

MA374: Financial Engineering Lab : Lab 9
Aman Bucha, Roll- 200123006

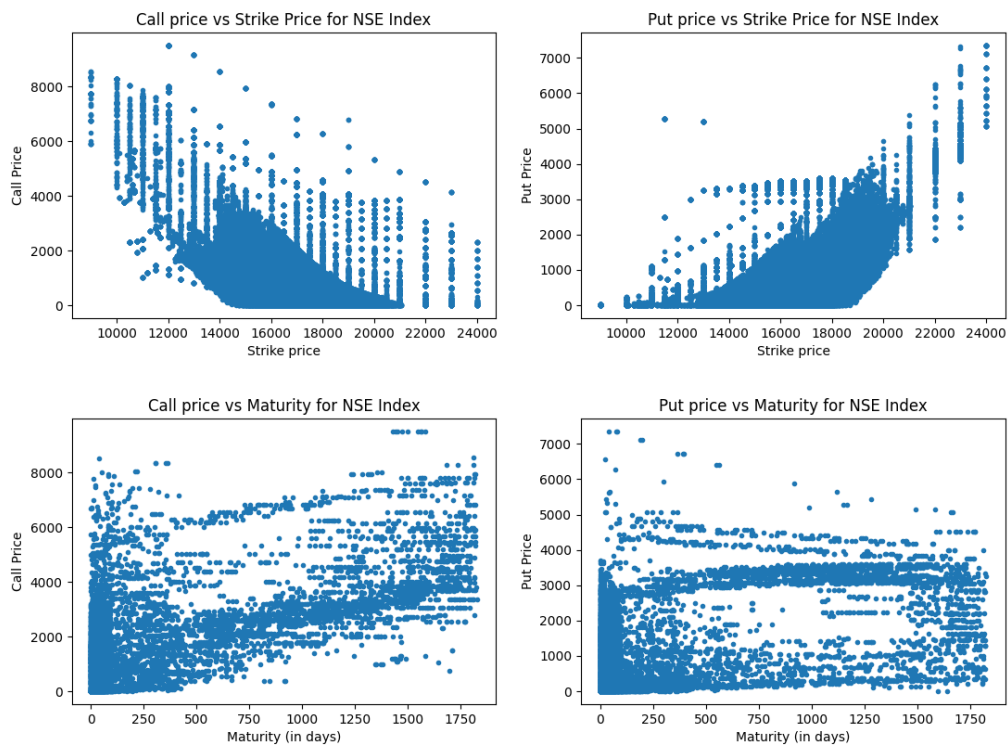
Question 1:

Data from the following stock options are collected (which are also mentioned in nsedata1.csv):

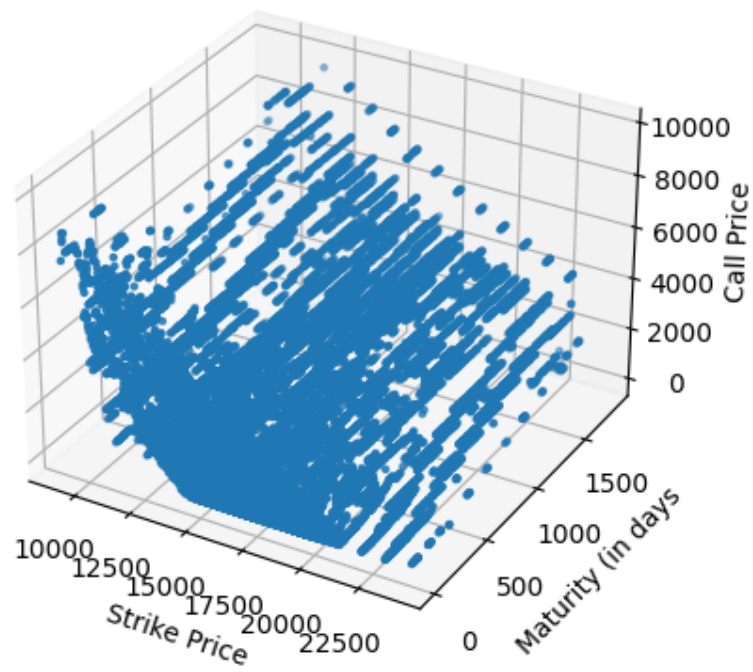
1. Nifty50
2. ITC
3. SBI
4. TCS
5. TITAN

Question 2.a:

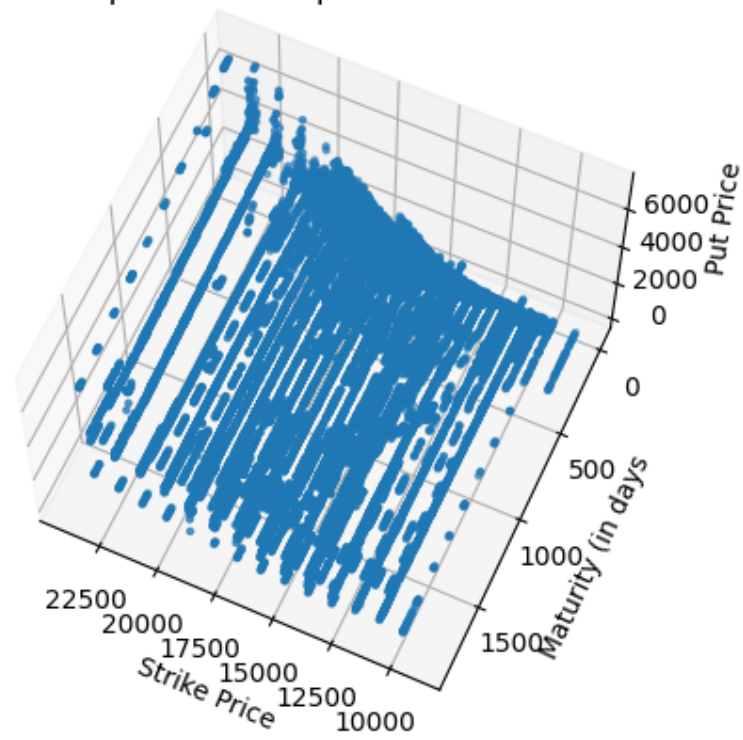
1. For Nifty50:



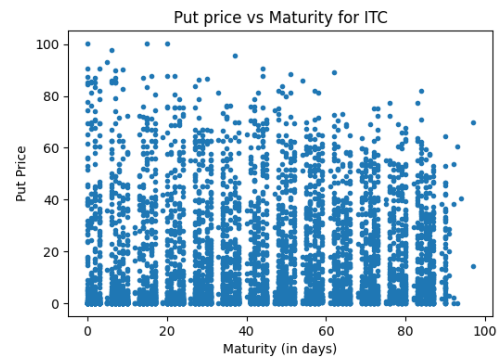
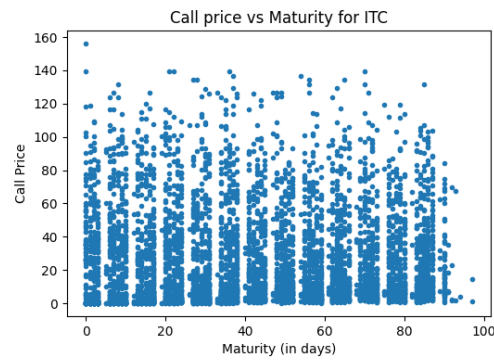
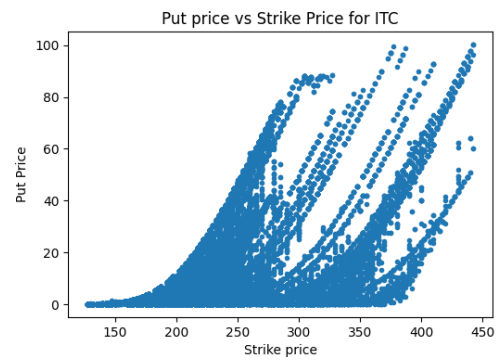
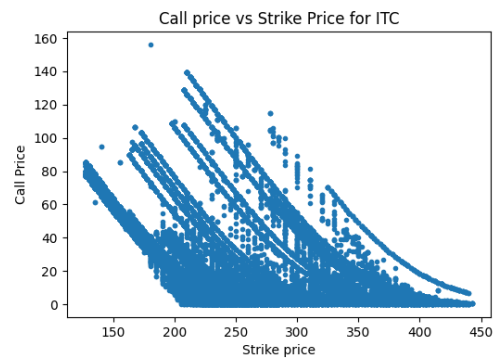
3D plot for Call Option - NSE Index



