

# MA 374 – Financial Engineering Lab

## Lab – 9

Name - Vishisht Priyadarshi

Roll No - 180123053

### 1 QUESTION - 1:

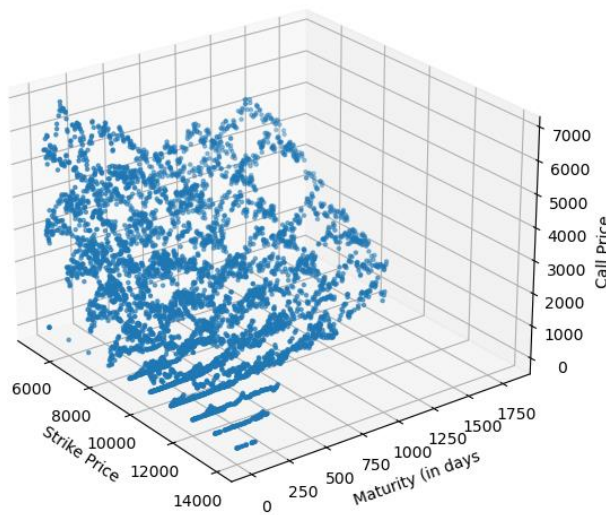
Data for following companies (from nsedata1) are taken for the analysis:

1. Tata Motors
2. HDFC Bank
3. Reliance
4. Heromotoco
5. Bajaj-Auto
6. NSE Index (NIFTY 50)

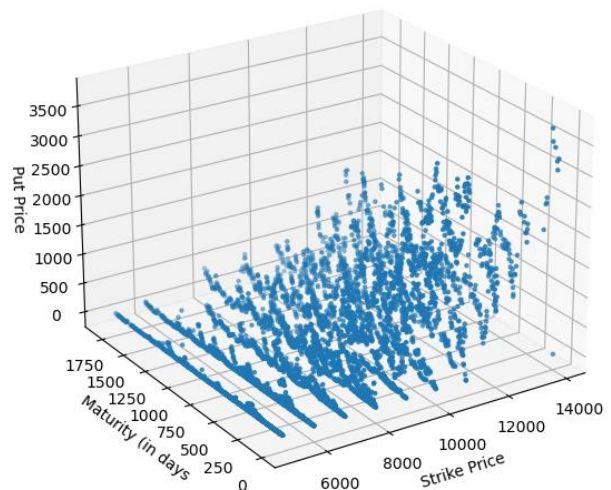
### 2 QUESTION - 2:

#### i. NIFTY50 –

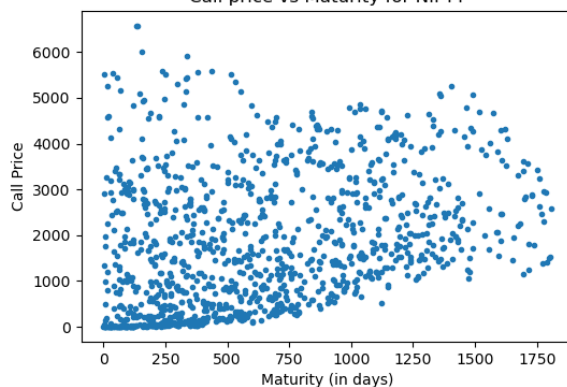
3D plot for Call Option - NIFTY



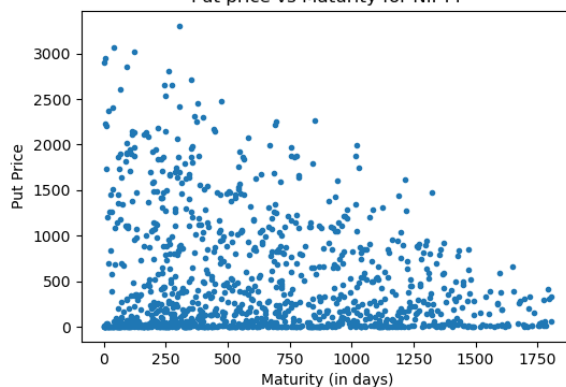
3D plot for Put Option - NIFTY

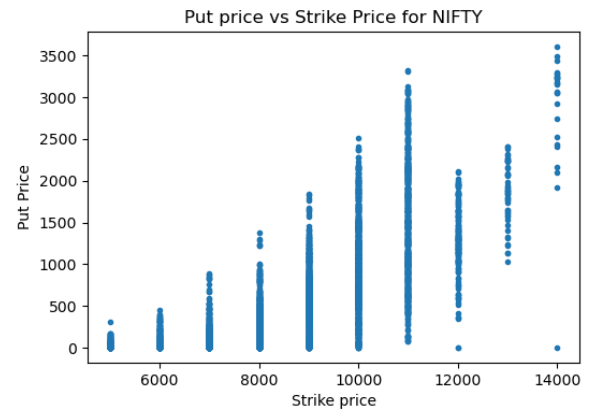
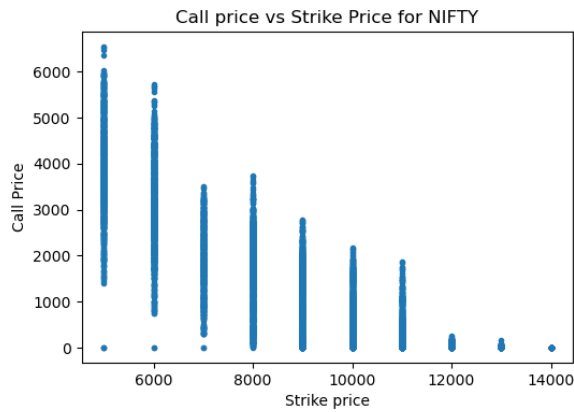


