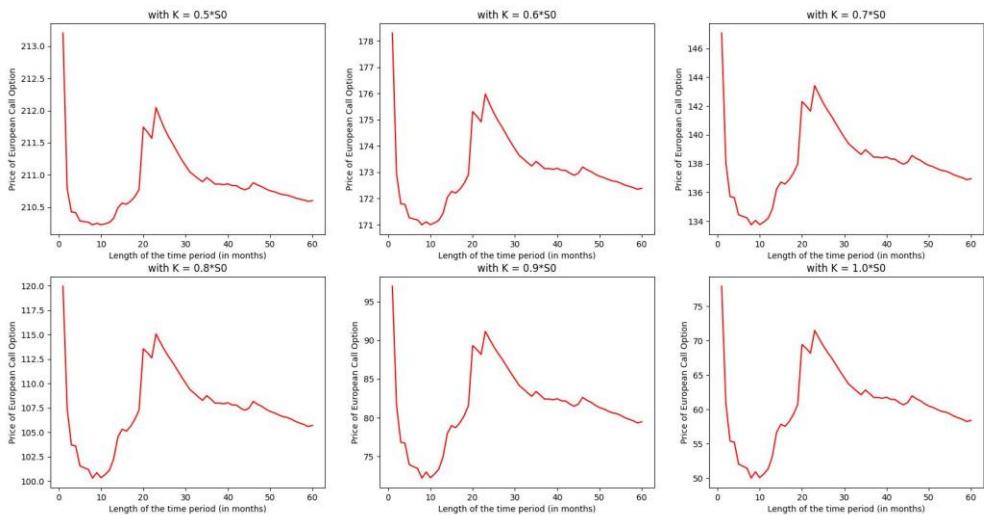
Prices of European Put Option for the stock MSFT



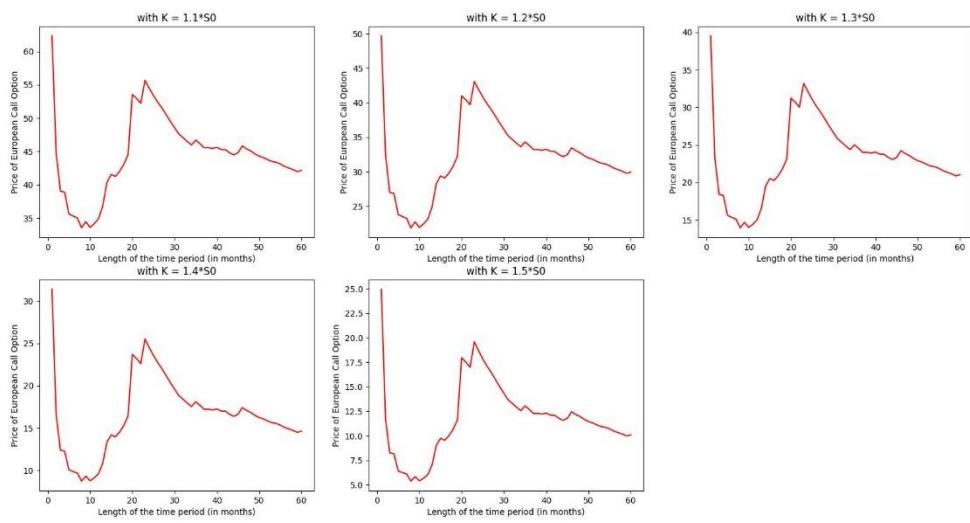
Historical Volatility versus time period for the stock: MSFT



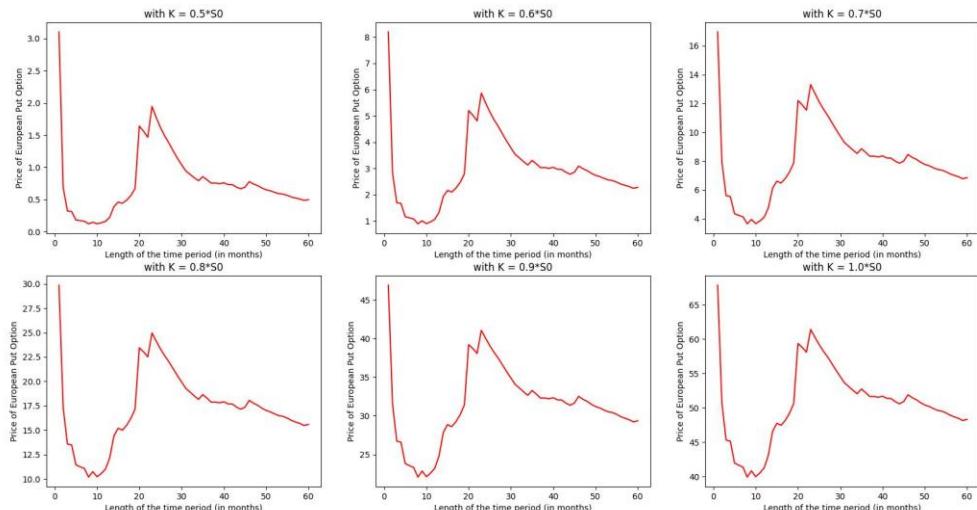
Prices of European Call Option for the stock: NFLX



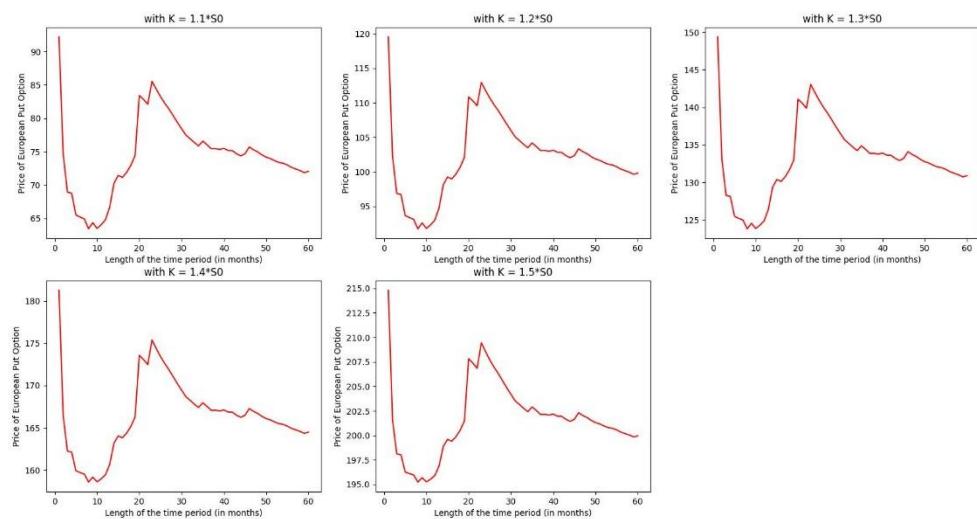
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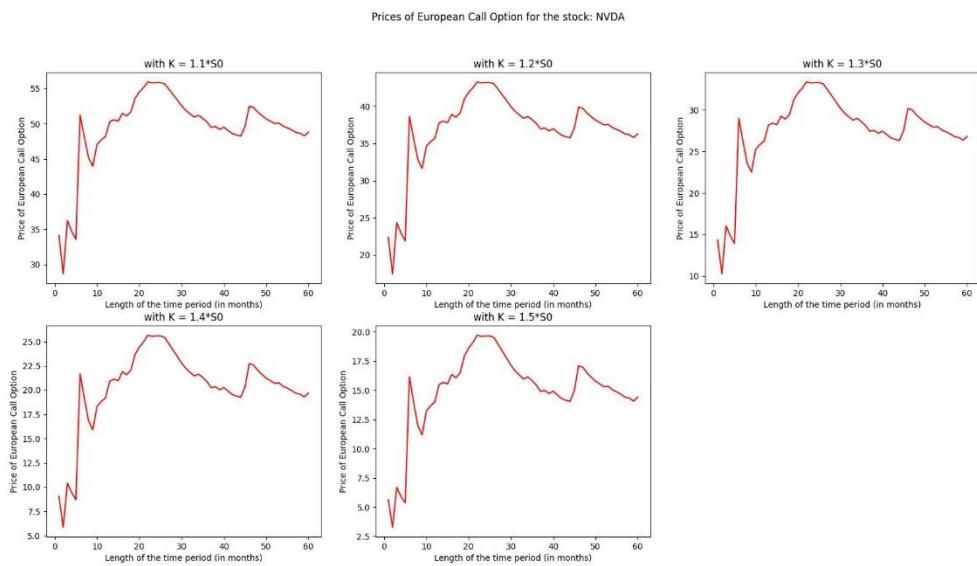
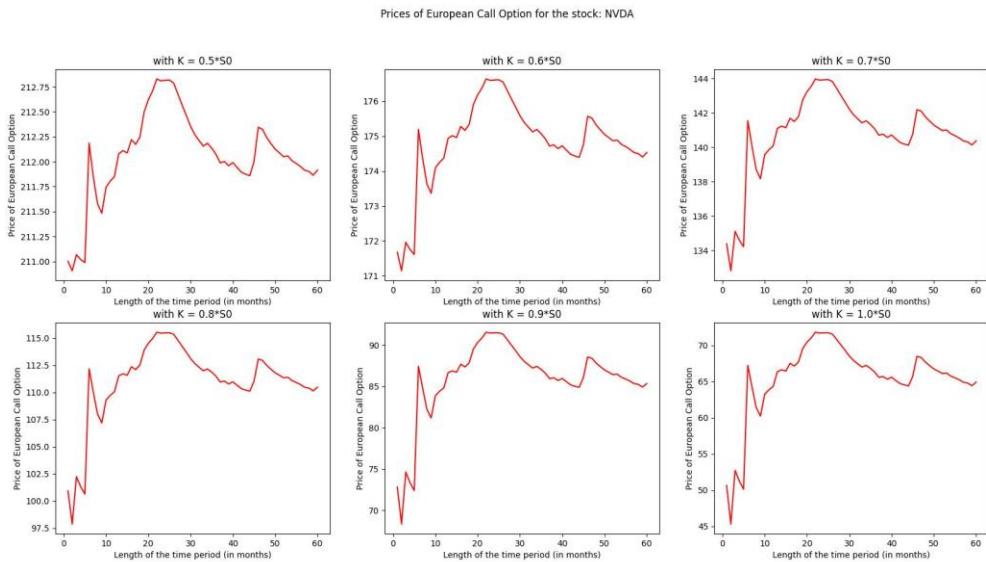
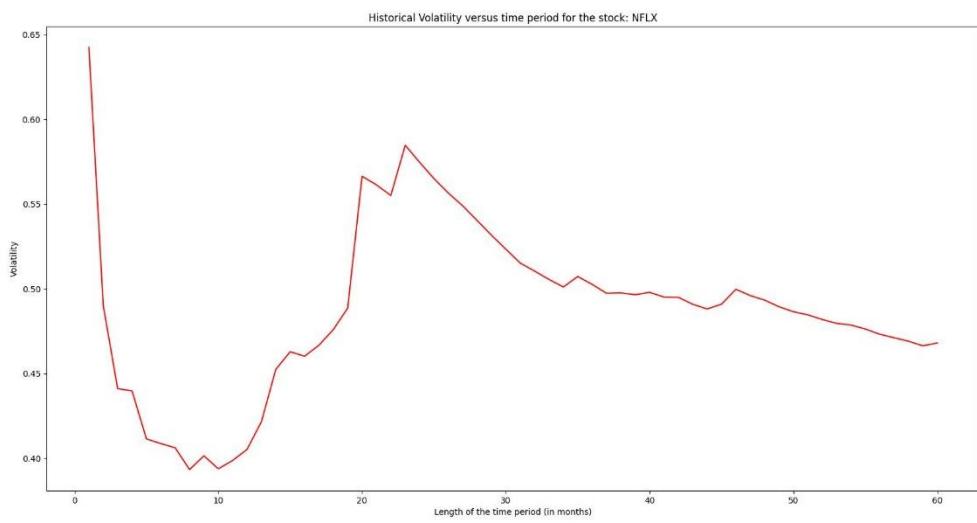


Prices of European Put Option for the stock NFLX

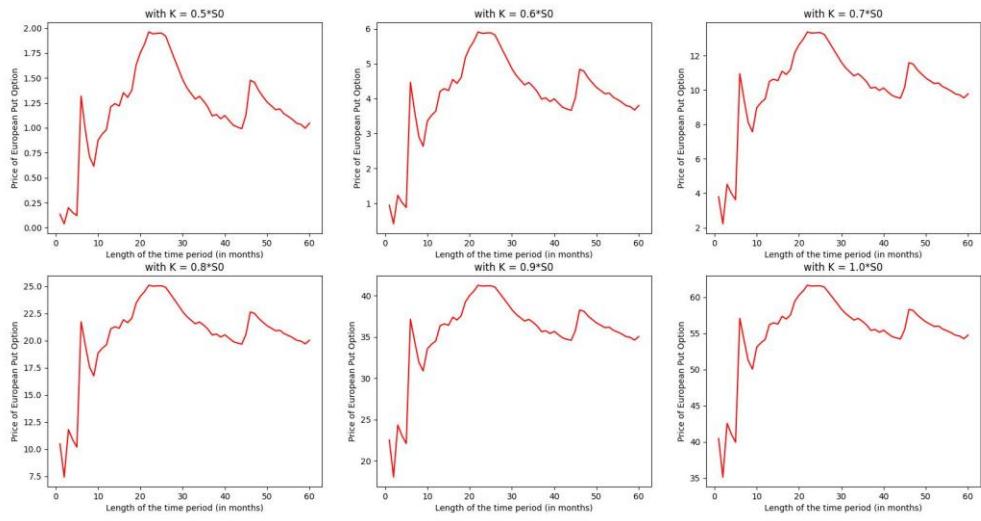


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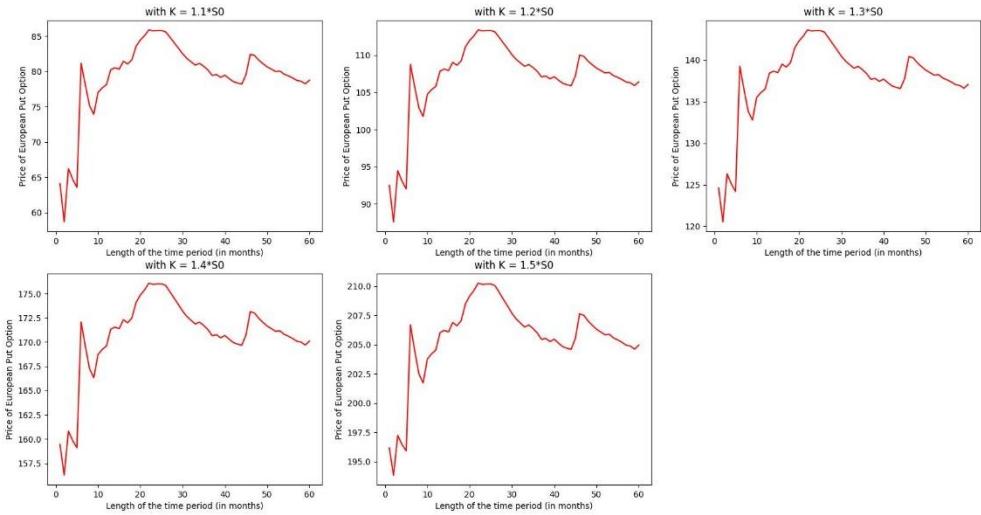




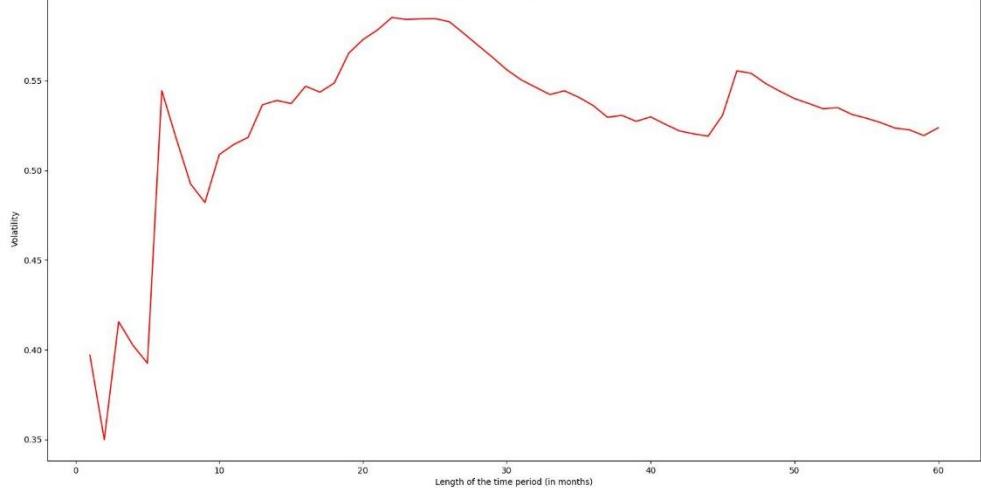
Prices of European Put Option for the stock NVDA



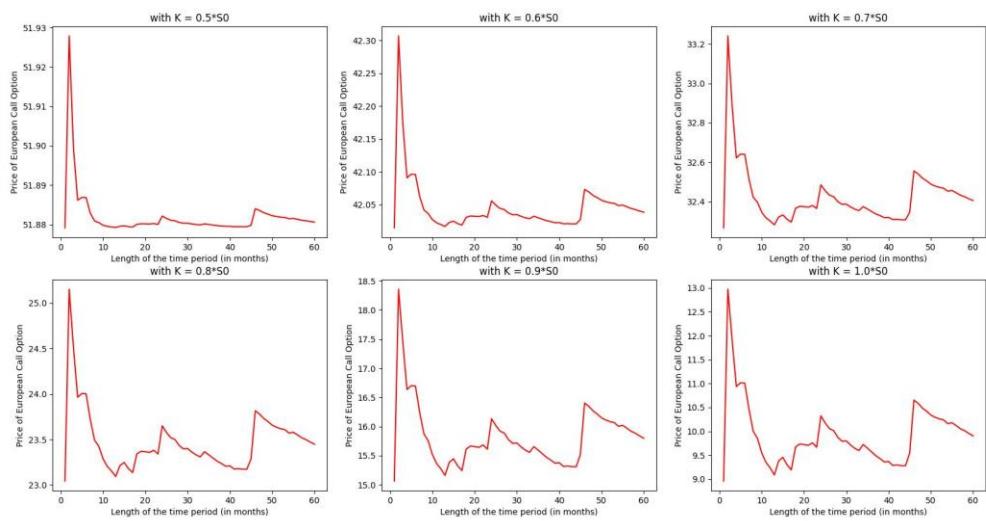
Prices of European Put Option for the stock NVDA



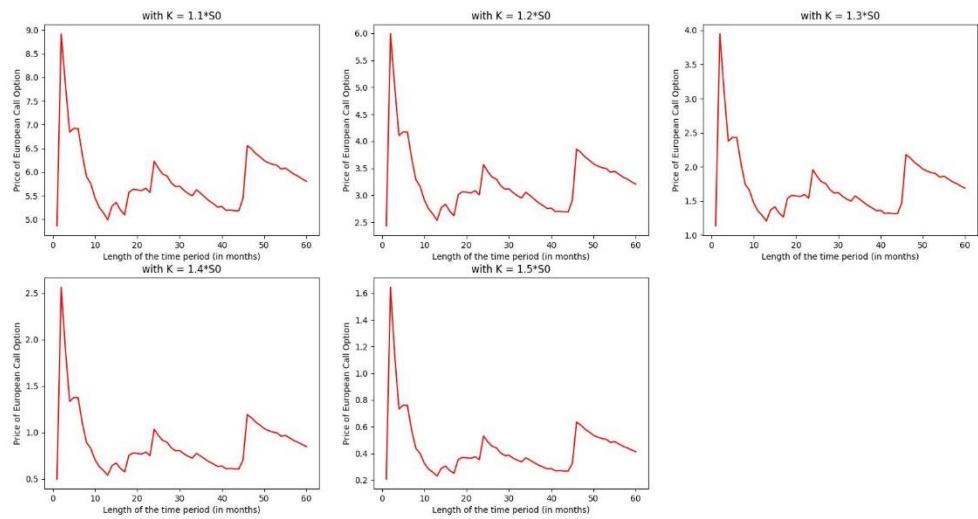
Historical Volatility versus time period for the stock: NVDA



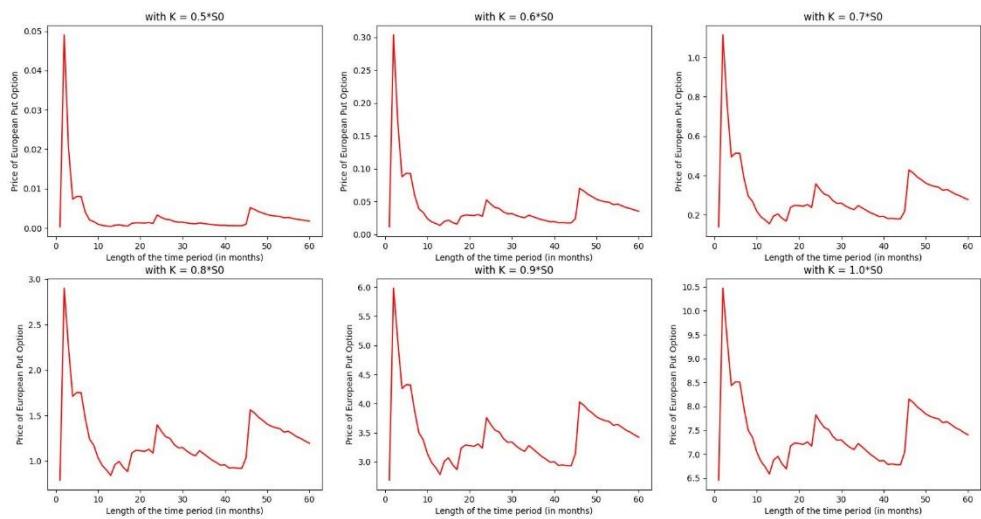
Prices of European Call Option for the stock: ORCL



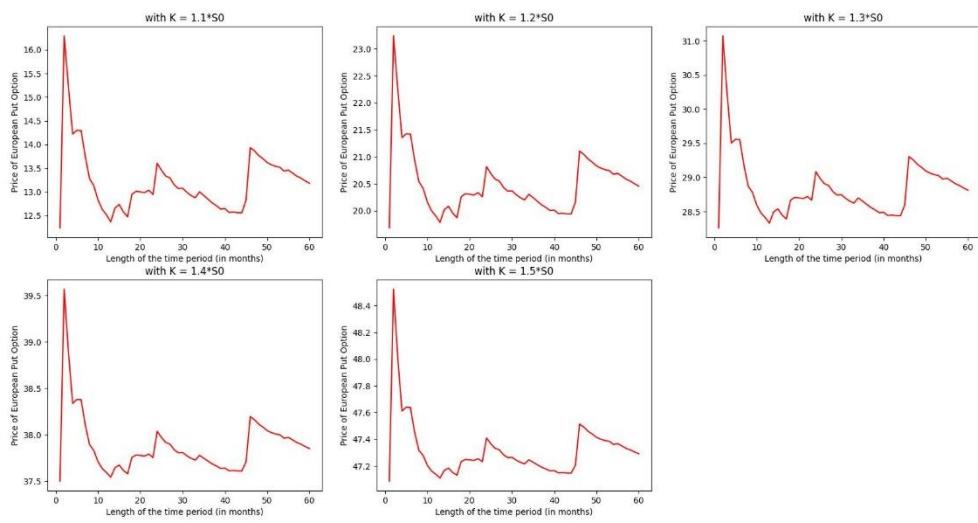
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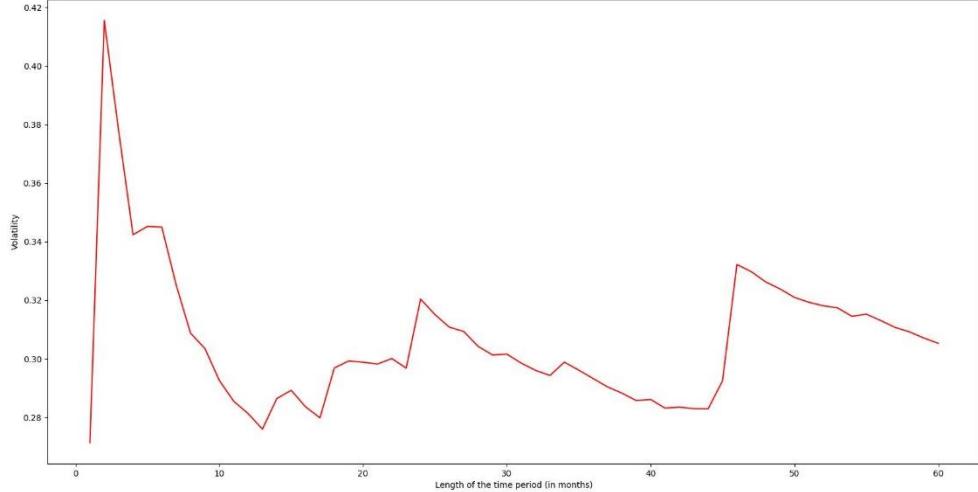
Prices of European Put Option for the stock ORCL



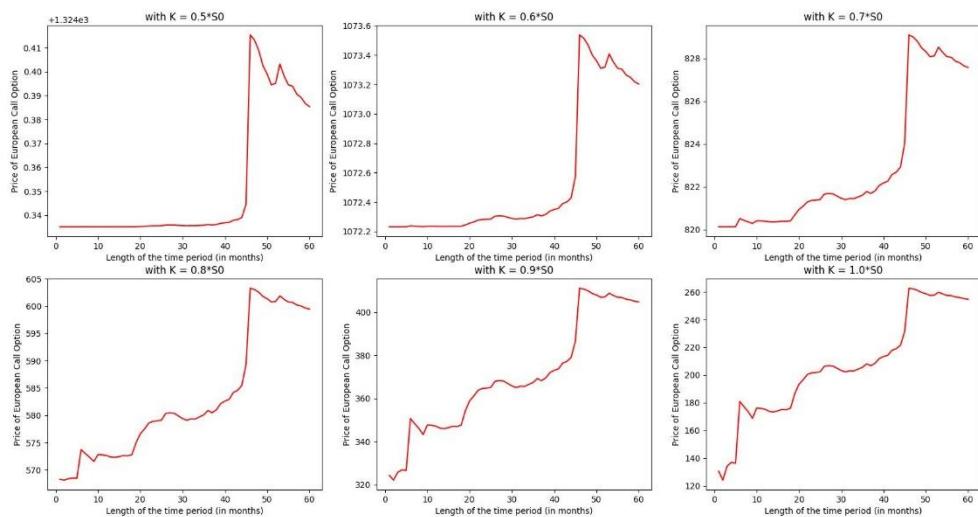
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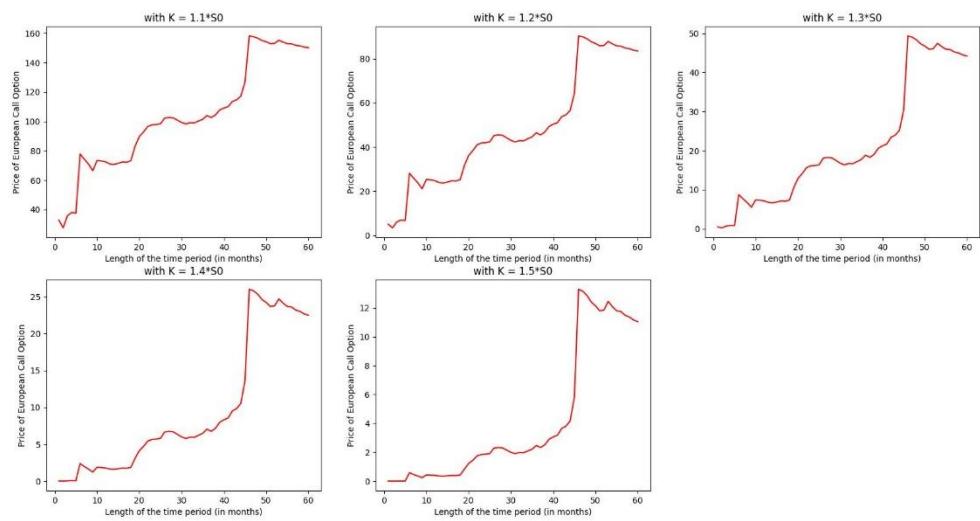
Historical Volatility versus time period for the stock: ORCL



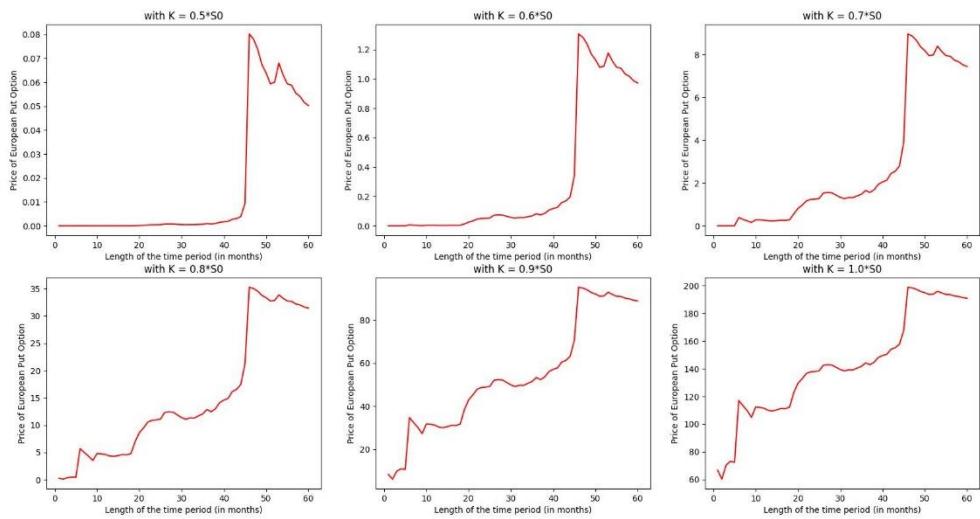
Prices of European Call Option for the stock: RELIANCE.BO