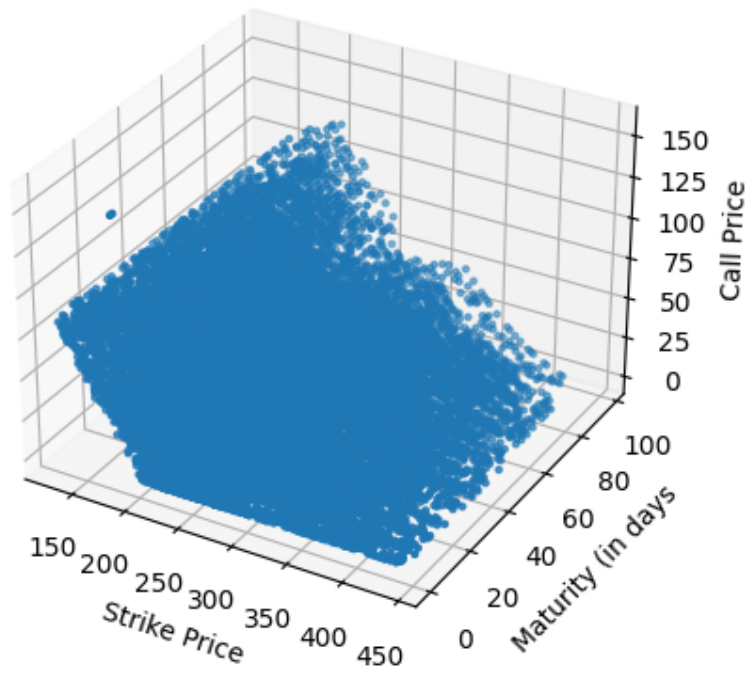
3D plot for Put Option - NSE Index



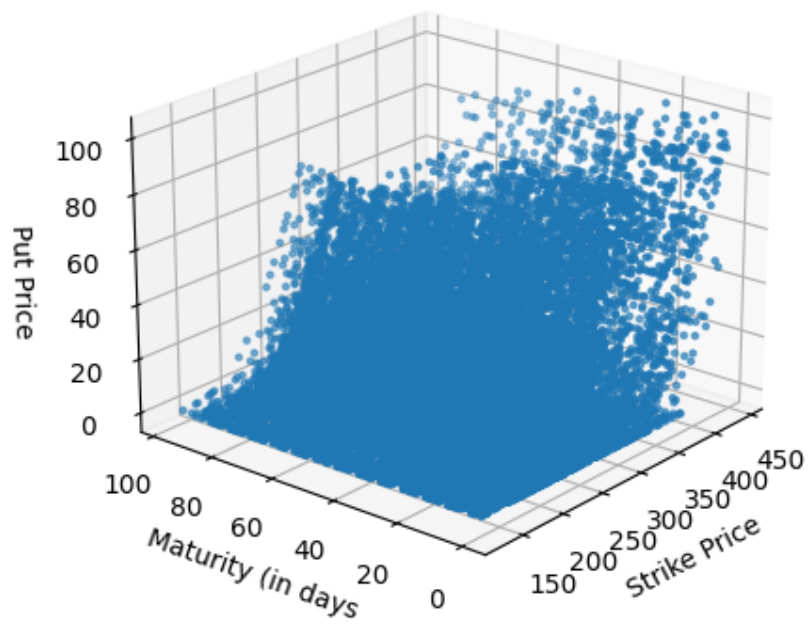
2. For ITC



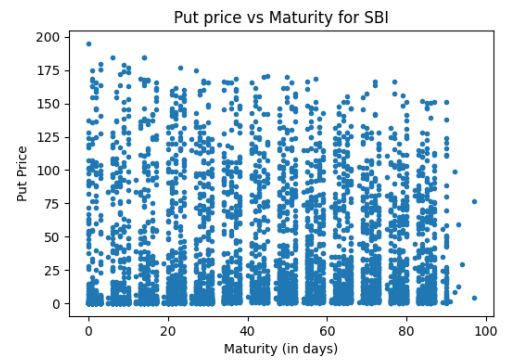
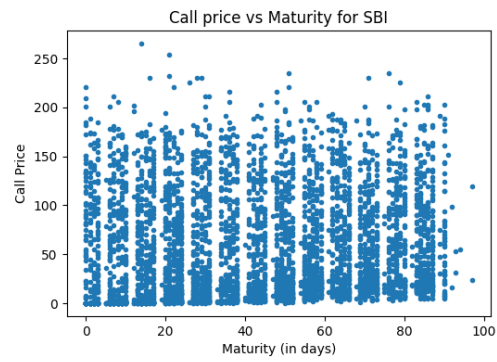
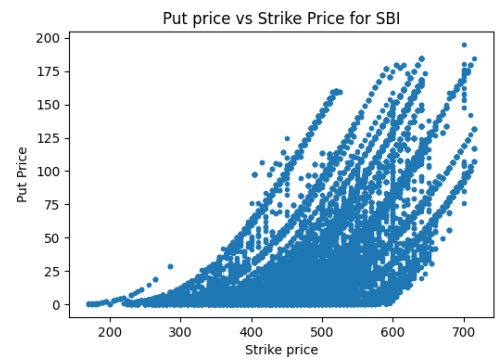
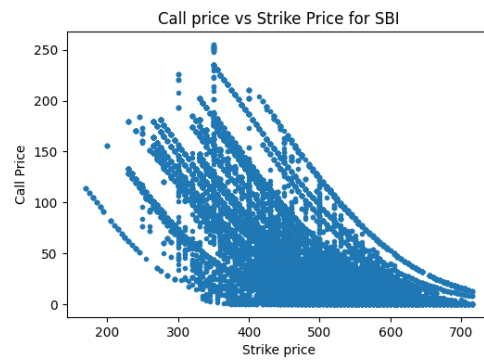
3D plot for Call Option - ITC