Call price vs Maturity for NIFTY



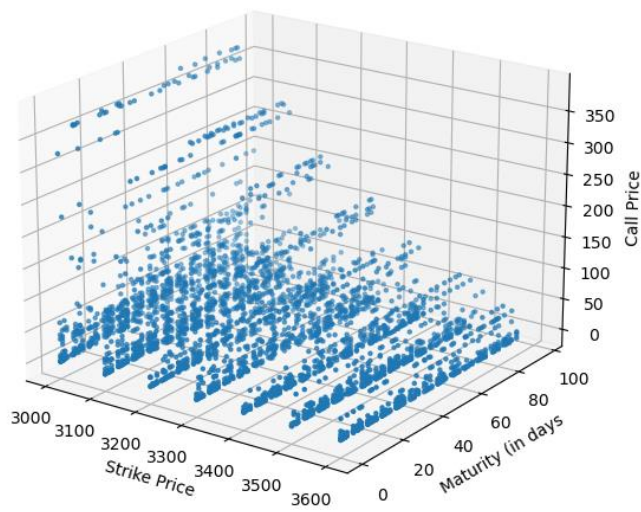
Put price vs Maturity for NIFTY



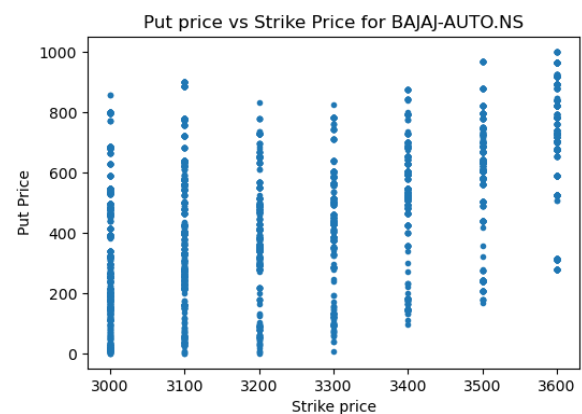
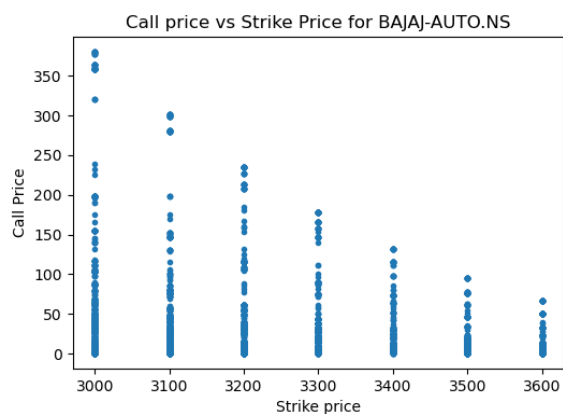
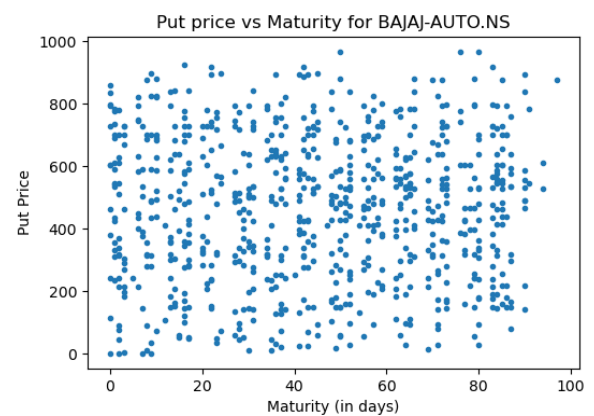
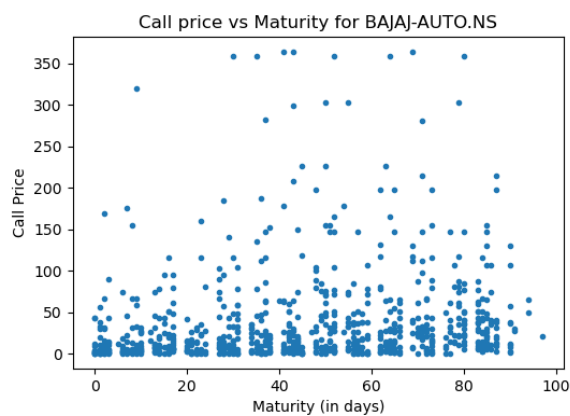
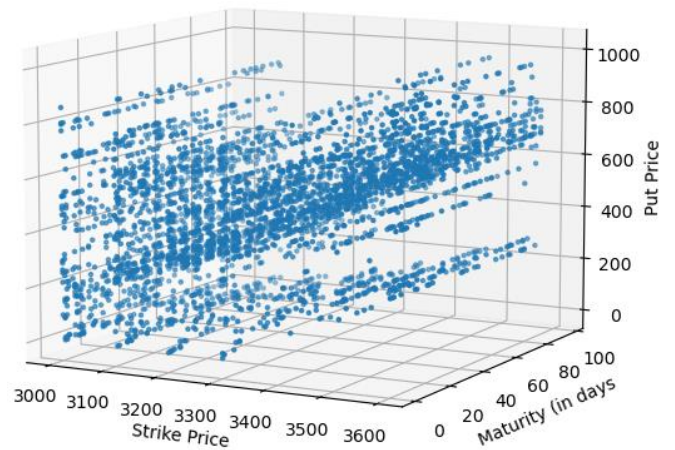


