MA374 – Financial Engineering Laboratory

Lab – 09

Dipanshu Goyal 210123083

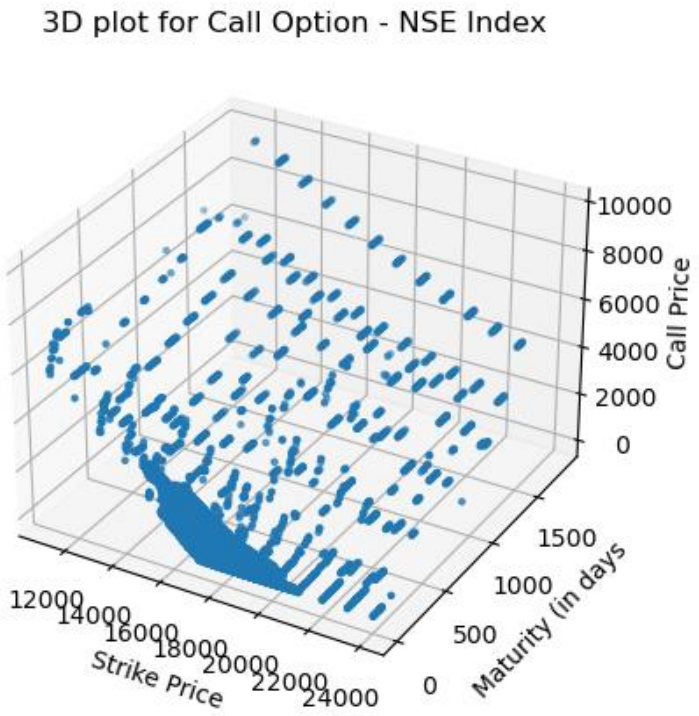
Ques – 1

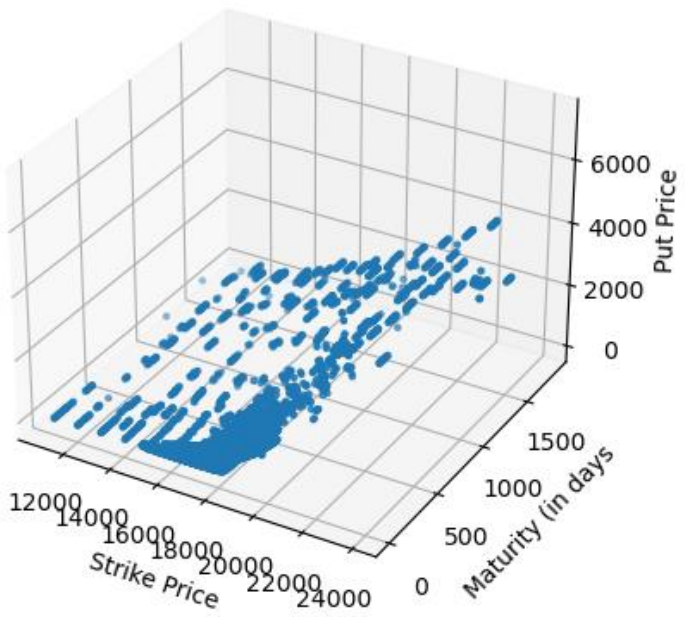
Data for the following companies are taken for analysis: -

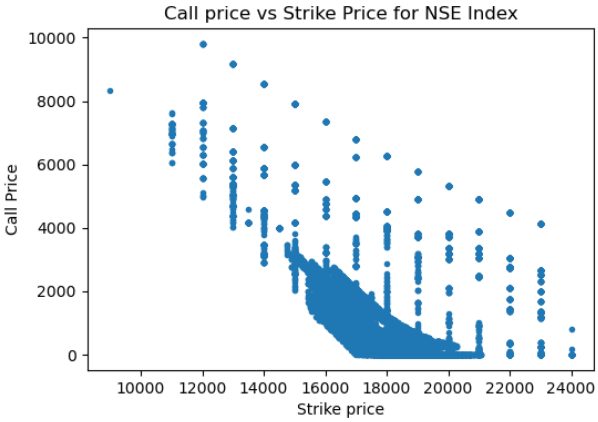
1. Ambuja Cements
2. Apollo Hospitals
3. InterGlobe Aviation
4. Maruti Suzuki
5. TCS
6. NSE Index

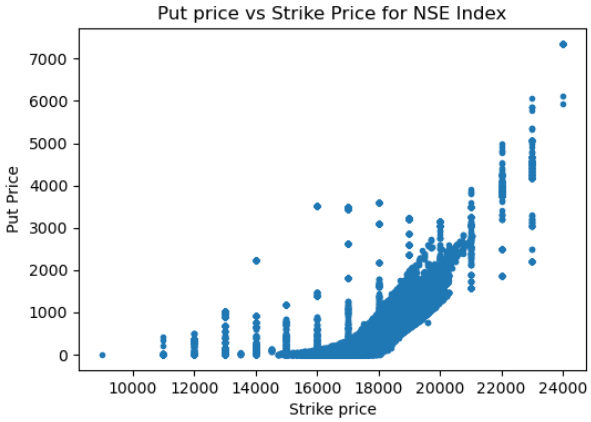
Ques – 2(a)

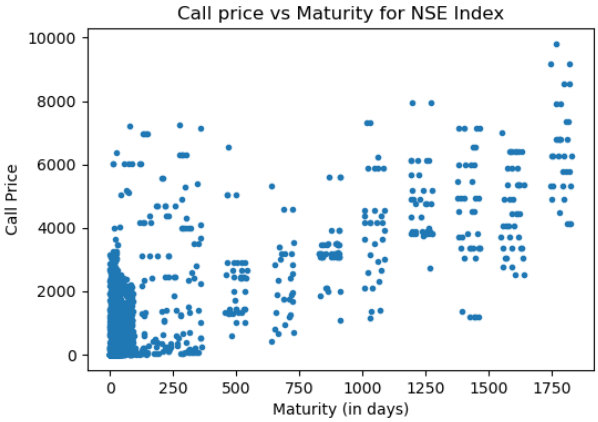
i. Nifty50

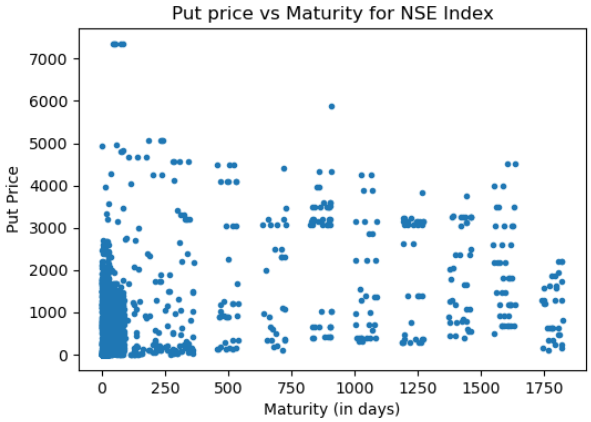



3D plot for Put Option - NSE Index
Put Price
6000
4000
2000
0
Maturity (in days
1500
1000
500
0
Strike Price
12000
14000
16000
18000
20000
22000
24000

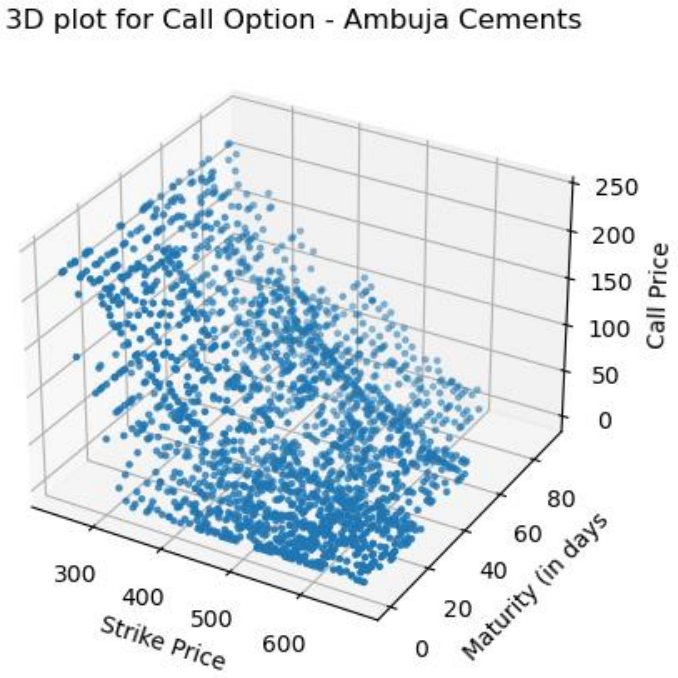

Call price vs Strike Price for NSE Index
Call Price
Strike price

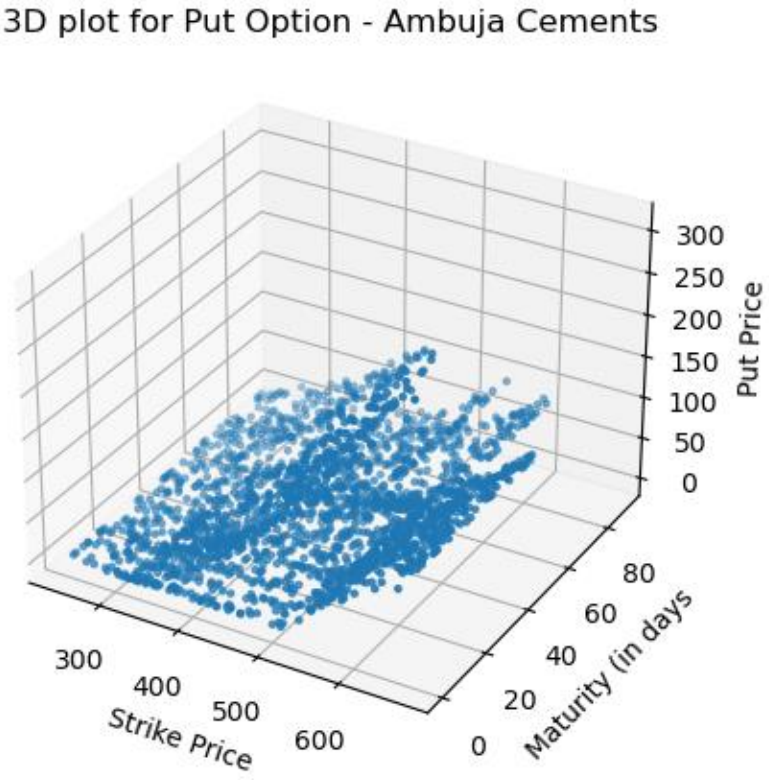

Put price vs Strike Price for NSE Index
Put Price
Strike price

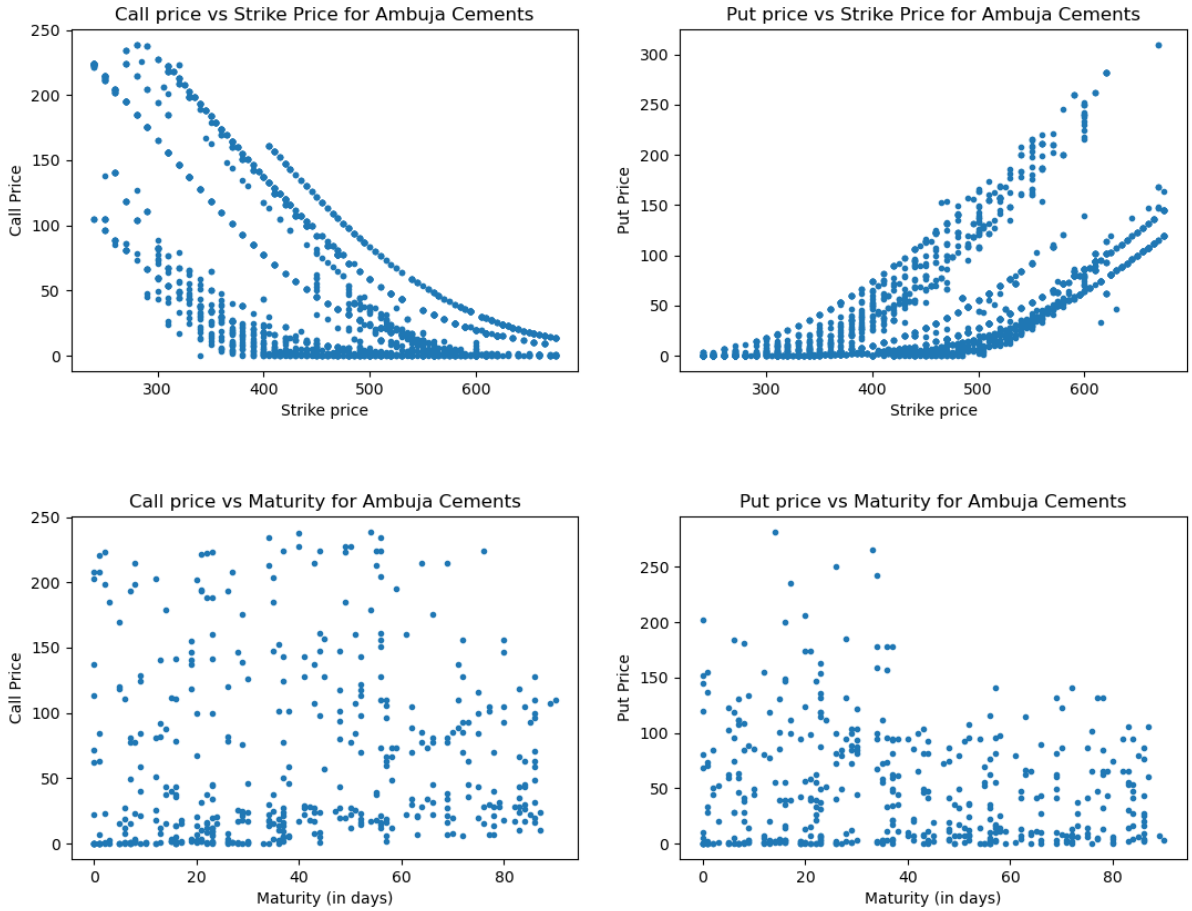

Call price vs Maturity for NSE Index
Call Price
Maturity (in days)