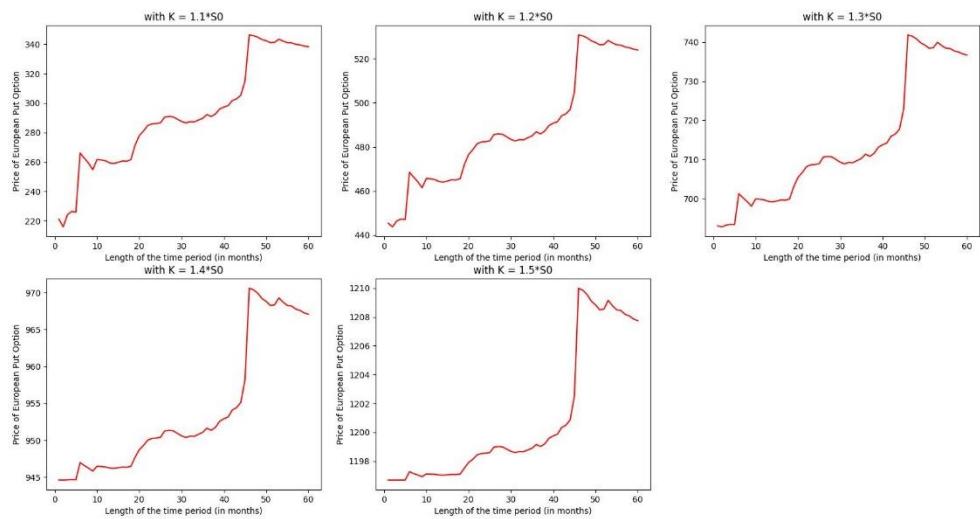
Prices of European Call Option for the stock: RELIANCE.BO

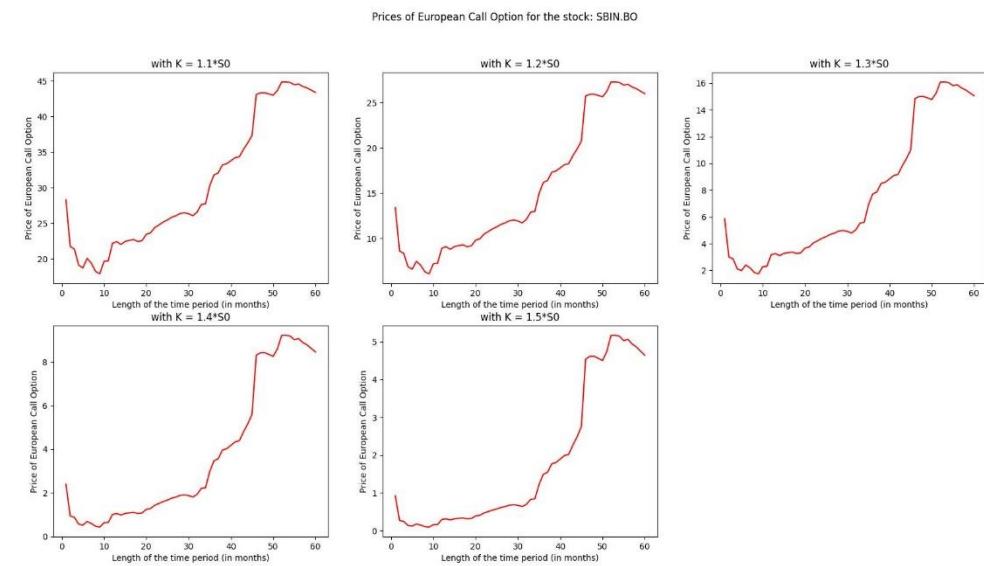
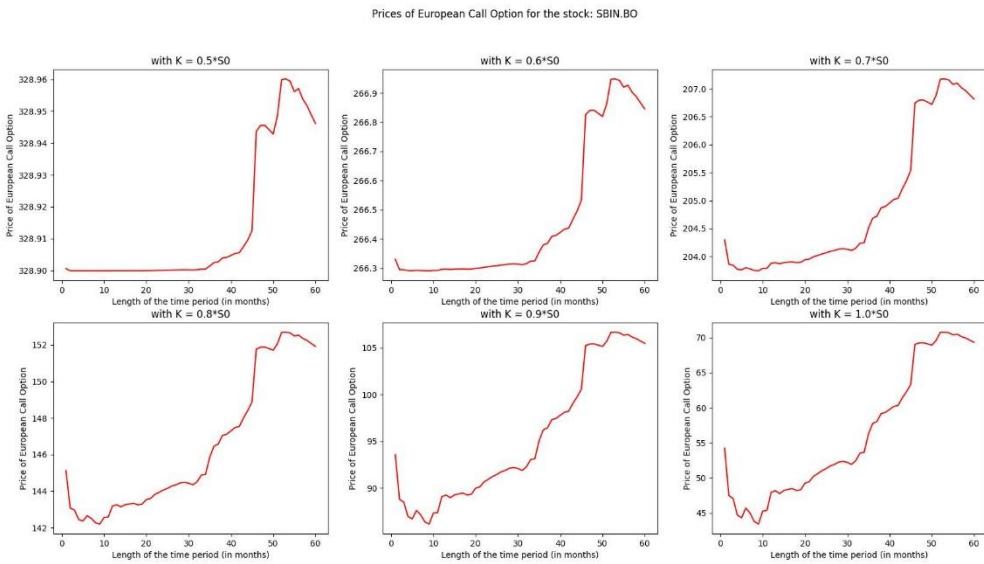
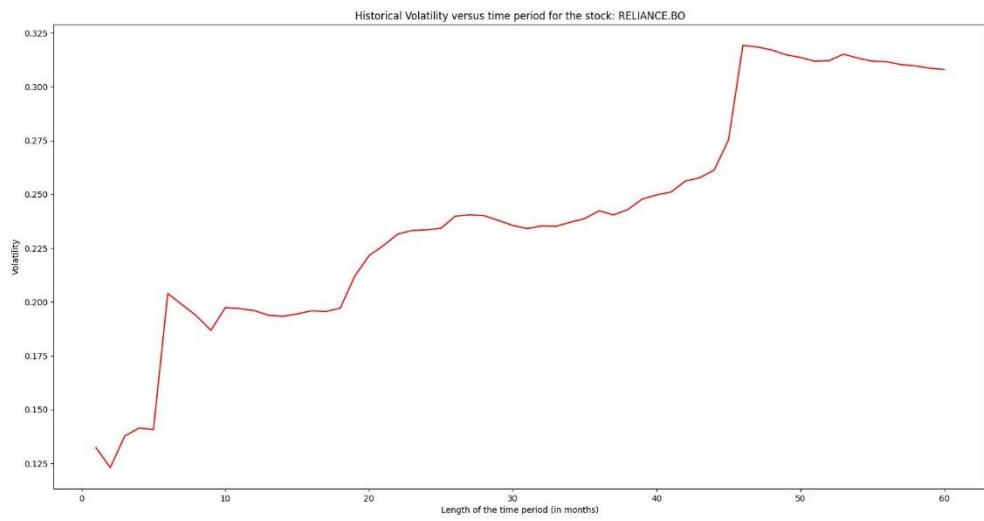


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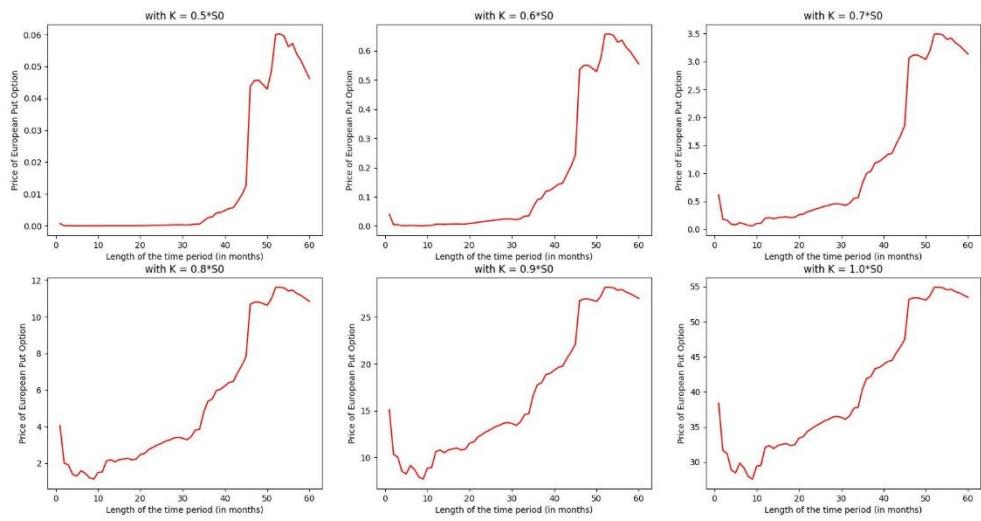


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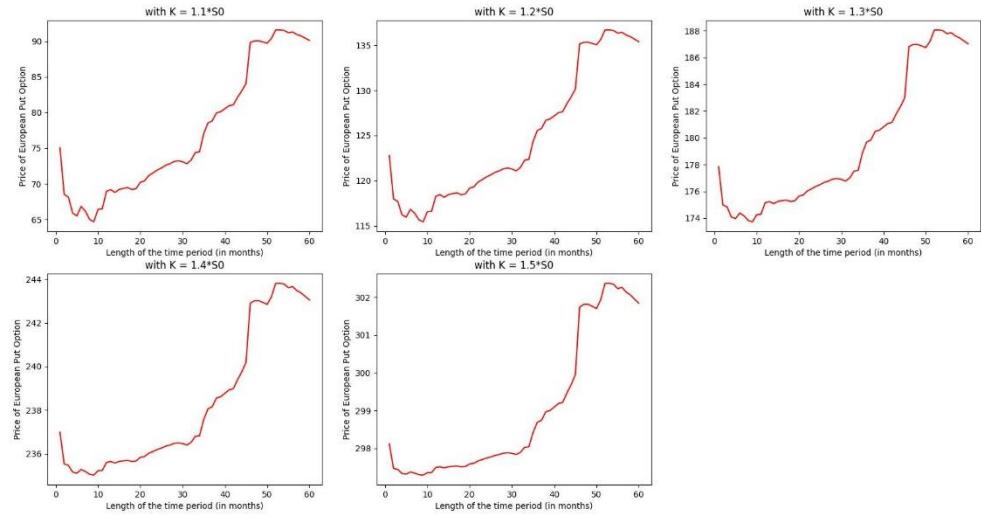




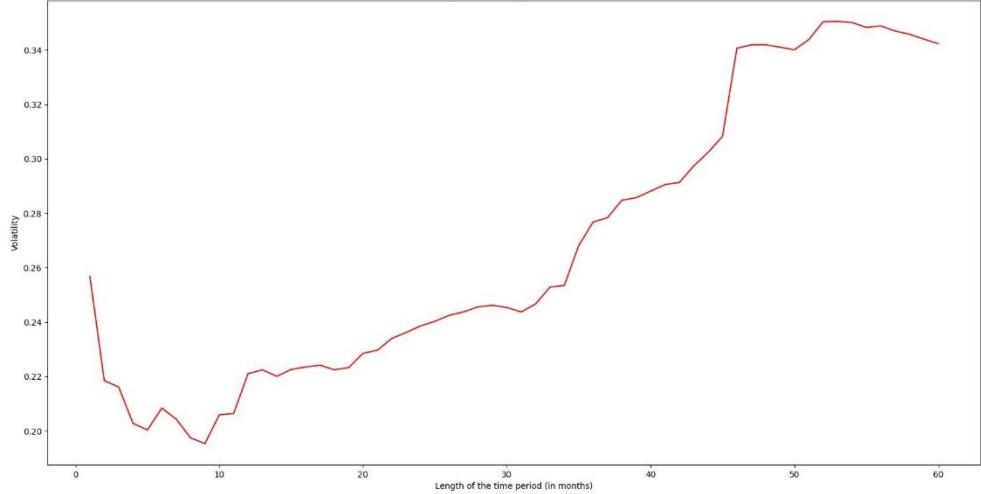
Prices of European Put Option for the stock SBIN.BO



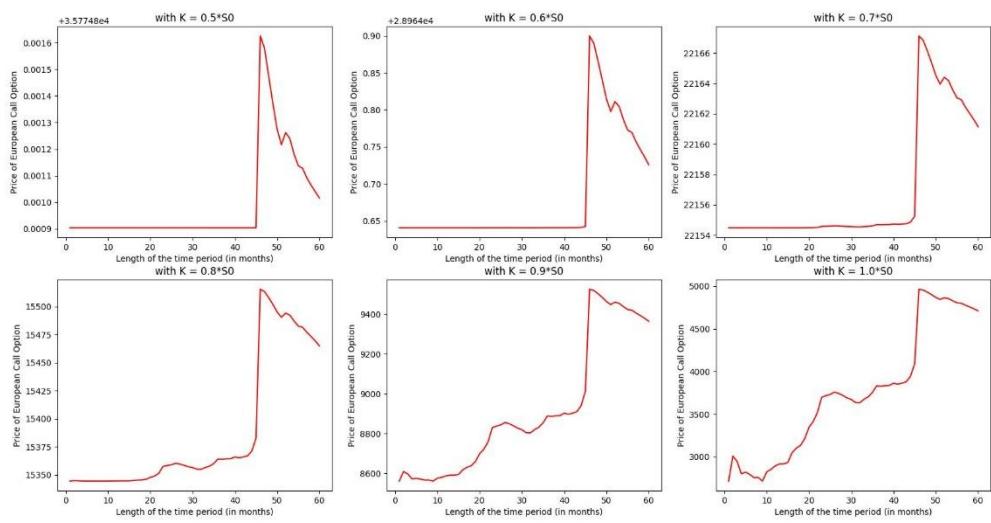
Prices of European Put Option for the stock SBIN.BO



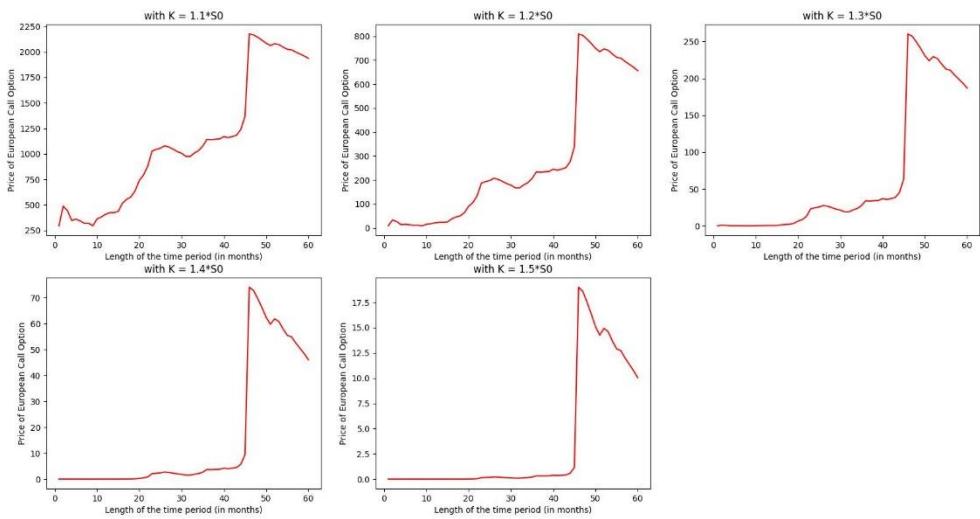
Historical Volatility versus time period for the stock: SBIN.BO



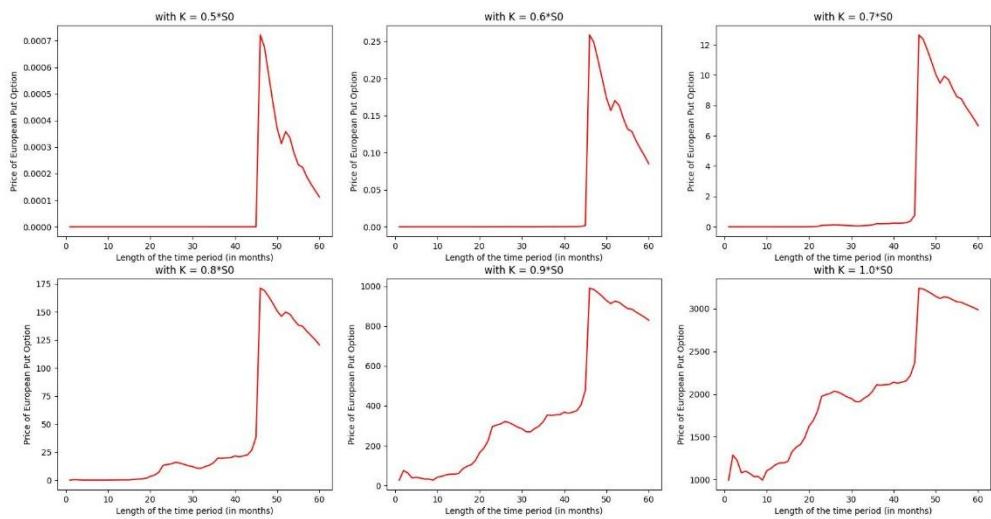
Prices of European Call Option for the stock: Sensex



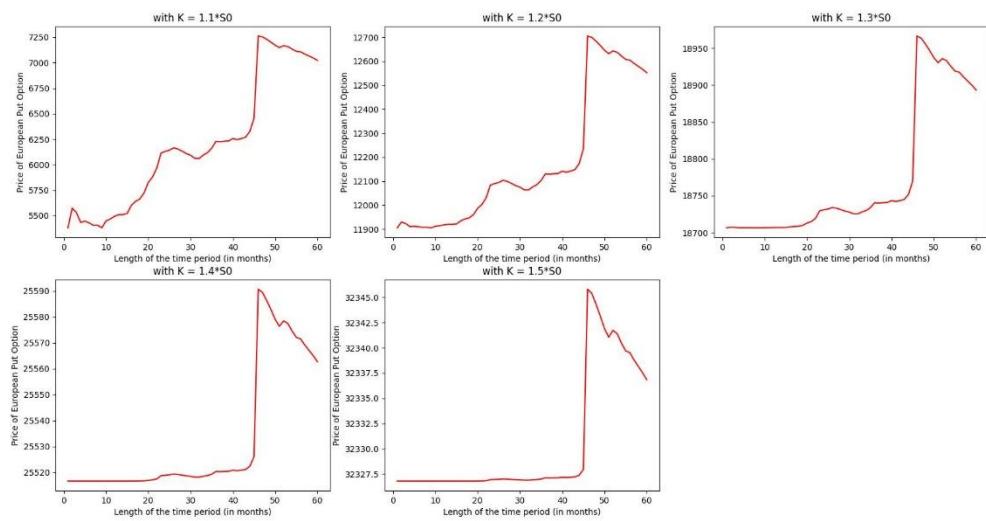
Prices of European Call Option for the stock: Sensex



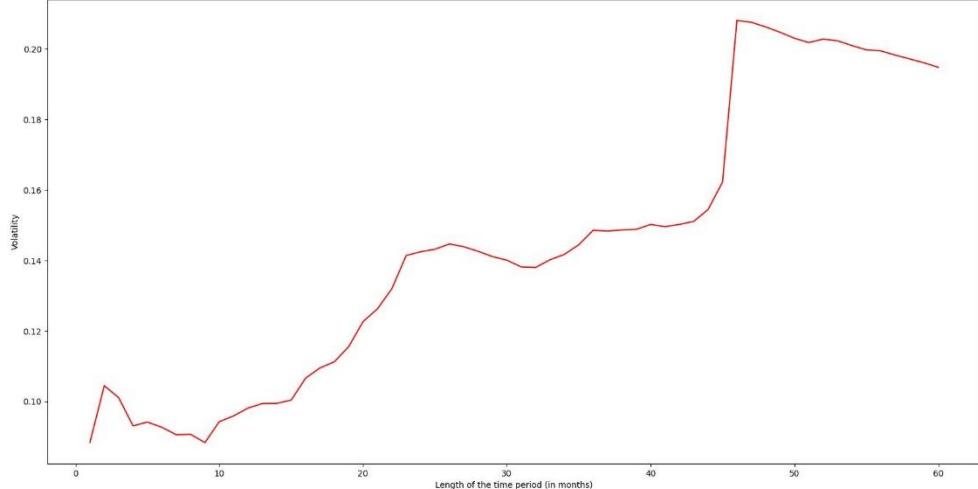
Prices of European Put Option for the stock Sensex



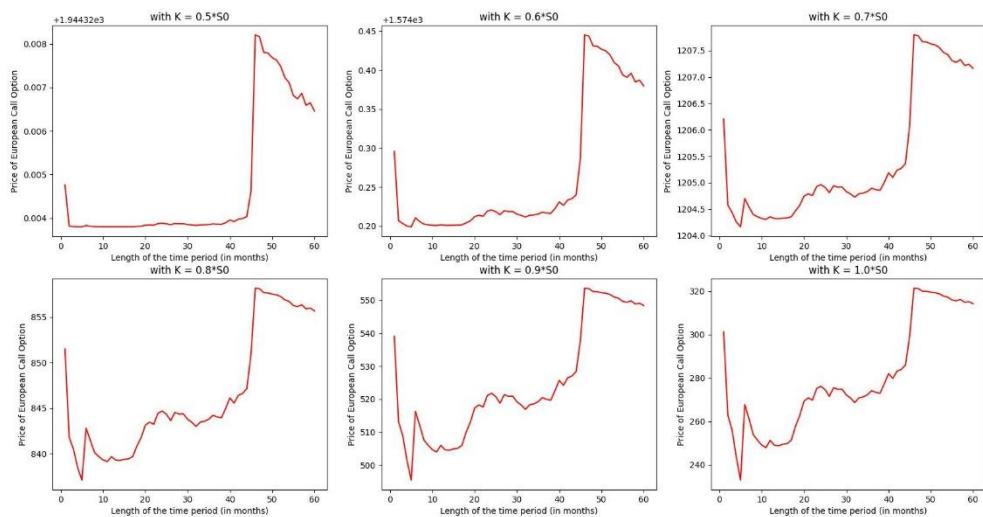
Prices of European Put Option for the stock Sensex



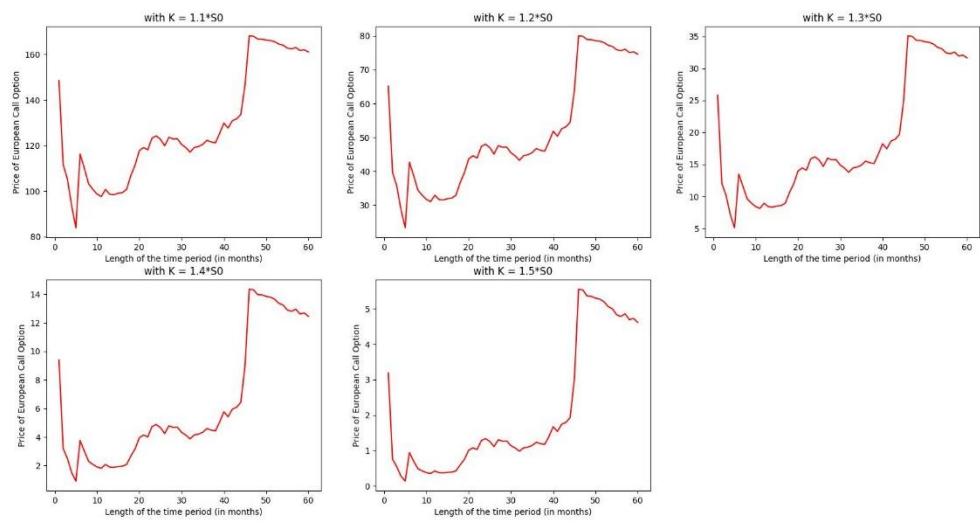
Historical Volatility versus time period for the stock: Sensex



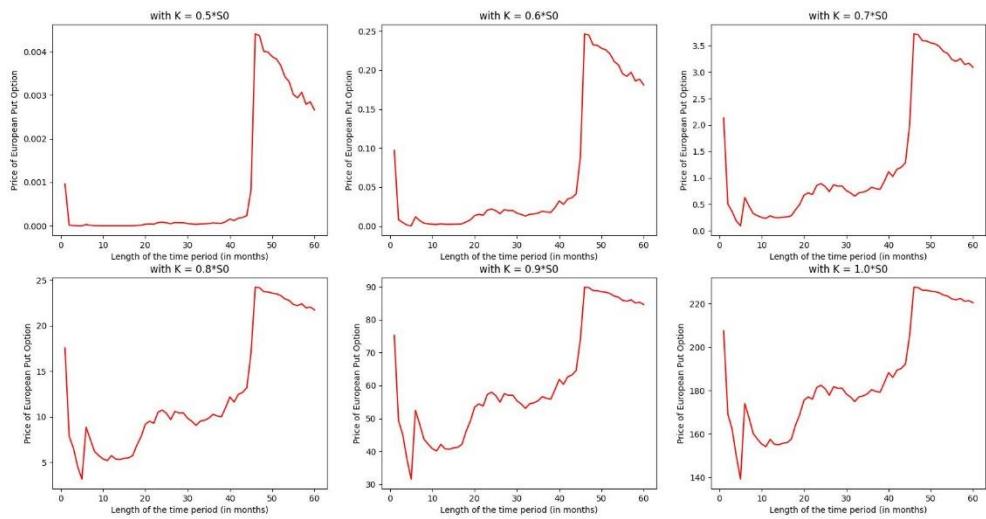
Prices of European Call Option for the stock: TCS.BO



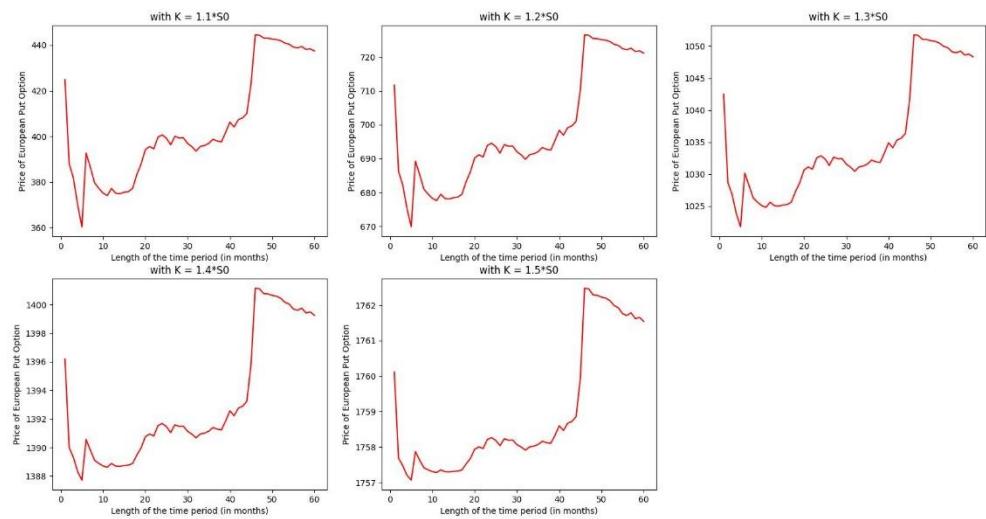
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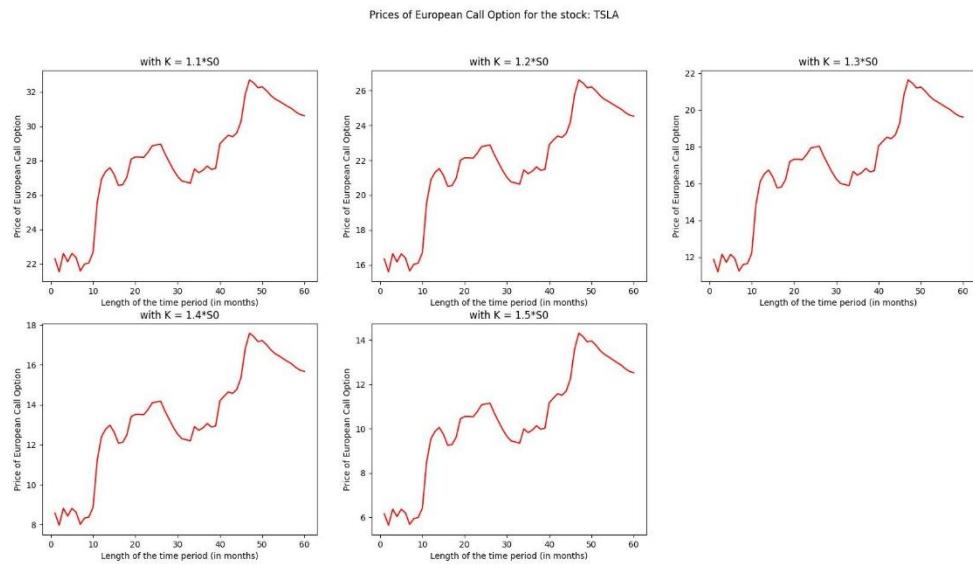
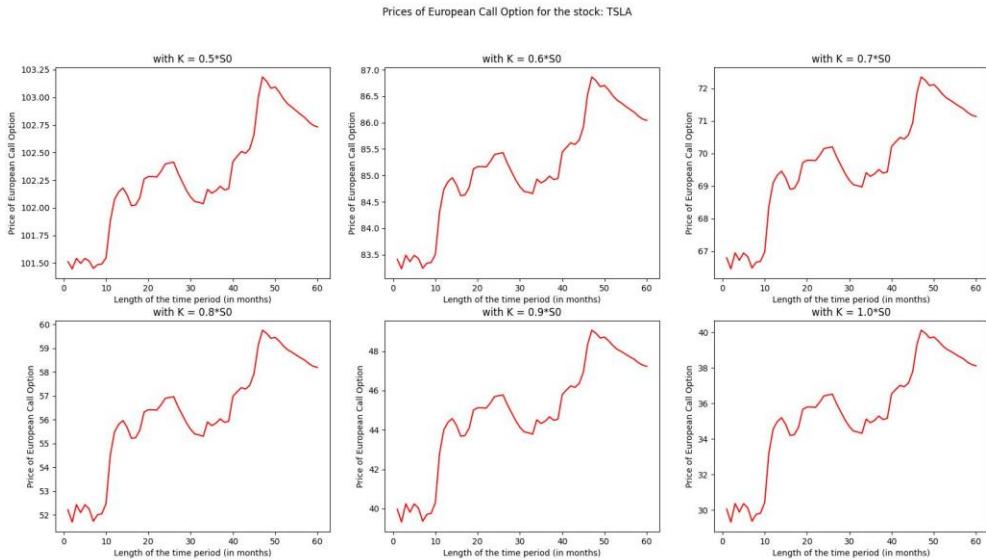
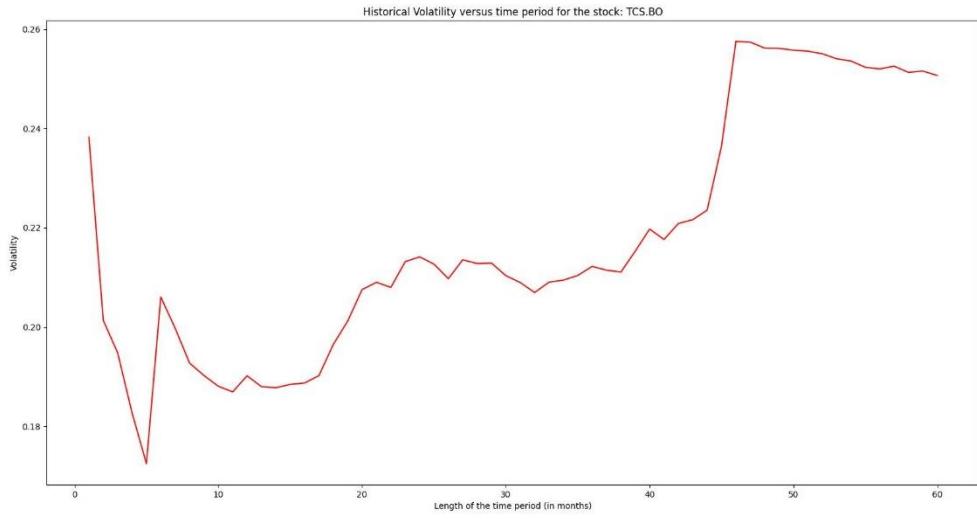