## ii. BAJAJ-AUTO –

3D plot for Call Option - BAJAJ-AUTO.NS

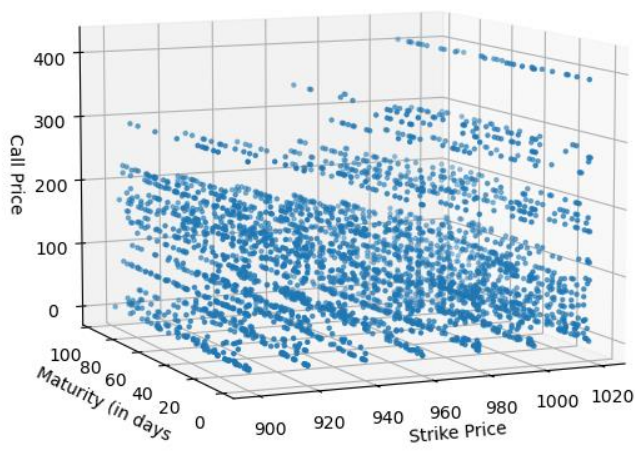


3D plot for Put Option - BAJAJ-AUTO.NS

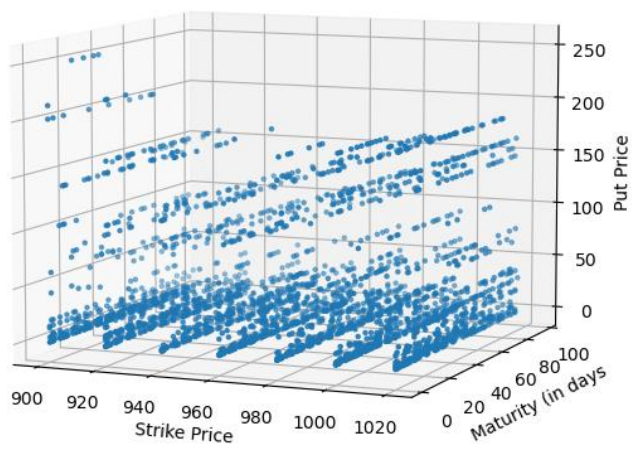


iii. HDFC Bank –

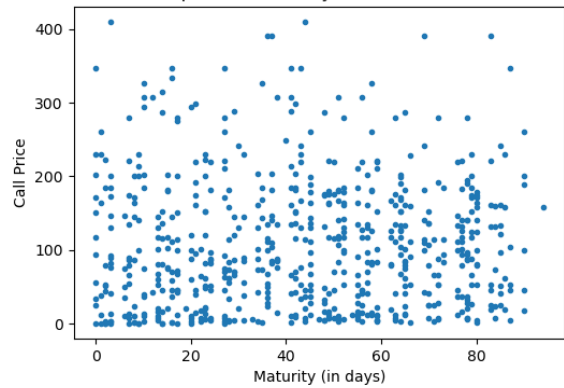
3D plot for Call Option - HDFCBANK.NS



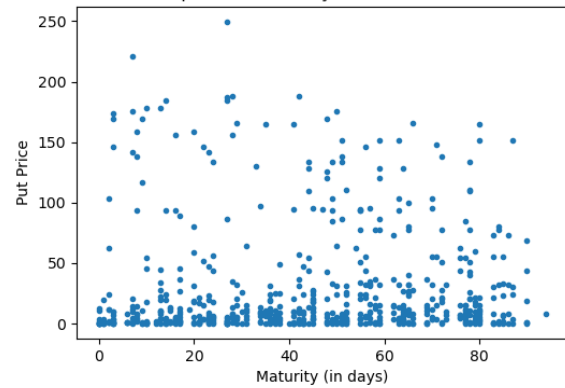
3D plot for Put Option - HDFCBANK.NS



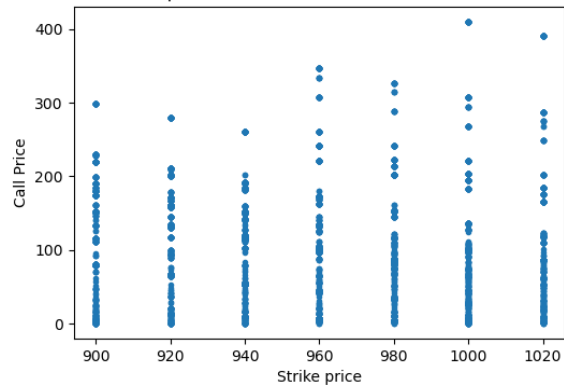