Put price vs Maturity for NSE Index
Put Price
Maturity (in days)

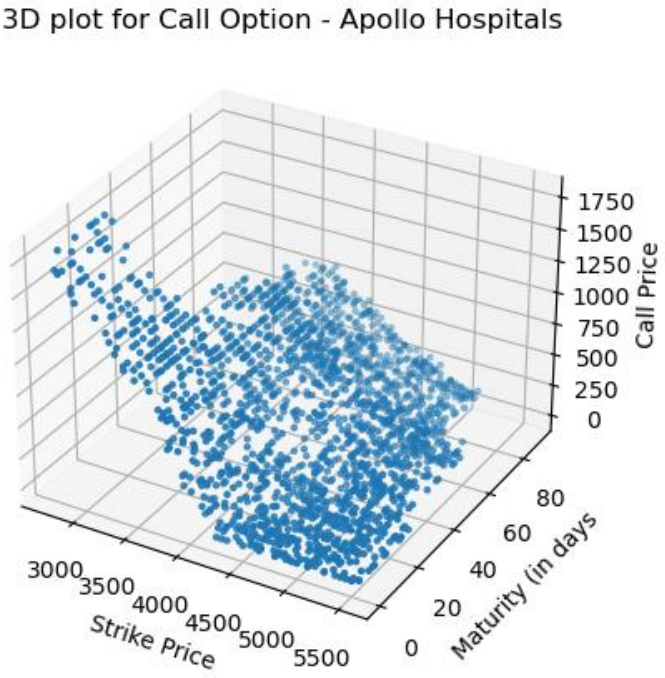
ii. Ambuja Cements

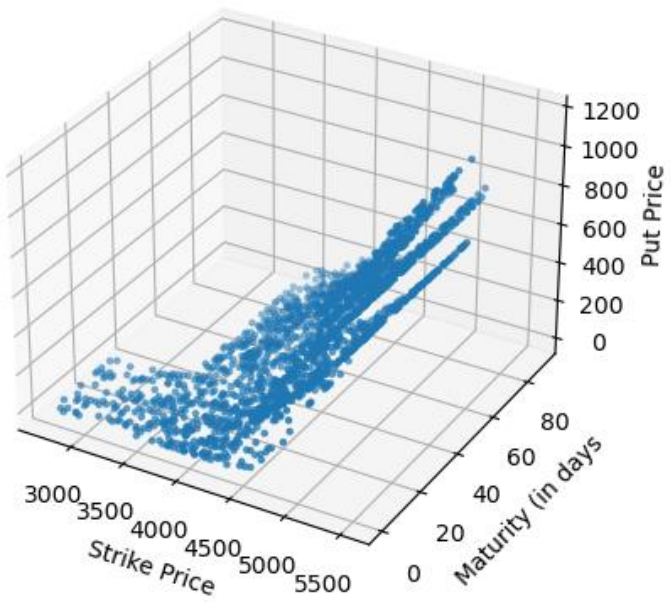


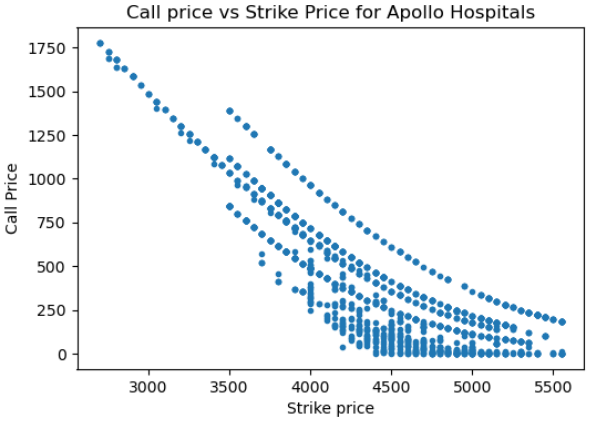


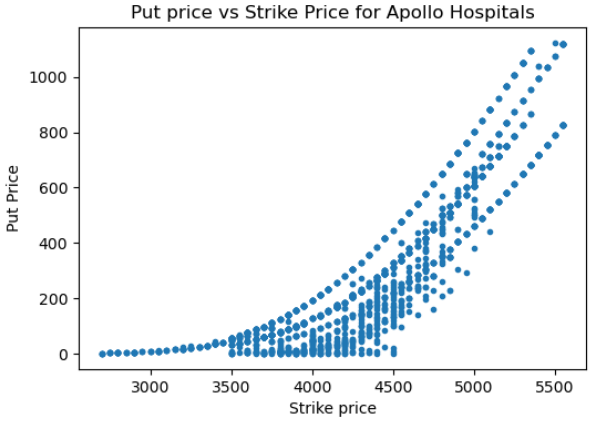


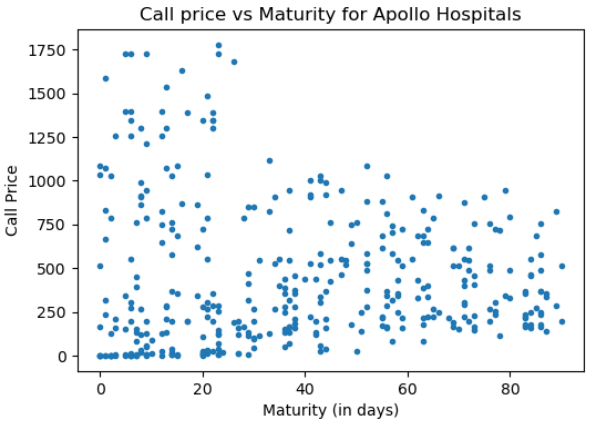
iii. Apollo Hospitals

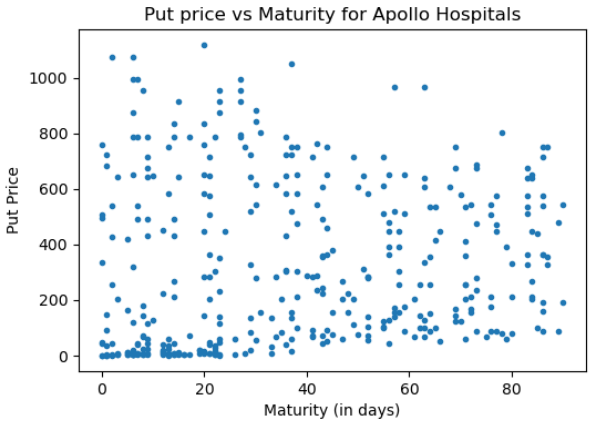



3D plot for Put Option - Apollo Hospitals
Put Price
Strike Price
Maturity (in days

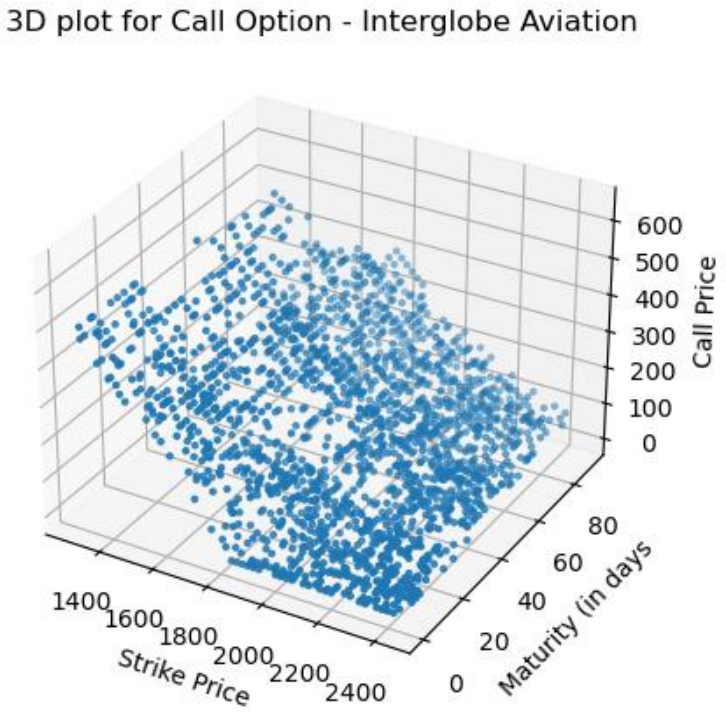

Call price vs Strike Price for Apollo Hospitals
Call Price
Strike price

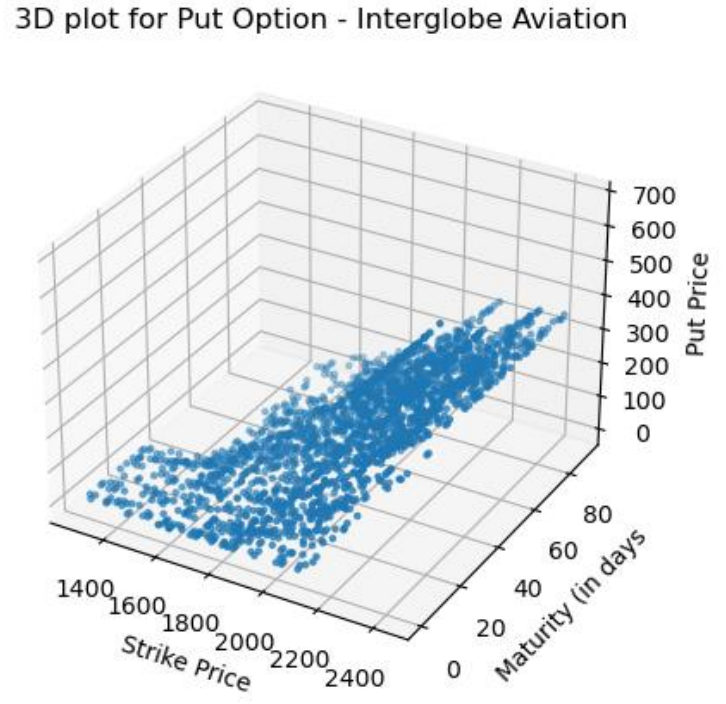

Put price vs Strike Price for Apollo Hospitals
Put Price
Strike price

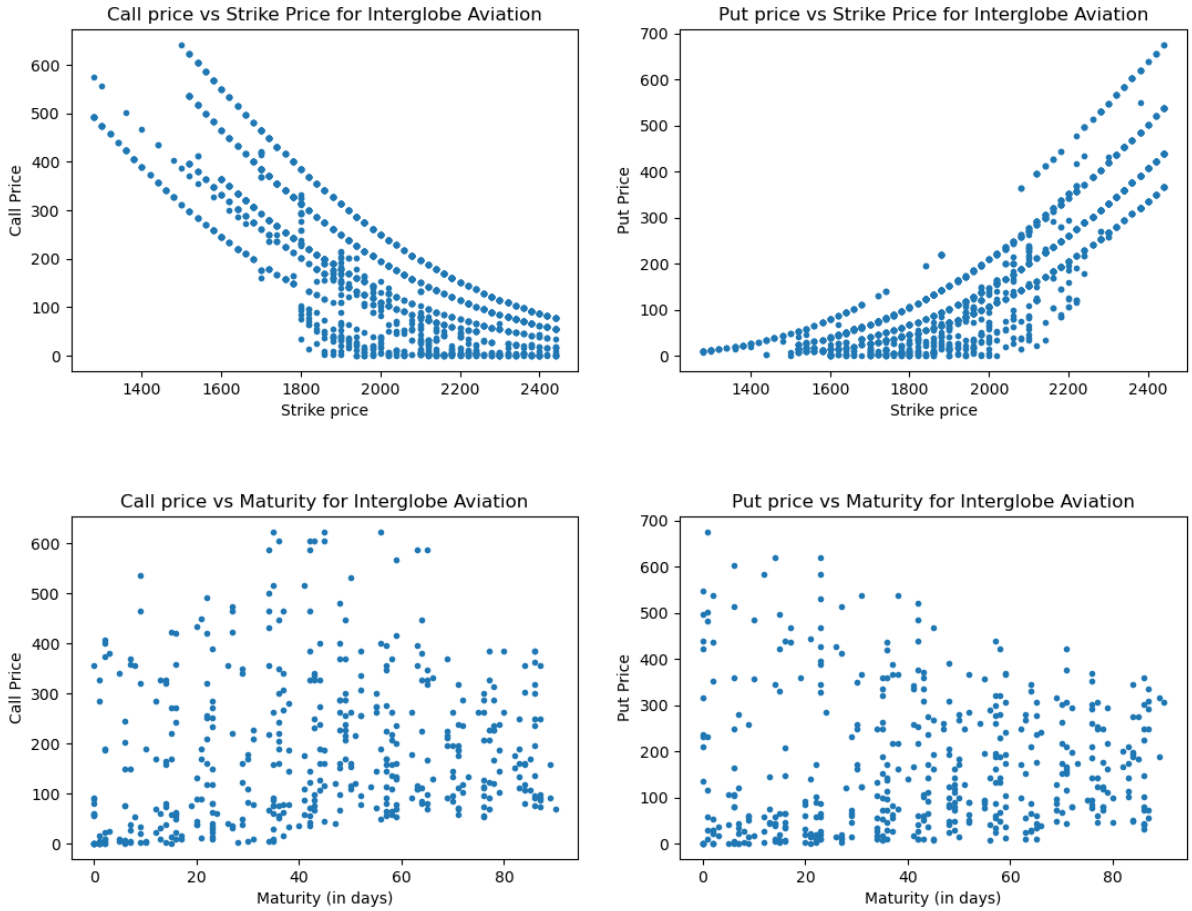

Call price vs Maturity for Apollo Hospitals
Call Price
Maturity (in days)


Put price vs Maturity for Apollo Hospitals
Put Price
Maturity (in days)