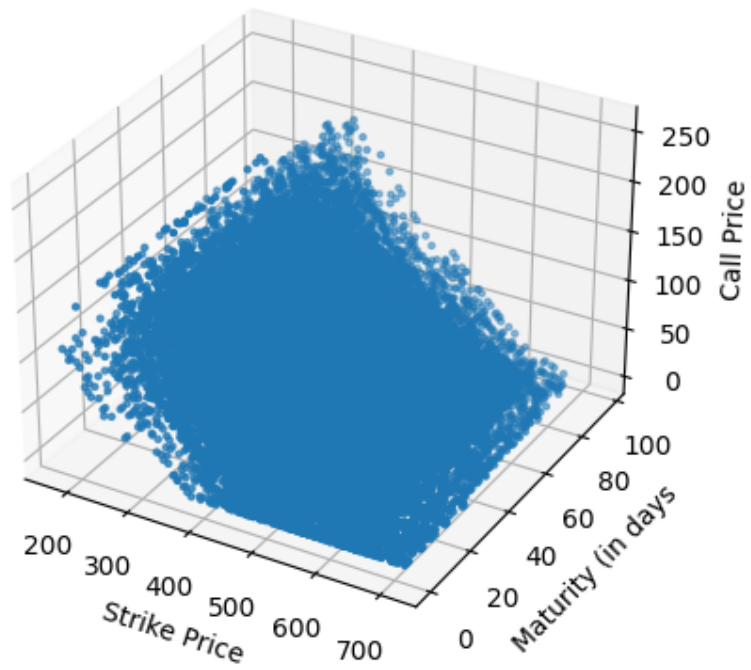
3D plot for Put Option - ITC



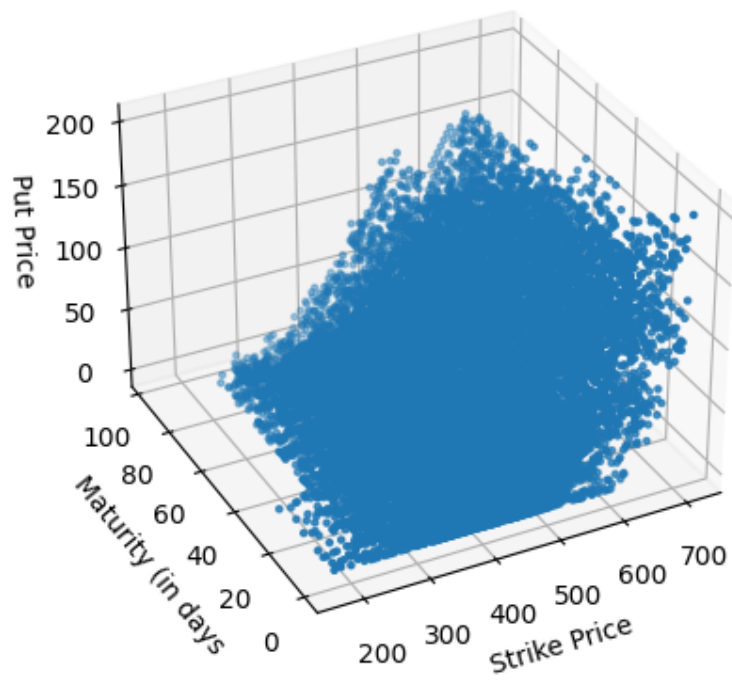
3. For SBI



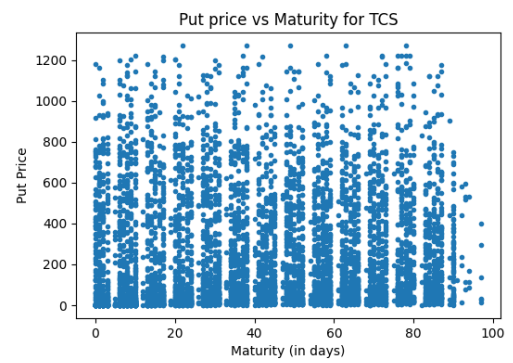
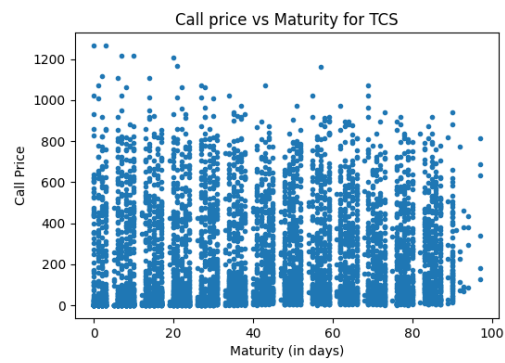
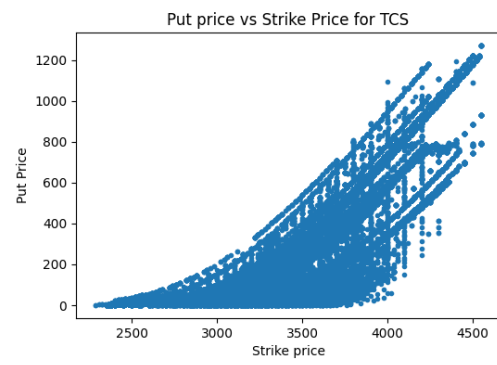
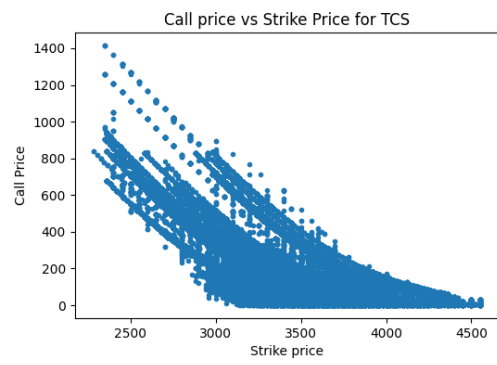
3D plot for Call Option - SBI



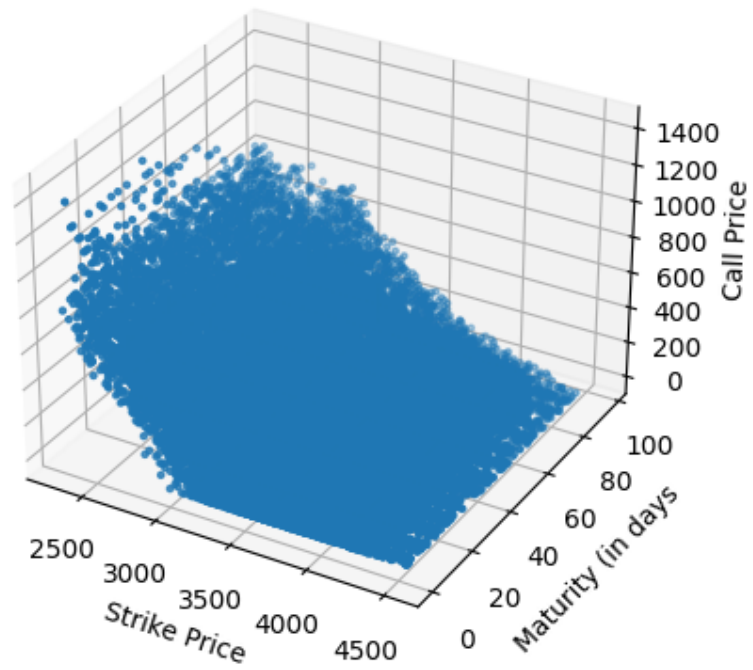
3D plot for Put Option - SBI



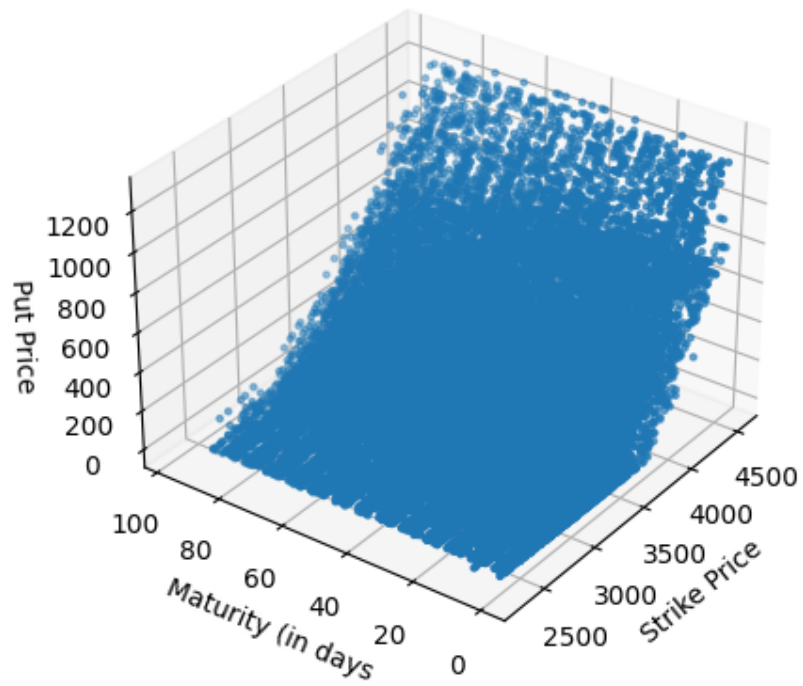
4. For TCS



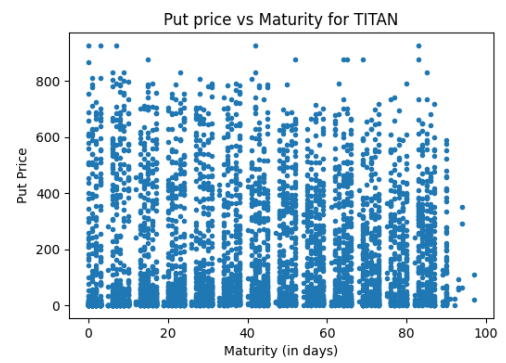
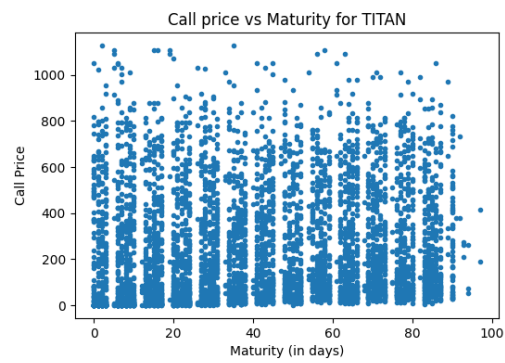
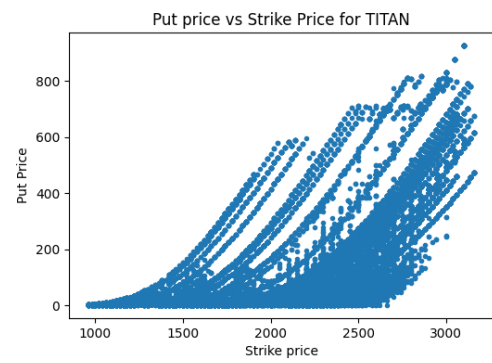
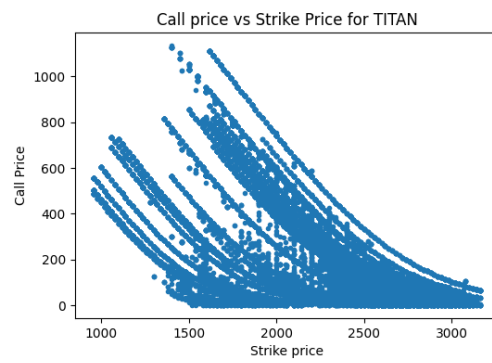
3D plot for Call Option - TCS