Prices of European Put Option for the stock TCS.BO

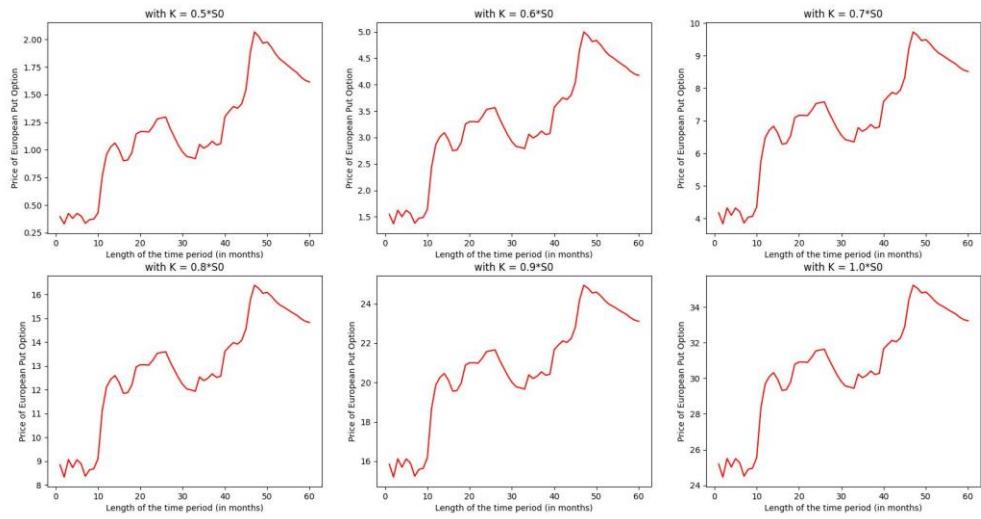


Prices of European Put Option for the stock TCS.BO

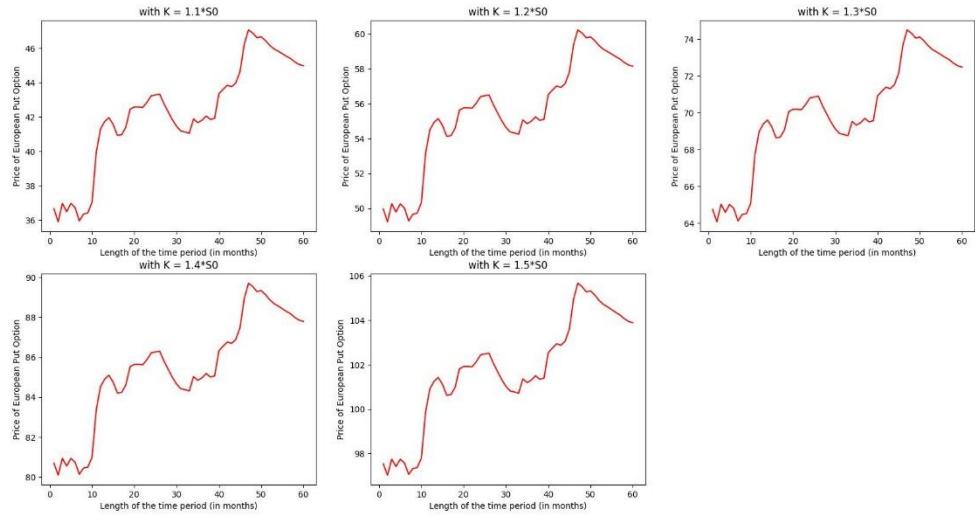




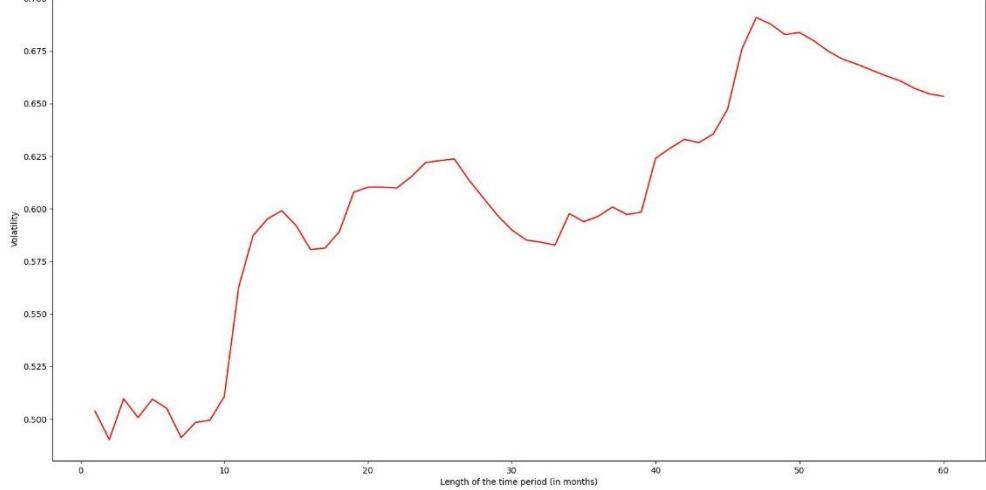
Prices of European Put Option for the stock TSLA



Prices of European Put Option for the stock TSLA

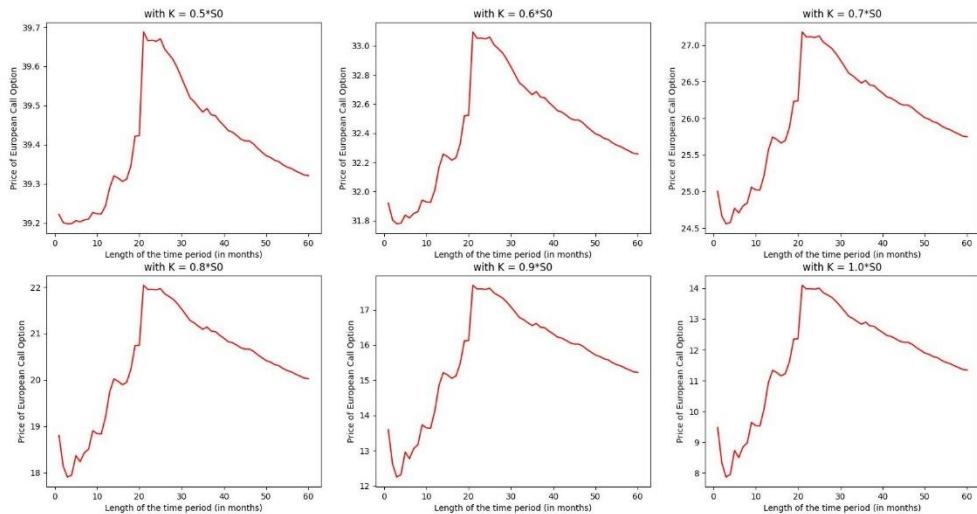


Historical Volatility versus time period for the stock: TSLA

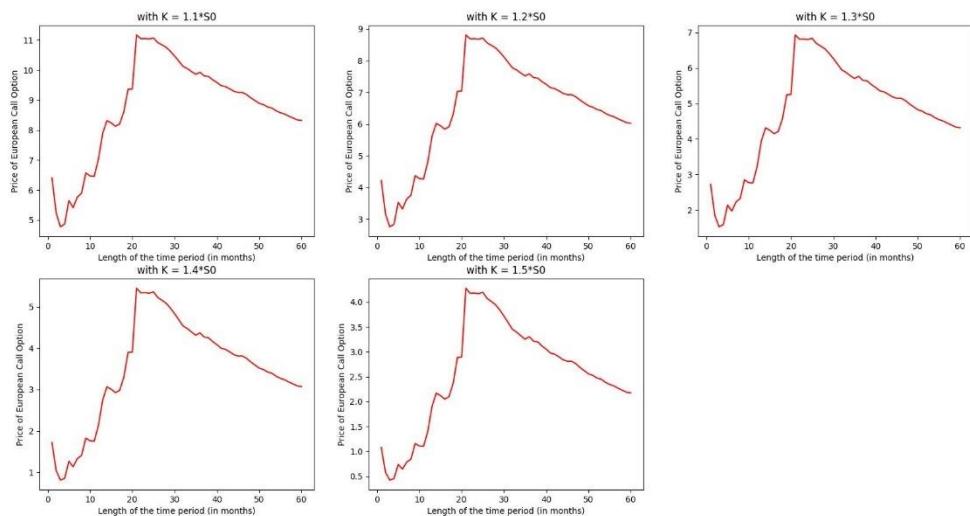


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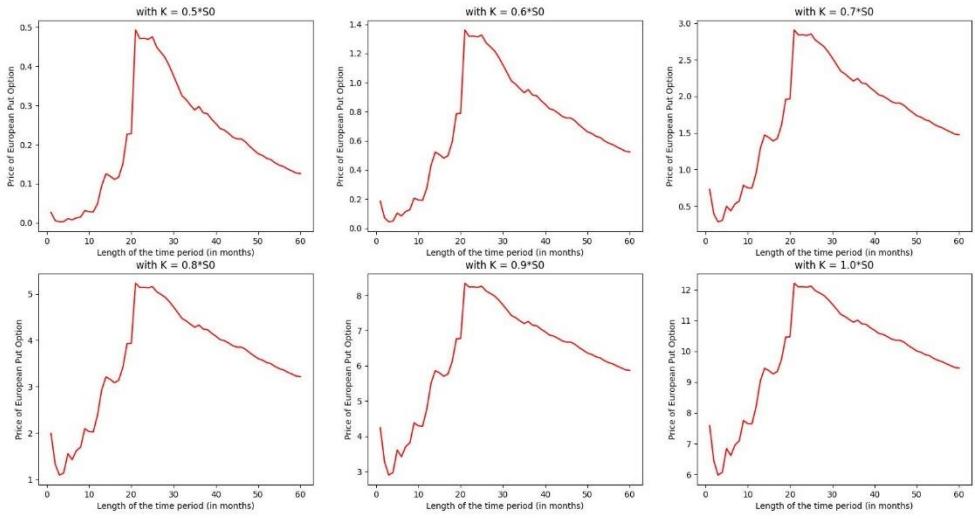
Prices of European Call Option for the stock: BABA



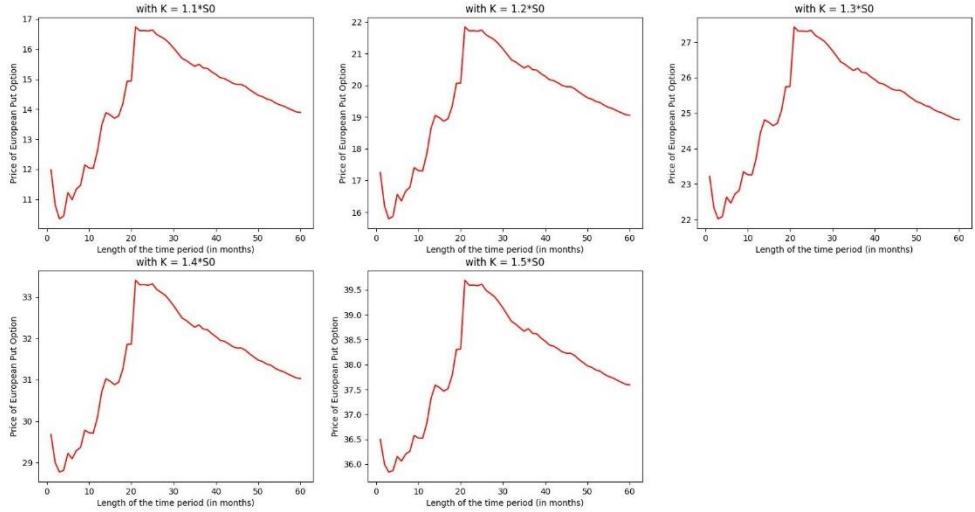
Prices of European Call Option for the stock: BABA



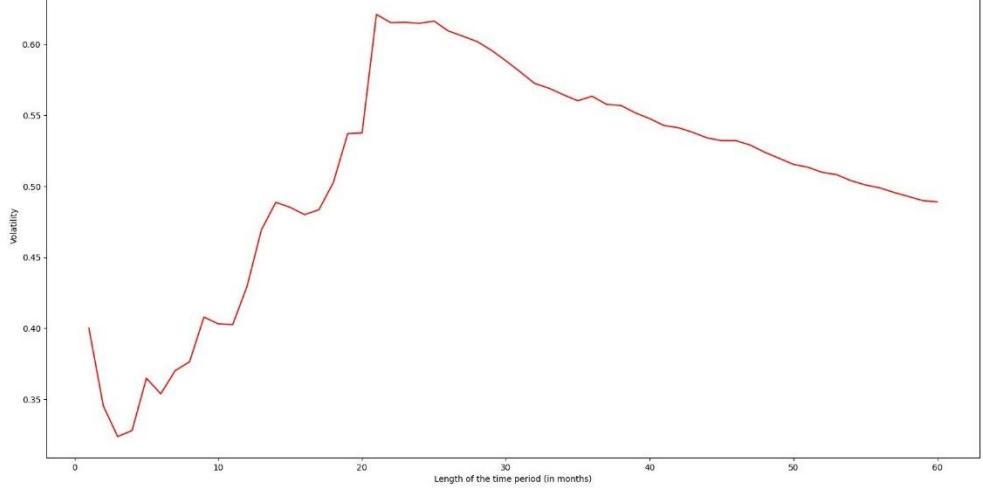
Prices of European Put Option for the stock BABA



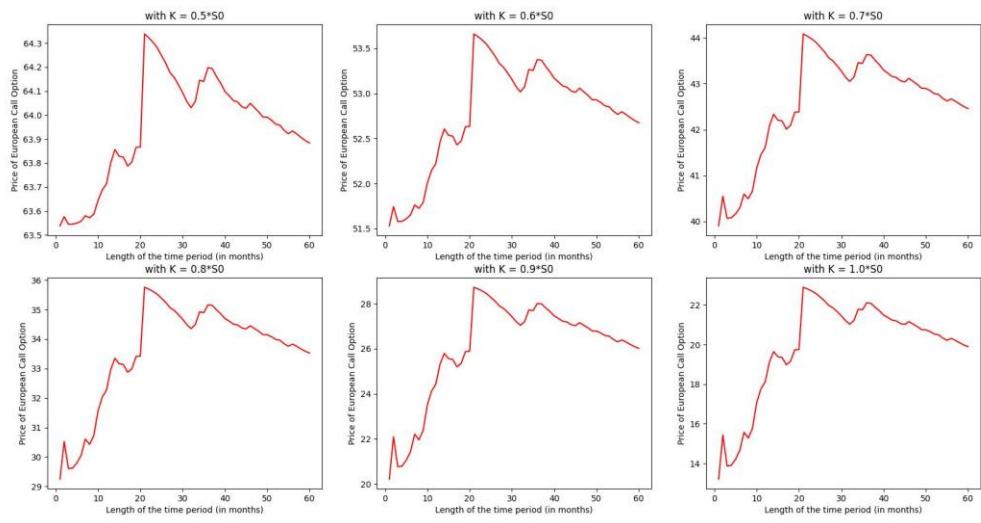
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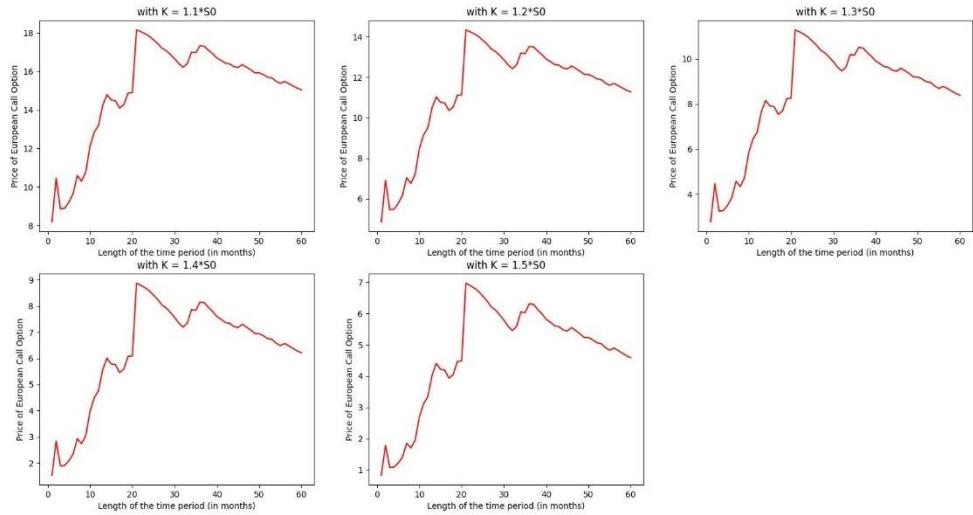
Historical Volatility versus time period for the stock: BABA



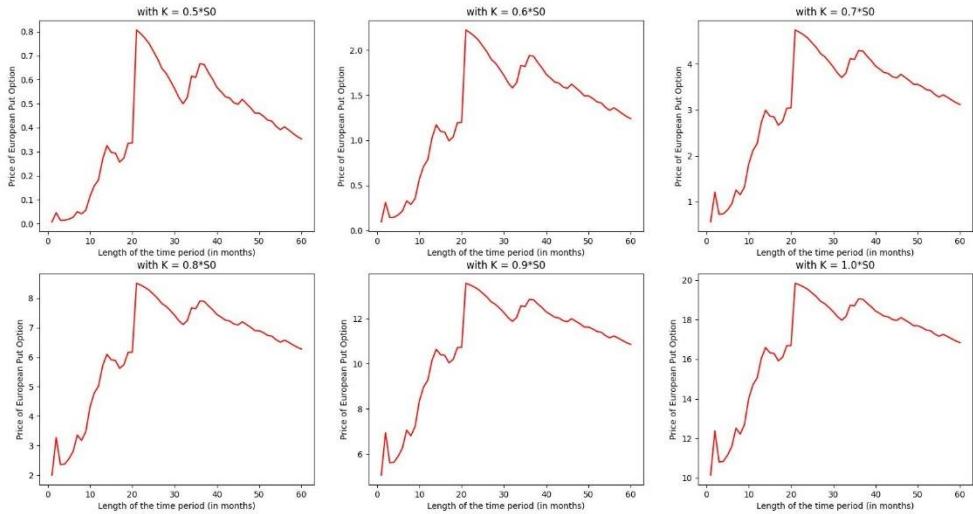
Prices of European Call Option for the stock: BIDU



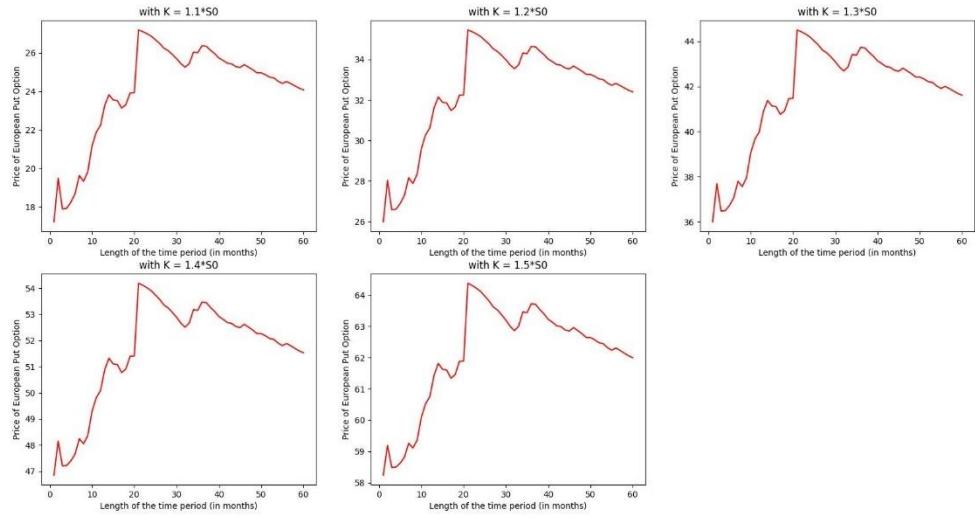
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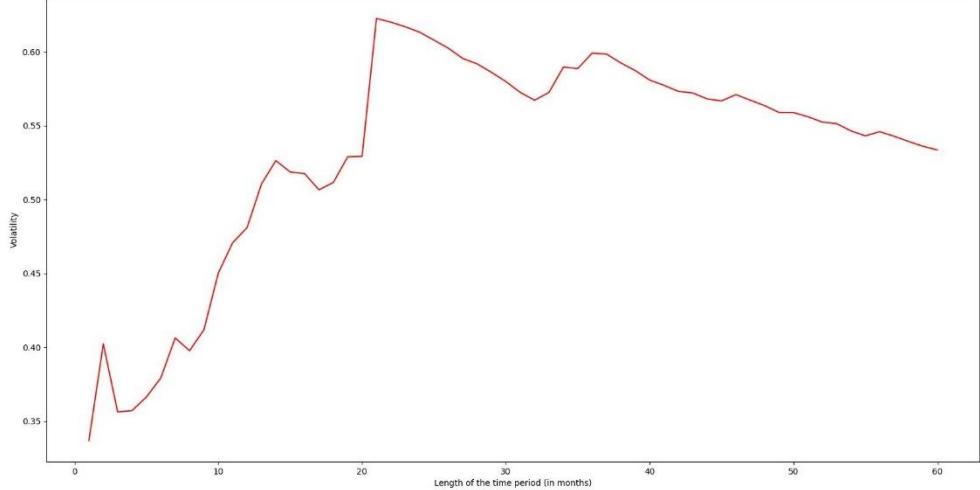
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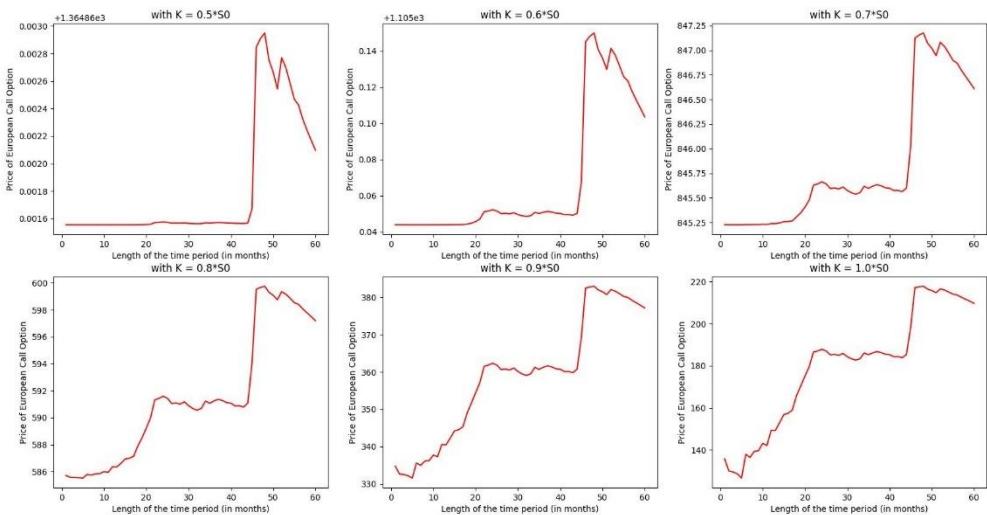
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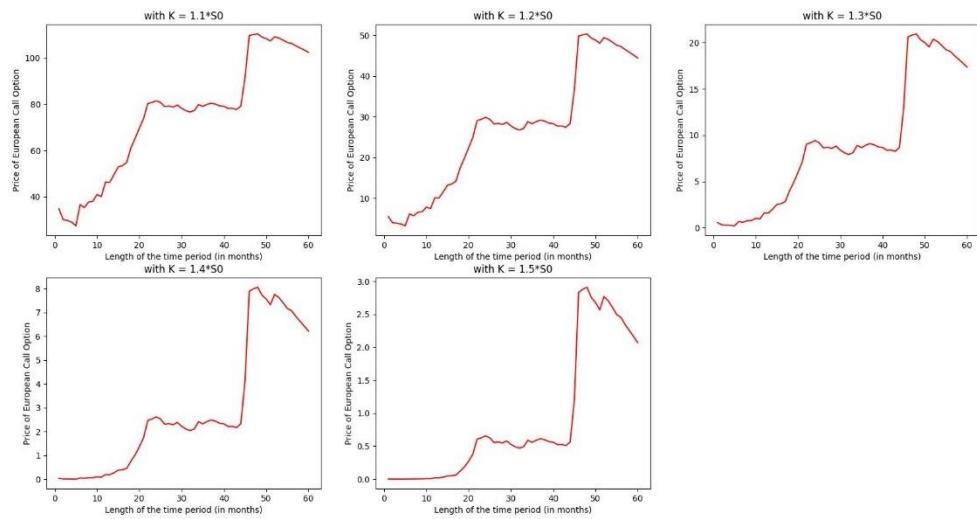
Historical Volatility versus time period for the stock: BIDU



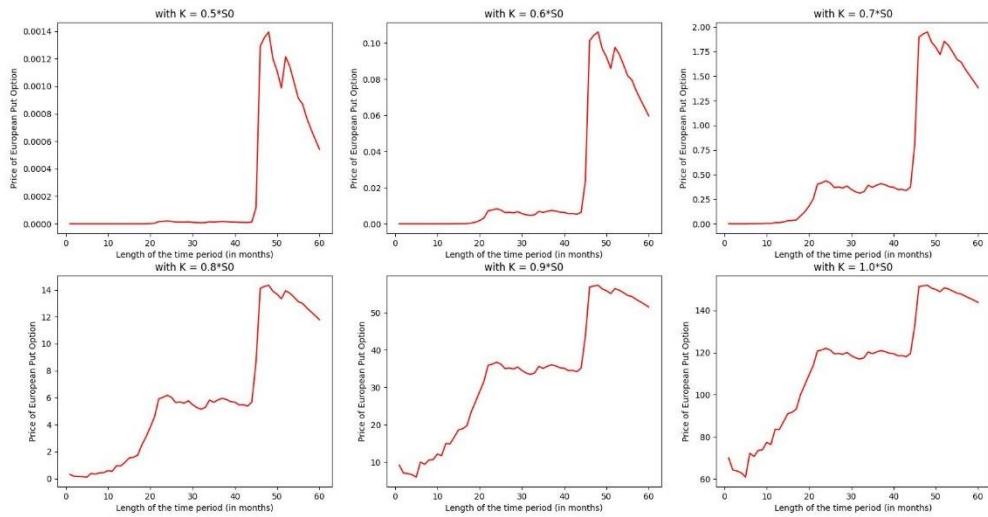
Prices of European Call Option for the stock: HINDUNILVR.NS