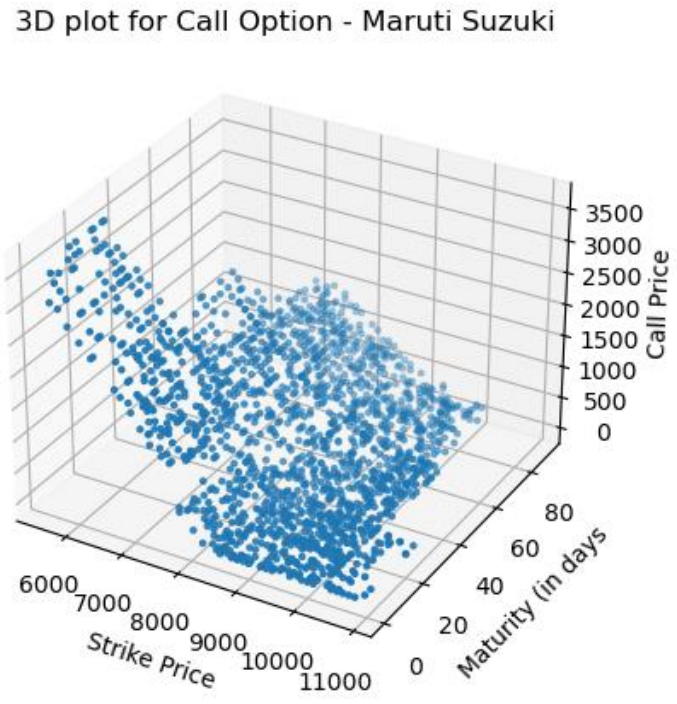
iv. InterGlobe Aviation

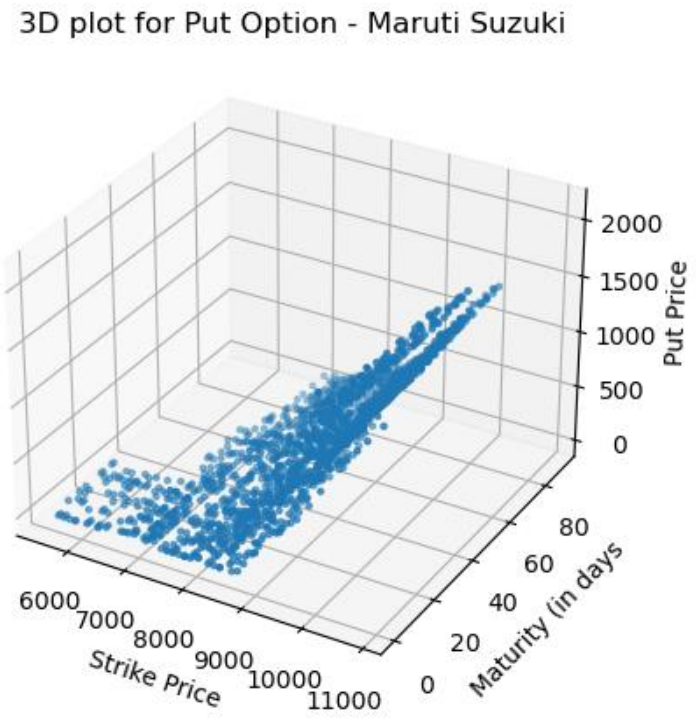


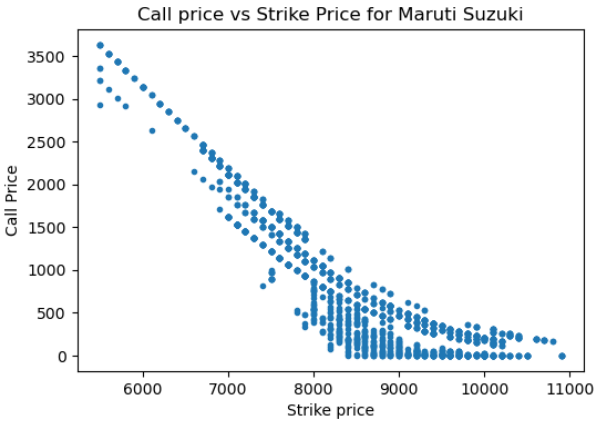


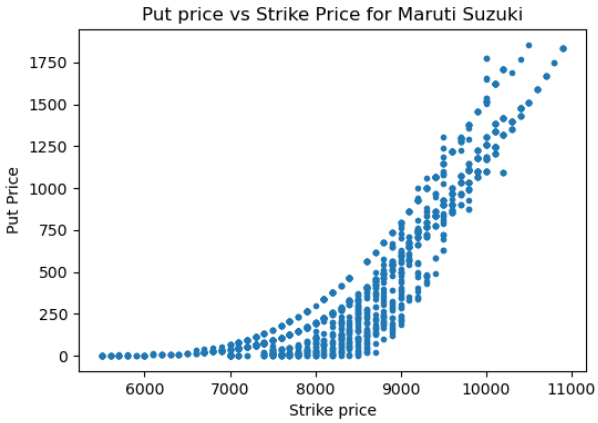


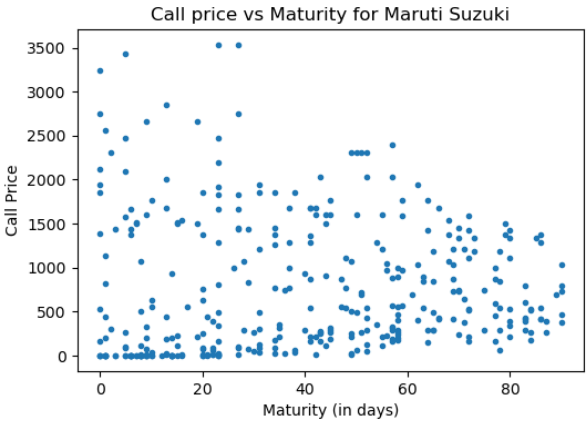
v. Maruti Suzuki

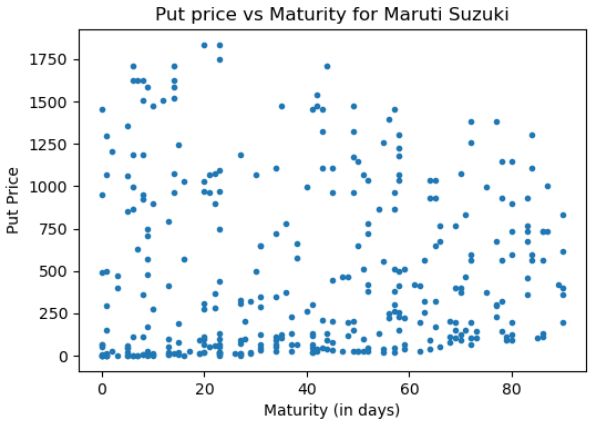



3D plot for Put Option - Maruti Suzuki
Put Price
2000
1500
1000
500
0
Maturity (in days
80
60
40
20
0
Strike Price
6000
7000
8000
9000
10000
11000

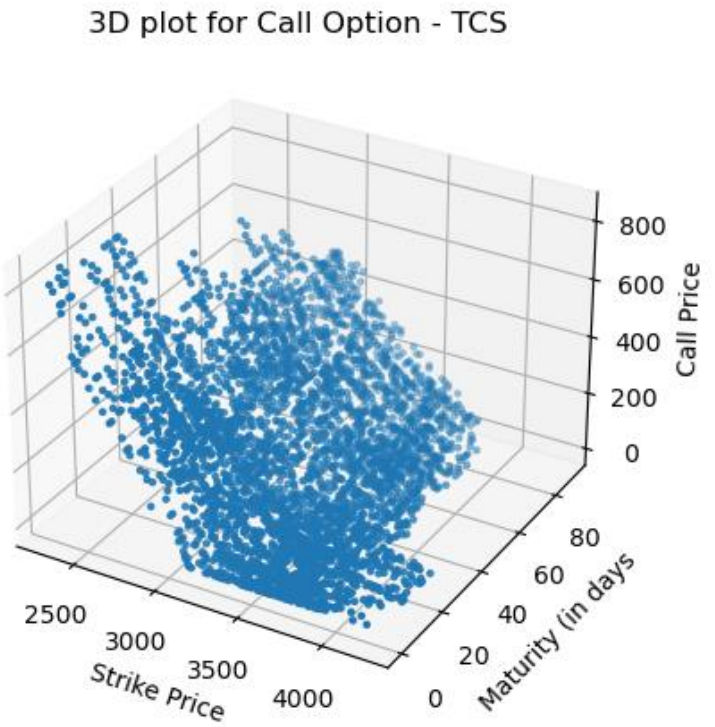

Call price vs Strike Price for Maruti Suzuki
Call Price
Strike price

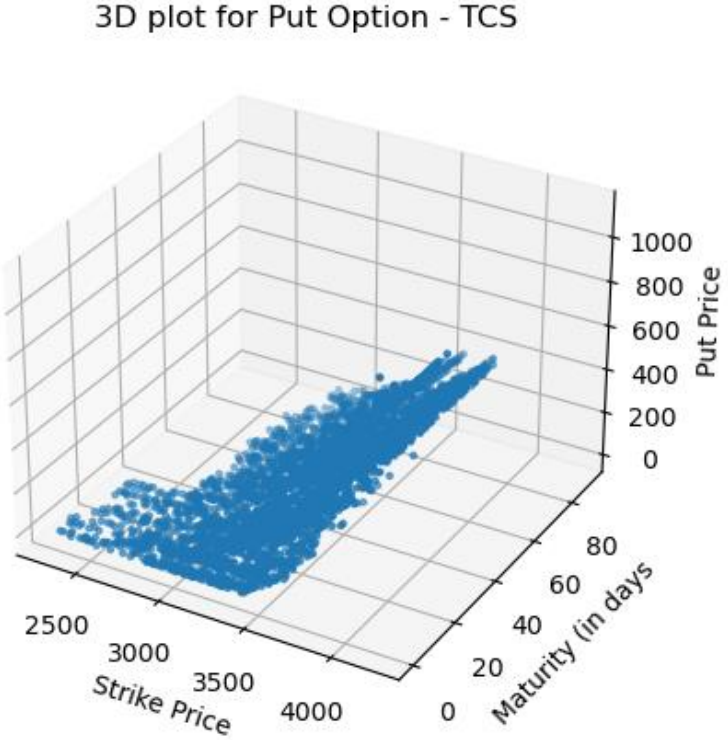

Put price vs Strike Price for Maruti Suzuki
Put Price
Strike price

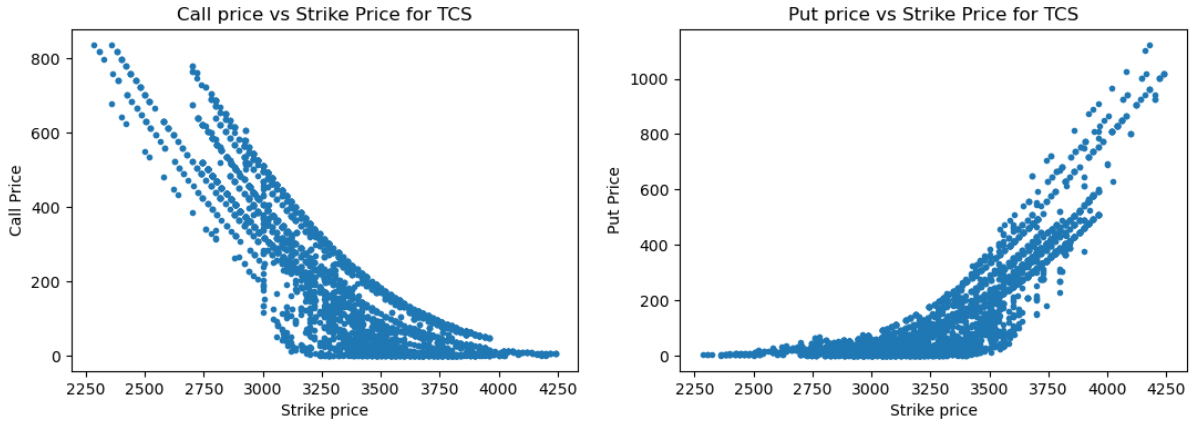

Call price vs Maturity for Maruti Suzuki
Call Price
Maturity (in days)

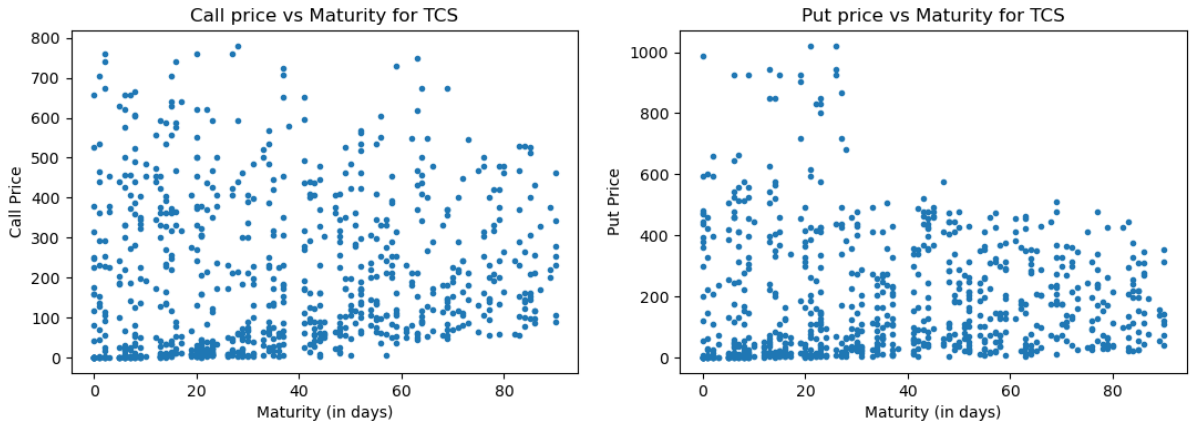

Put price vs Maturity for Maruti Suzuki
Put Price
Maturity (in days)

vi. TCS


3D plot for Call Option - TCS
Call Price
800
600
400
200
0
Strike Price
2500
3000
3500
4000
Maturity (in days
0
20
40
60
80


3D plot for Put Option - TCS
Put Price
1000
800
600
400
200
0
Strike Price
2500
3000
3500
4000
Maturity (in days
0
20
40
60
80





Observations: -

1. We can observe that the price of call option decreases and that of put option increases with an increase in strike price.
2. But the plot for call option and put option doesn't exactly match with our expectations. The general trend is that the price of call option tends to increase while that of put option tends to decrease with an increase in maturity period.