Call price vs Maturity for HDFCBANK.NS



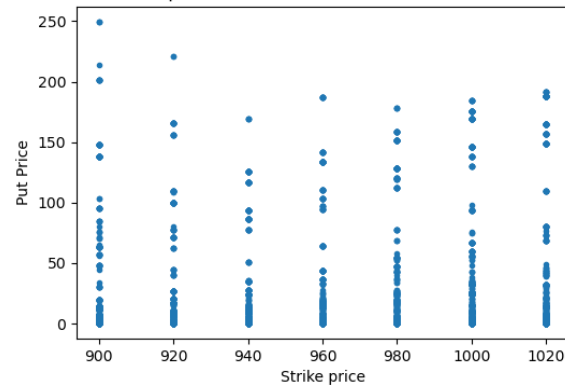
Put price vs Maturity for HDFCBANK.NS



Call price vs Strike Price for HDFCBANK.NS

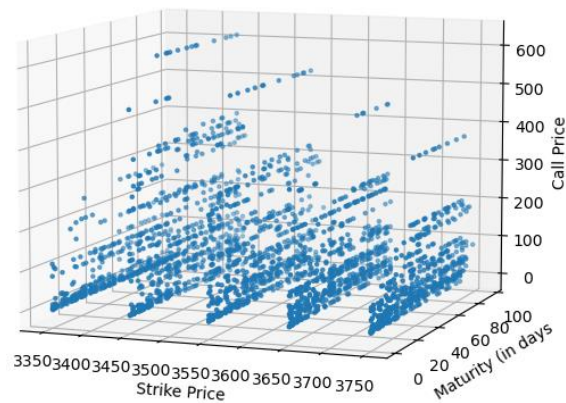


Put price vs Strike Price for HDFCBANK.NS

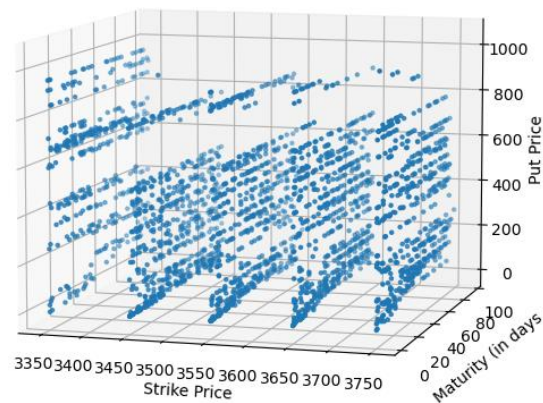


iv. HEROMOTOCO –

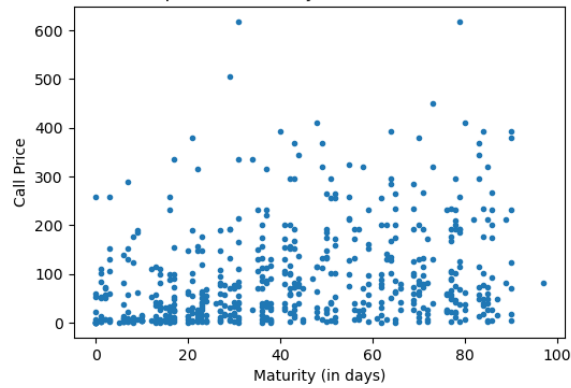
3D plot for Call Option - HEROMOTOCO.NS



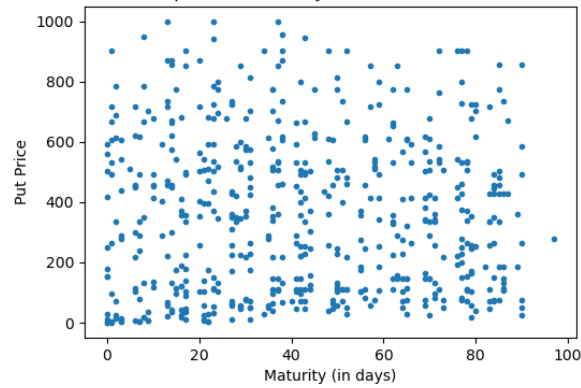