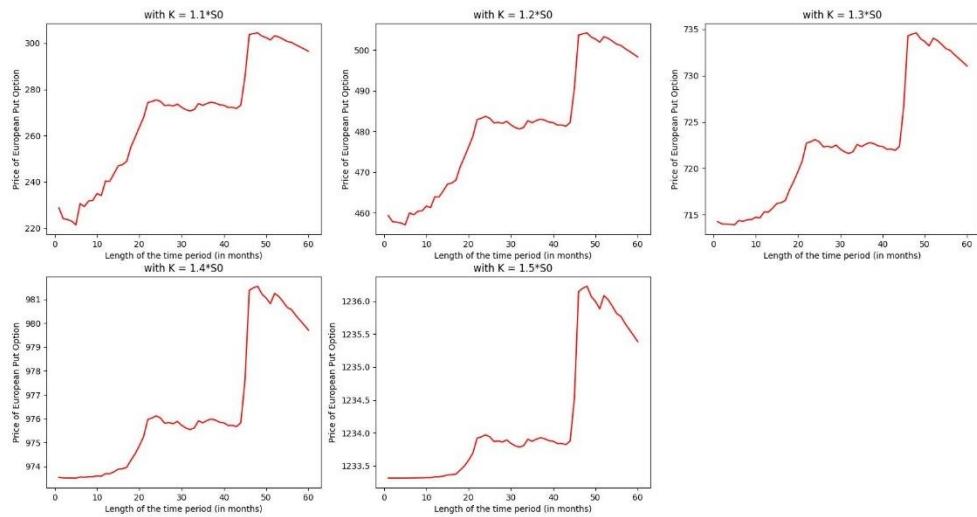
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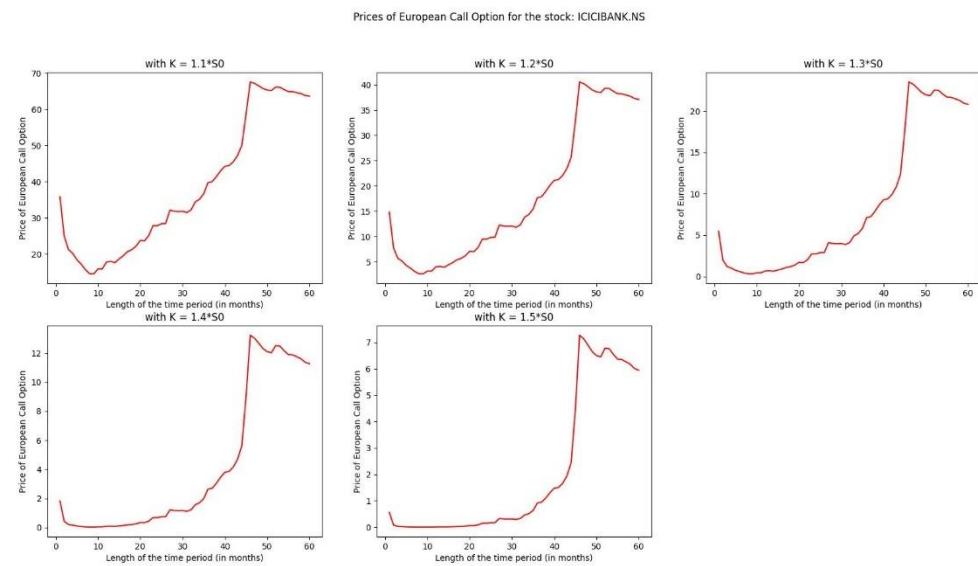
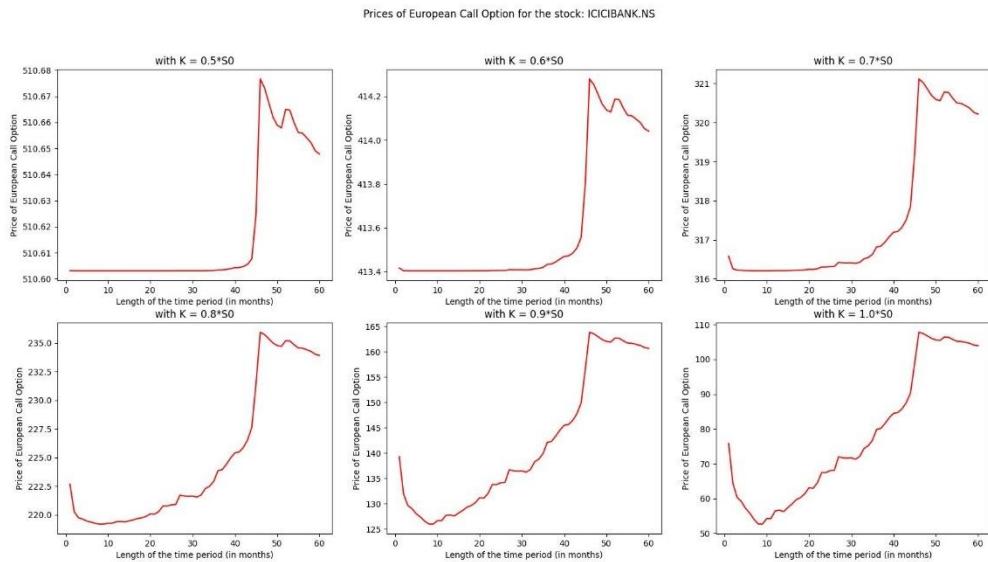
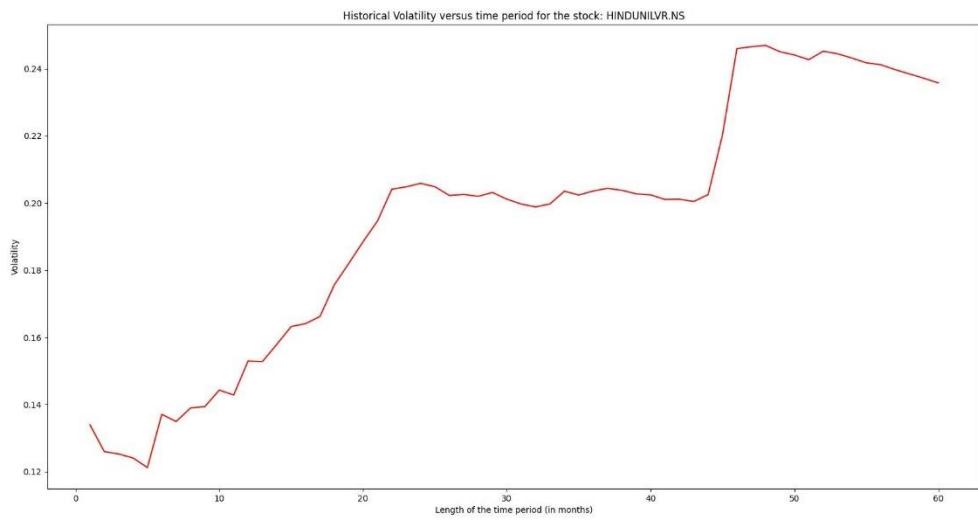


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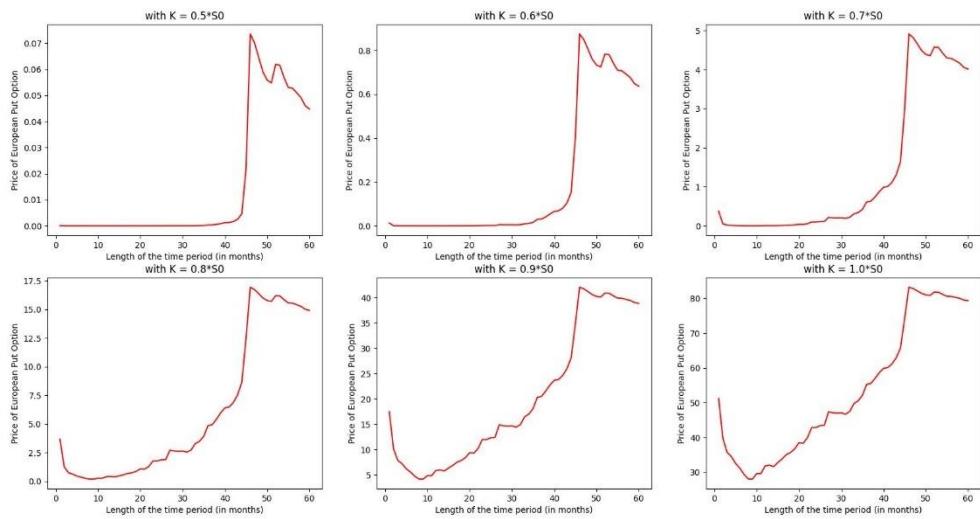


Prices of European Put Option for the stock HINDUNILVR.NS

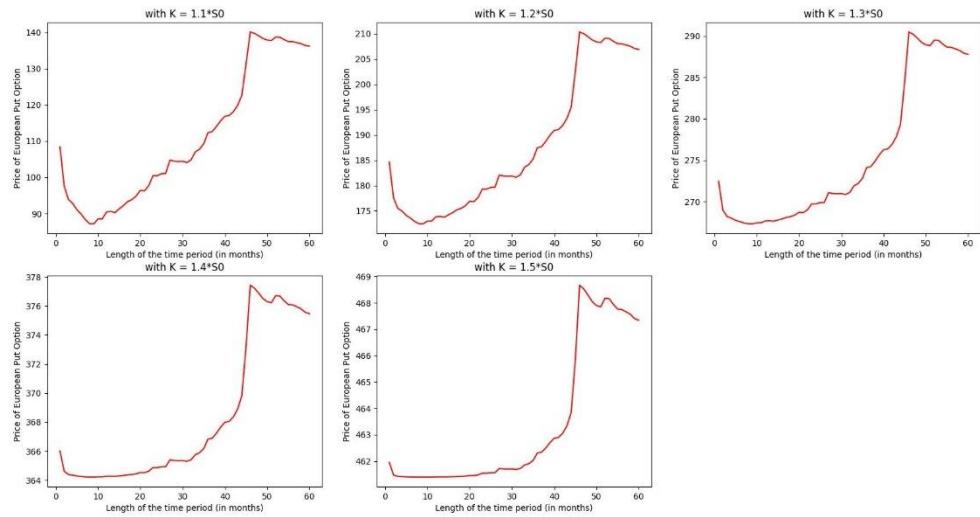




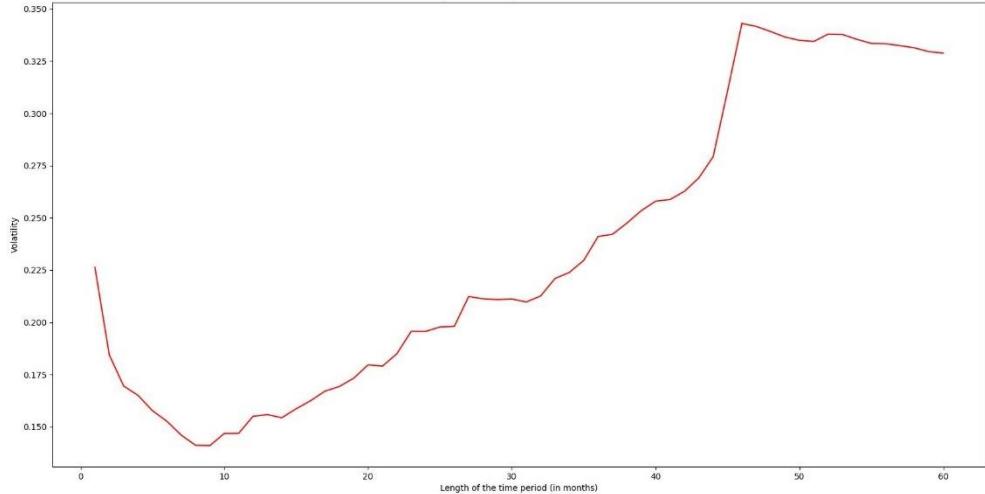
Prices of European Put Option for the stock ICICIBANK.NS



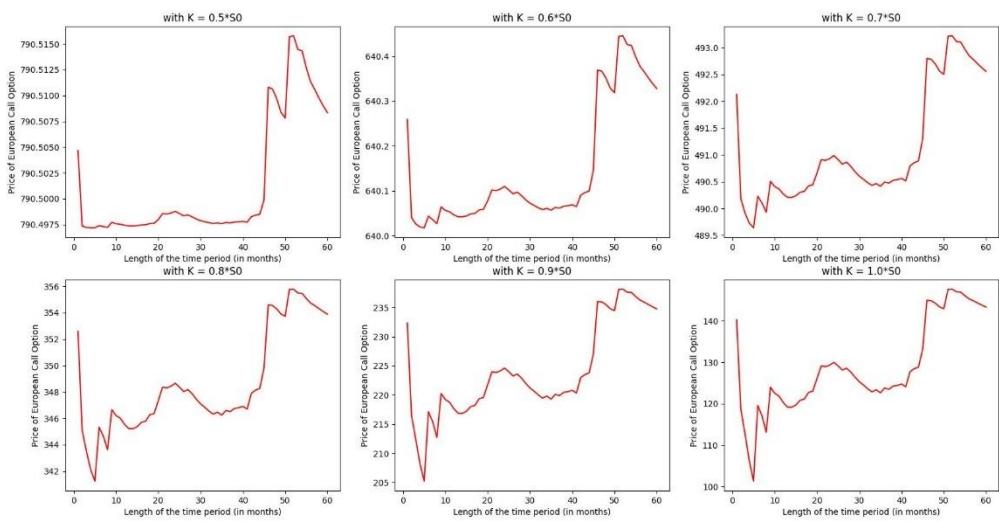
Prices of European Put Option for the stock ICICIBANK.NS



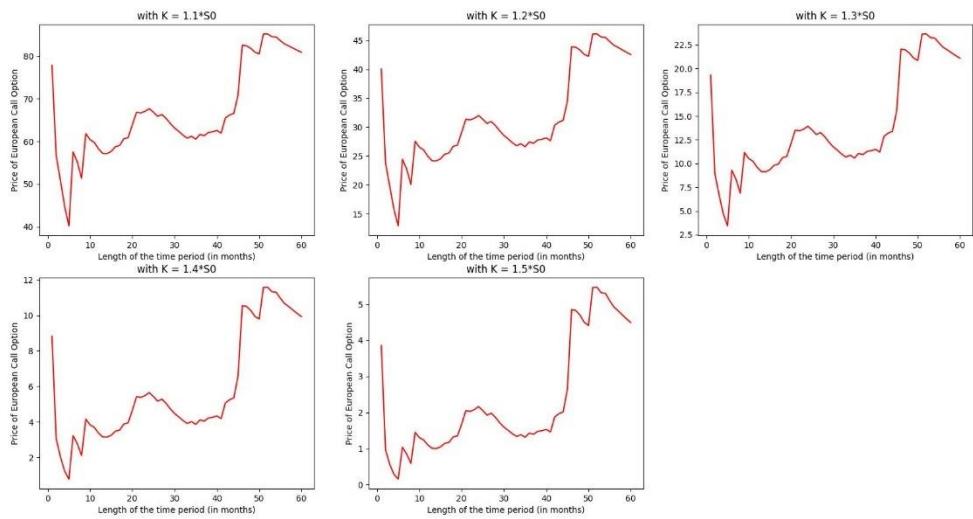
Historical Volatility versus time period for the stock: ICICIBANK.NS



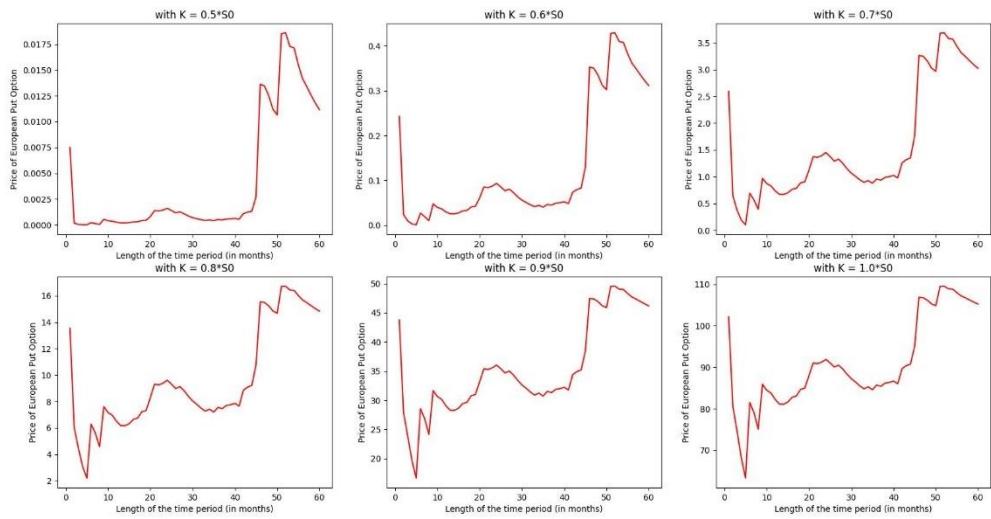
Prices of European Call Option for the stock: INFY.NS



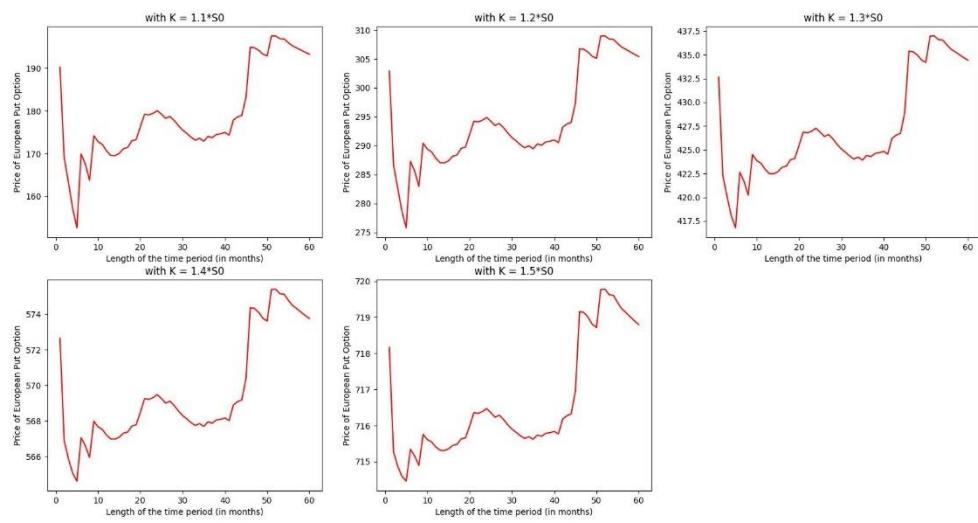
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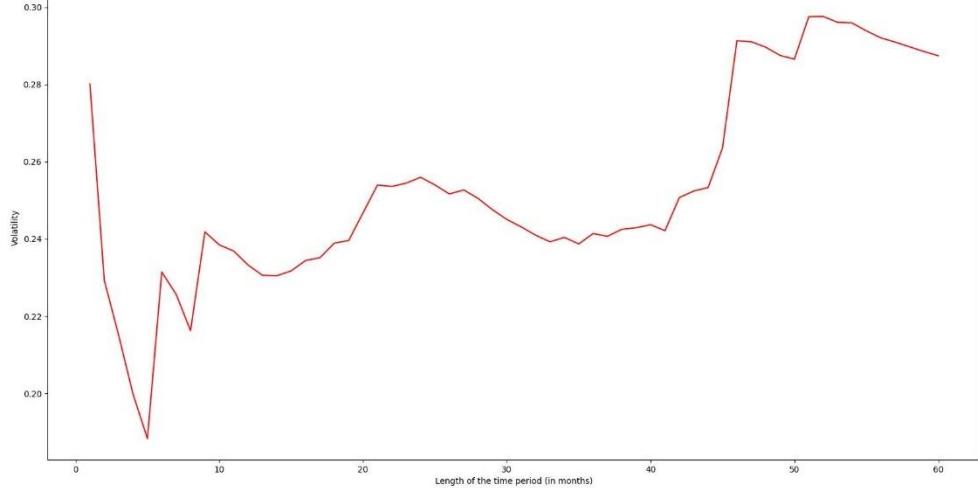
Prices of European Put Option for the stock INFY.NS



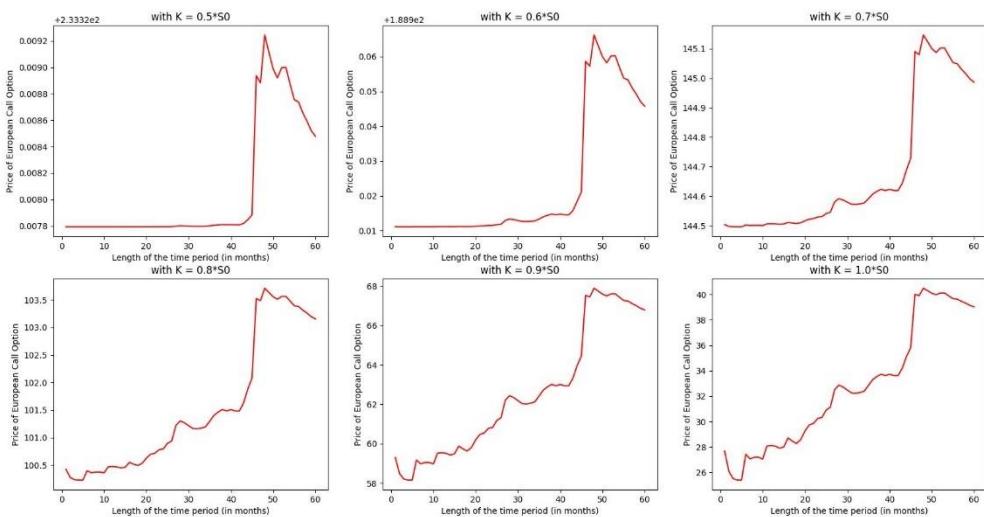
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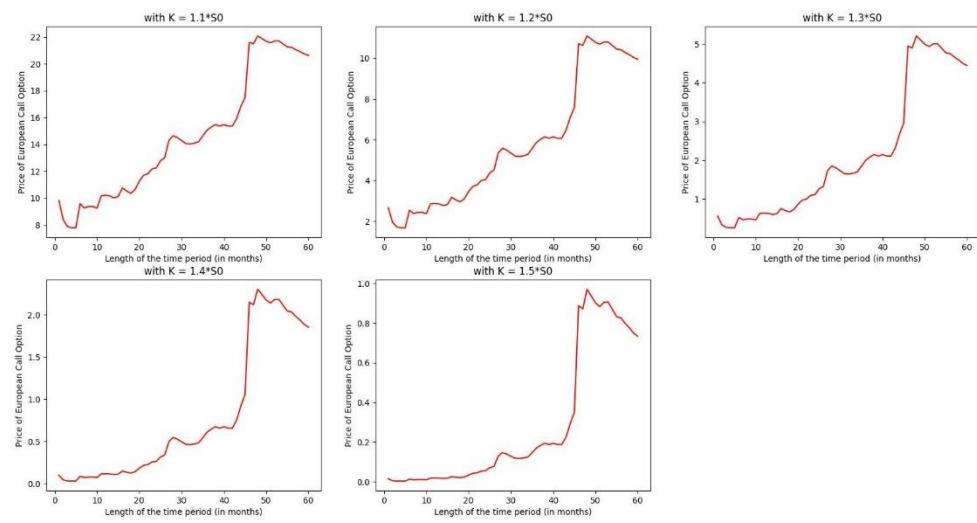
Historical Volatility versus time period for the stock: INFYNS



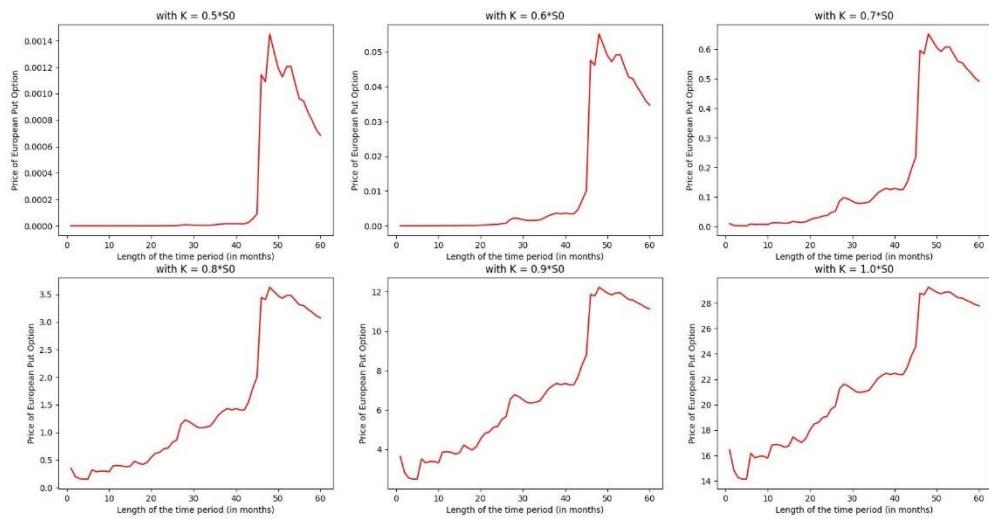
Prices of European Call Option for the stock: ITC.NS



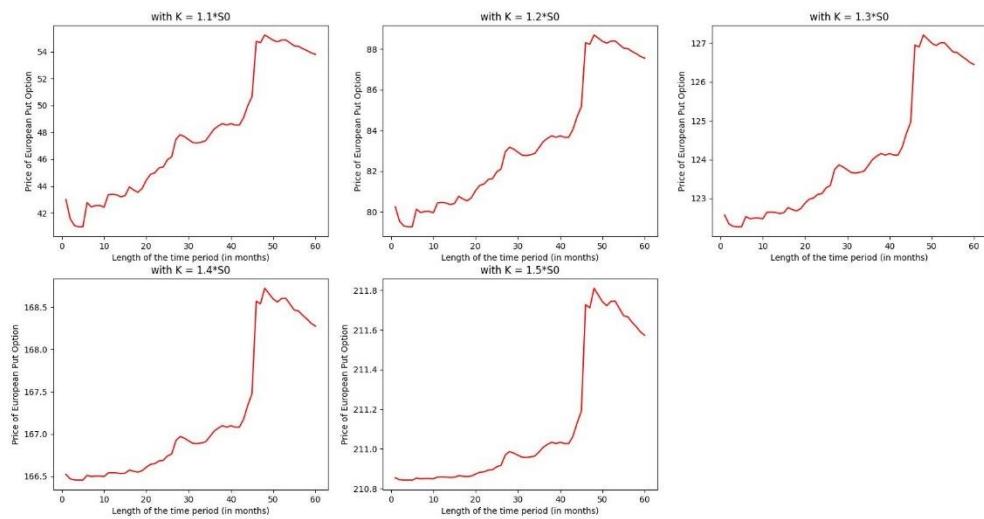
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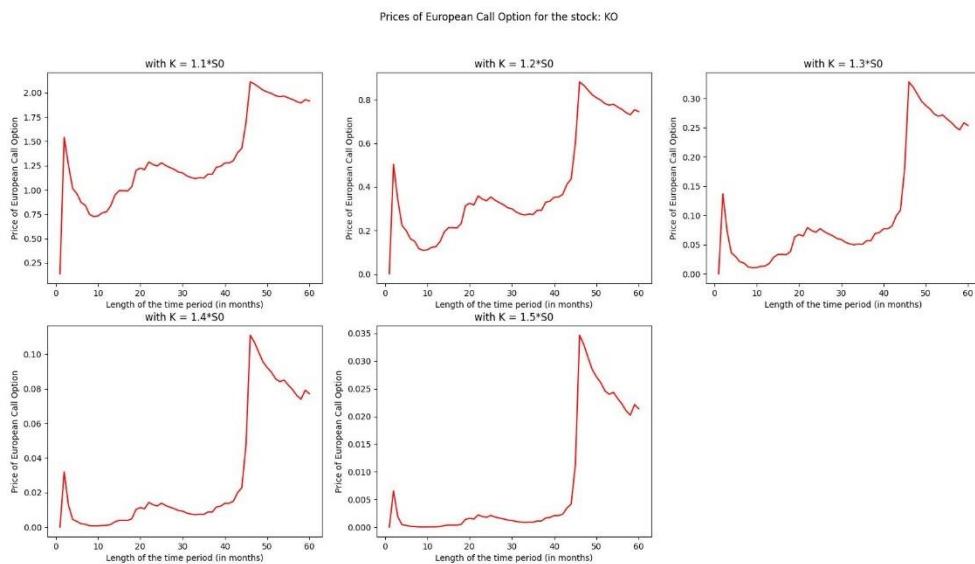
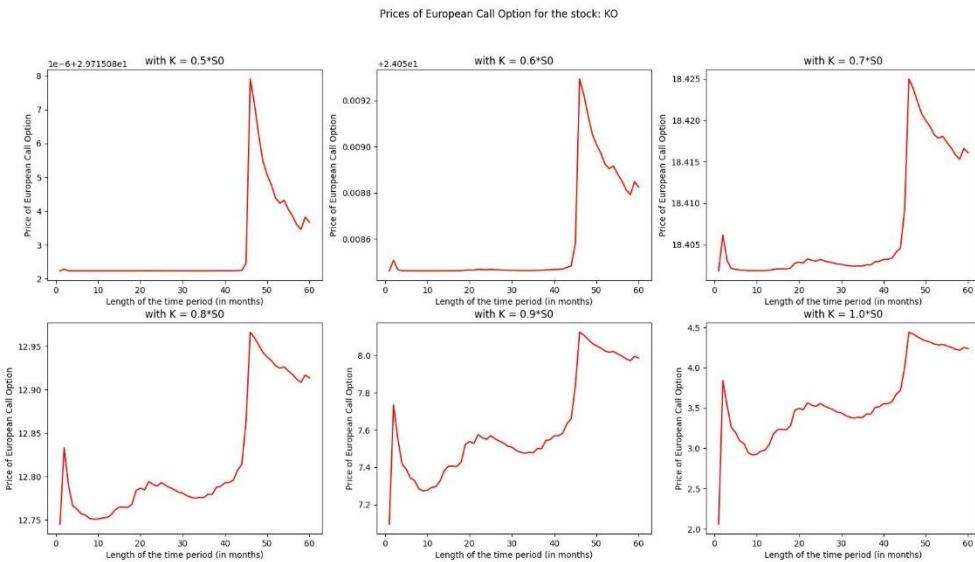
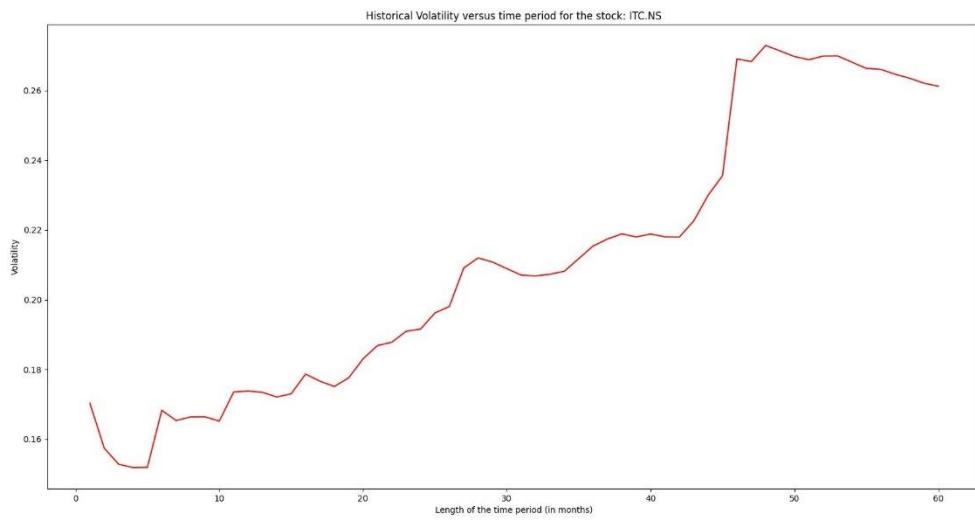