Ques – 2(b)

Newton-Raphson method is used to find out the implied volatility from the BSM formula.

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

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

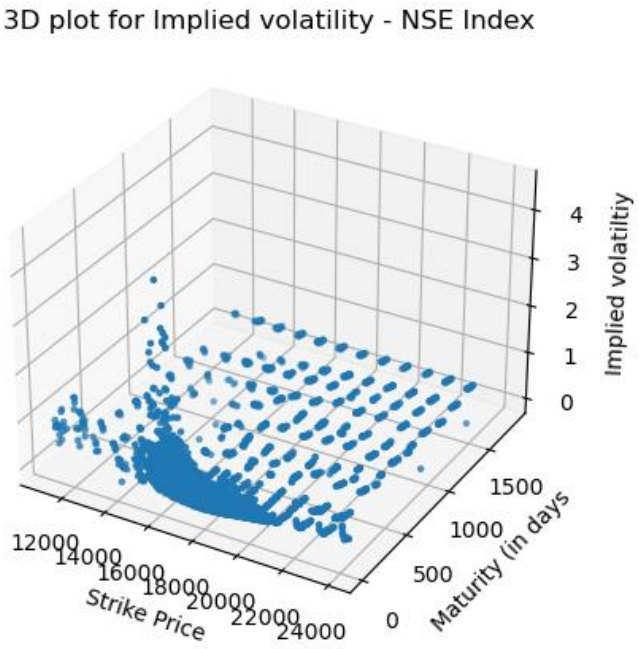
where,

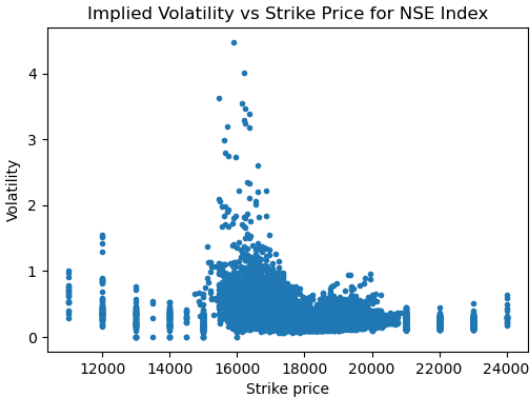
$$d_1 = \frac{\log\left(\frac{x}{K}\right) + (r + \frac{1}{2}\sigma^2)(T-t)}{\sigma\sqrt{T-t}}$$

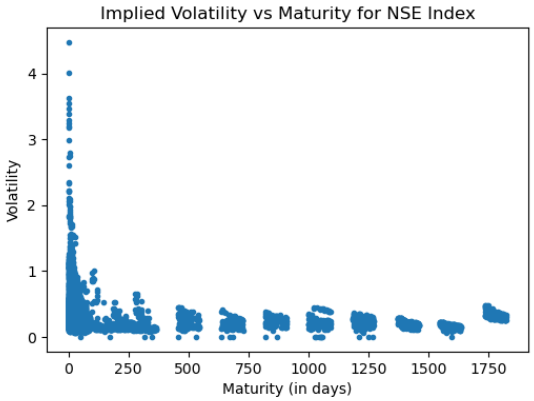
$$d_2 = \frac{\log\left(\frac{x}{K}\right) + (r - \frac{1}{2}\sigma^2)(T-t)}{\sigma\sqrt{T-t}}$$