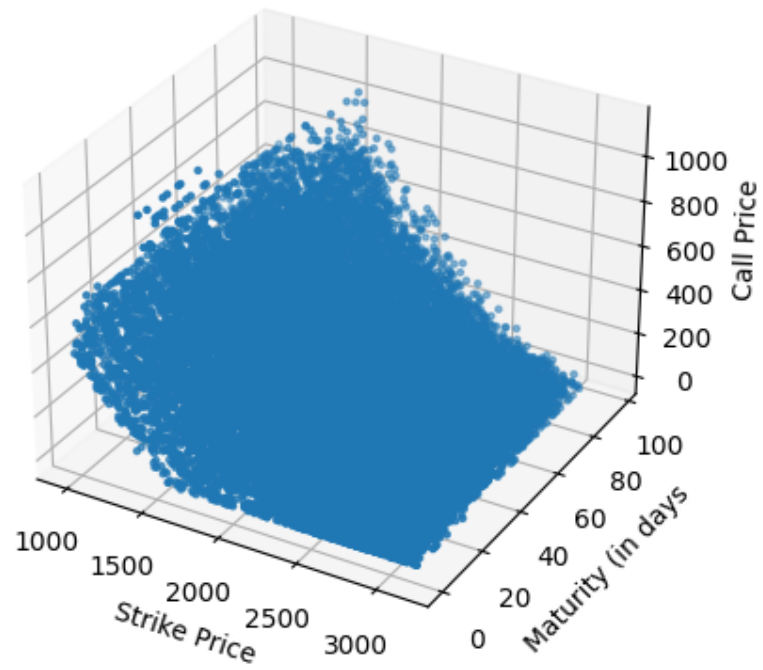
3D plot for Put Option - TCS



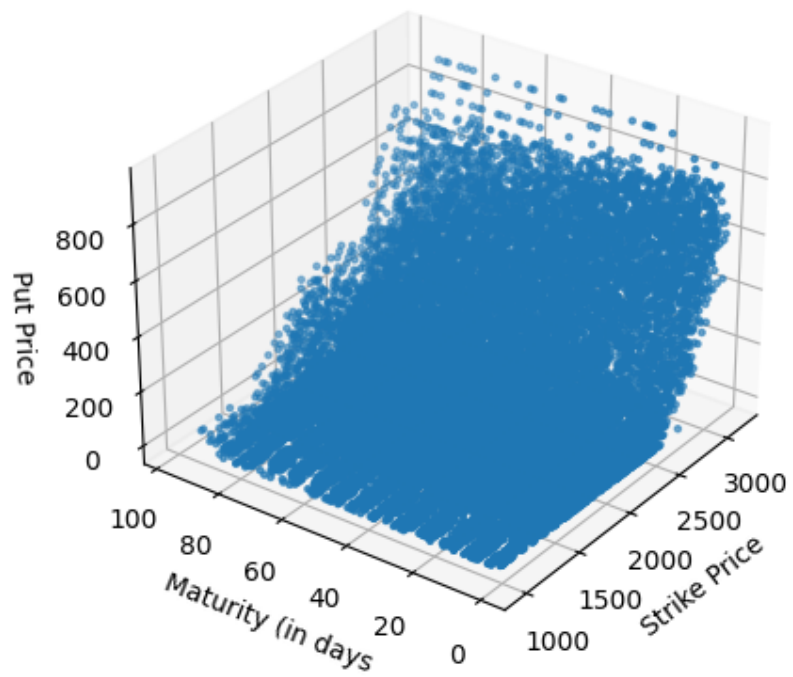
5. For Titan



3D plot for Call Option - TITAN



3D plot for Put Option - TITAN



Observations –

1. The lack of sufficient data adds difficulty in making proper analysis, but general trends can be figured out by considering the plots for NIFTY50 since it has larger data-points. The other plots also show similar trends.
2. We can observe that the price of call option decreases and that of put option increases with an increase in strike price. This trend is within our expectations.
3. 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.
4. Apart from the strike price and maturity period, the options value also seems to depend on when the price was collected. This means that even if the period values are same, the prices may differ if they are collected at different point of time (e.g., collection from 30 march 2021 – 28 Feb 2022 will show different price from that of 1st March 2022 – 28 Feb 2023 even if all the parameters are kept same). This is due to the fact that the real market has several other random components, which affect the prices. Owing to this reason only, the scatter plots are constructed to capture all these factors.

Question 2.b)

Newton-Raphson method is used to find out the implied volatility from the BSM formula. This method takes the following form:

$$\sigma_{n+1} = \sigma_n - \frac{F(\sigma_n)}{F'(\sigma_n)}$$

where,

$$F(\sigma) = C(\sigma) - C^*$$

$$C(\sigma) = \text{BSM formula with } \sigma \text{ as unknown parameter}$$

$$C^* = \text{Observed call option price}$$

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,

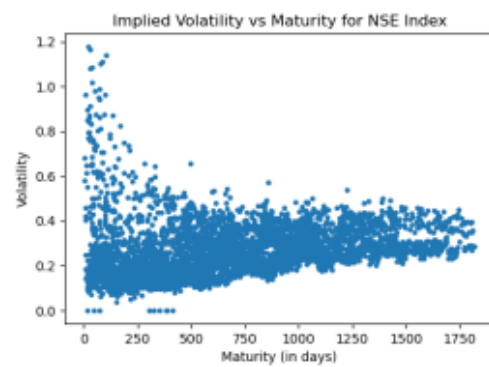
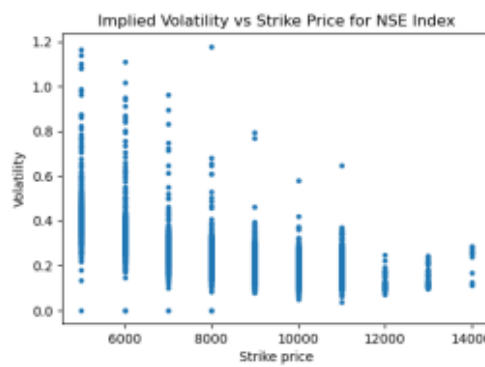
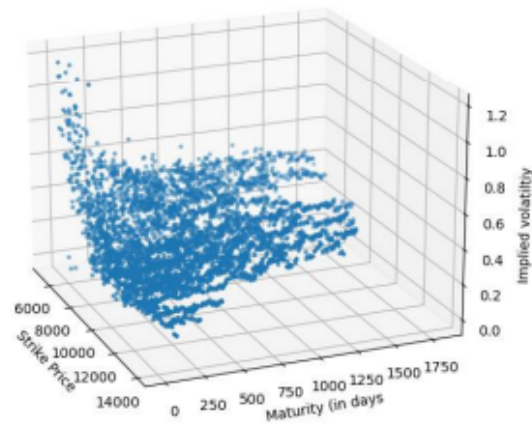
$$d_1 = \frac{\log\left(\frac{x}{K}\right) + \left(r + \frac{1}{2}\sigma^2\right)(T-t)}{\sigma\sqrt{T-t}}$$

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

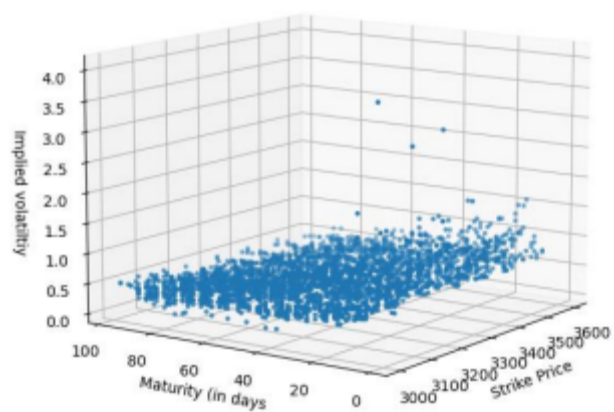
$$N(x) = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^x e^{-\frac{1}{2}y^2} dy$$