Prices of European Put Option for the stock ITC.NS

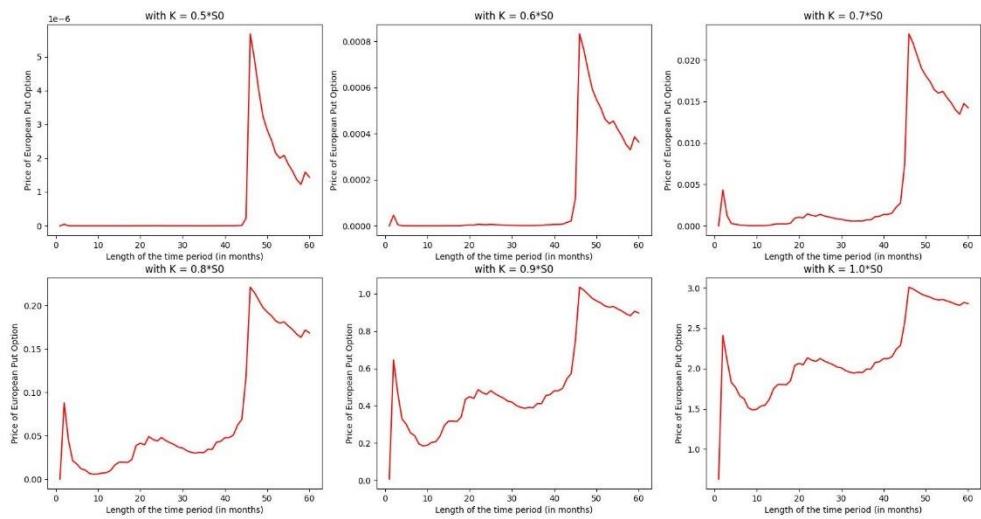


Prices of European Put Option for the stock ITC.NS

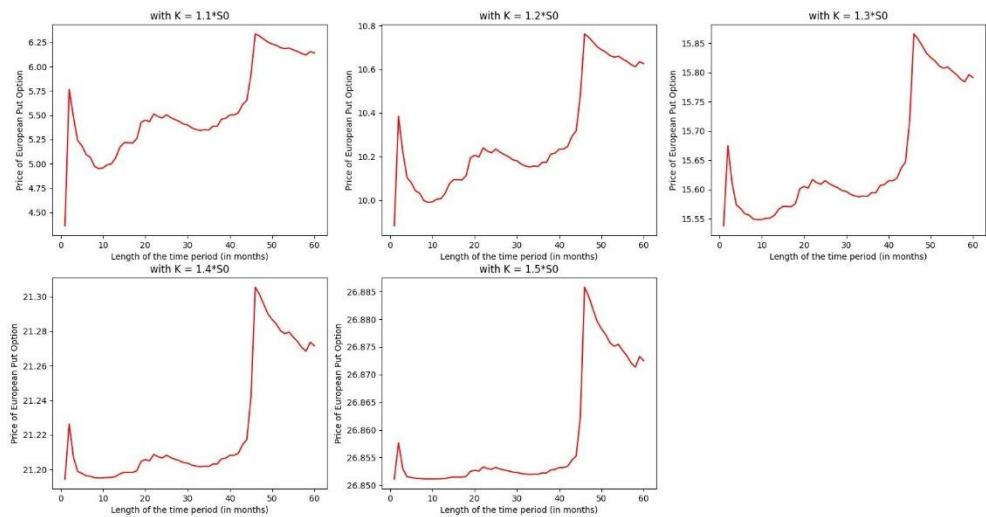




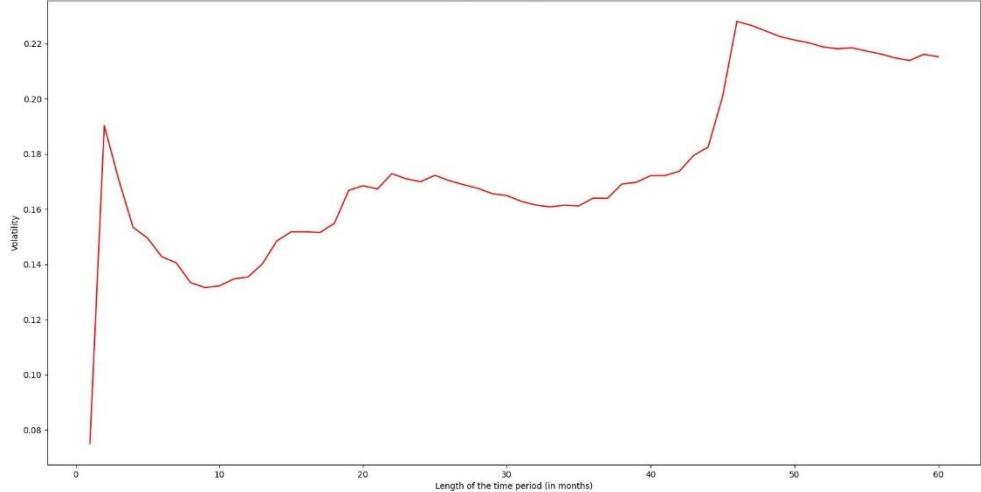
Prices of European Put Option for the stock KO



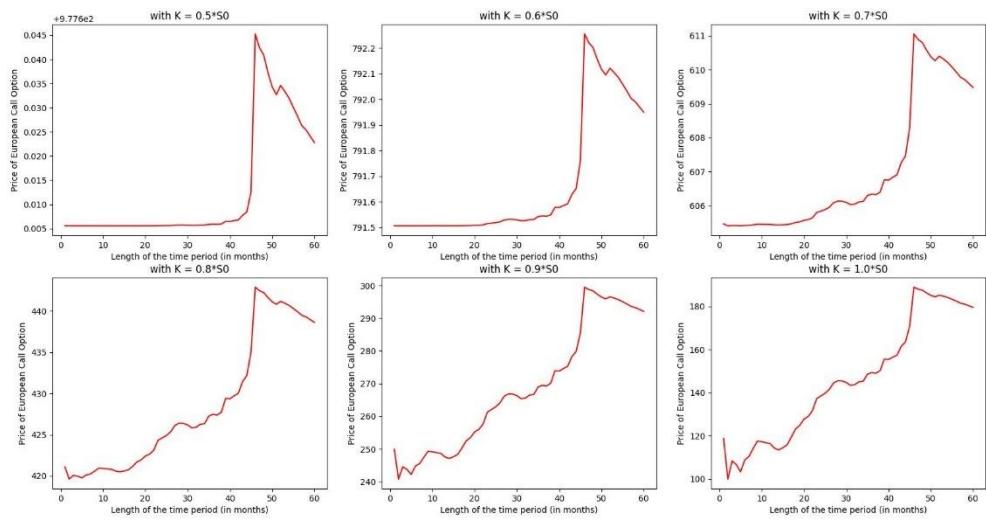
Prices of European Put Option for the stock KO



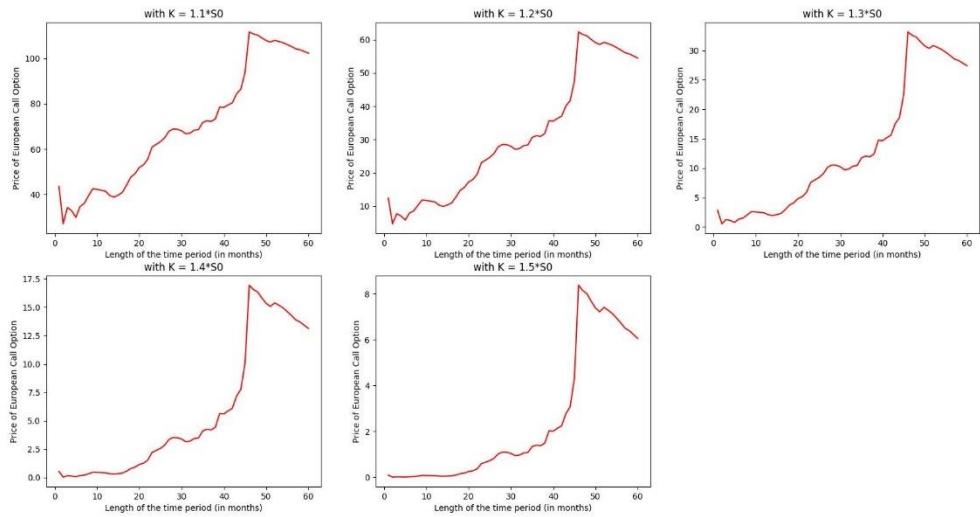
Historical Volatility versus time period for the stock: KO



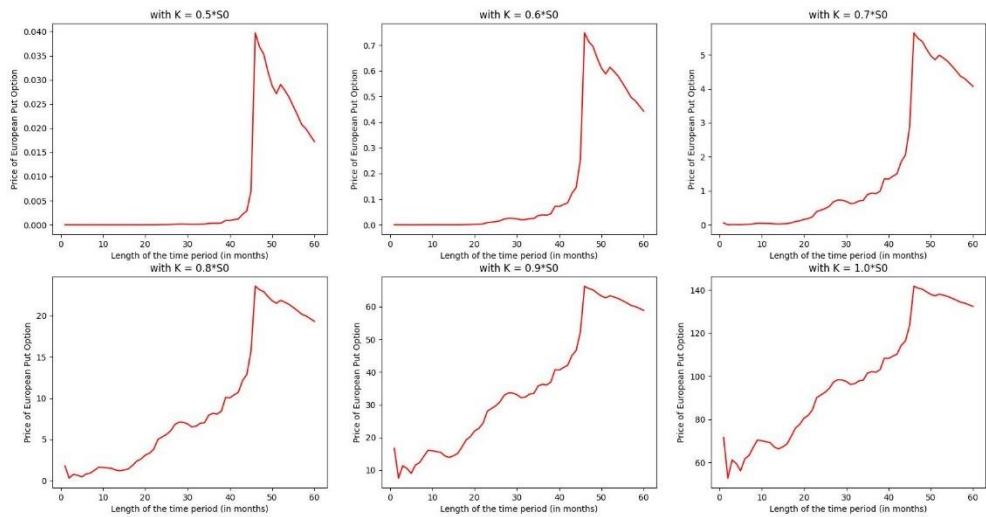
Prices of European Call Option for the stock: KOTAKBANK.NS



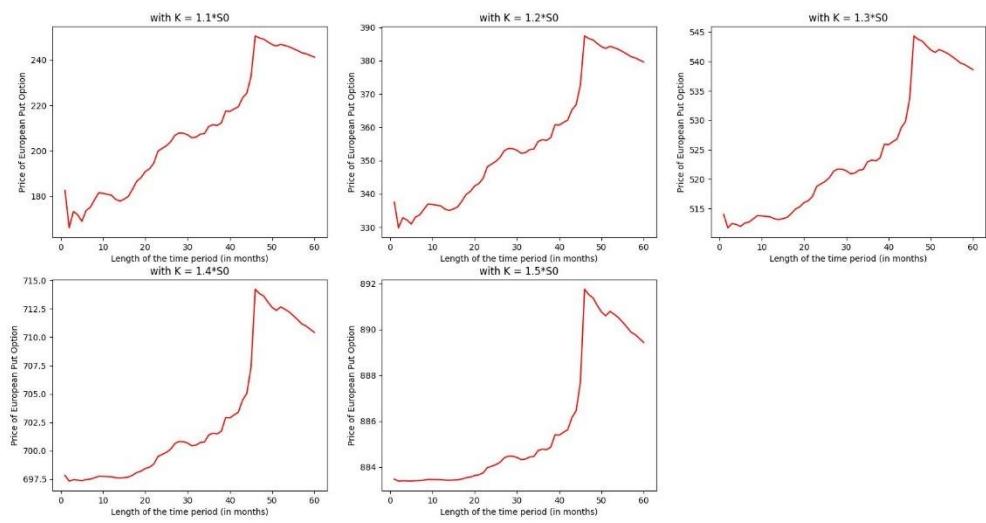
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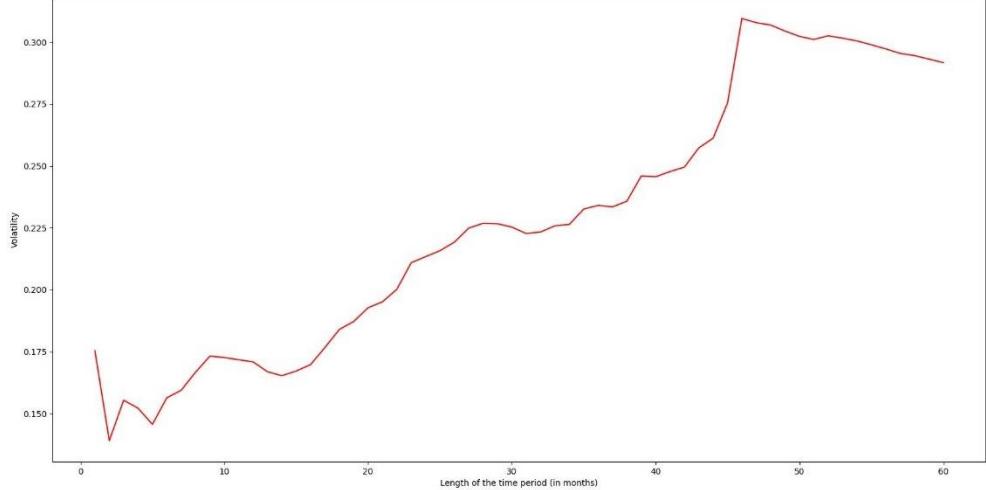
Prices of European Put Option for the stock KOTAKBANK.NS



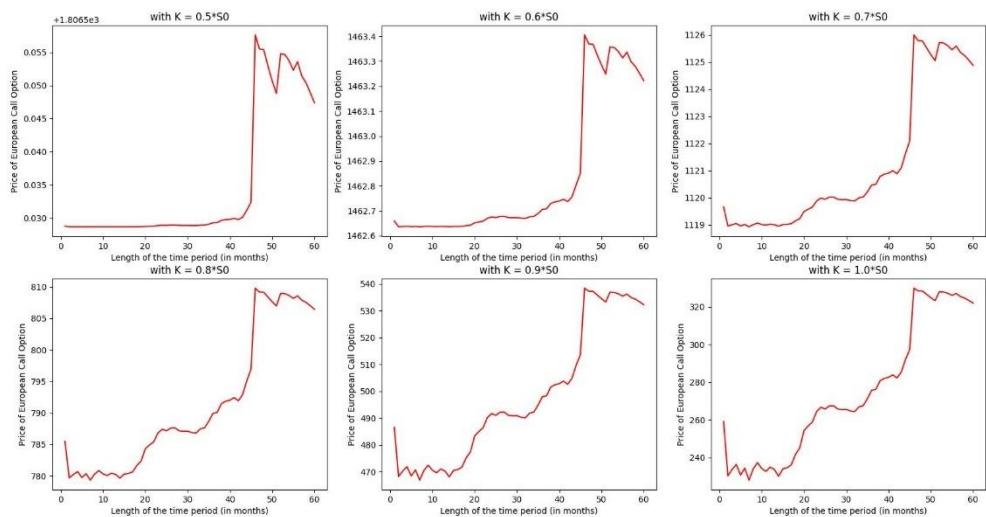
Prices of European Put Option for the stock KOTAKBANK.NS



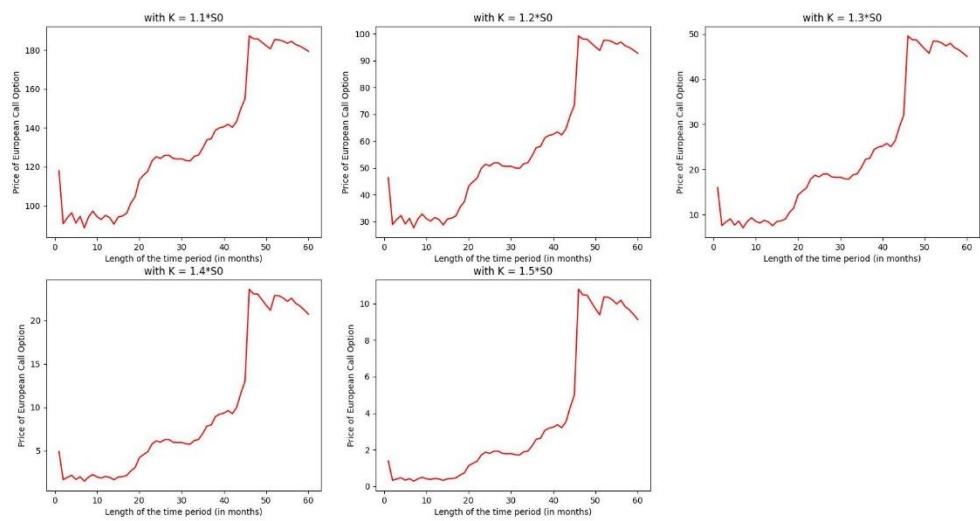
Historical Volatility versus time period for the stock: KOTAKBANK.NS



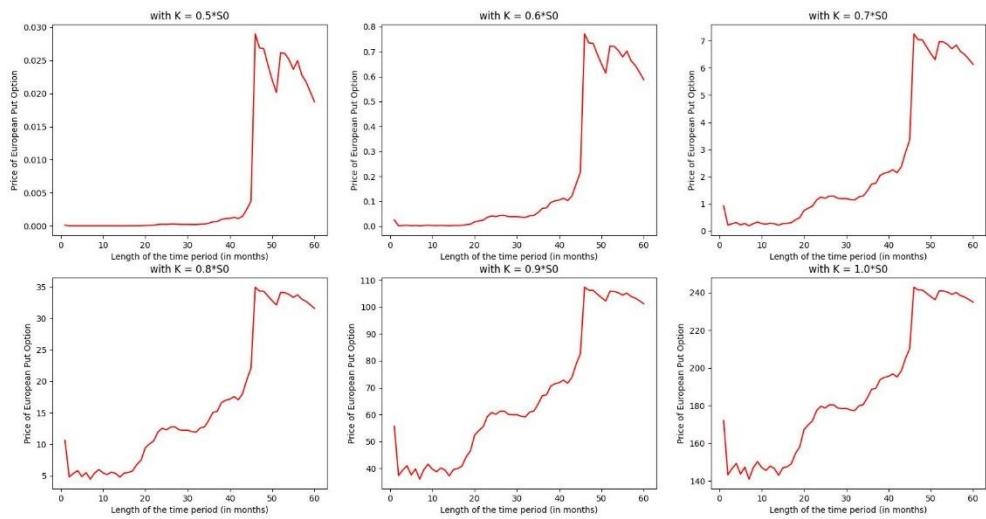
Prices of European Call Option for the stock: LT.NS



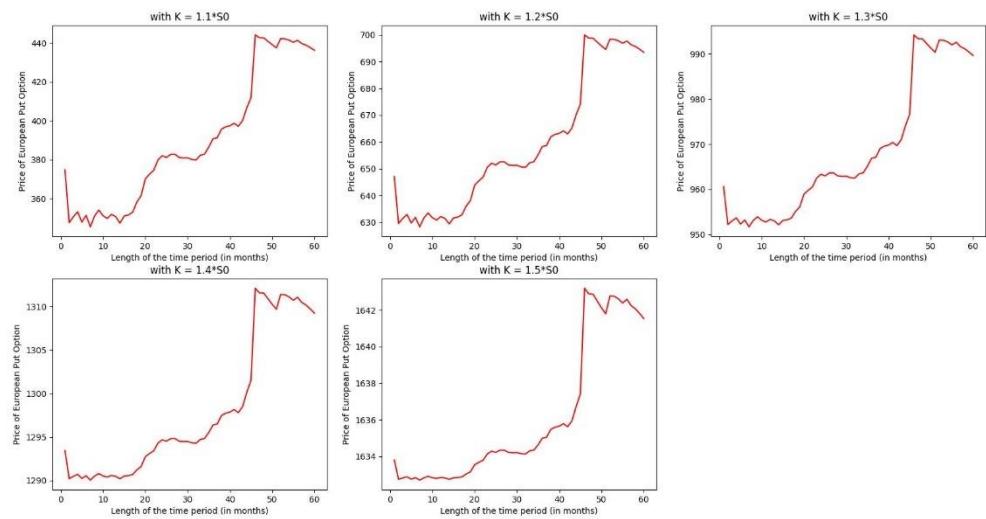
Prices of European Call Option for the stock: LT.NS

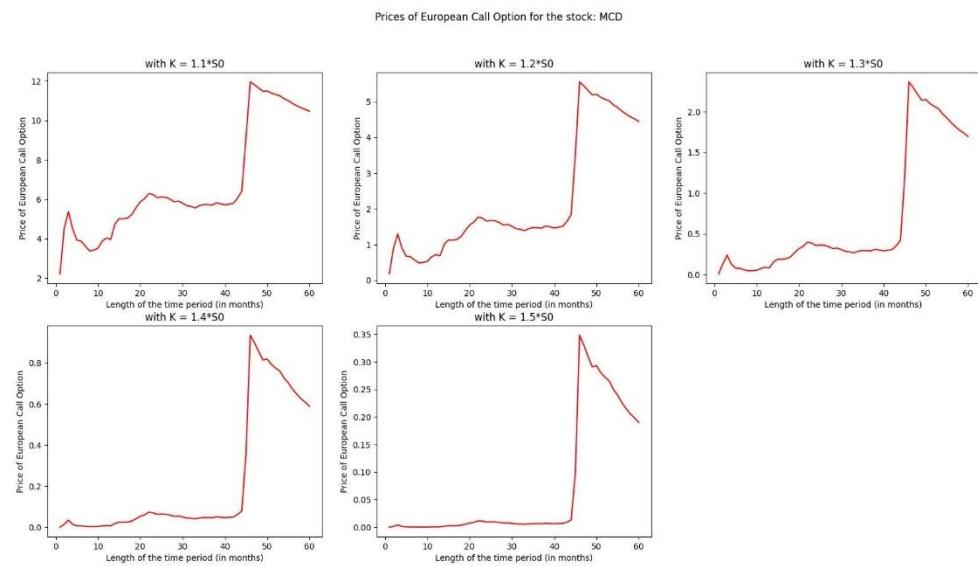
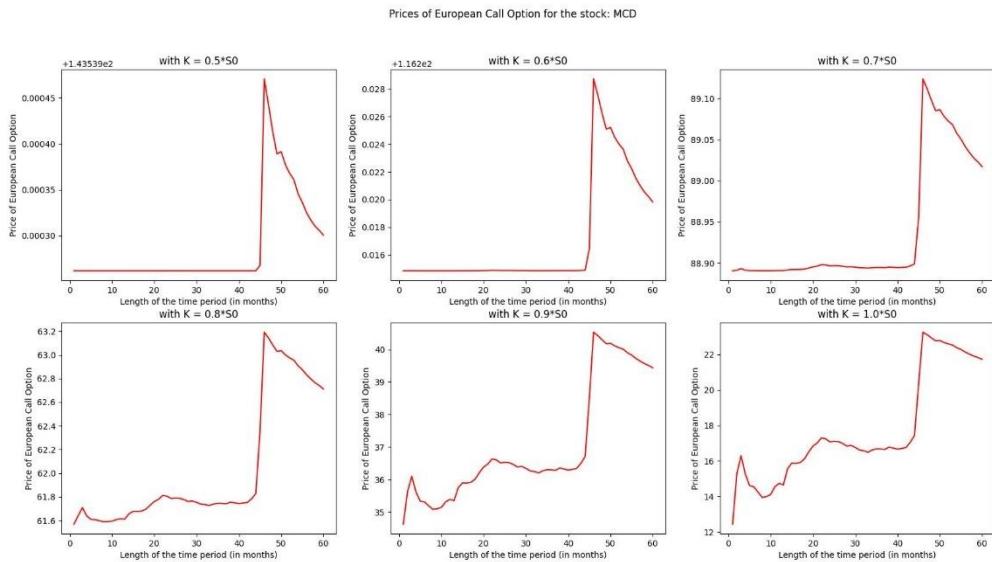
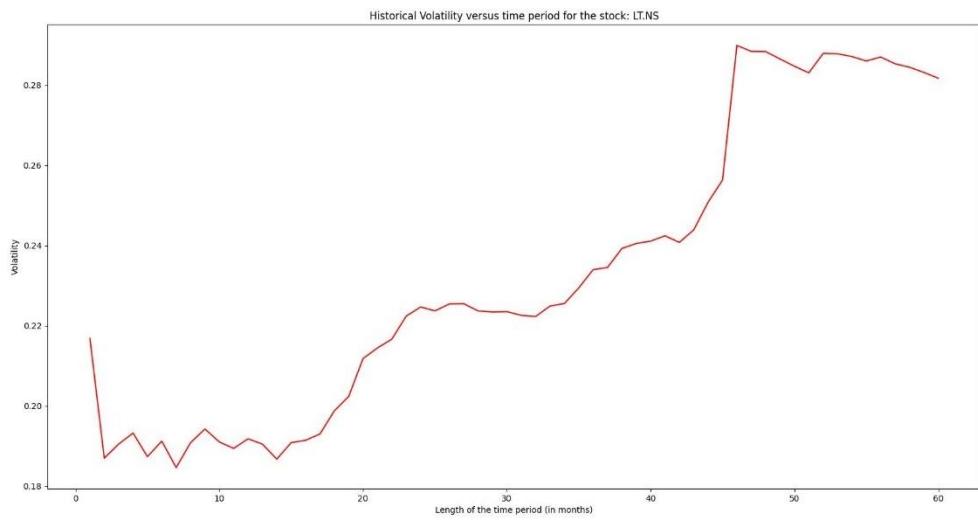


Prices of European Put Option for the stock LT.NS

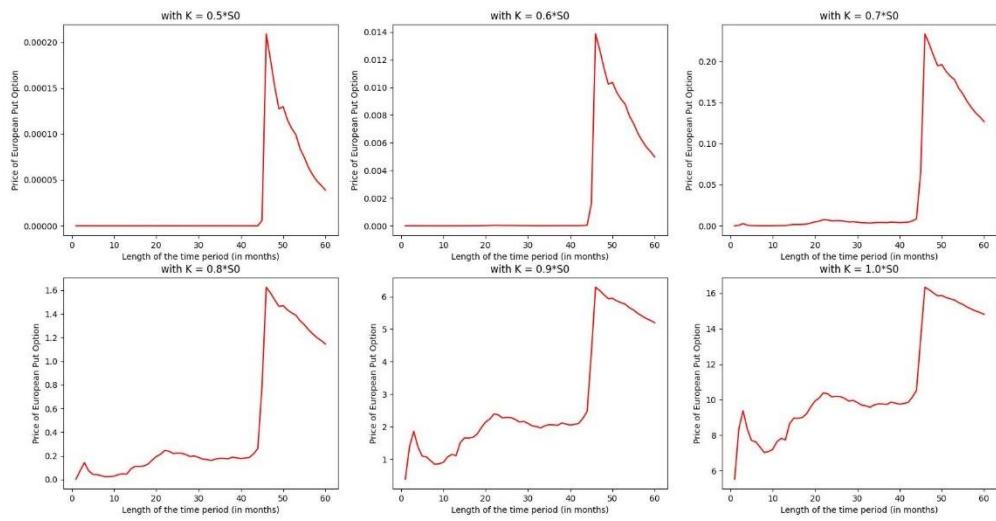


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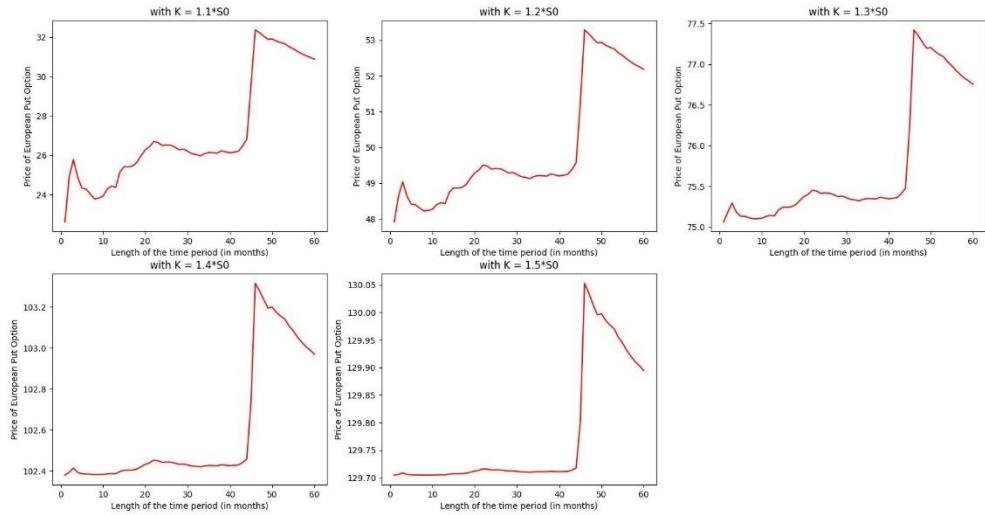




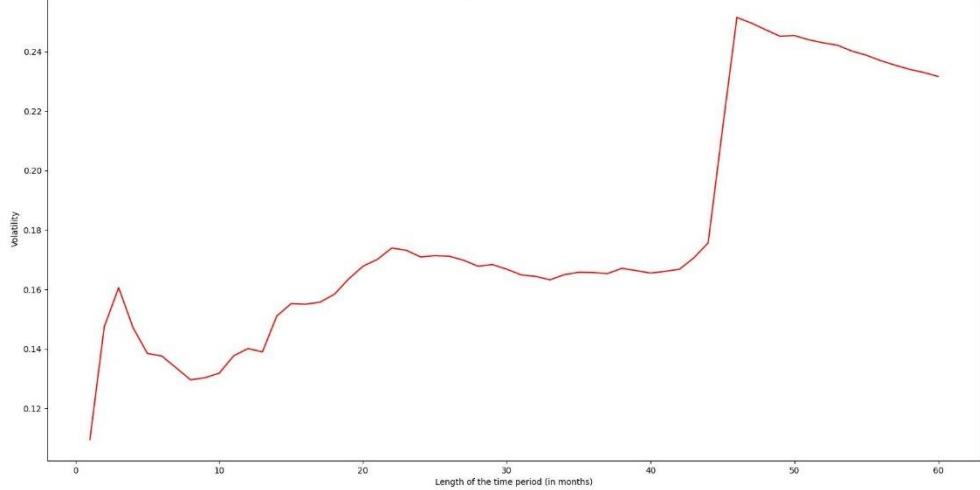
Prices of European Put Option for the stock MCD



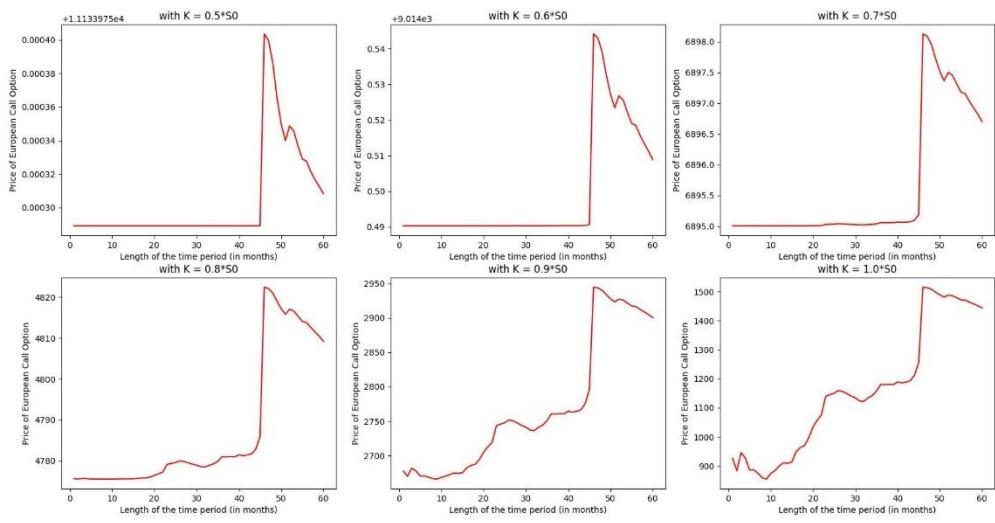
Prices of European Put Option for the stock MCD