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

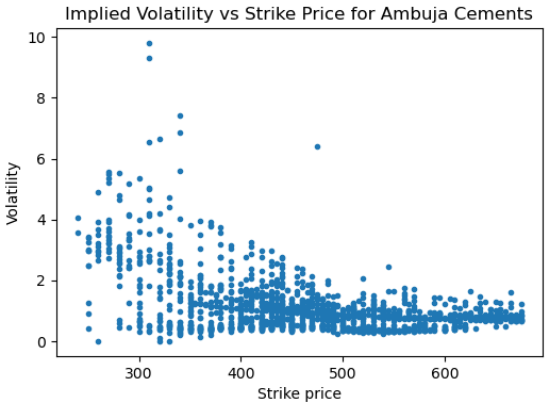
i. Nifty50

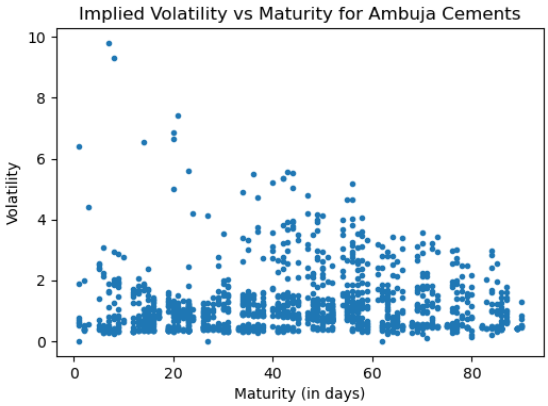


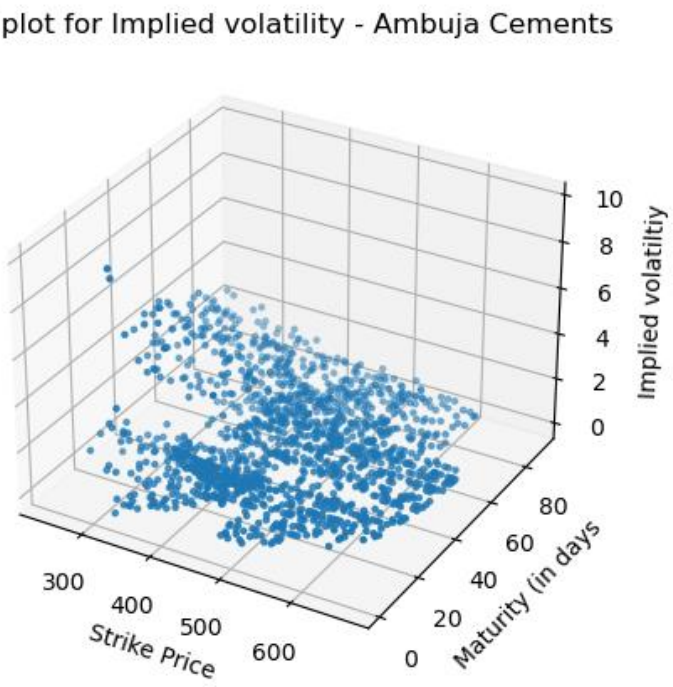




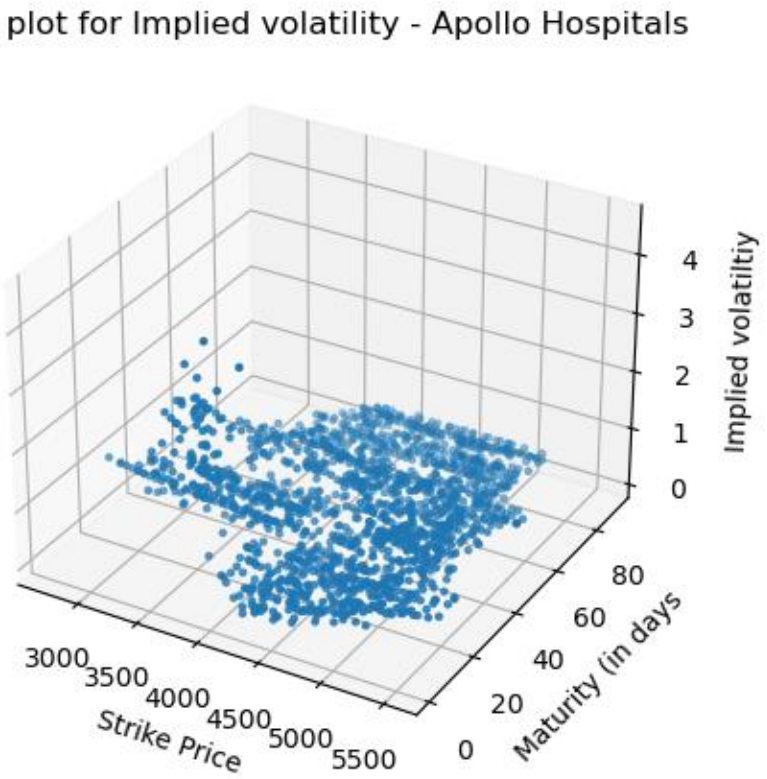
ii. Ambuja Cements

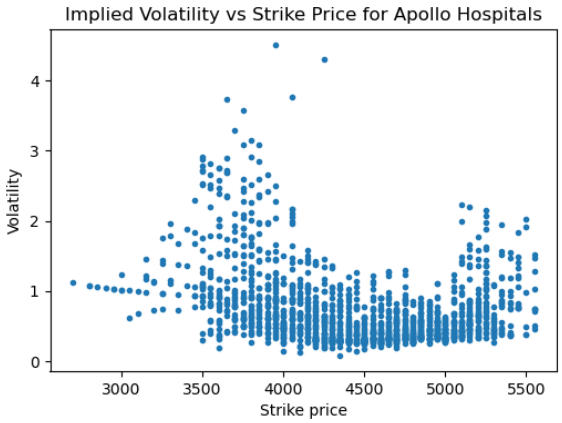


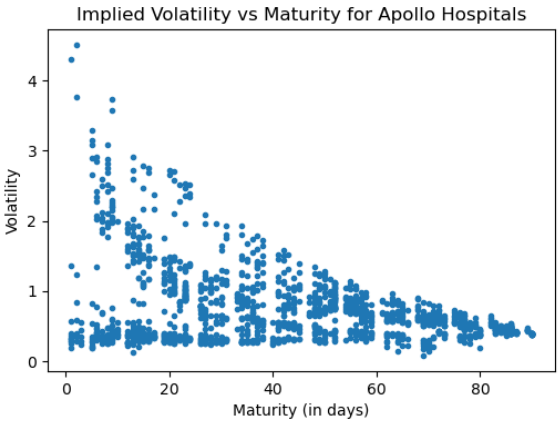




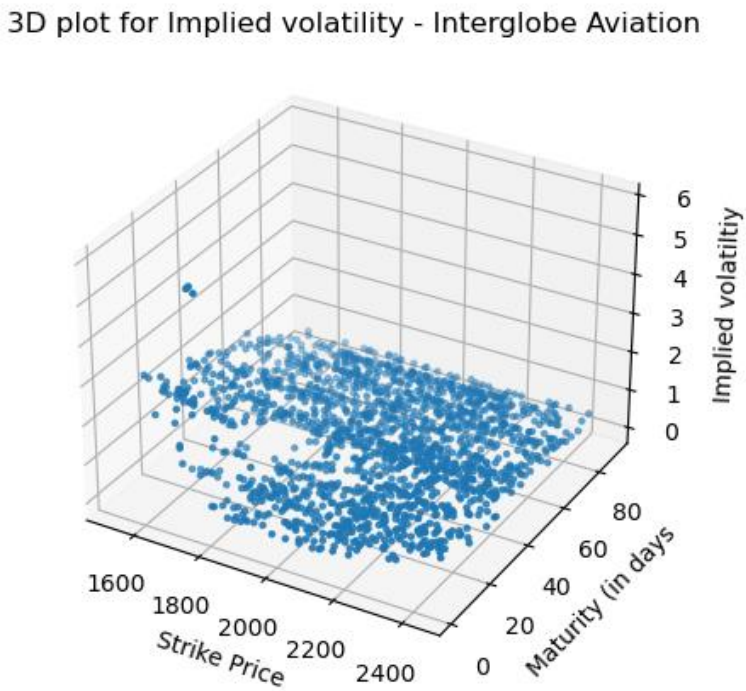
iii. Apollo Hospitals

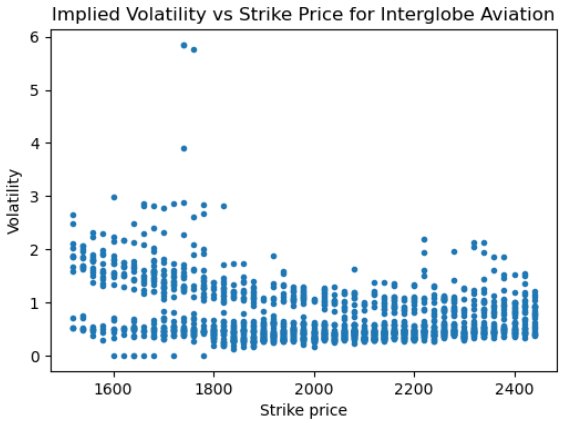


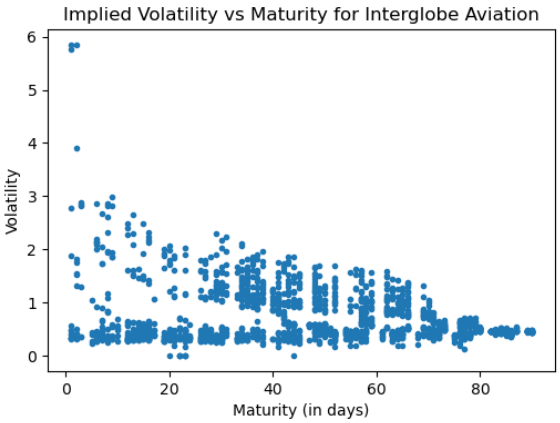




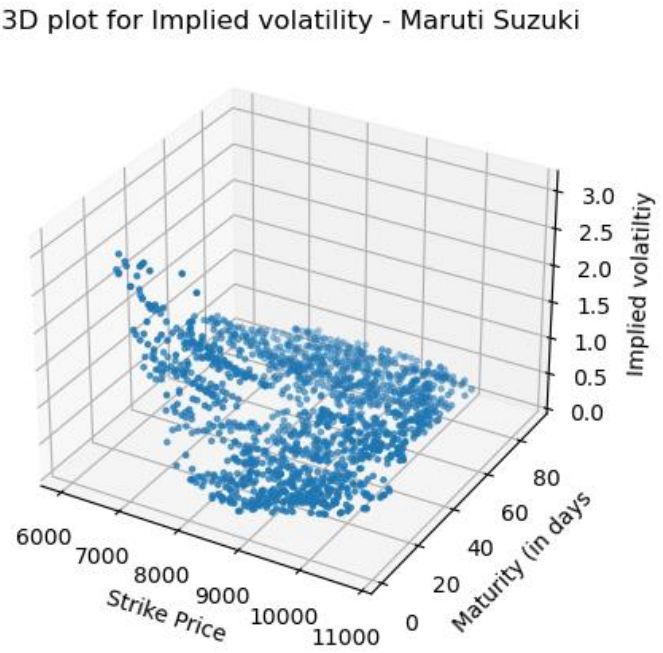
iv. InterGlobe Aviation

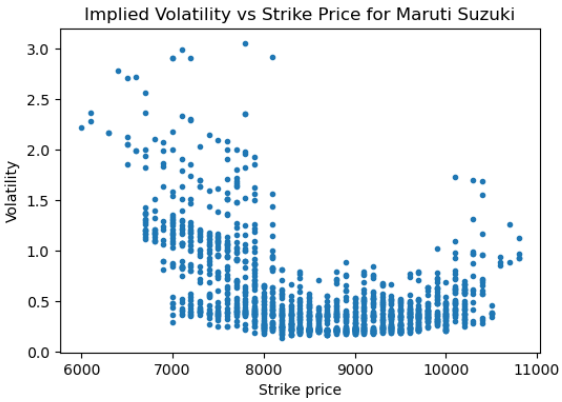


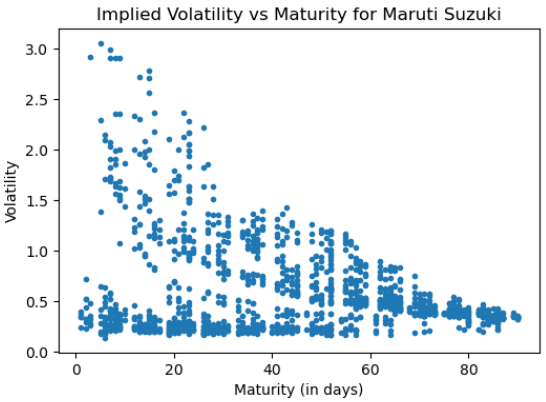




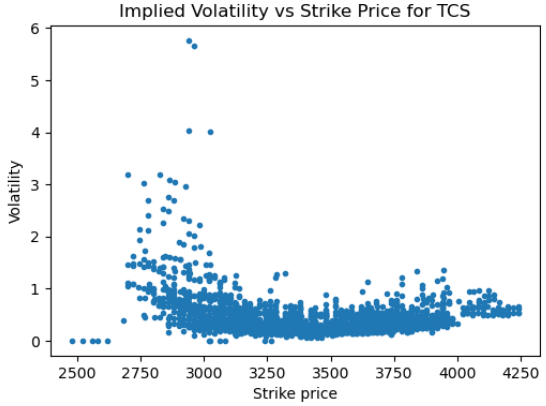
v. Maruti Suzuki

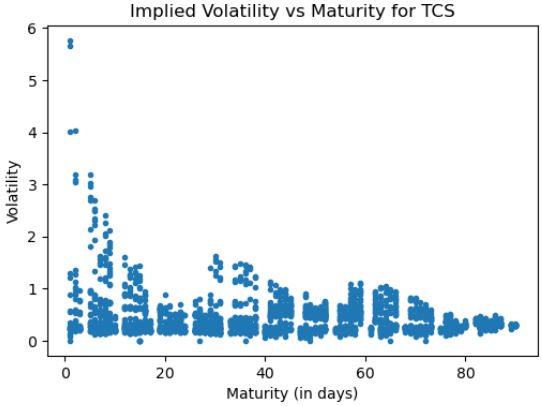


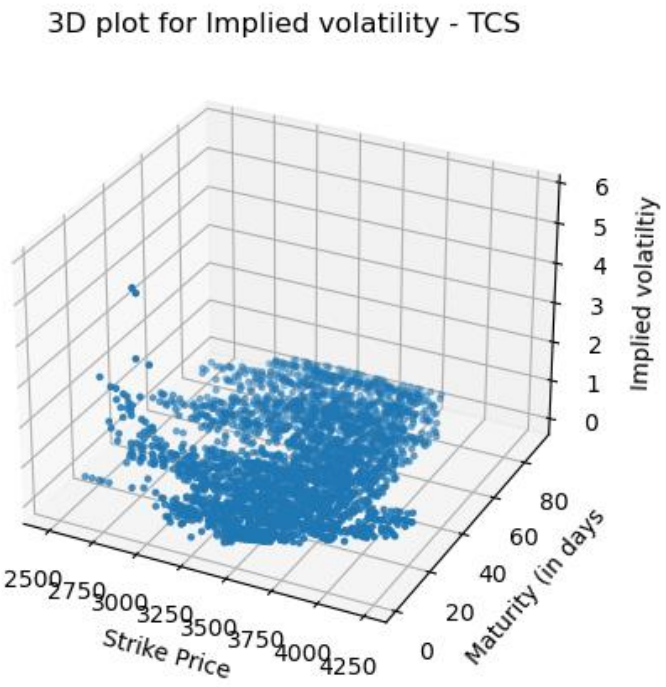




vi. TCS





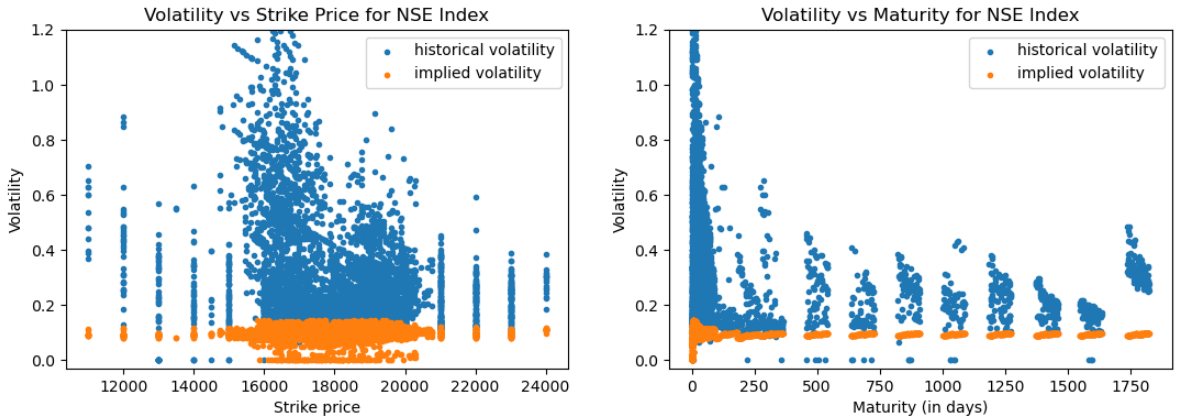


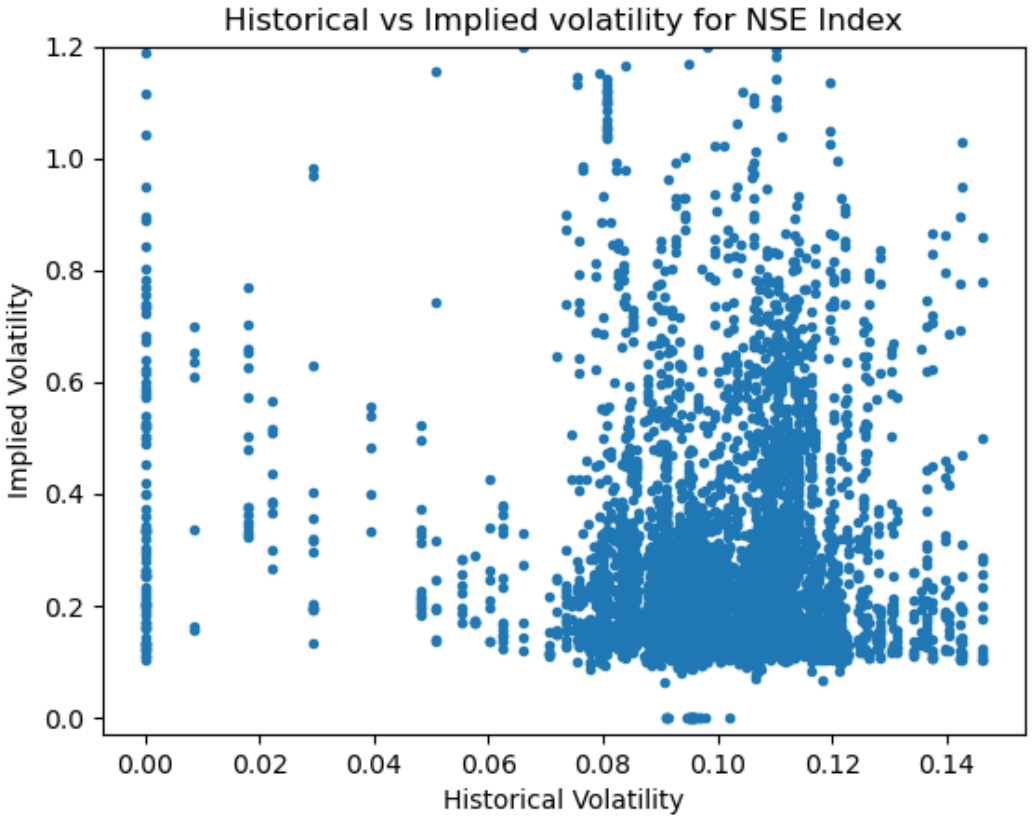
<u>Observations</u>: -

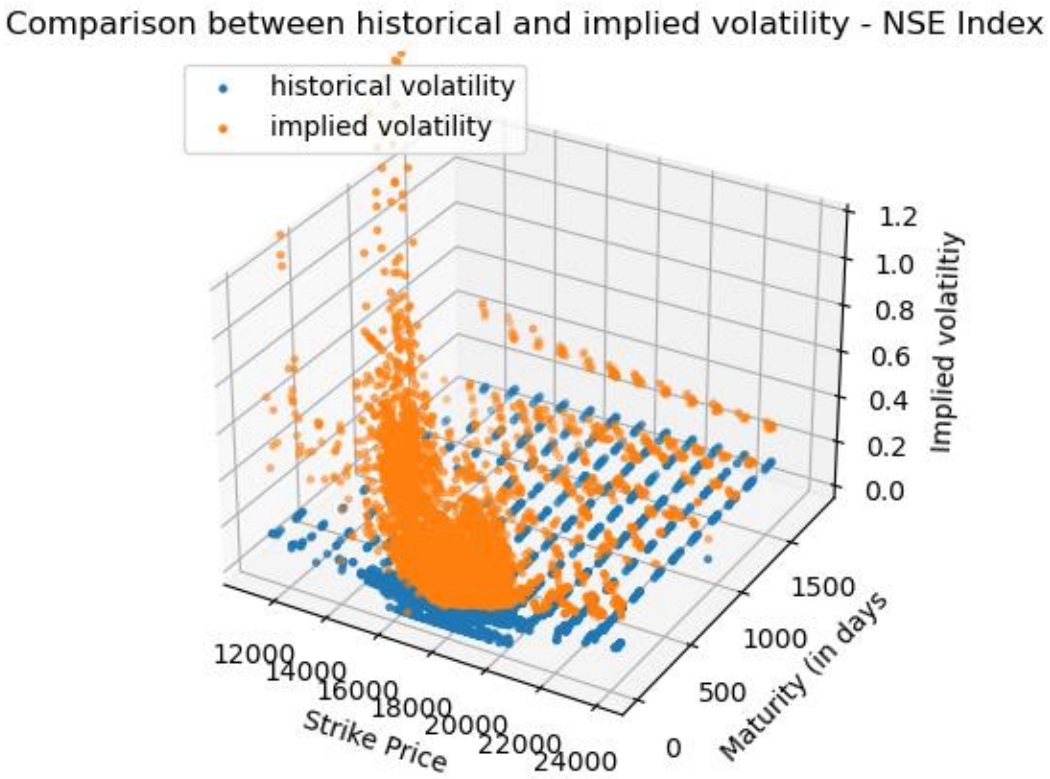
1. Theoretically, the implied volatility is generally a convex function of strike price, and the curve so formed is known as the **Volatility Smile**. But this feature is not prominently observed in some of the plotted curves. In some curves, we can observe bit of a smile like shape.
2. The volatility generally tends to decrease for larger maturity values, but for some of the above plots this nature is not very much observed.