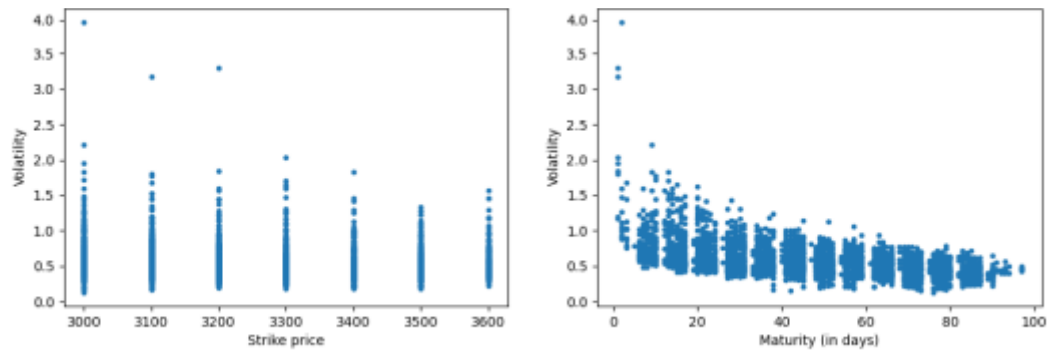
1. For nifty 50

3D plot for Implied volatility - NSE Index

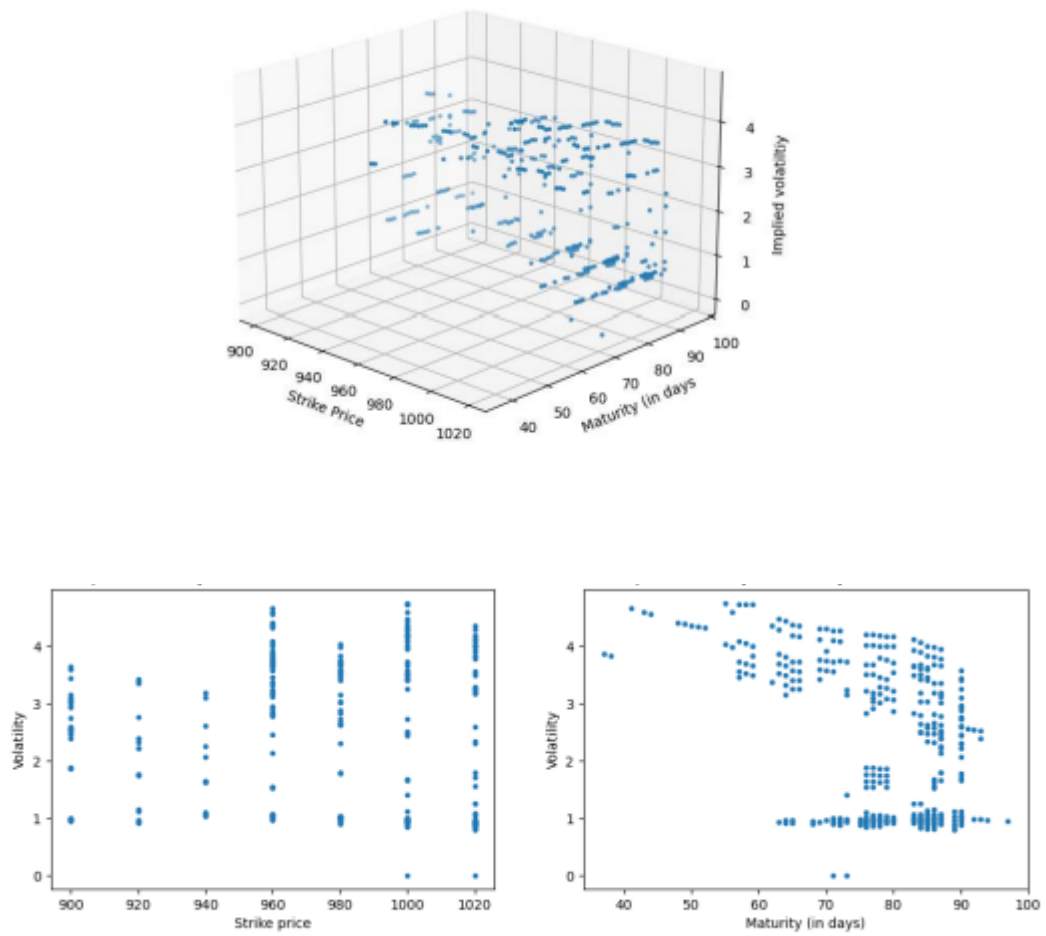


2. For ITC

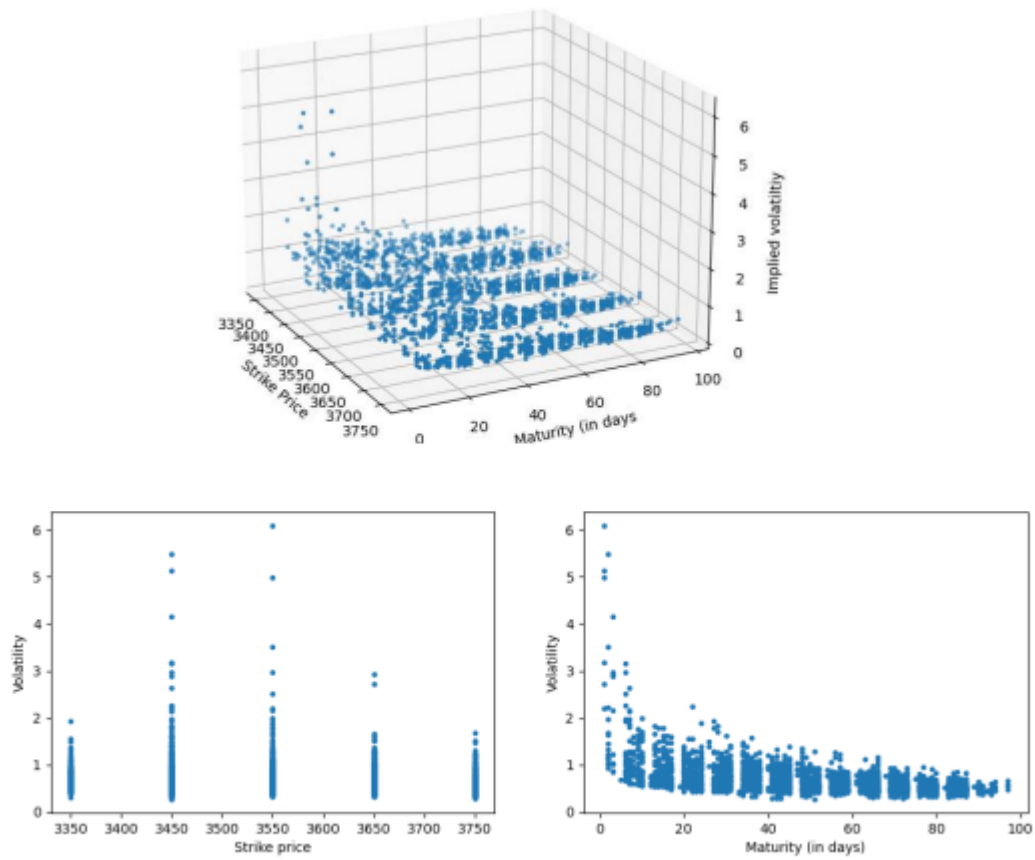




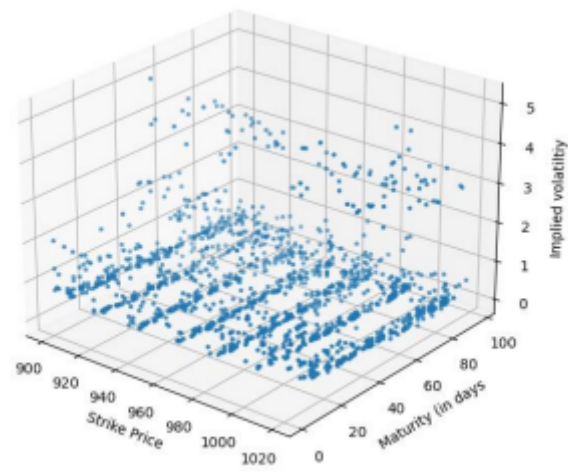
3.For SBI

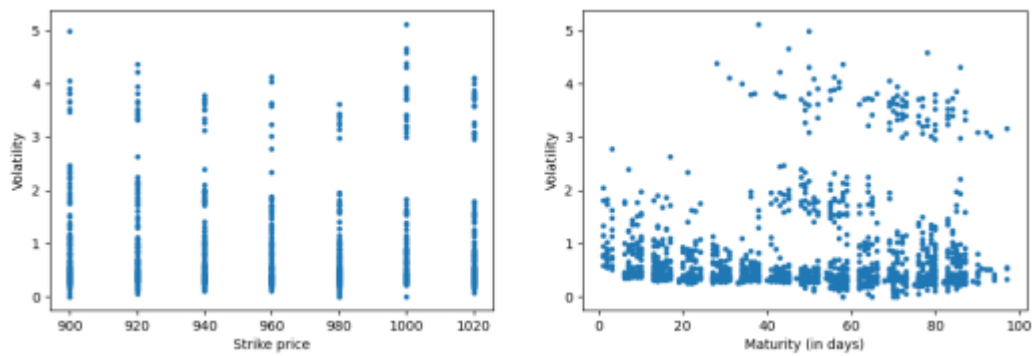


4. For TCS



5. For Titan



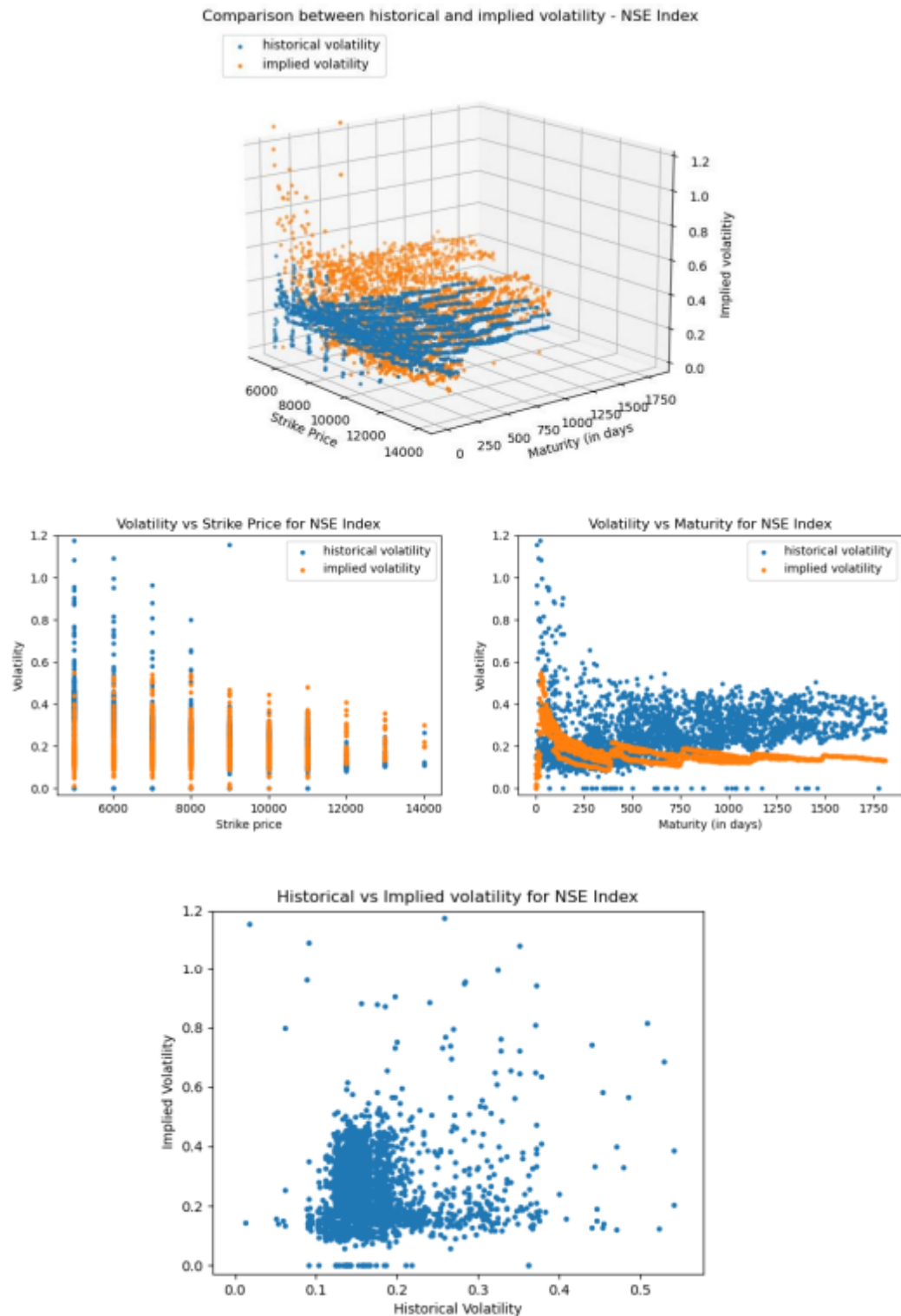


Observations –

1. The lack of sufficient data adds difficulty in making proper analysis, but general trends can be figured out by considering the plots for NIFTY50 since it has larger data-points. The other plots also show similar trends.
2. 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 the plotted curves.
3. The volatility generally tends to decrease for larger maturity values, but for some of the above plots this nature is not very much observed.
4. Apart from the strike price and maturity period, the implied volatility seems to also depend on when the price was collected. This means that even if the period values are same, the prices may differ if they are collected at different point of time (e.g., collection from 30 march 2021 – 28 Feb 2022 will show different price from that of 1st March 2022 – 28 Feb 2023 even if all the parameters are kept same). This is due to the fact that the real market has several other random components, which affect the prices. Owing to this reason, the scatter plots are constructed to capture all these factors.