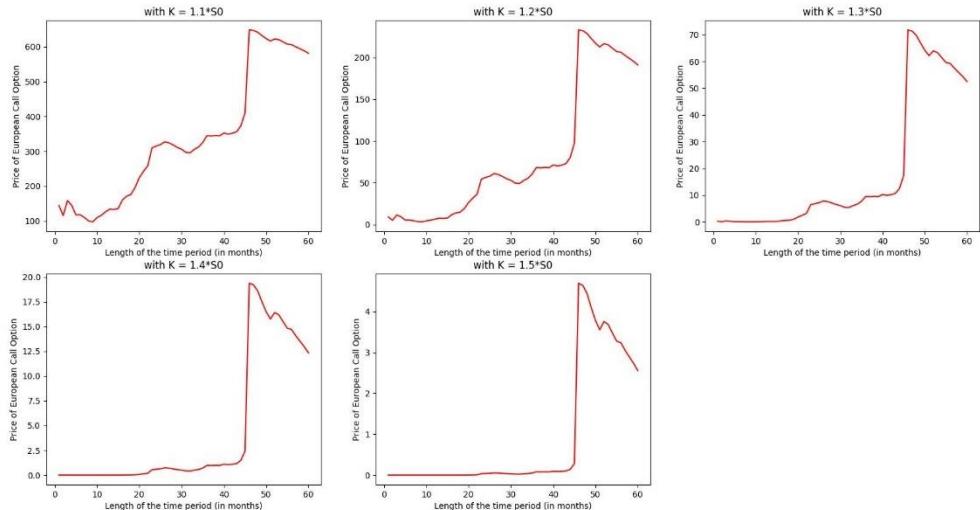
Historical Volatility versus time period for the stock: MCD



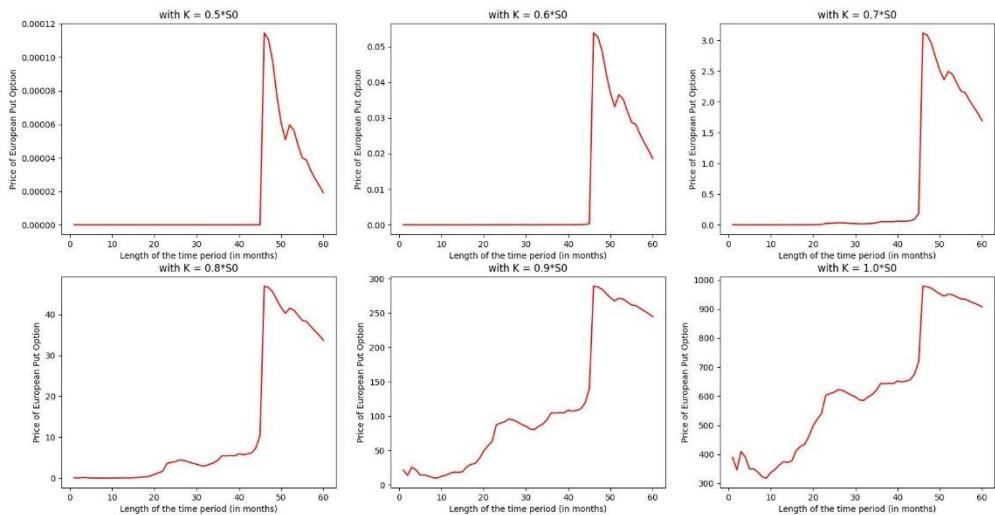
Prices of European Call Option for the stock: Nifty



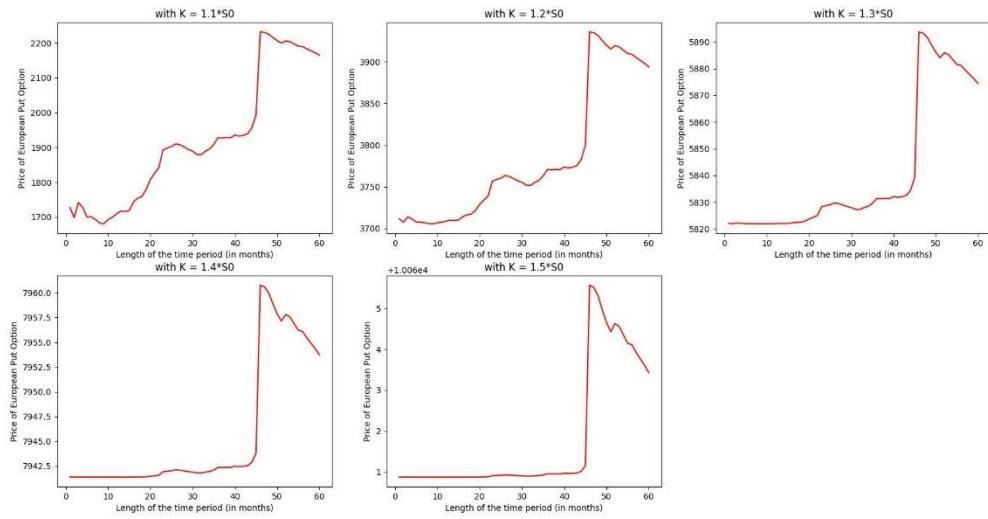
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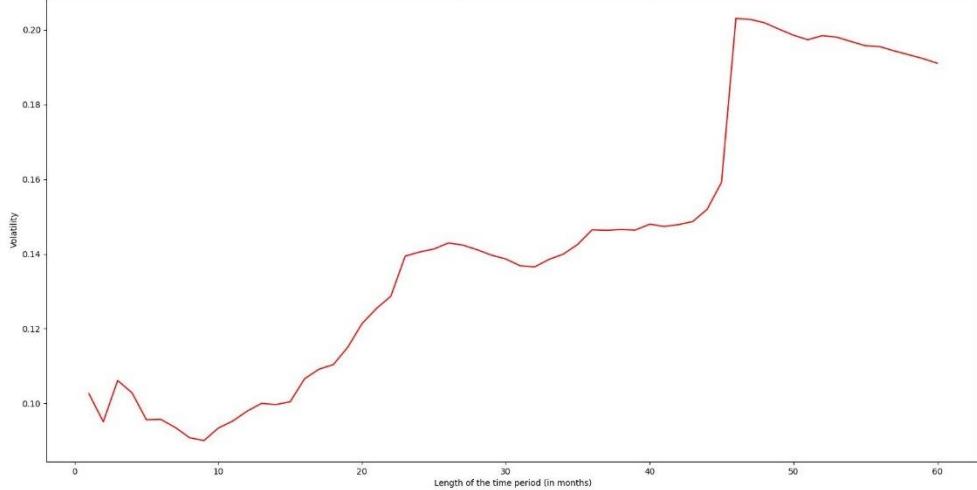
Prices of European Put Option for the stock Nifty



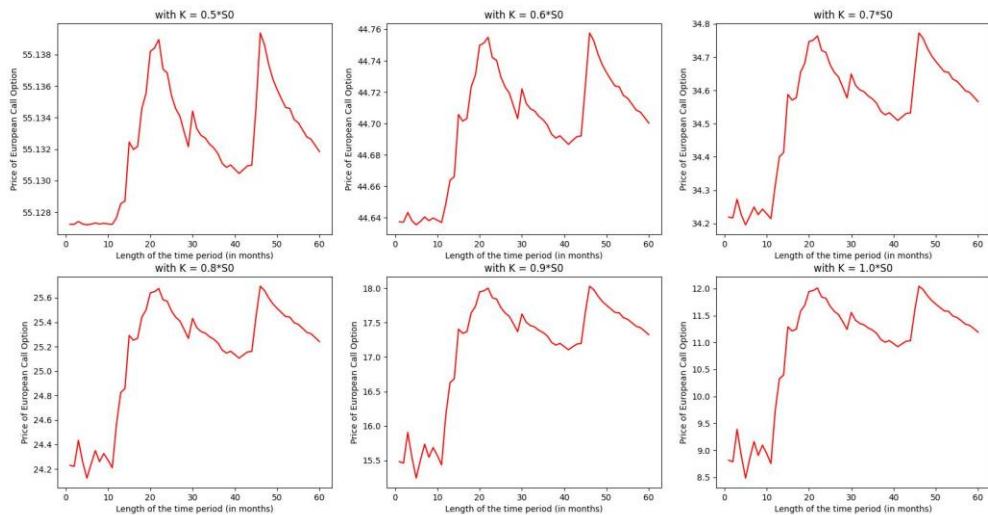
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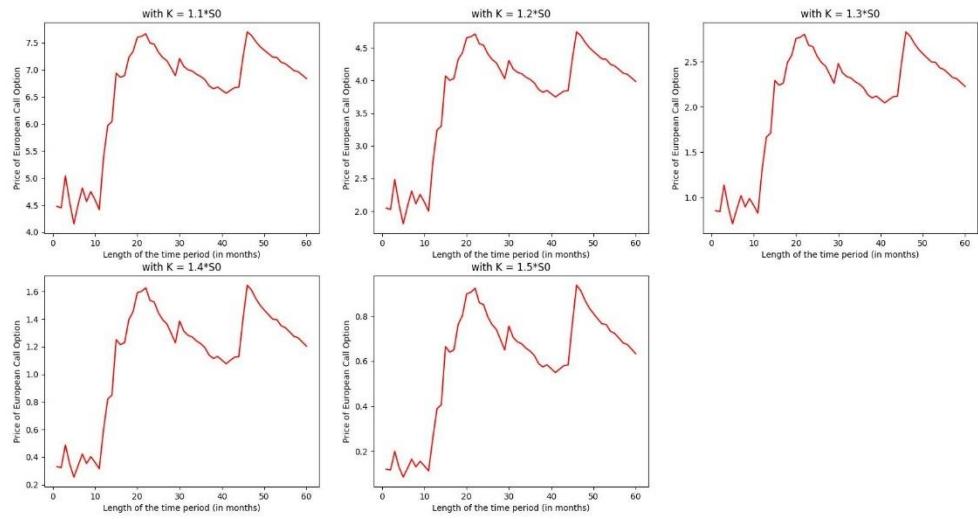
Historical Volatility versus time period for the stock: Nifty



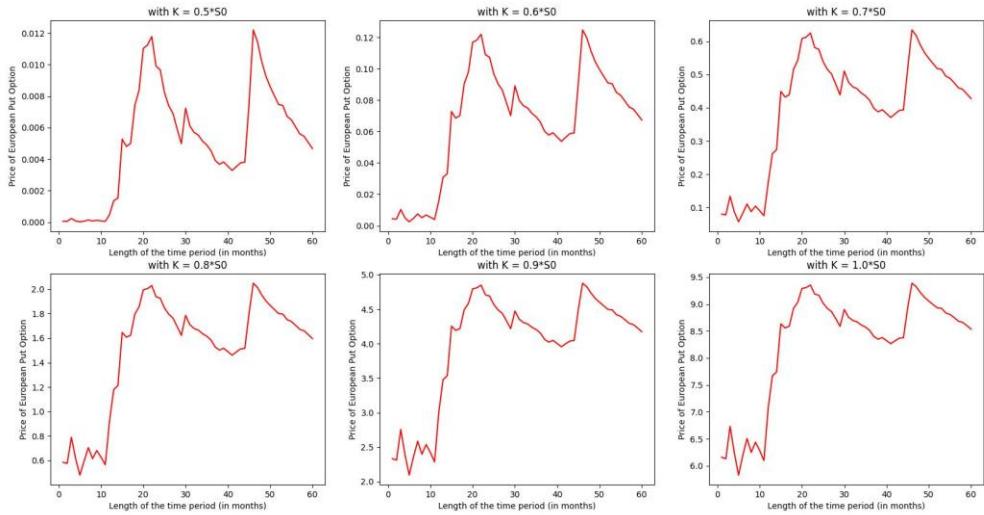
Prices of European Call Option for the stock: NKE



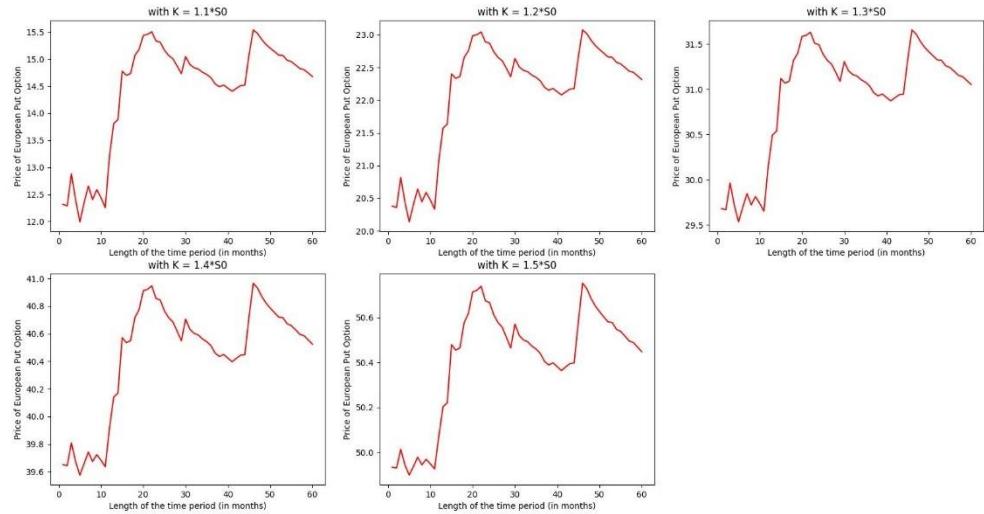
Prices of European Call Option for the stock: NKE

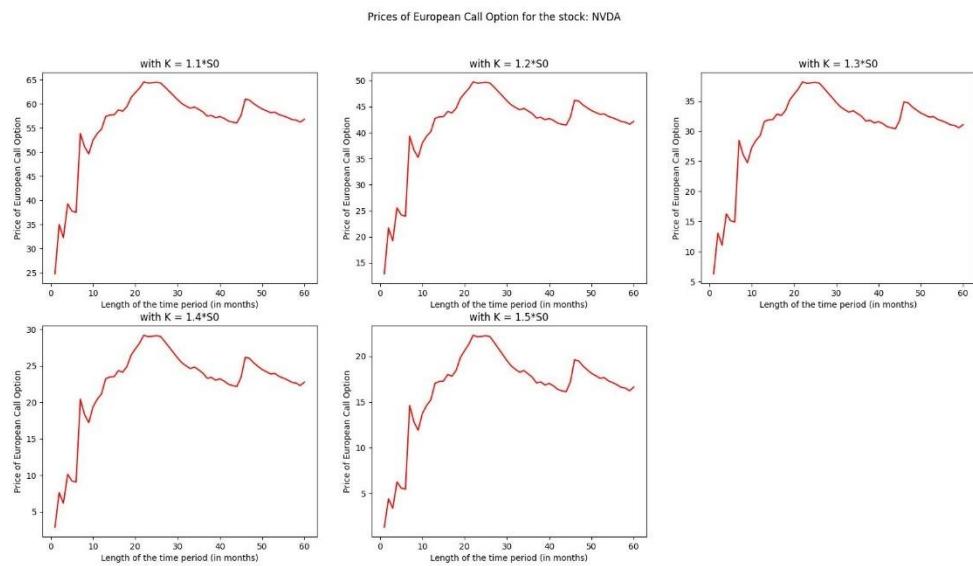
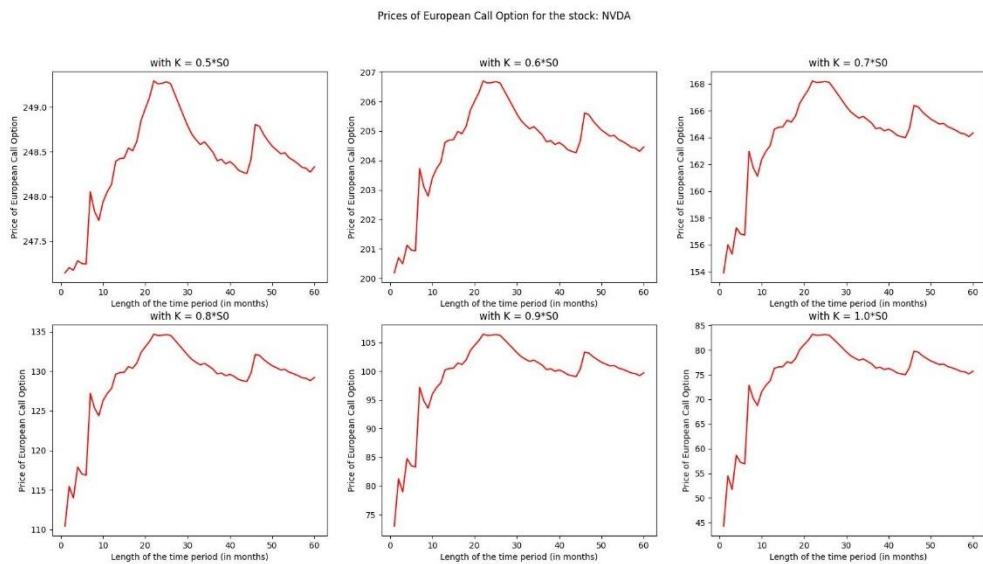
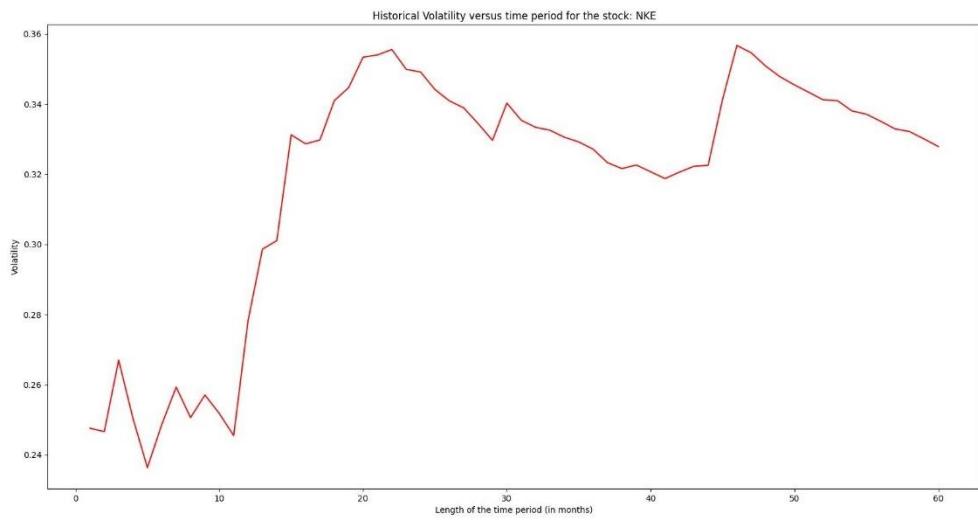


Prices of European Put Option for the stock NKE

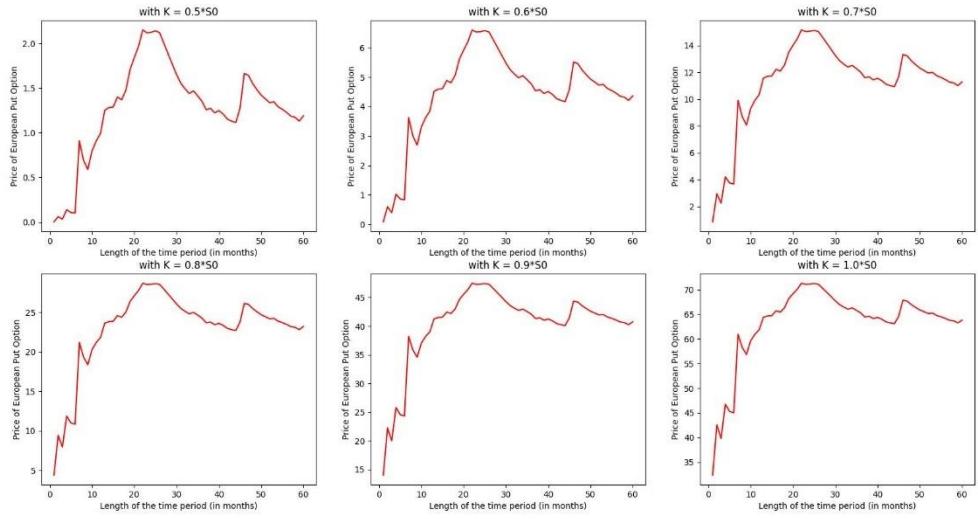


Prices of European Put Option for the stock NKE

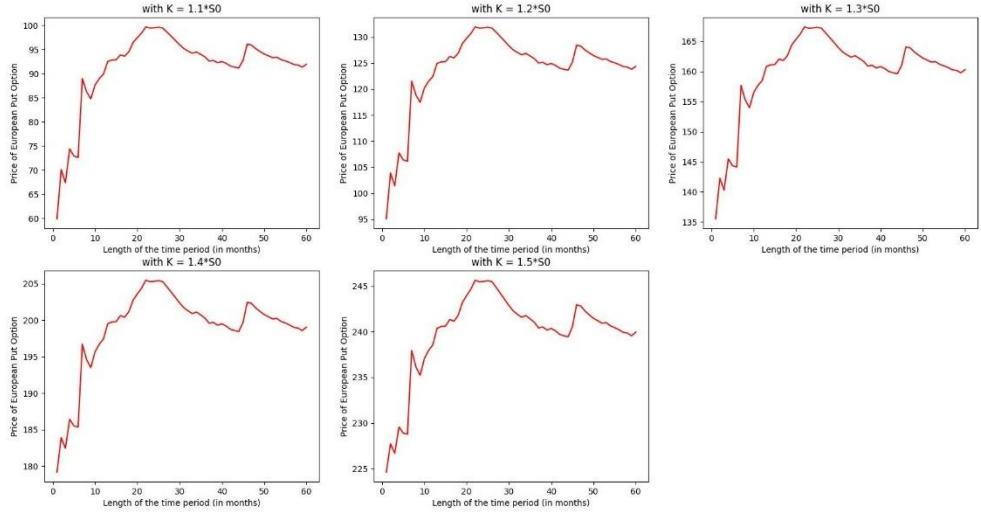




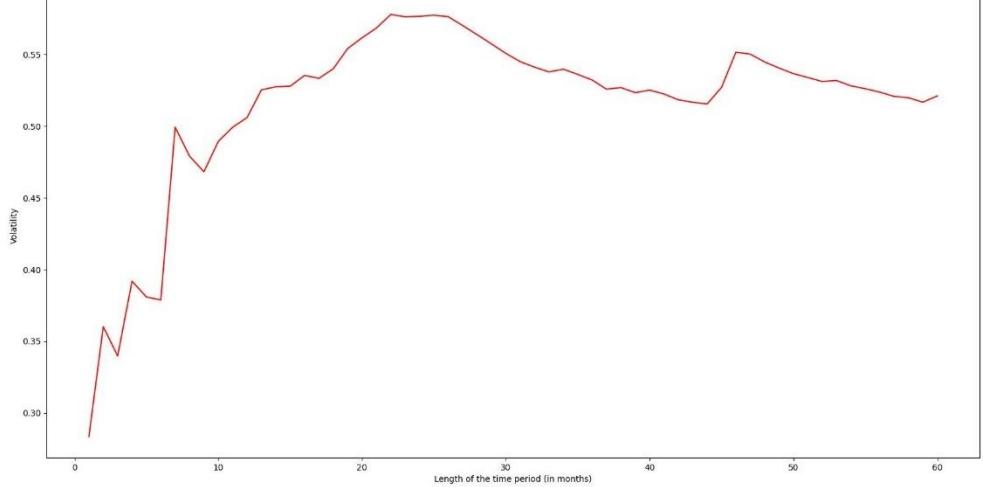
Prices of European Put Option for the stock NVDA



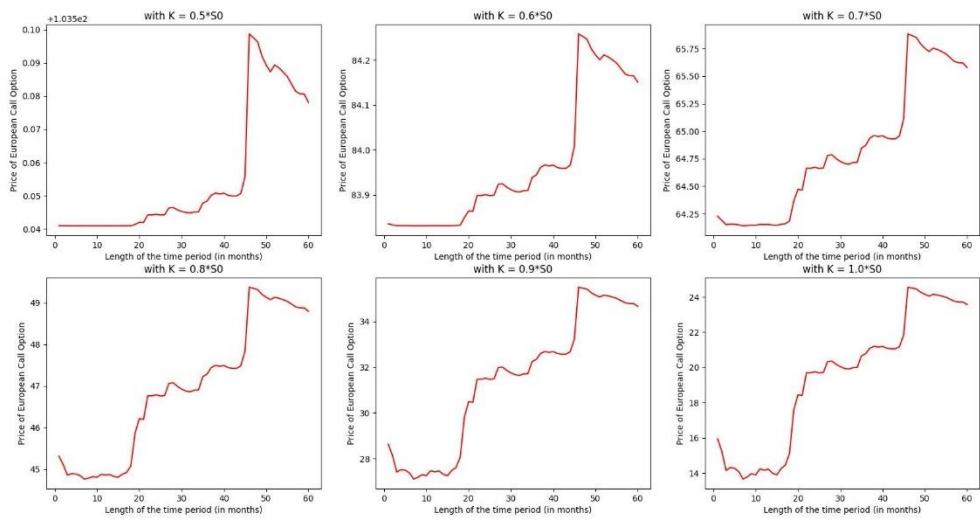
Prices of European Put Option for the stock NVDA



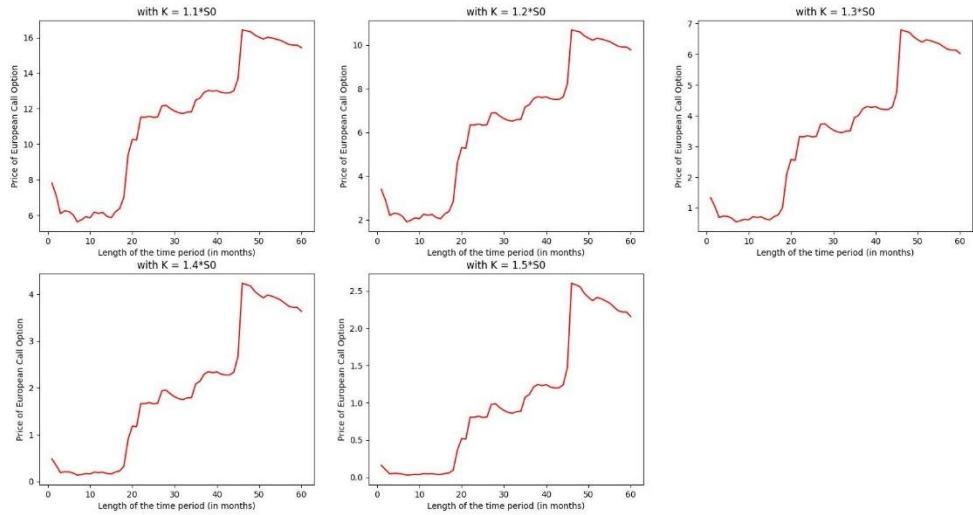
Historical Volatility versus time period for the stock: NVDA



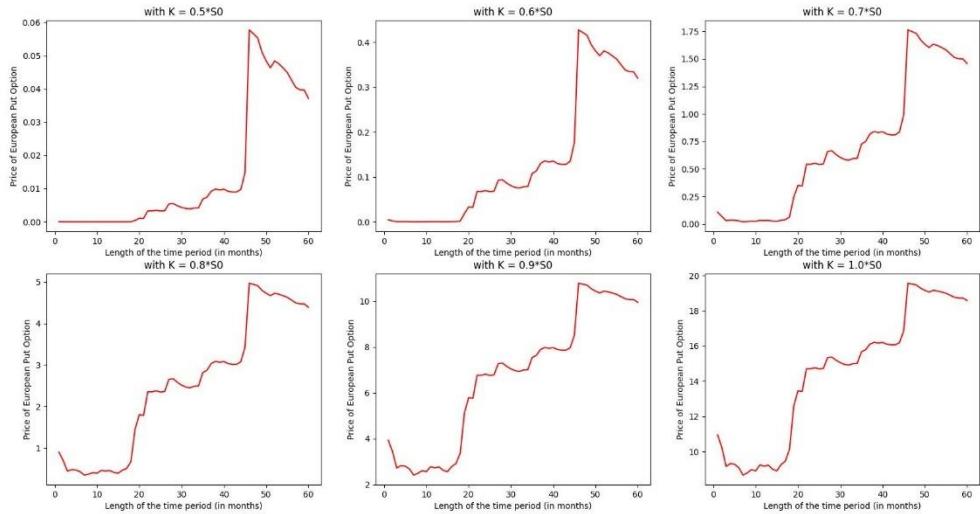
Prices of European Call Option for the stock: ONGC.NS



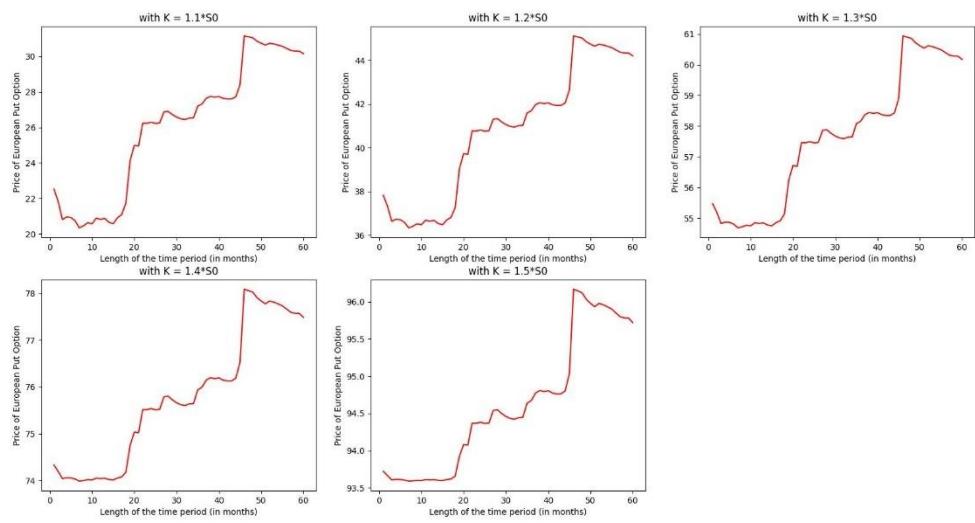
Prices of European Call Option for the stock: ONGC.NS