Ques – 2(c)

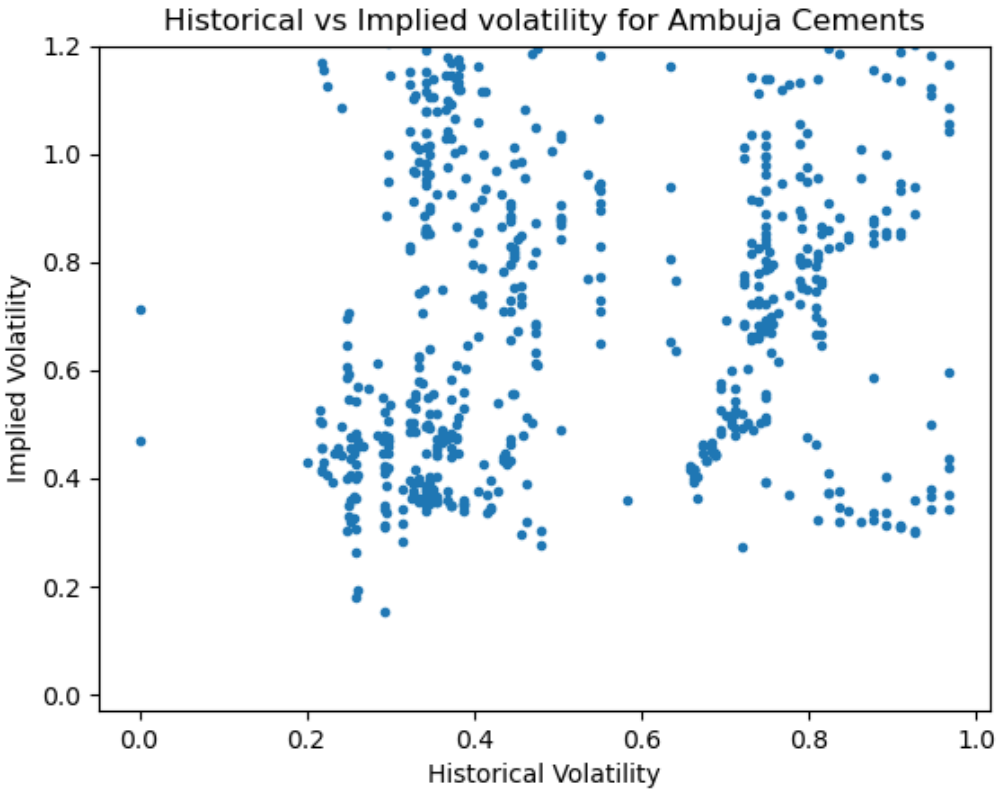
i. Nifty50

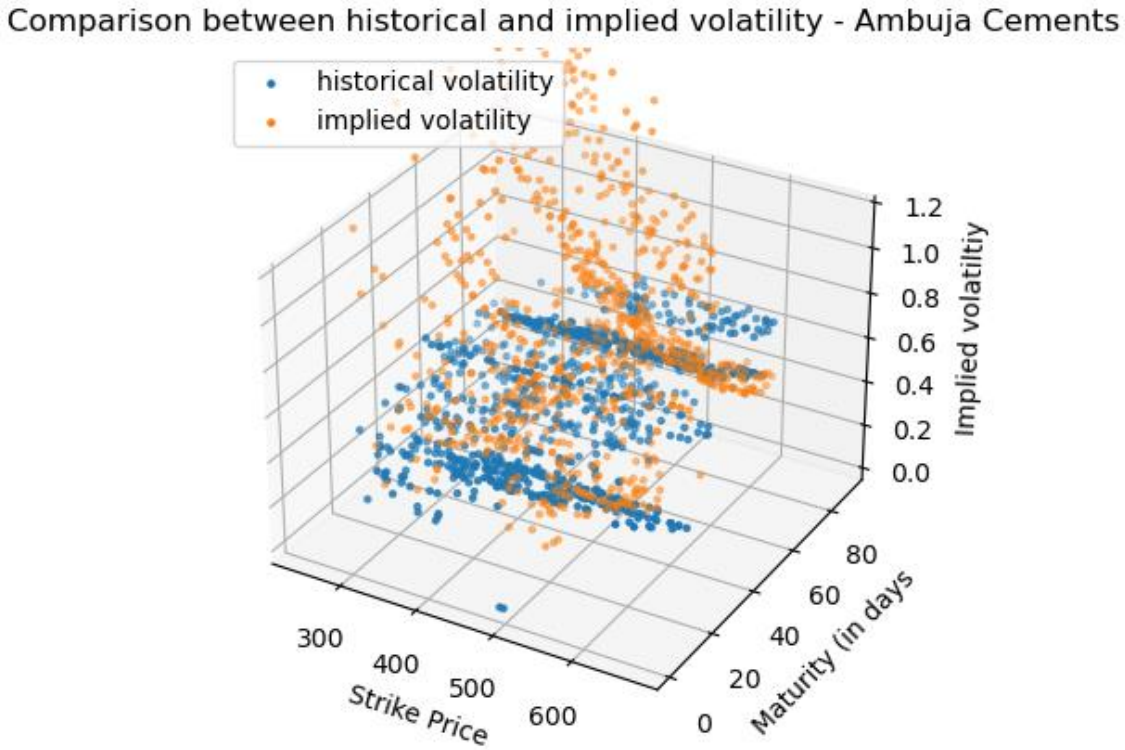


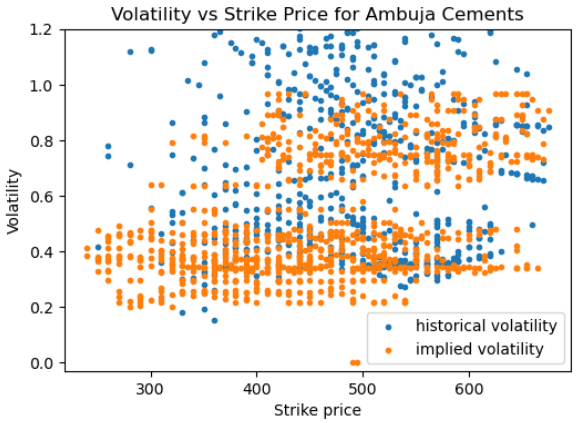

Historical vs Implied volatility for NSE Index
Implied Volatility
Historical Volatility
0.0
0.2
0.4
0.6
0.8
1.0
1.2
0.00
0.02
0.04
0.06
0.08
0.10
0.12
0.14

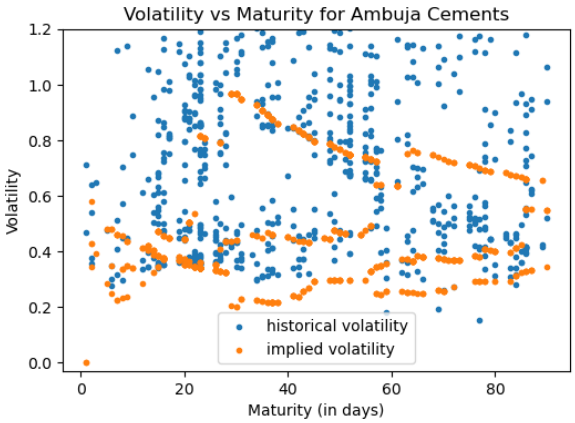

Comparison between historical and implied volatility - NSE Index
historical volatility
implied volatility
Implied volatiltiy
Strike Price
Maturity (in days
12000
14000
16000
18000
20000
22000
24000
0
500
1000
1500
0.0
0.2
0.4
0.6
0.8
1.0
1.2