Question 2.c)

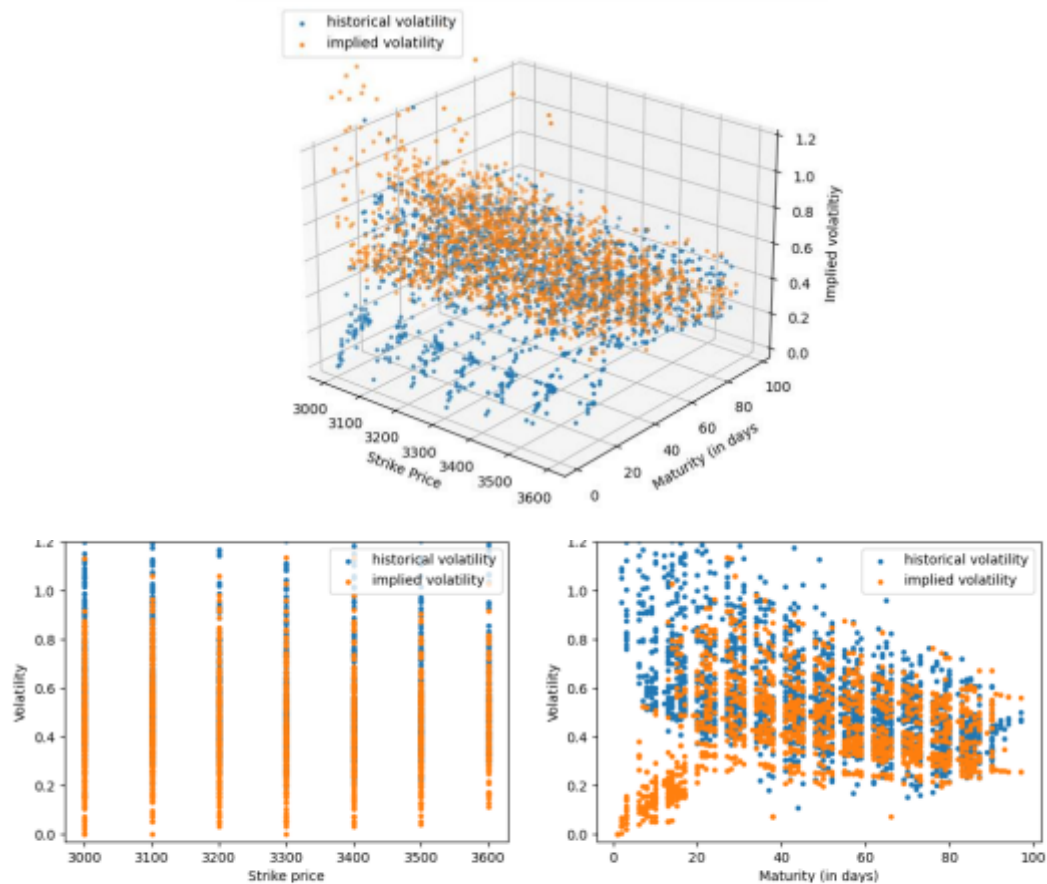
1. For Nifty 50

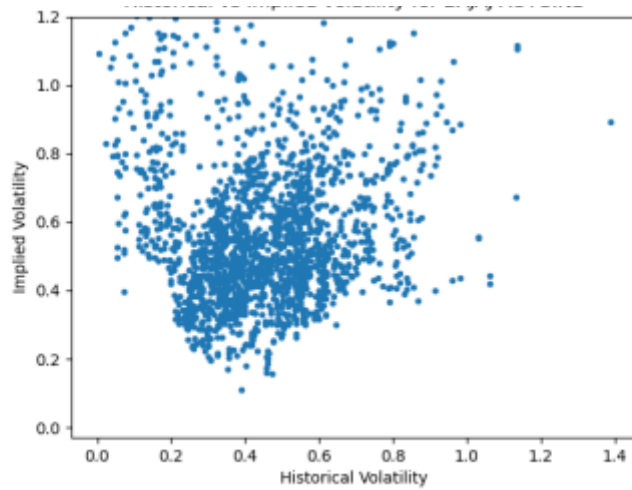


The tabular data (only few data-points) is as follows:

***** For NSE Index *****						
SI No.	Call Price	Stock Price (\$0)	Maturity (in days)	Historical Volatility	Implied Volatility	
1	1829.15	6221.15	1093	0.147627	0.317806	
2	1599.85	6211.15	356	0.12712	0.292159	
3	792.25	6211.15	728	0.145847	0.242531	
4	2436.8	6211.15	1092	0.147723	0.35713	
5	403.8	6191.45	355	0.12712	0.242903	
6	137.3	6191.45	355	0.12712	0.221836	
7	768.9	6191.45	727	0.145847	0.239152	
8	2752	6191.45	1455	0.135583	0.373214	
9	2398.7	6162.25	1088	0.147797	0.358096	
10	1720.1	6162.25	1088	0.147797	0.300416	
11	123.9	6174.6	351	0.127286	0.217387	
12	2366.9	6174.6	1087	0.147797	0.344476	
13	2381.25	6168.35	1086	0.14786	0.351621	
14	360.5	6171.45	349	0.128418	0.230915	
15	1261.1	6171.45	721	0.146511	0.268744	
16	1681.75	6171.45	1085	0.148167	0.288436	
17	2706.1	6171.45	1449	0.135906	0.365388	
18	2014	6272.75	720	0.146757	0.296225	
19	352	6272.75	720	0.146757	0.196255	
20	2421.55	6272.75	1812	0.134594	0.31515	