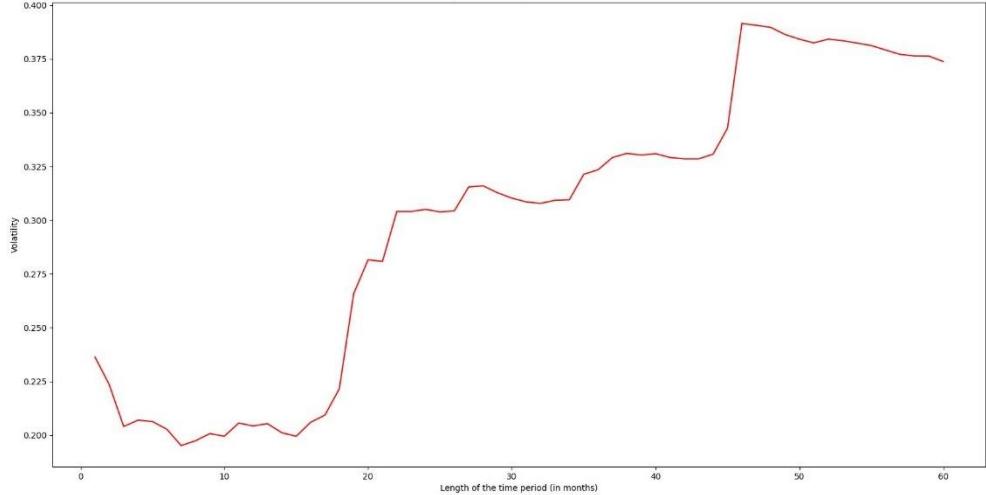
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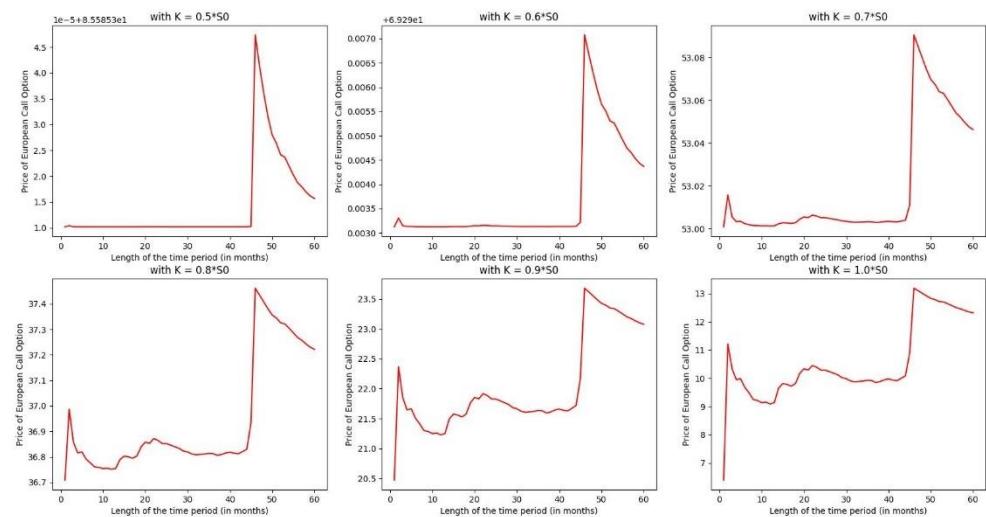
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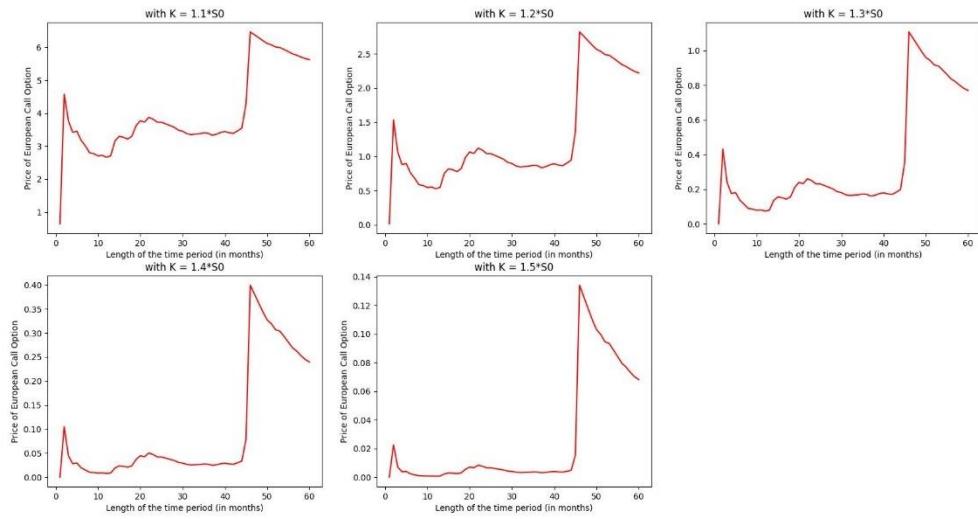
Historical Volatility versus time period for the stock: ONGC.NS



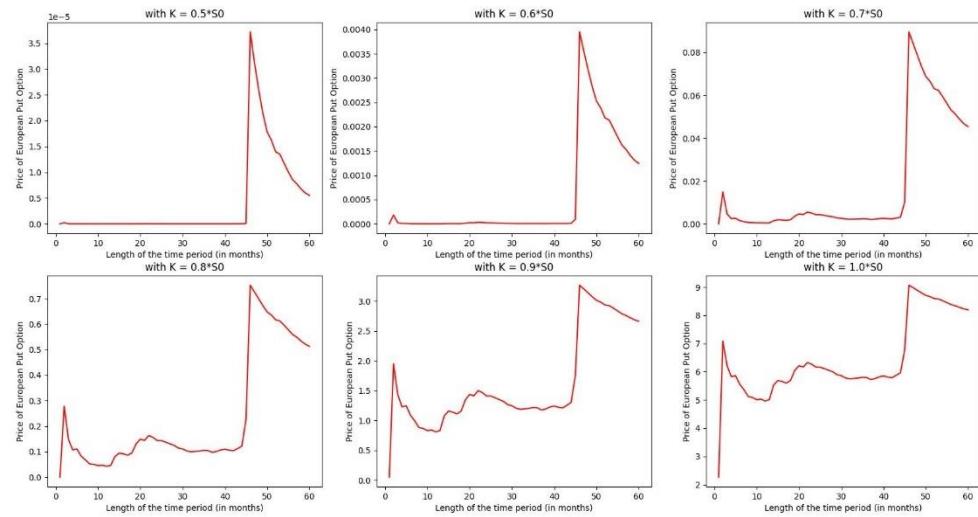
Prices of European Call Option for the stock: PEP



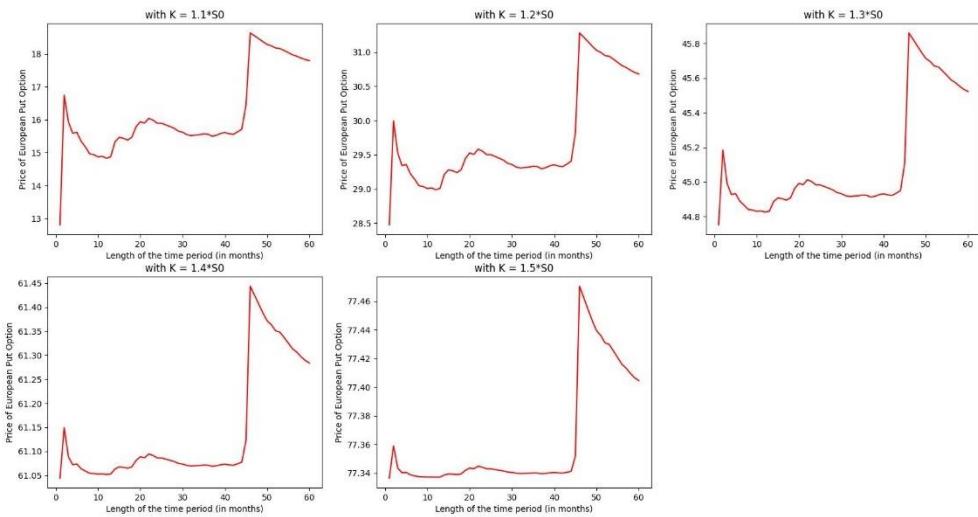
Prices of European Call Option for the stock: PEP

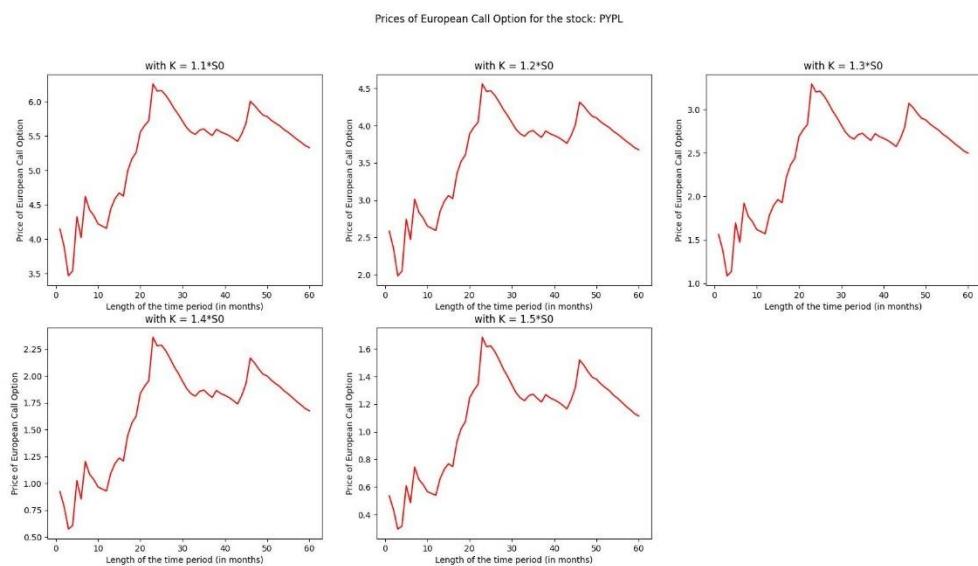
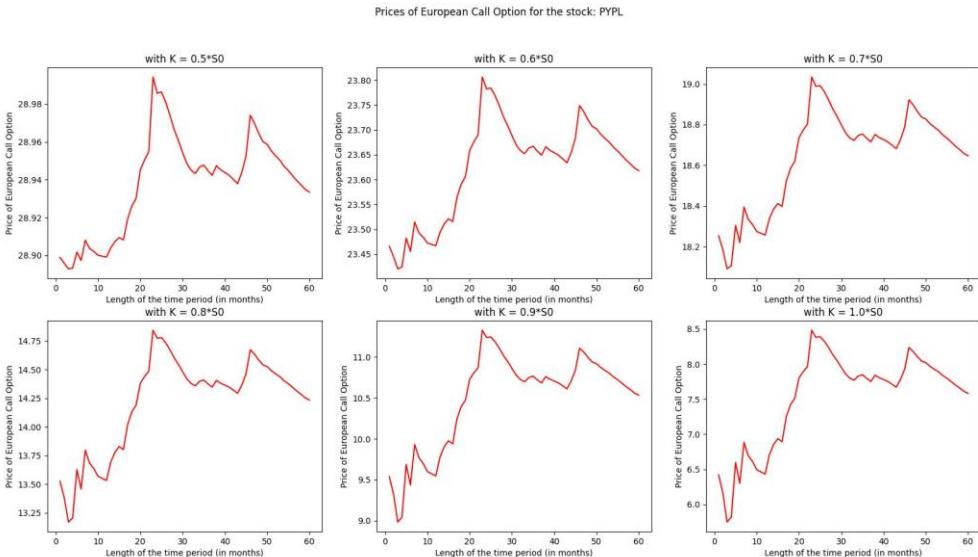
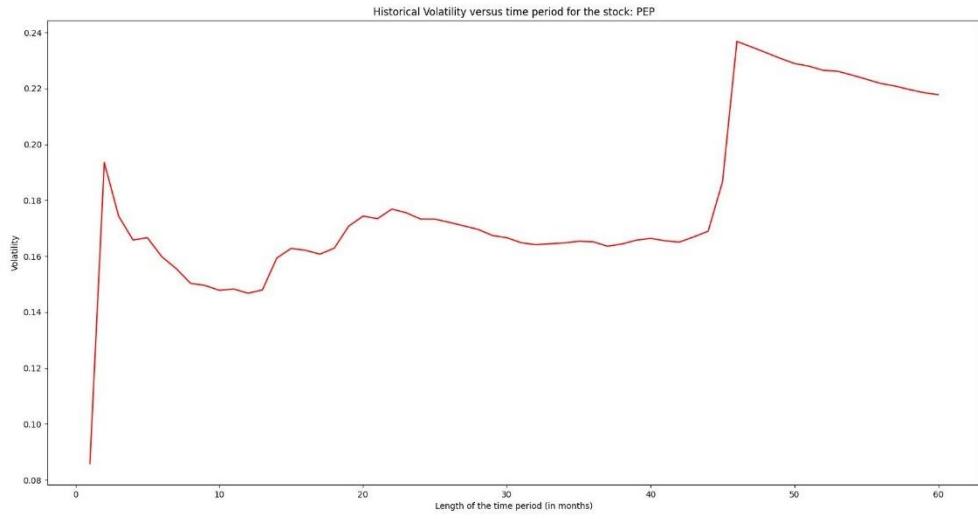


Prices of European Put Option for the stock PEP

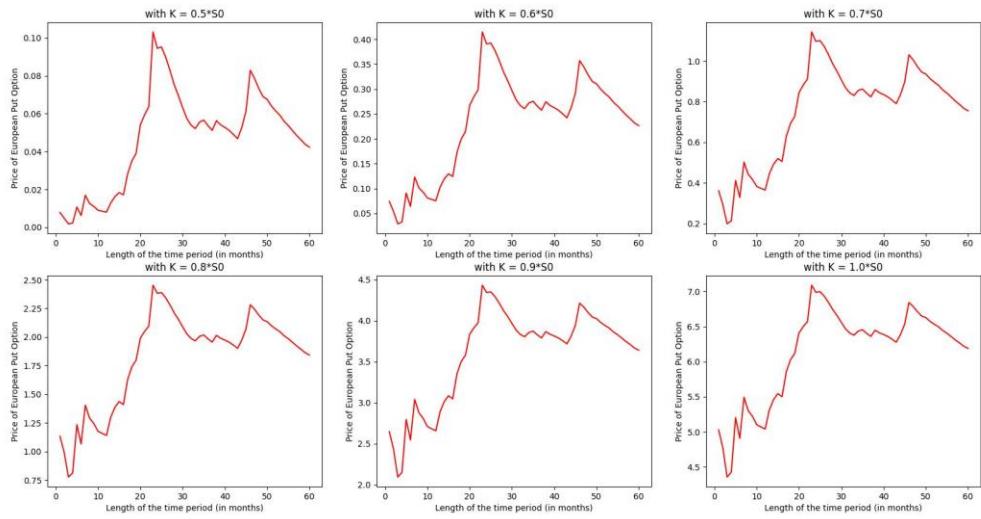


Prices of European Put Option for the stock PEP

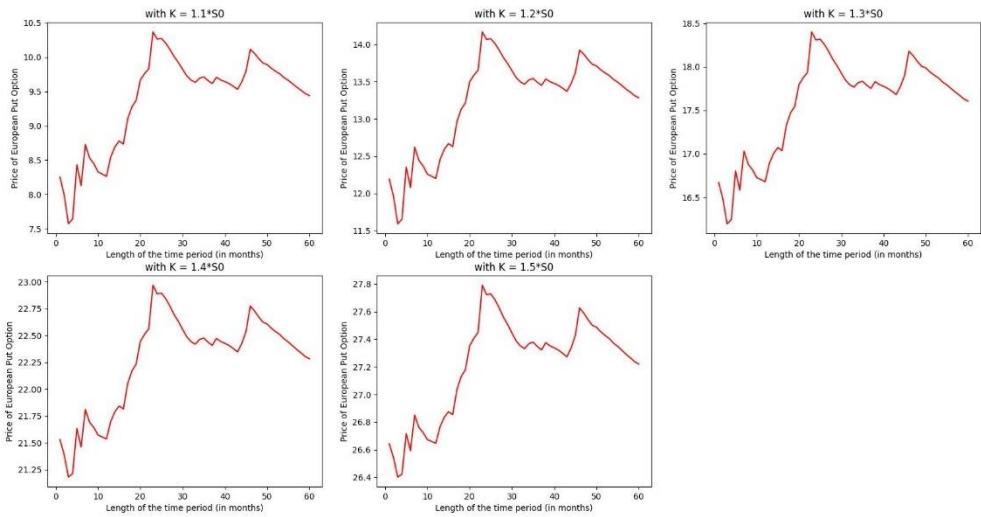




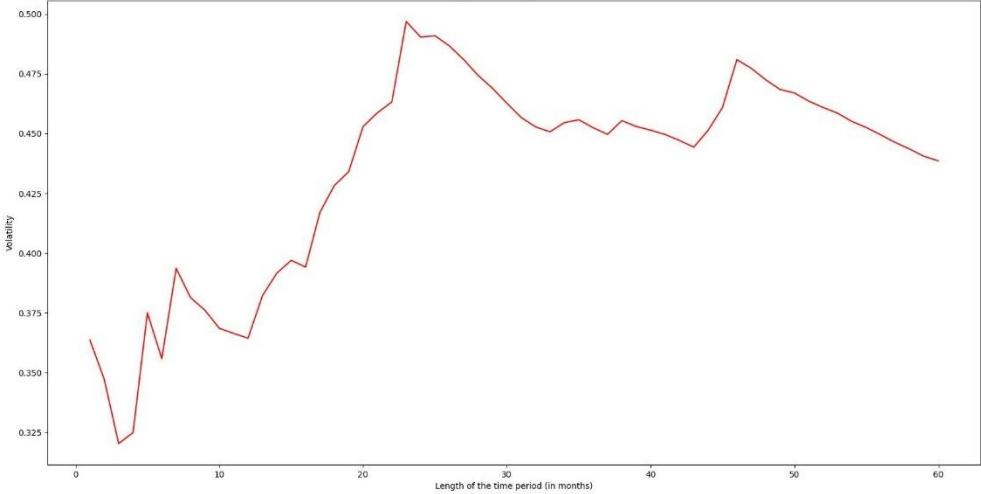
Prices of European Put Option for the stock PYPL.



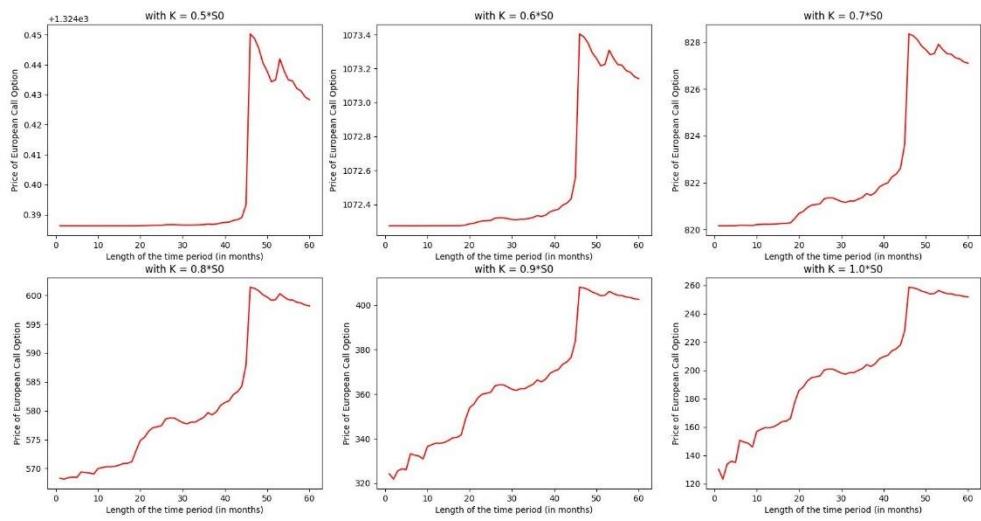
Prices of European Put Option for the stock PYPL



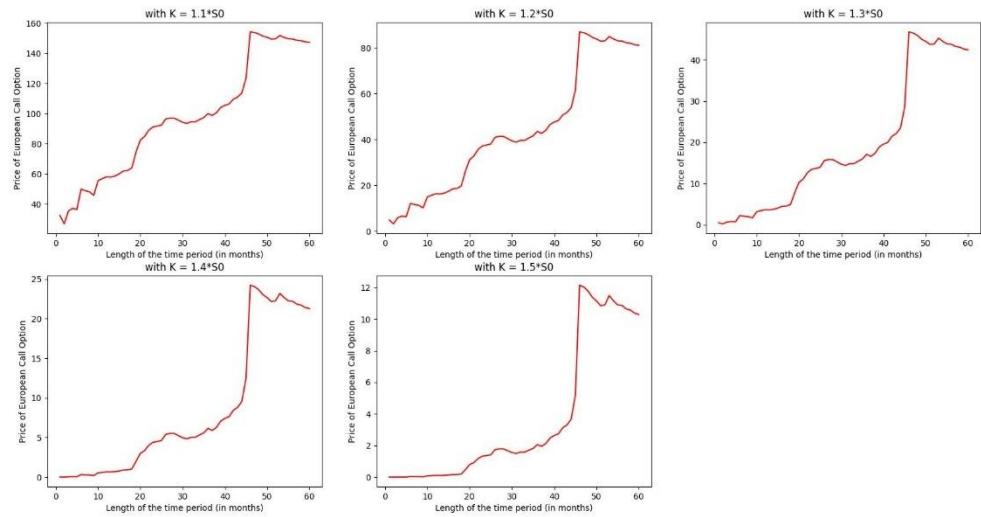
Historical Volatility versus time period for the stock: PYPL



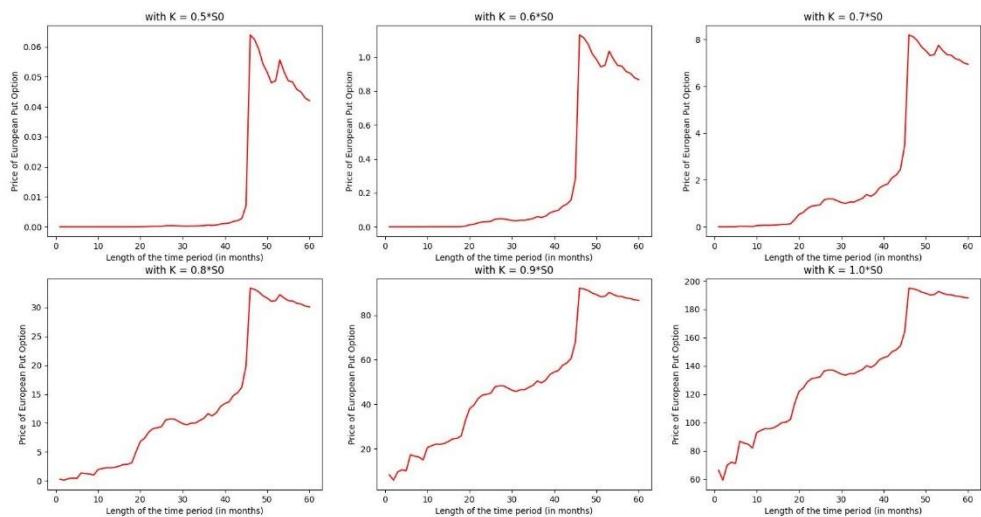
Prices of European Call Option for the stock: RELIANCE.NS



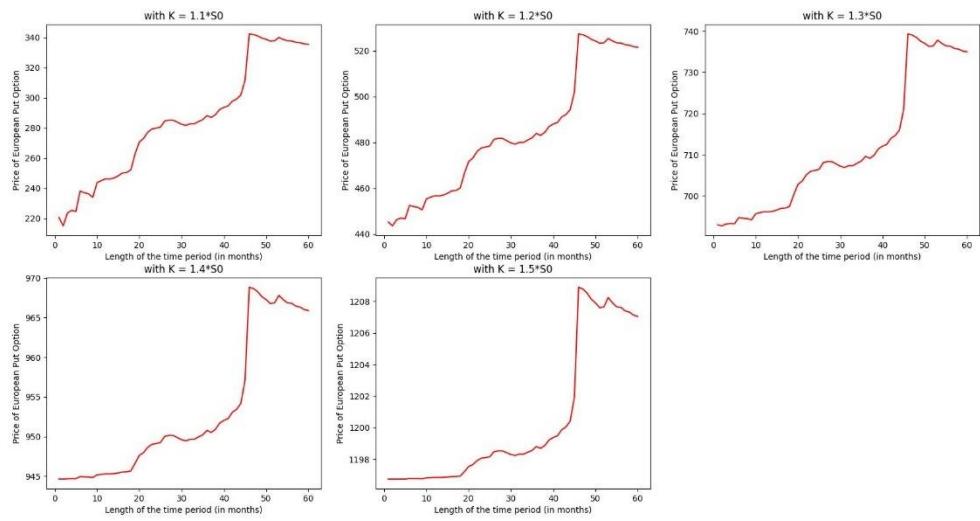
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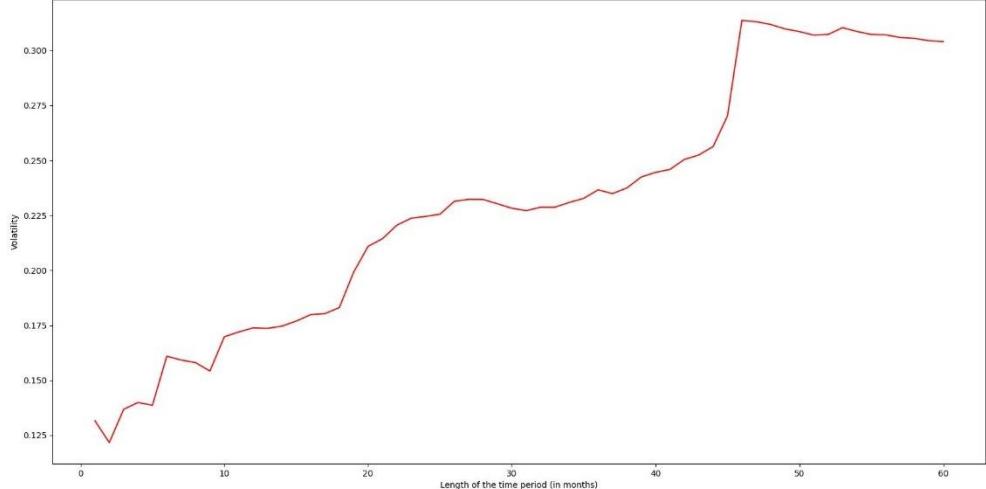
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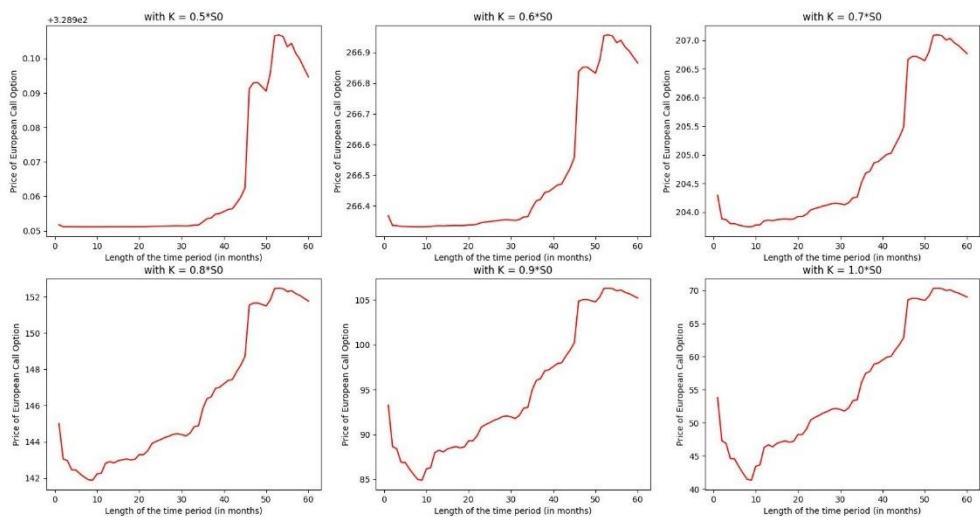
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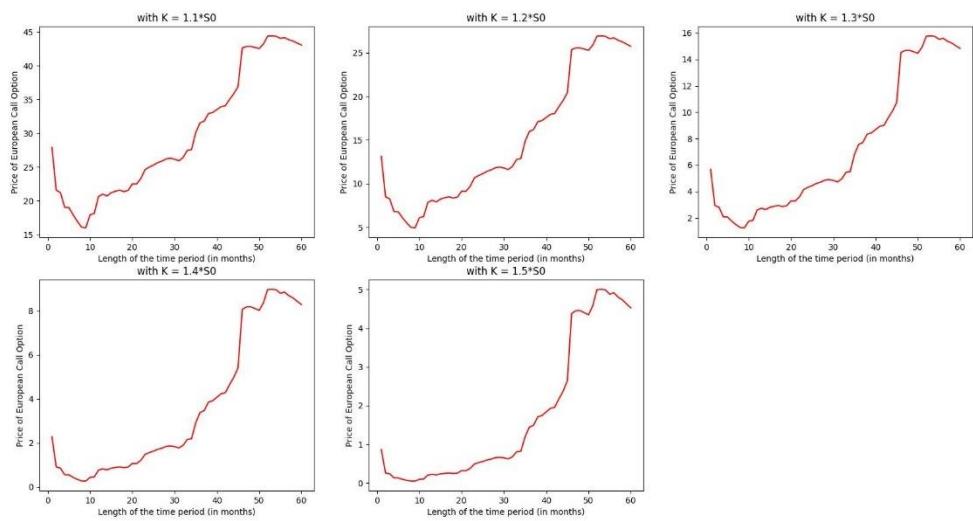
Historical Volatility versus time period for the stock: RELIANCE.NS