ii. Ambuja Cements

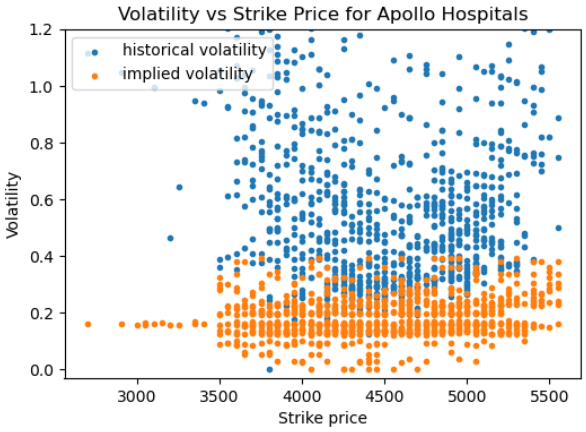


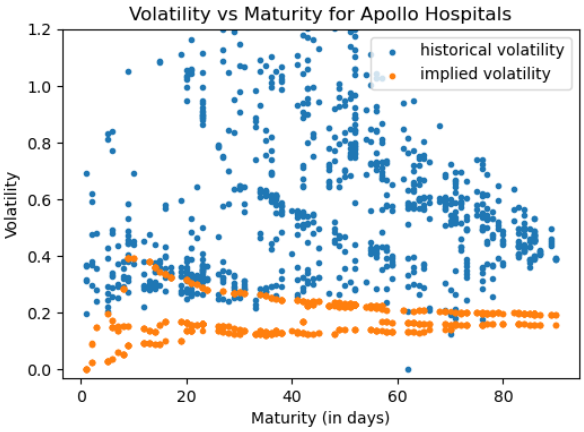


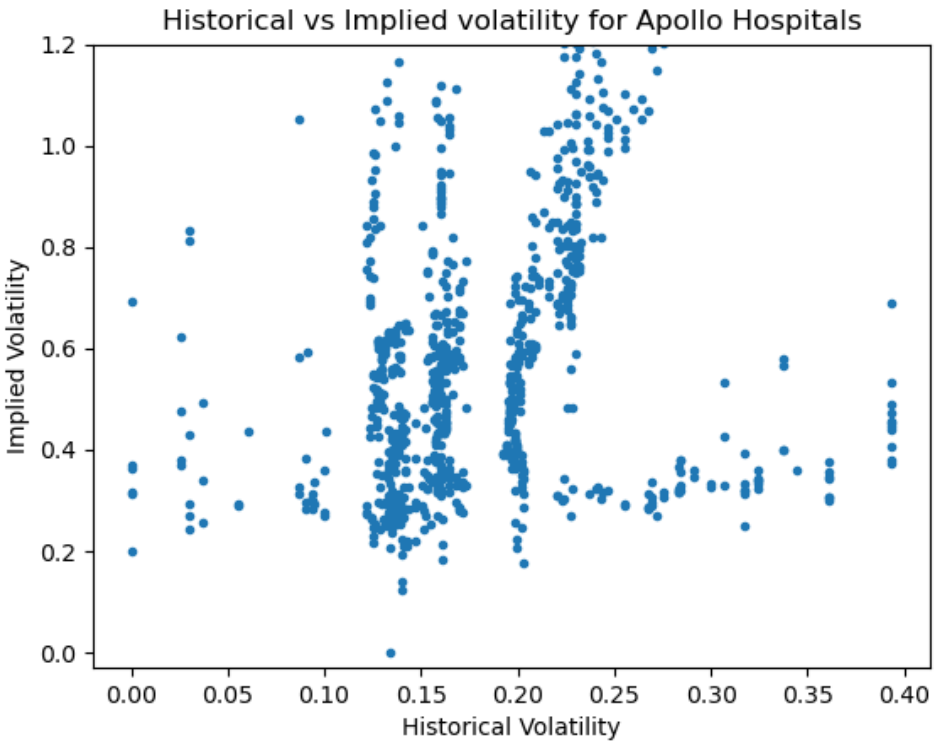


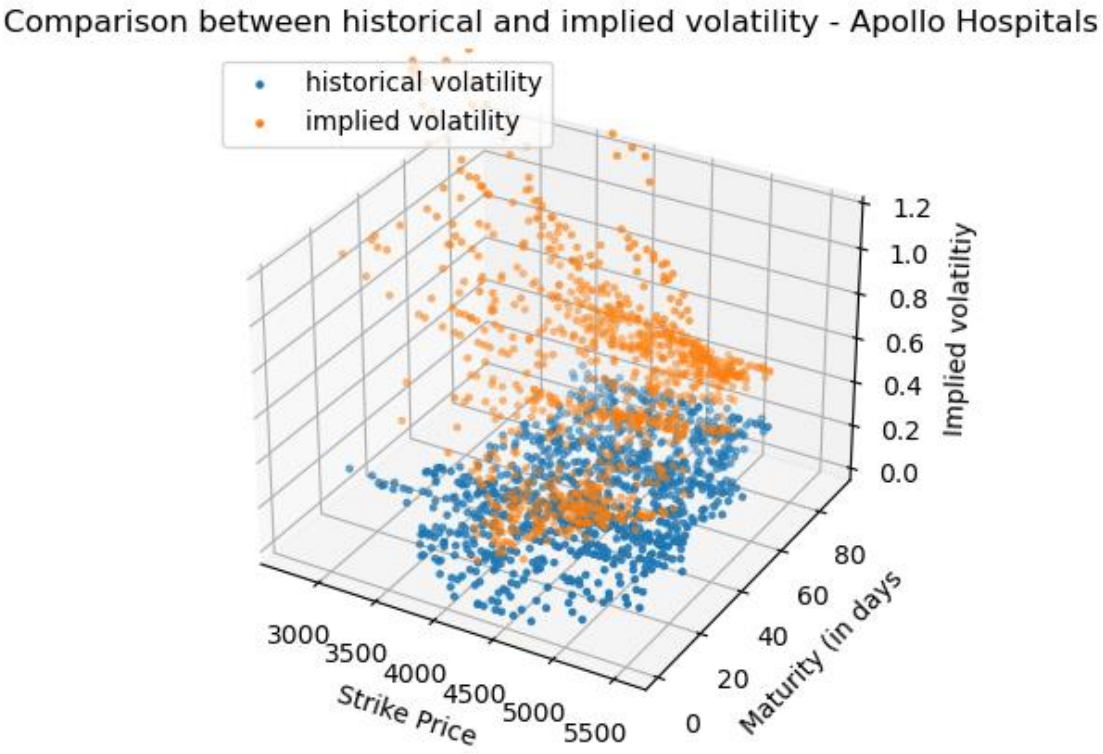


iii. Apollo Hospitals

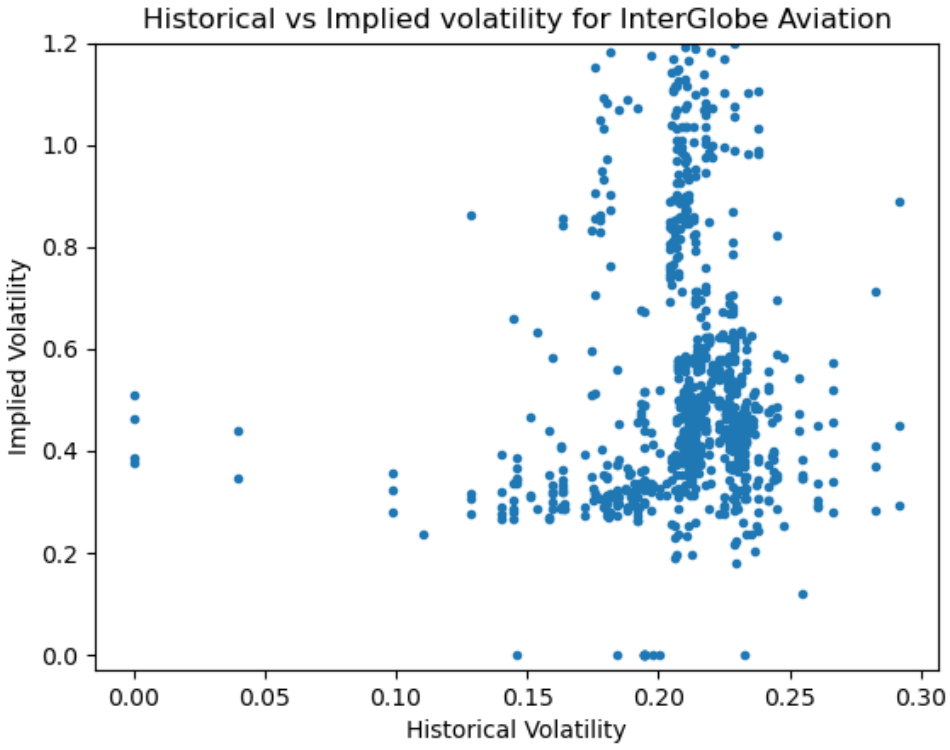


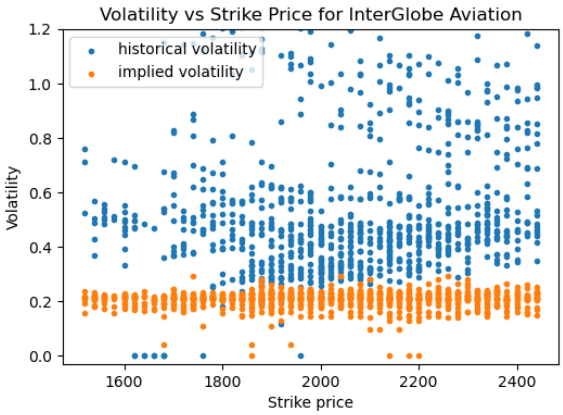


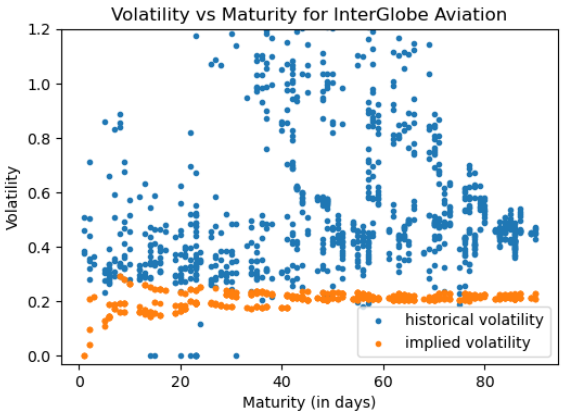


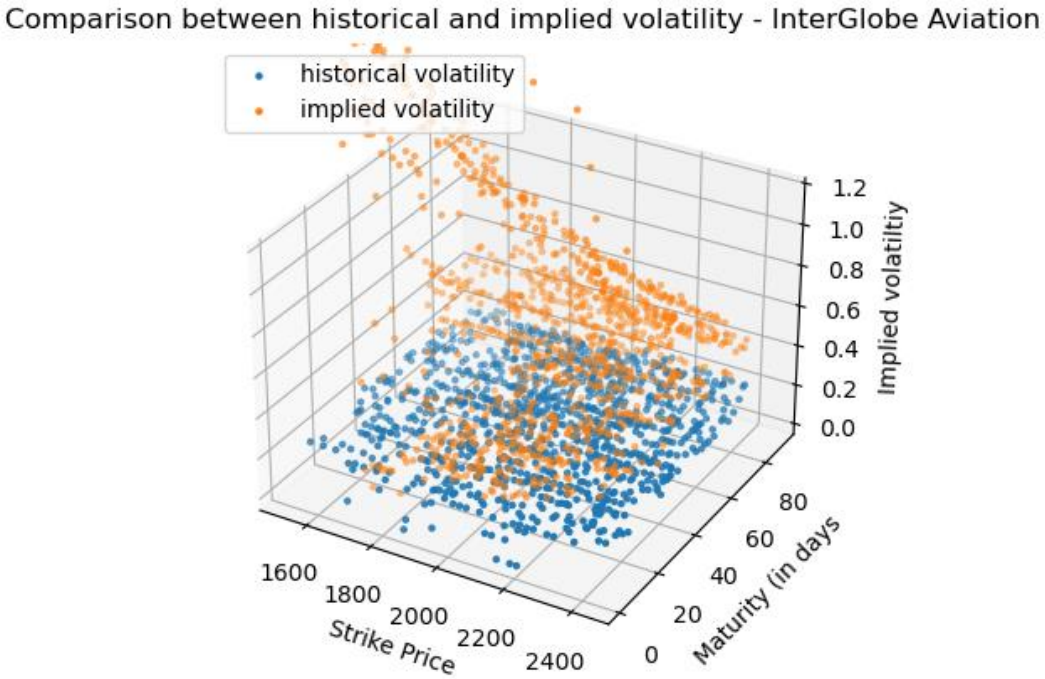


iv. InterGlobe Aviation

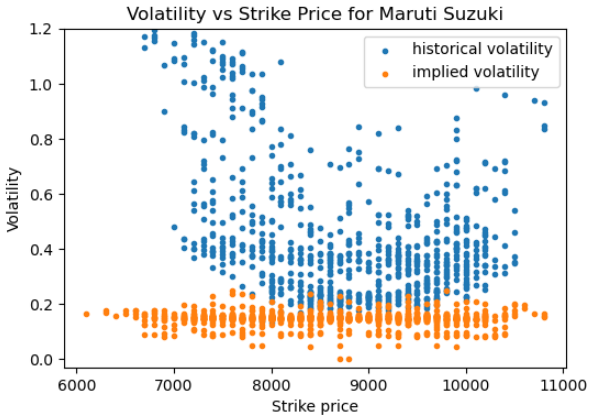


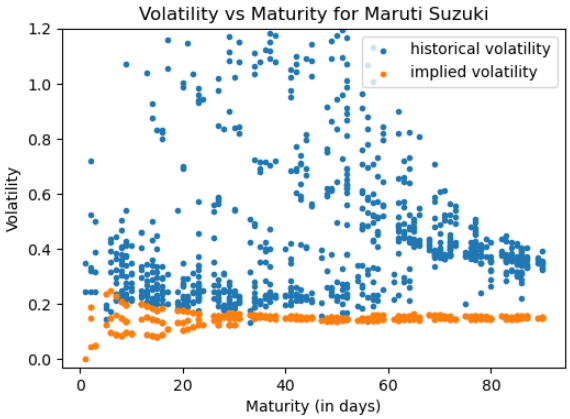


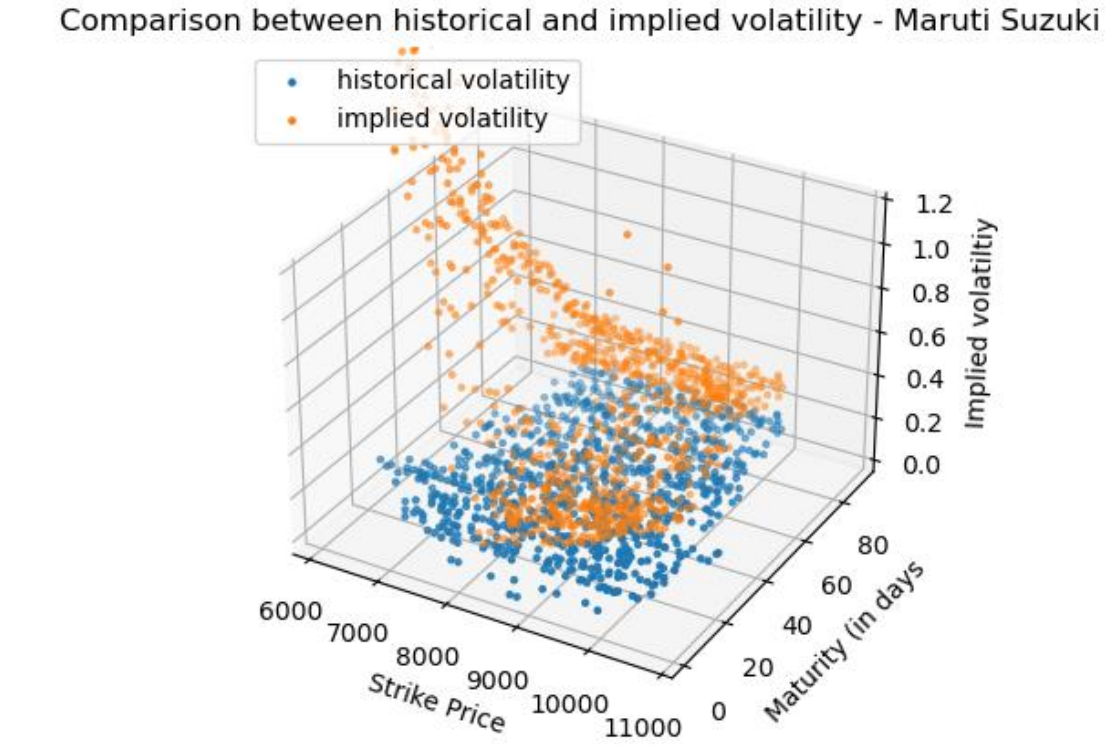


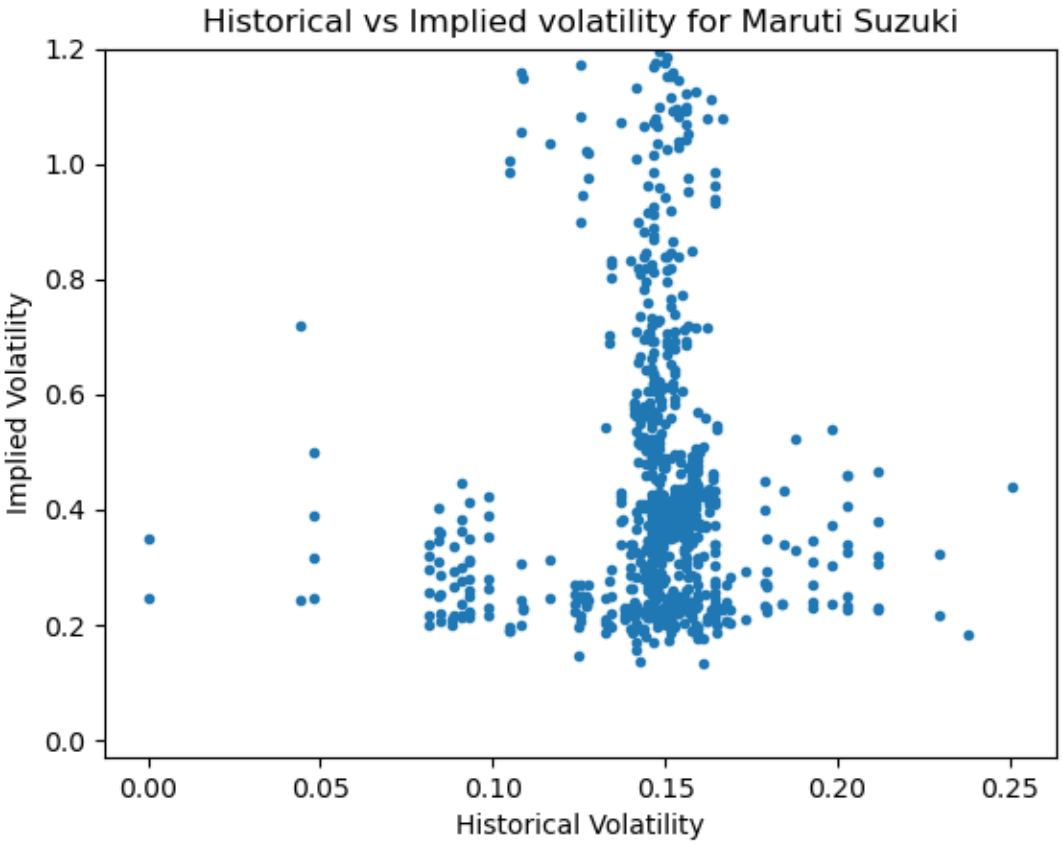


v. Maruti Suzuki

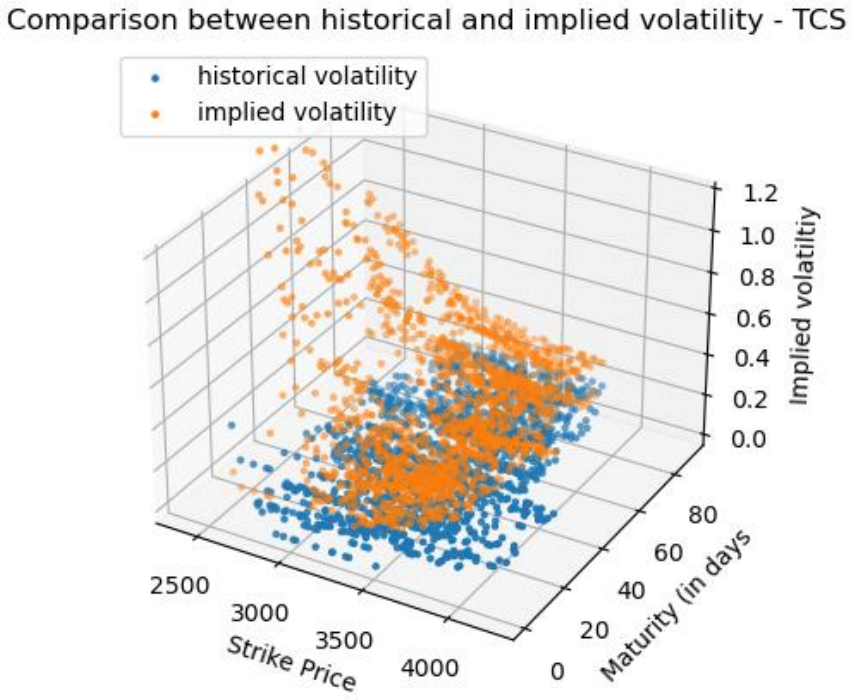


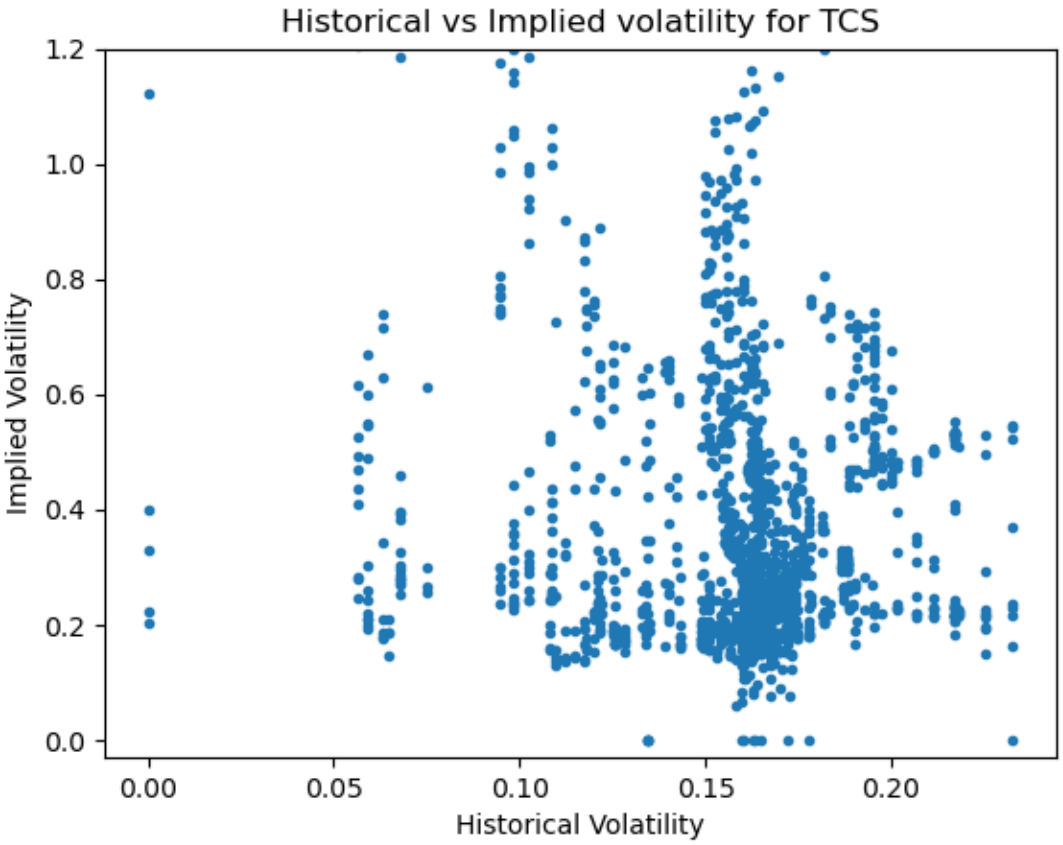


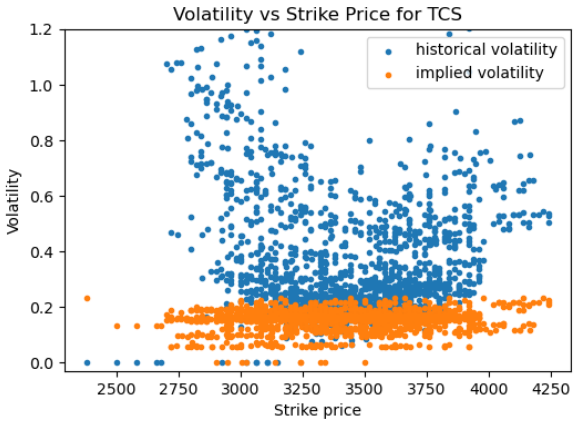

Comparison between historical and implied volatility - Maruti Suzuki
historical volatility
implied volatility
Implied volatiltiy
1.2
1.0
0.8
0.6
0.4
0.2
0.0
Strike Price
6000
7000
8000
9000
10000
11000
Maturity (in days
0
20
40
60
80

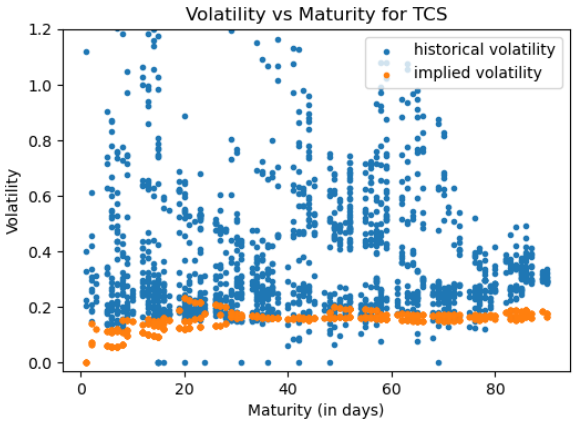

Historical vs Implied volatility for Maruti Suzuki
Implied Volatility
Historical Volatility
0.0
0.2
0.4
0.6
0.8
1.0
1.2
0.00
0.05
0.10
0.15
0.20
0.25

vi. TCS


Comparison between historical and implied volatility - TCS
historical volatility
implied volatility
Implied volatiltiy
1.2
1.0
0.8
0.6
0.4
0.2
0.0
Maturity (in days
80
60
40
20
0
Strike Price
2500
3000
3500
4000


Historical vs Implied volatility for TCS
Implied Volatility
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0.00
0.05
0.10
0.15
0.20
Historical Volatility





Tabular Data (for few points)**: -**

********** For NSE Index **********

SI No.	Call Price	Stock Price (S0)	Maturity (in days)	Historical Volatility	Implied Volatility
1	2934.9	18191	7	0.085219	0.730068
2	1.1	18191	7	0.085219	0.199349
3	122.6	18191	7	0.085219	0.117769
4	1.05	18191	7	0.085219	0.261815
5	475.55	18191	7	0.085219	0.14509
6	613.55	18191	7	0.085219	0.140538
7	568.95	18191	7	0.085219	0.150372
8	2743.2	18191	7	0.085219	0.719412
9	2367.2	18191	7	0.085219	0.701084
10	2321.1	18191	7	0.085219	0.699139
11	2695.6	18191	7	0.085219	0.716863
12	520	18191	7	0.085219	0.142585
13	1.05	18191	7	0.085219	0.351335
14	2506.85	18191	7	0.085219	0.707515
15	1	18191	7	0.085219	0.338042
16	1543.05	18191	7	0.085219	0.674112
17	2	18191	14	0.110508	0.197546
18	1327.3	18191	14	0.110508	0.440969
19	4.9	18191	14	0.110508	0.136632
20	1938	18191	14	0.110508	0.426916

********** For Ambuja Cements **********

SI No.	Call Price	Stock Price (S0)	Maturity (in days)	Historical Volatility	Implied Volatility
1	29	518.4	1	0	0.712496
2	132.75	518.4	28	0.323464	1.15054
3	74.75	518.4	28	0.323464	0.485992
4	128.35	518.4	28	0.323464	1.1301
5	17.35	518.4	28	0.323464	0.824233
6	19.6	518.4	28	0.323464	0.827632
7	14.65	518.4	28	0.323464	0.396325
8	146.2	518.4	28	0.323464	1.21646
9	107.3	518.4	28	0.323464	1.04359
10	19.2	518.4	57	0.723714	0.682521
11	48.35	518.4	57	0.723714	0.774482
12	46	518.4	57	0.723714	0.766731
13	20.35	518.4	57	0.723714	0.686054
14	105.4	518.4	57	0.723714	0.993735
15	43.75	518.4	57	0.723714	0.759507
16	109.35	518.4	57	0.723714	1.01166
17	103.3	522.75	27	0.327651	0.968792
18	3.95	522.75	27	0.327651	0.388983
19	48.15	522.75	27	0.327651	0.501684
20	6.55	522.75	27	0.327651	0.375401

********** For Apollo Hospitals **********

SI No.	Call Price	Stock Price (S0)	Maturity (in days)	Historical Volatility	Implied Volatility
1	320	4588.65	1	0	1.35771
2	199.2	4588.65	1	0	0.694085
3	4.75	4588.65	1	0	0.370371
4	103.6	4588.65	28	0.153934	0.702079
5	530.05	4588.65	28	0.153934	0.584562
6	14.7	4588.65	28	0.153934	0.344432
7	357.55	4588.65	57	0.225654	0.697057
8	706.9	4588.65	57	0.225654	0.801588
9	423.5	4588.65	57	0.225654	0.714734