2. For ITC

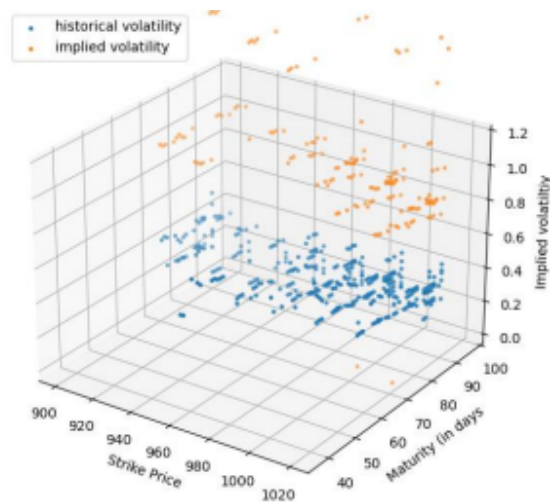


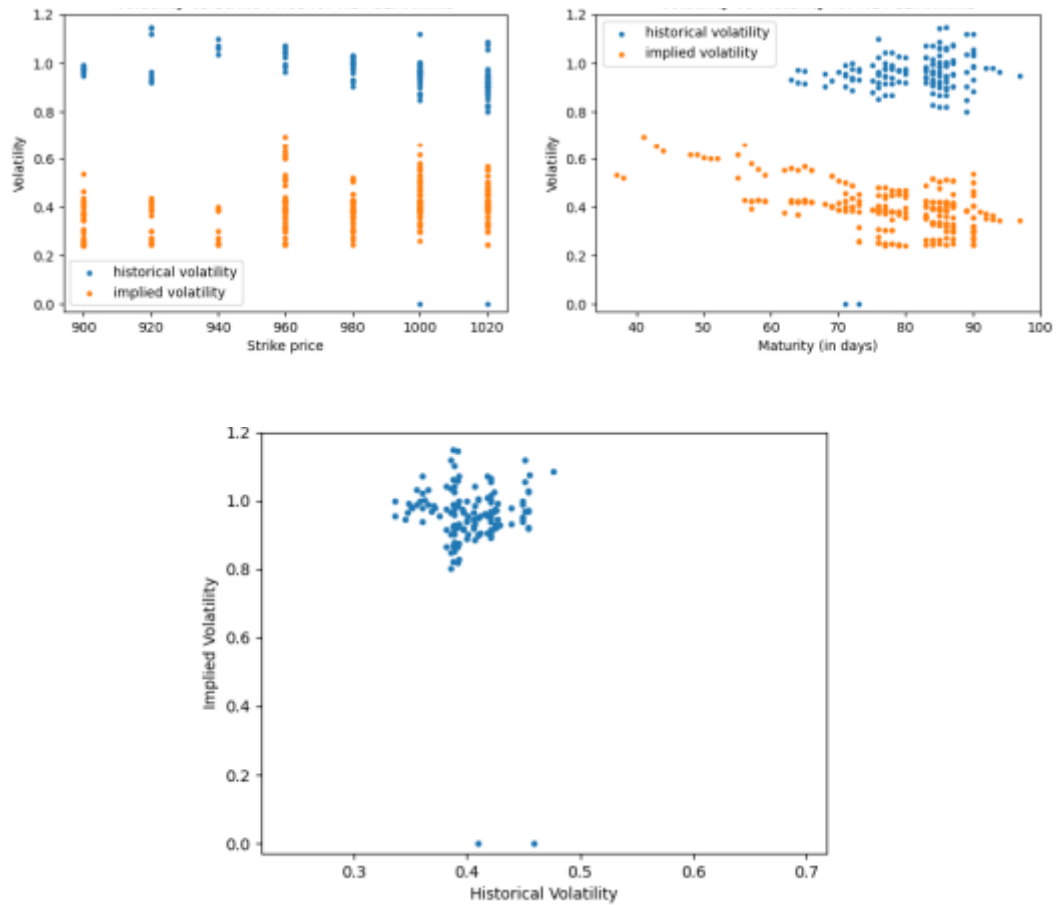


The tabular data (only few data-points) is as follows:

SI No.	Call Price	Stock Price (S0)	Maturity (in days)	Historical Volatility	Implied Volatility
1	5.45	2215.31	51	0.49812	0.432511
2	5.45	2212.25	49	0.494436	0.443322
3	2.85	2188.76	44	0.537696	0.472136
4	23.65	2188.76	80	0.725489	0.519242
5	36.6	2194.05	79	0.725489	0.544327
6	36.6	2237.08	78	0.74477	0.521265
7	23.65	2282.95	76	0.763014	0.480021
8	1.8	2287.08	10	0.149027	0.75584
9	5.45	2301.97	35	0.640773	0.467394
10	1.8	2285.06	7	0.156701	0.907154
11	5.45	2275.33	29	0.690235	0.534089
12	23.65	2249.9	64	0.829041	0.545329
13	14.9	2249.9	64	0.829041	0.525475
14	10	2272.58	90	0.671608	0.394937
15	31.15	2268.71	87	0.672838	0.451843
16	2.85	2239.49	22	0.744717	0.633249
17	36.6	2245.99	57	0.8663	0.607484
18	36.6	2254.59	55	0.877404	0.612544
19	23.65	2250.08	52	0.847297	0.607136
20	2.85	2245.08	15	0.576556	0.763593

3.For SBI

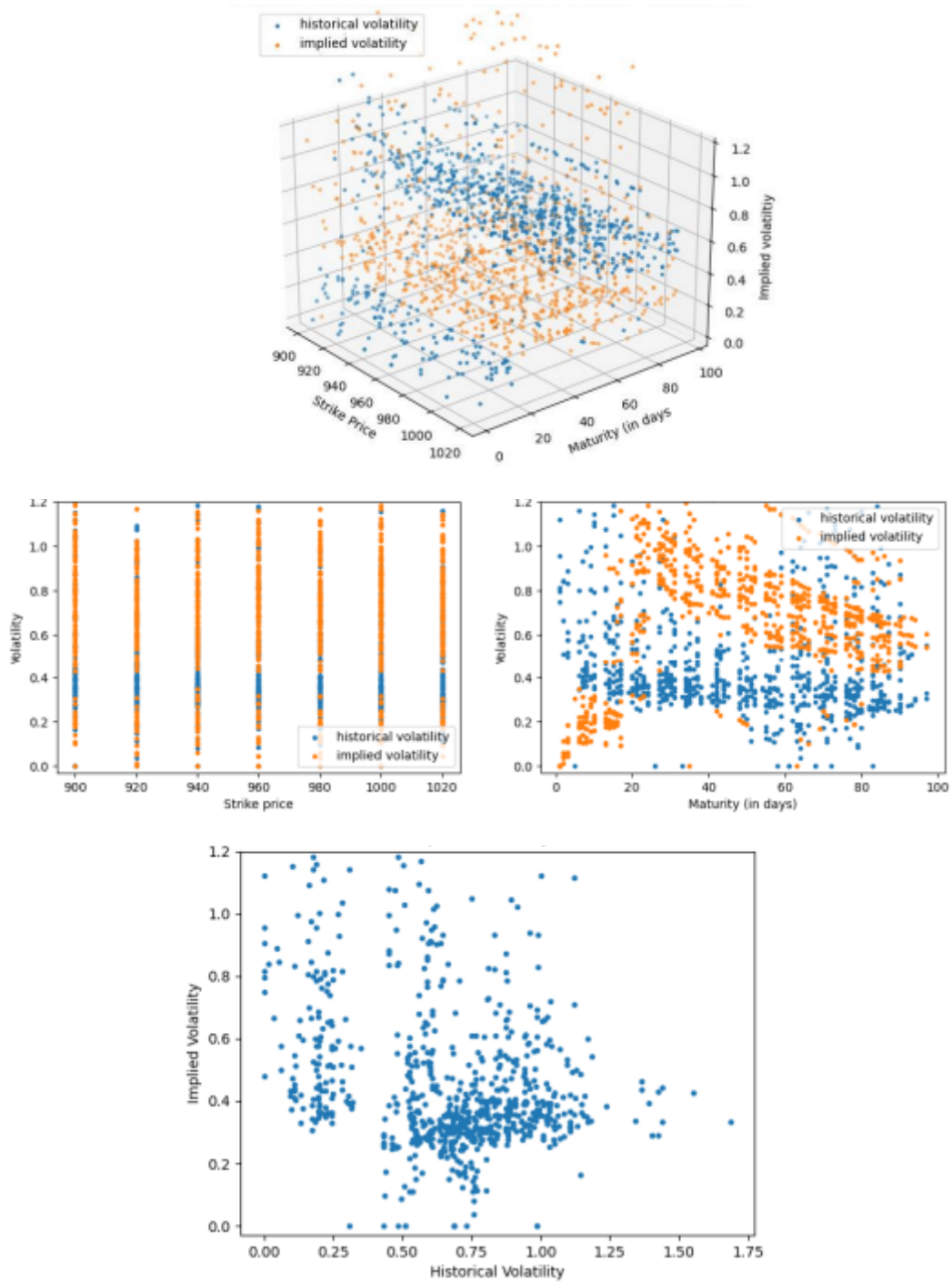




The tabular data (only few data-points) is as follows:

SI No.	Call Price	Stock Price (₹)	Maturity (in days)	Historical Volatility	Implied Volatility
1	2.75	341.983	93	0.349957	0.981824
2	1.8	389.878	72	0.438511	0.93215
3	2.75	386.749	71	0.427235	0.993337
4	4.9	412.737	83	0.360245	1.02353
5	12.3	419.964	89	0.385825	1.11988
6	8.15	418.206	84	0.393064	1.07263
7	5.25	418.013	77	0.388235	1.04389
8	2	430.636	65	0.420388	0.968178
9	228.3	539.623	90	0.295234	2.97174
10	174.85	518.264	91	0.383103	2.55457
11	174.85	533.167	87	0.402446	2.52671
12	113.75	509.624	90	0.300928	2.06553
13	80.75	509.624	90	0.300928	1.78466
14	23.45	493.119	84	0.246856	1.25147
15	80.7	499.357	76	0.253369	1.87575
16	56.25	499.357	76	0.253369	1.64759
17	46.1	499.357	76	0.253369	1.5477
18	230.4	555.763	79	0.241299	3.08416
19	230.4	564.452	73	0.256541	3.14877
20	260.5	576.103	90	0.271845	3.10514

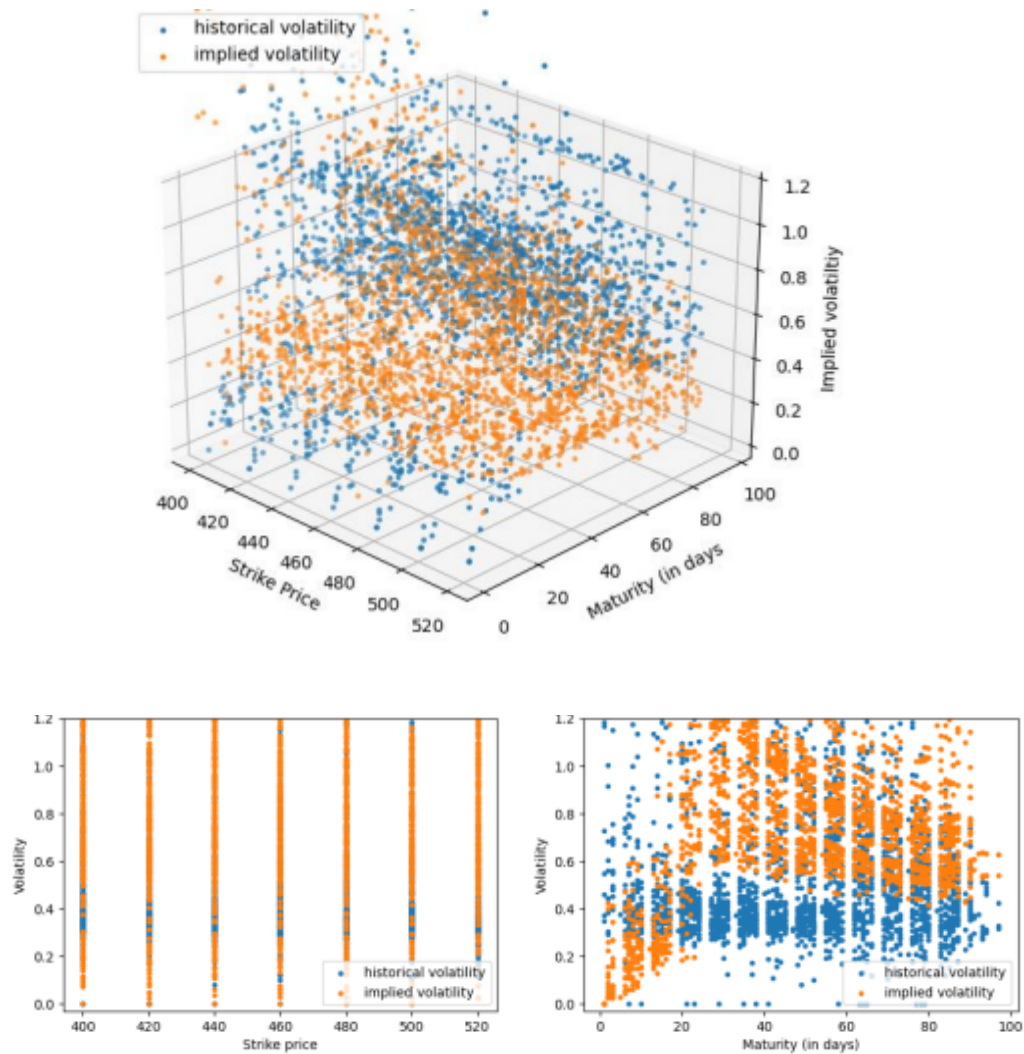
4. For TCS

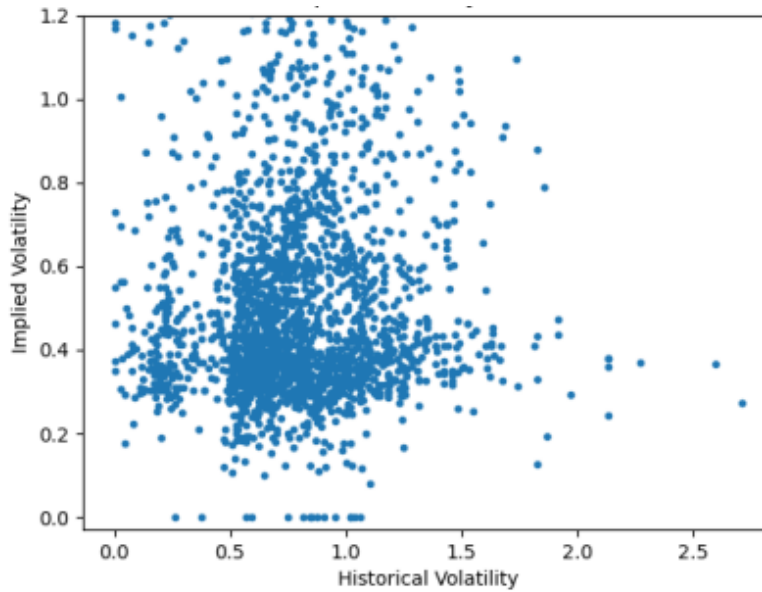


The tabular data (only few data-points) is as follows:

SI No.	Call Price	Stock Price (\$)	Maturity (in days)	Historical Volatility	Implied Volatility
1	1.15	375.517	90	0.449249	0.872105
2	3	378.826	85	0.450162	0.994229
3	1.9	408.119	83	0.450801	0.882131
4	1.15	408.119	83	0.450801	0.835815
5	6.95	412.883	77	0.450474	1.07805
6	4.6	425.3	70	0.504649	1.02786
7	1.9	415.817	69	0.477376	0.949972
8	1.9	436.918	59	0.585383	0.973636
9	91.3	511.238	76	0.535933	1.96922
10	91.3	534.07	69	0.622591	1.95975
11	116	516.326	86	0.452604	2.07652
12	59	513.227	85	0.453428	1.61172
13	75.75	584.643	64	0.727783	1.73756
14	296.85	599.846	87	0.651258	3.32845
15	89.55	599.846	59	0.777704	1.8645
16	75.75	599.846	59	0.777704	1.74833
17	52.25	599.846	59	0.777704	1.54219
18	296.85	599.435	86	0.655459	3.35086
19	250.35	599.435	86	0.655459	2.9844
20	313.3	597.716	85	0.686759	3.52438

5. For Titan:





The tabular data (only few data-points) is as follows:

SI No.	Call Price	Stock Price (₹)	Maturity (in days)	Historical Volatility	Implied Volatility
1	8.8	369.243	29	0.912775	0.815407
2	15.5	366.682	55	0.628143	0.669637
3	8	357.179	54	0.628143	0.390358
4	5.8	361.365	51	0.63768	0.415714
5	10.95	361.365	80	0.605585	0.424611
6	7	361.365	80	0.605585	0.416235
7	16.65	359.543	79	0.605585	0.450308
8	10.95	364.614	78	0.616998	0.414461
9	15.5	362.349	48	0.589697	0.746551
10	1.5	361.414	20	1.62288	0.336342
11	15.5	370.425	44	0.567156	0.726834
12	7	366.141	72	0.512458	0.419299
13	4.35	366.141	72	0.512458	0.415125
14	10.95	364.122	70	0.517964	0.44191
15	7	364.122	70	0.517964	0.434654
16	6.4	369.194	37	0.604466	0.350673
17	15.5	378.943	36	0.617671	0.743412
18	15.5	380.223	35	0.630366	0.744747
19	5.3	364.762	33	0.631266	0.373036
20	7	364.762	62	0.539743	0.460521

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 like NIFTY50 and TCS, implied volatility is generally higher while for stocks like ITC and TITAN, 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.