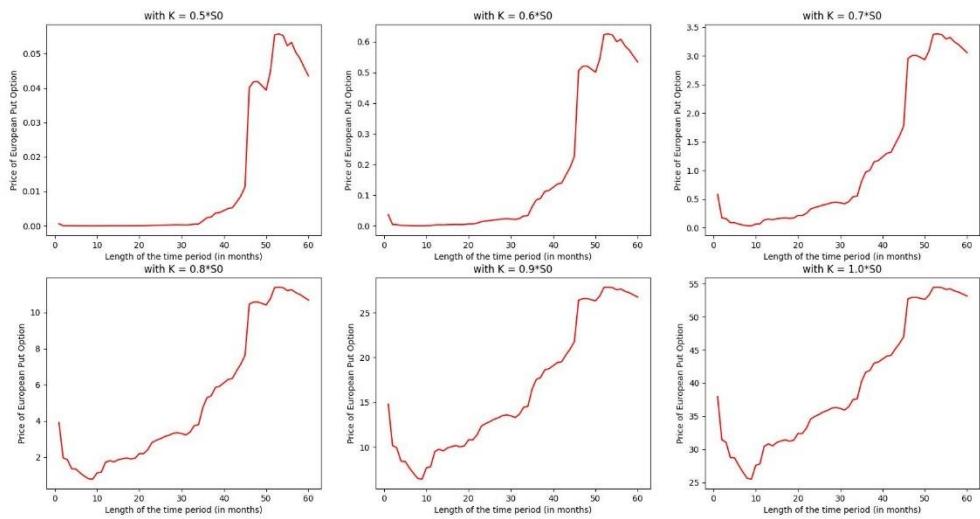
Prices of European Call Option for the stock: SBIN.NS



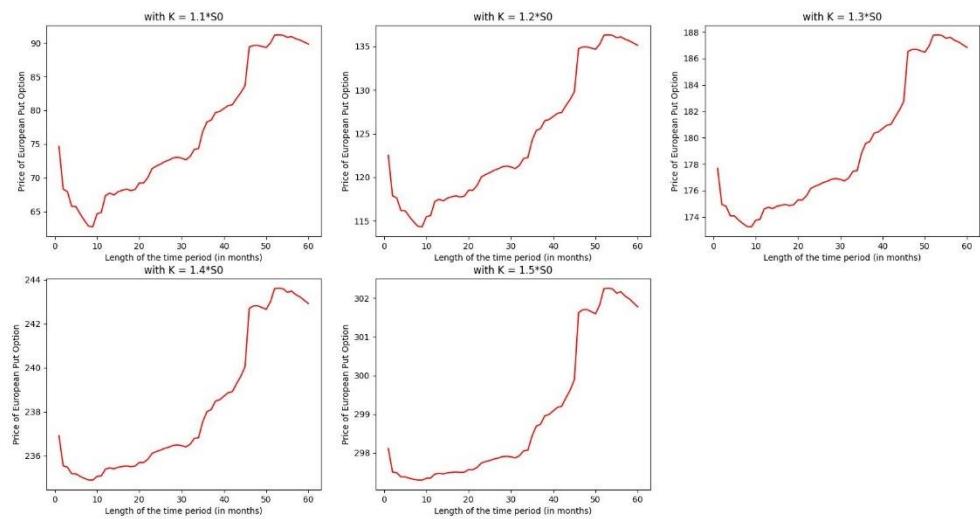
Prices of European Call Option for the stock: SBIN.NS

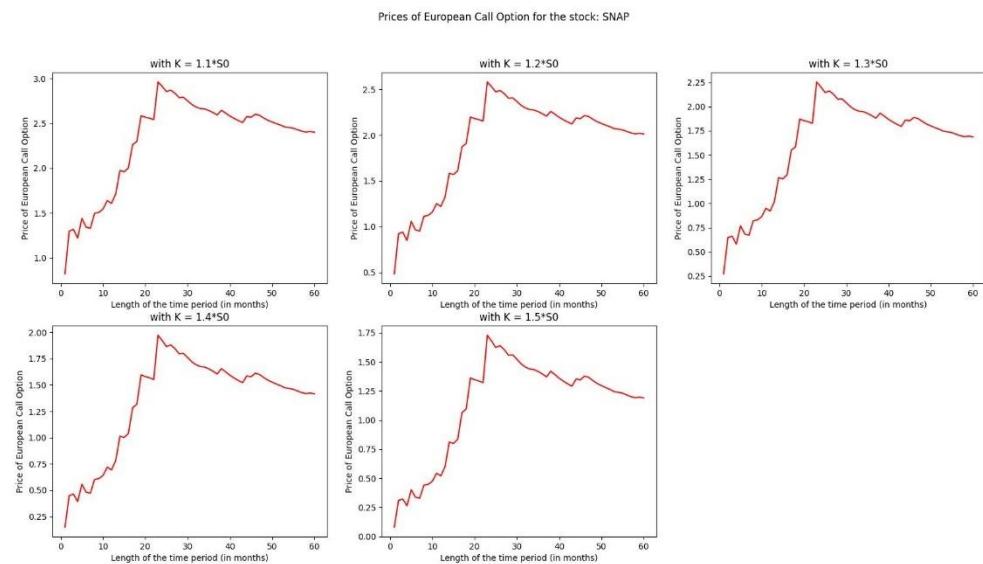
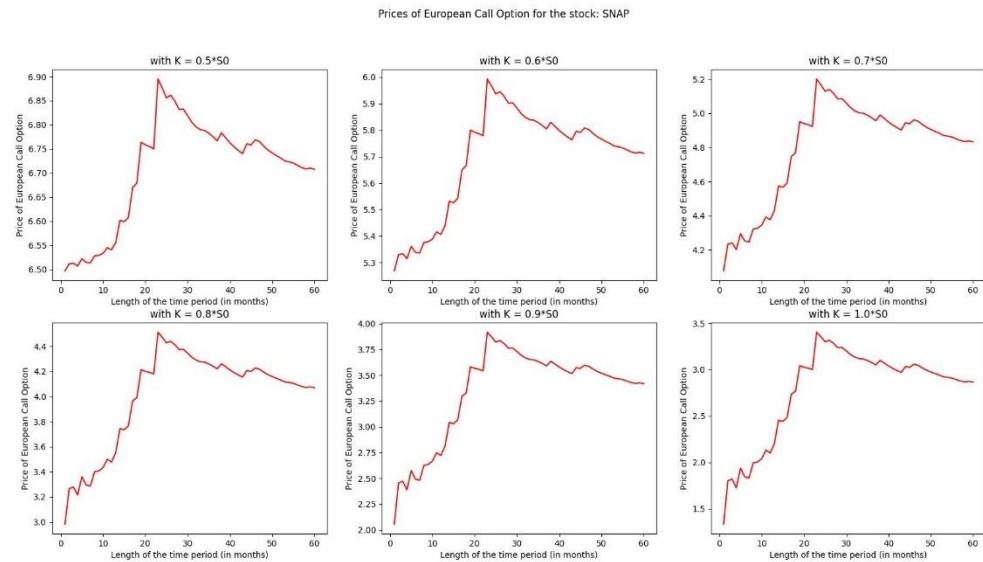
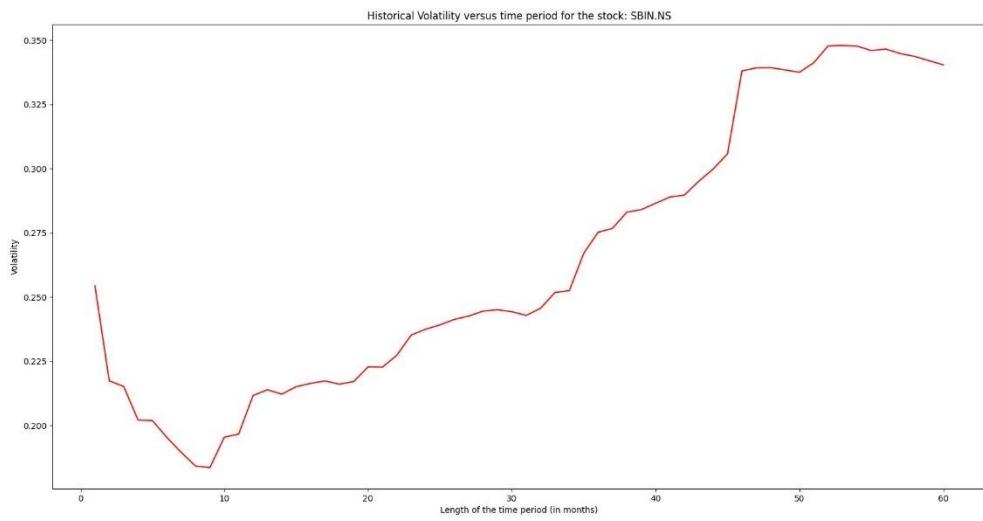


Prices of European Put Option for the stock SBIN.NS

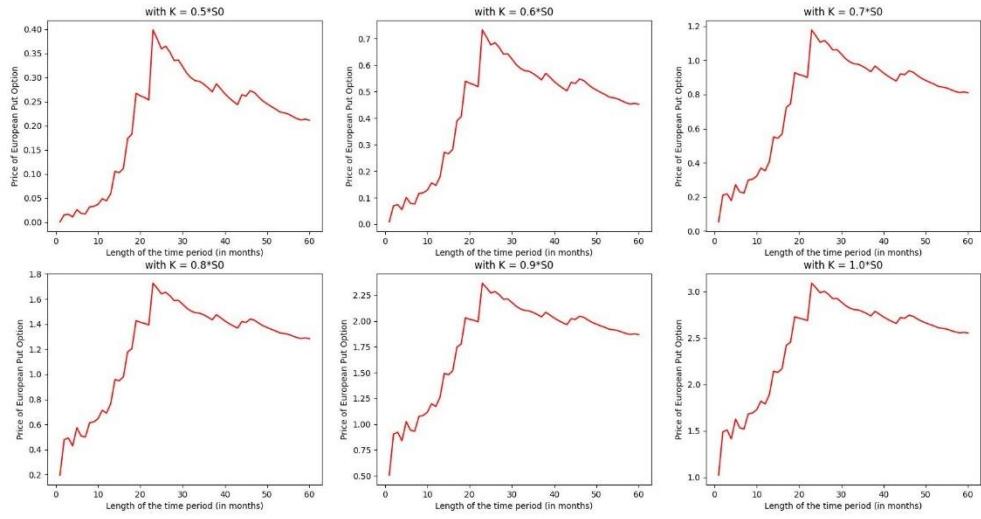


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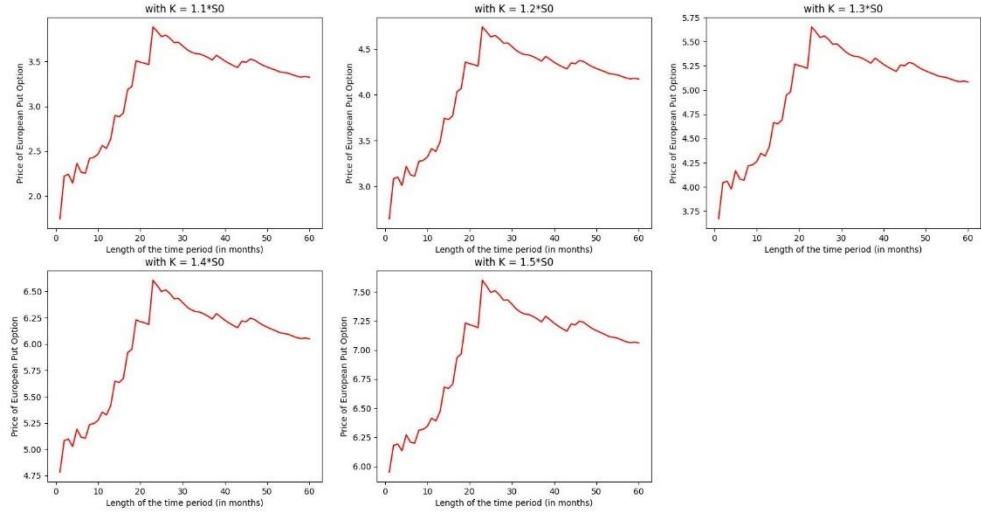




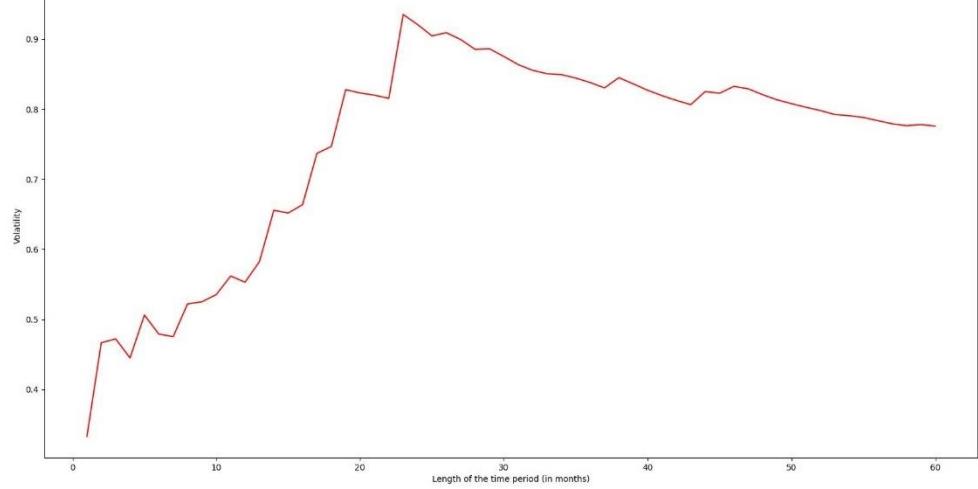
Prices of European Put Option for the stock SNAP



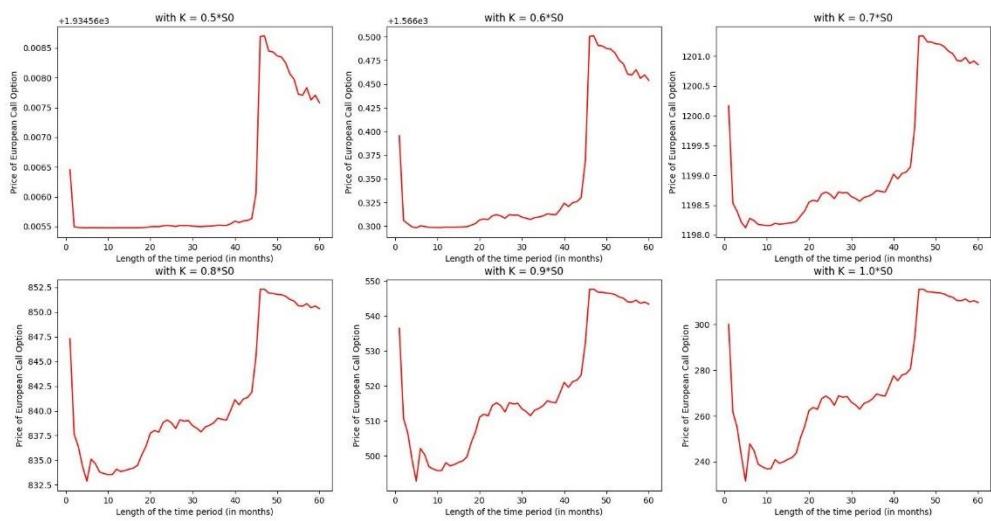
Prices of European Put Option for the stock SNAP



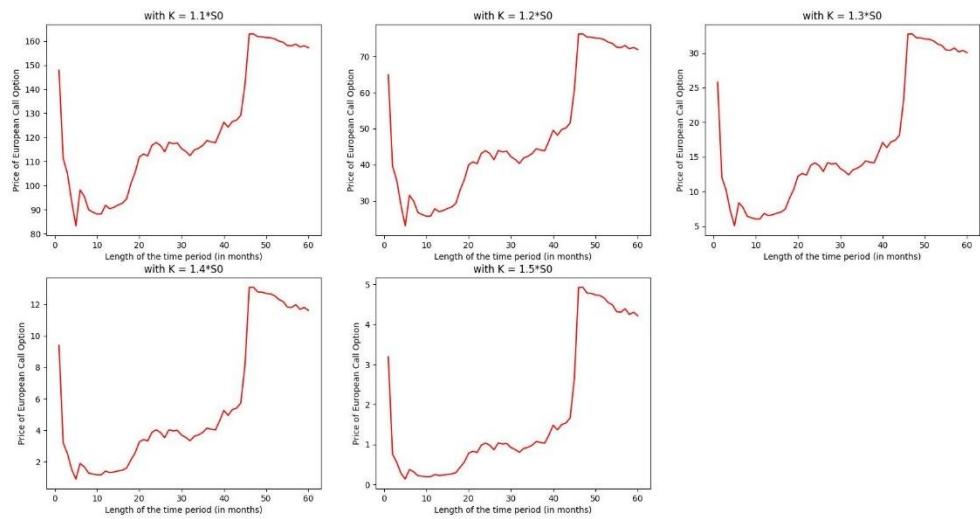
Historical Volatility versus time period for the stock: SNAP



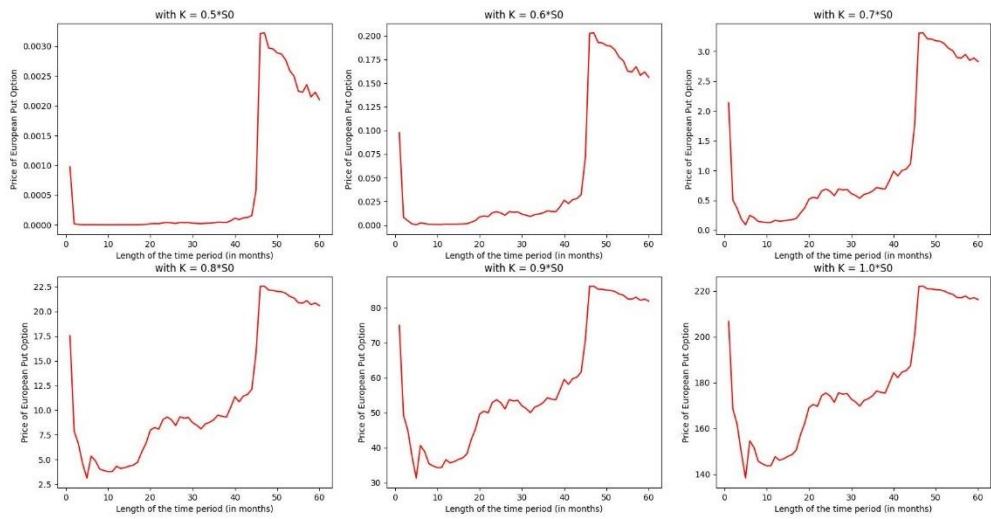
Prices of European Call Option for the stock: TCS.NS



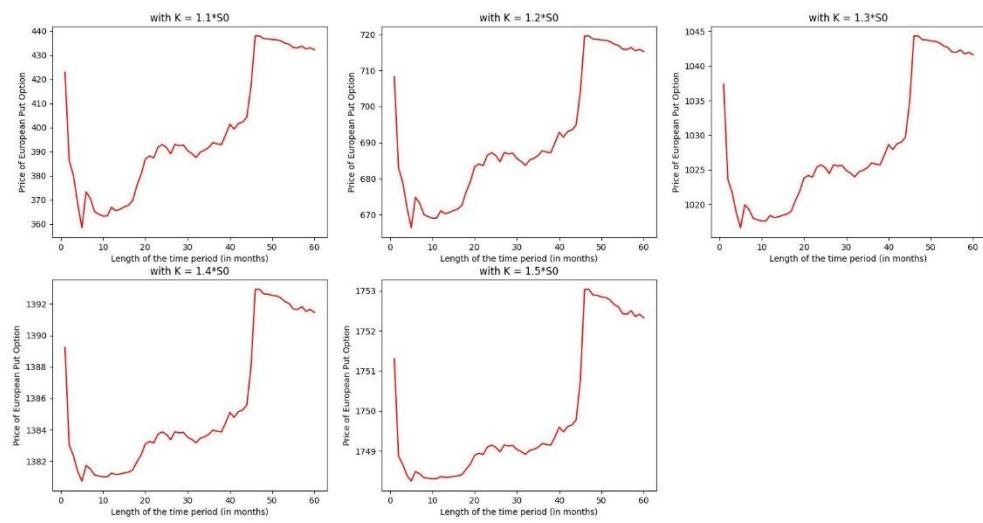
Prices of European Call Option for the stock: TCS.NS



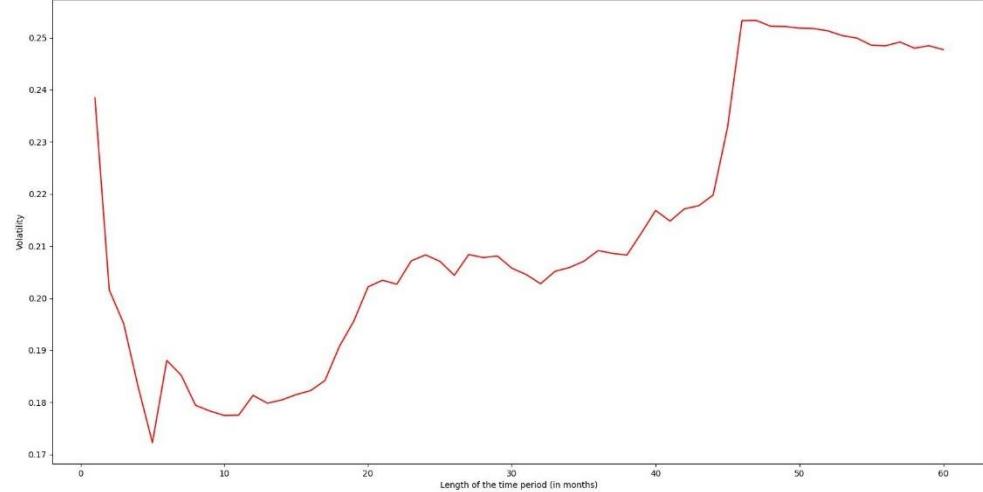
Prices of European Put Option for the stock TCS.NS



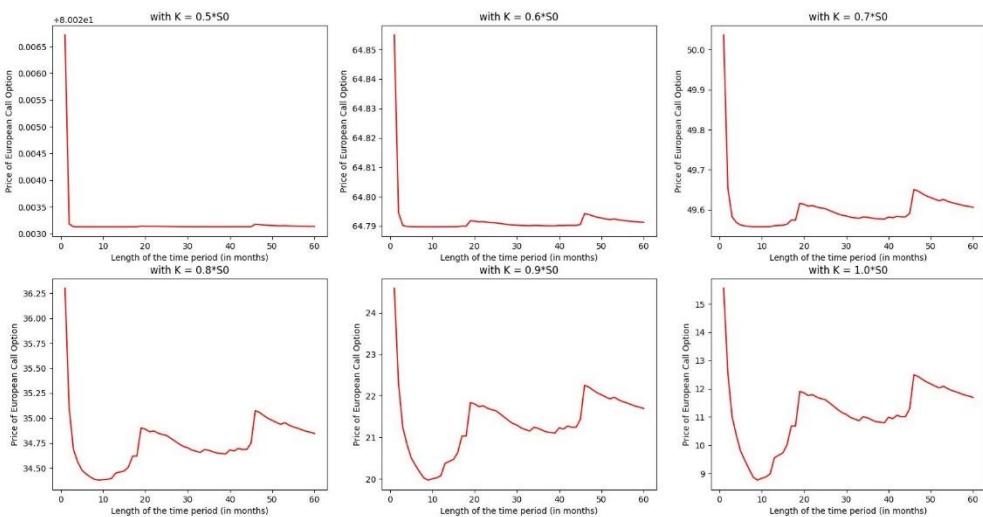
Prices of European Put Option for the stock TCS.NS



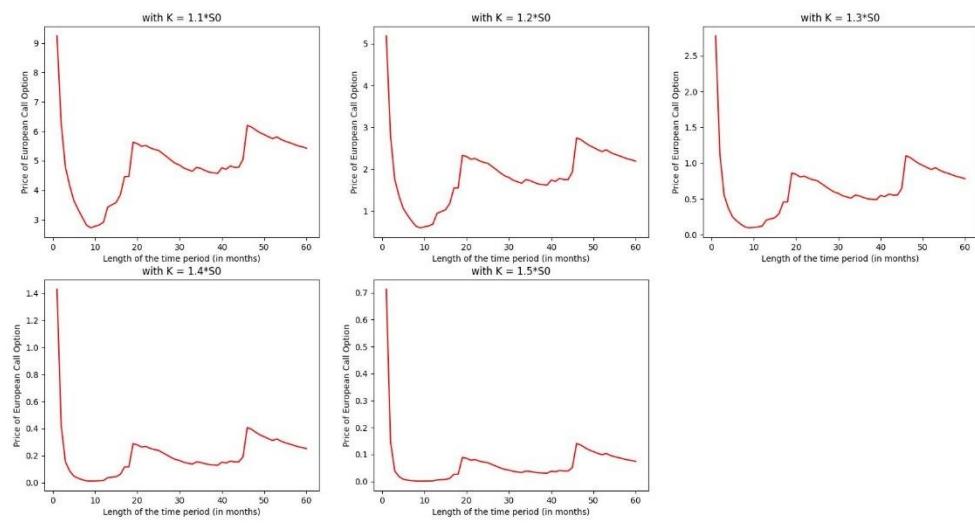
Historical Volatility versus time period for the stock: TCS.NS



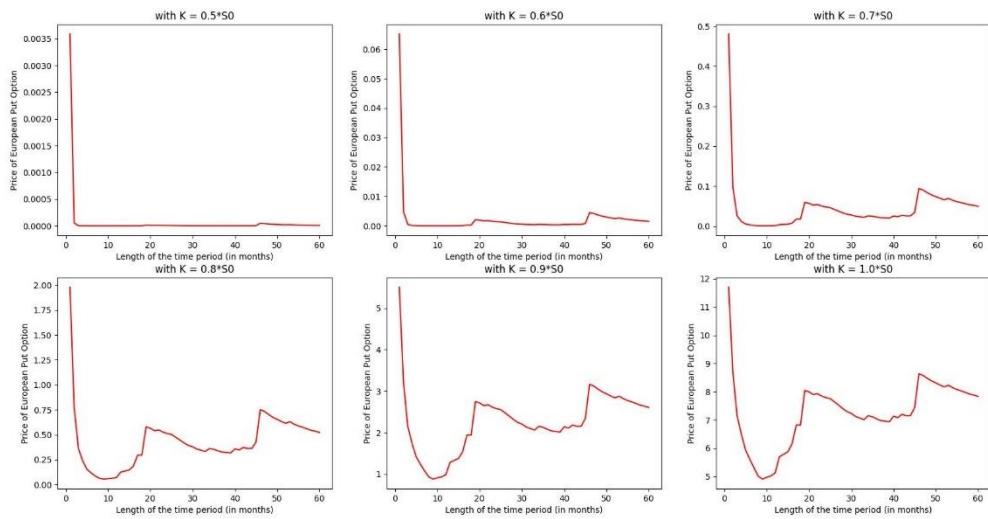
Prices of European Call Option for the stock: WMT

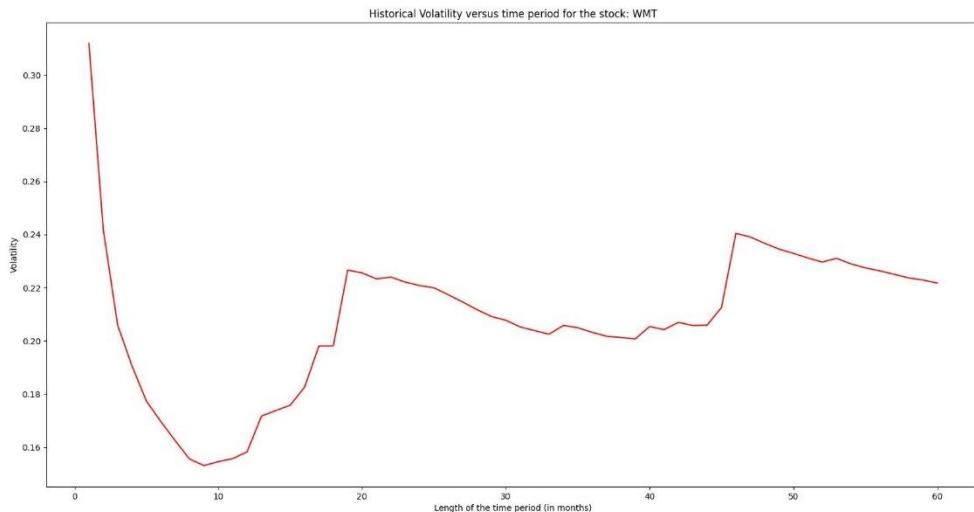
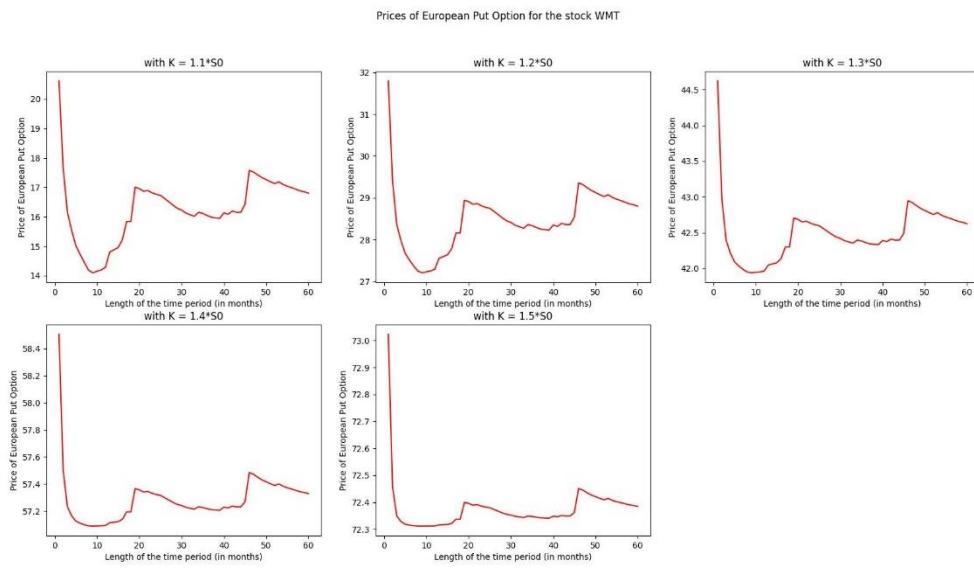


Prices of European Call Option for the stock: WMT



Prices of European Put Option for the stock WMT





## Question 2:

2. Collect the data of option prices on NIFTY index for a time interval depending on the availability of data (going backwards from March 29, 2023). The data at each time point should comprise of prices of calls and puts of various maturities and strike prices. Put all these data in an Excel file and name it as “NIFTYoptiondata”.

The collected data is in the file NIFTYoptiondata.csv