10	740.65	4588.65	57	0.225654	0.813352
11	282.35	4588.65	57	0.225654	0.677657
12	318.2	4588.65	57	0.225654	0.686831
13	240	4588.65	57	0.225654	0.484466
14	10	4524.45	27	0.15353	0.380927
15	79.1	4524.45	27	0.15353	0.323428
16	160.25	4524.45	27	0.15353	0.748581
17	10.15	4524.45	27	0.15353	0.349442
18	911.45	4524.45	27	0.15353	0.575959
19	120.1	4524.45	27	0.15353	0.752063
20	95.2	4524.45	27	0.15353	0.324803

********** For InterGlobe Aviation **********

SI No.	Call Price	Stock Price (S0)	Maturity (in days)	Historical Volatility	Implied Volatility
1	89.9	2015.2	28	0.188824	0.35216
2	102	2015.2	57	0.226773	0.413523
3	170.1	2015.2	57	0.226773	0.34357
4	114.8	2015.2	57	0.226773	0.402584
5	144.3	2015.2	57	0.226773	0.374164
6	152.55	2015.2	57	0.226773	0.365173
7	90.4	2015.2	57	0.226773	0.42292
8	70.65	2015.2	57	0.226773	0.438779
9	30.2	2015.65	27	0.193565	0.477207
10	74.35	2015.65	27	0.193565	0.333172
11	36	2015.65	27	0.193565	0.361543
12	51.15	2015.65	56	0.229601	0.457202
13	96.05	2015.65	56	0.229601	0.421813
14	114.8	2015.65	56	0.229601	0.405839
15	189.1	2015.65	56	0.229601	0.317002
16	199.2	2015.65	56	0.229601	0.298213
17	70.65	2015.65	56	0.229601	0.442443
18	231.75	2015.65	56	0.229601	0.179703
19	77.65	2007.7	26	0.197337	0.328751
20	41.1	2007.7	26	0.197337	0.437005

********** For Maruti Suzuki **********

SI No.	Call Price	Stock Price (S0)	Maturity (in days)	Historical Volatility	Implied Volatility
1	2.45	8421.05	1	0	0.351212
2	517.05	8421.05	28	0.15361	0.245036
3	2562.3	8421.05	28	0.15361	1.78538
4	164.95	8421.05	28	0.15361	0.838404
5	1583.05	8421.05	28	0.15361	1.32402
6	7.15	8421.05	28	0.15361	0.307722
7	32.15	8421.05	57	0.141801	0.28277
8	2028.65	8421.05	57	0.141801	1.00912
9	126.95	8421.05	57	0.141801	0.233298
10	2396.6	8421.05	57	0.141801	1.13054
11	359.9	8421.05	57	0.141801	0.602758
12	888.05	8421.05	57	0.141801	0.707937
13	32.75	8435.8	27	0.157593	0.227841
14	164.95	8435.8	27	0.157593	0.849732
15	1664.85	8435.8	27	0.157593	1.37152
16	2008.8	8435.8	27	0.157593	1.52543
17	2467.75	8435.8	27	0.157593	1.75265
18	2753.25	8435.8	27	0.157593	1.90571
19	230	8435.8	27	0.157593	0.213671
20	1833.7	8435.8	27	0.157593	1.44525

********** For TCS **********

SI No.	Call Price	Stock Price (S0)	Maturity (in days)	Historical Volatility	Implied Volatility
1	24.4	3257.1	1	0	0.204964
2	123.25	3257.1	28	0.201686	0.236141
3	9.85	3257.1	28	0.201686	0.482468
4	10.7	3257.1	28	0.201686	0.482209
5	3.65	3257.1	28	0.201686	0.327089
6	30.85	3257.1	28	0.201686	0.472315
7	214	3257.1	28	0.201686	0.397333
8	109.55	3257.1	28	0.201686	0.231006
9	12.6	3257.1	28	0.201686	0.227129
10	87.45	3257.1	28	0.201686	0.22981
11	640	3257.1	57	0.188535	0.739073
12	58.15	3257.1	57	0.188535	0.440342
13	131.4	3257.1	57	0.188535	0.470309
14	604.3	3257.1	57	0.188535	0.714888
15	7	3257.1	57	0.188535	0.228527
16	74.5	3257.1	57	0.188535	0.447701
17	407.05	3257.1	57	0.188535	0.595797
18	105.45	3257.1	57	0.188535	0.459991
19	309.6	3257.1	57	0.188535	0.546546
20	9.85	3268.75	27	0.206897	0.48504

Observations: -

1. Historical volatility is an estimate of the volatility over the past period of time, while the implied volatility is the estimation of the volatility for the upcoming months.

2. For data of some of the stocks, implied volatility is generally higher while for other stocks, historical volatility is generally higher than the implied volatility. The significant difference between these 2 values arises due to a number of factors present in real market.

3. The plot for historical vs implied volatility very well captures this relation. Other plots show the dependence of different types of volatility with varying strike price and maturity.