3D plot for Put Option - HEROMOTOCO.NS



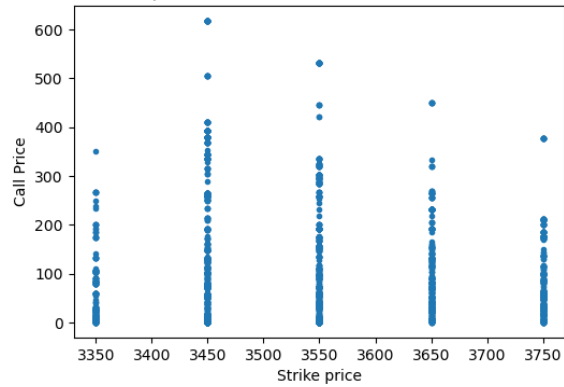
Call price vs Maturity for HEROMOTOCO.NS



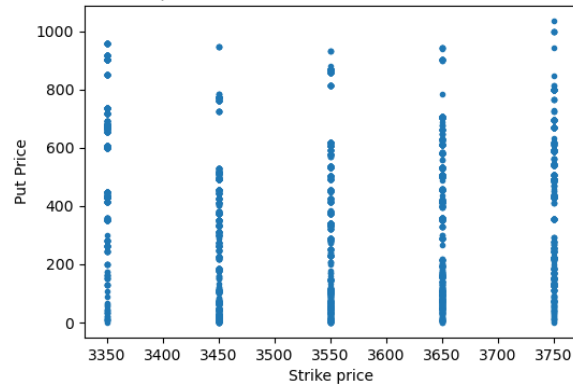
Put price vs Maturity for HEROMOTOCO.NS



Call price vs Strike Price for HEROMOTOCO.NS



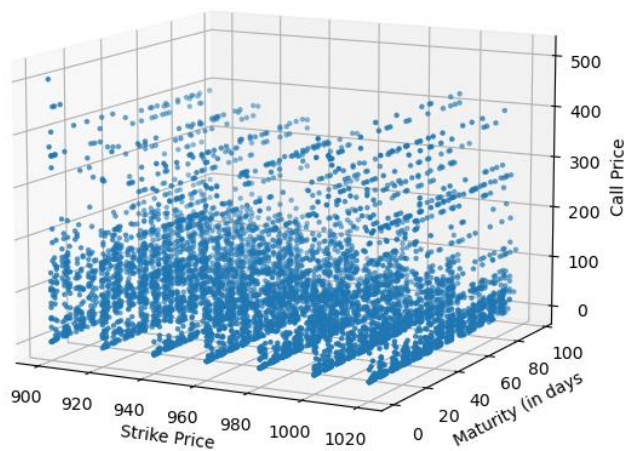
Put price vs Strike Price for HEROMOTOCO.NS



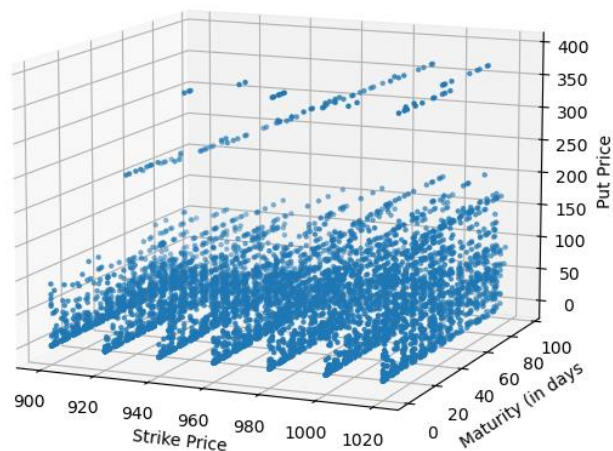


## v. RELIANCE –

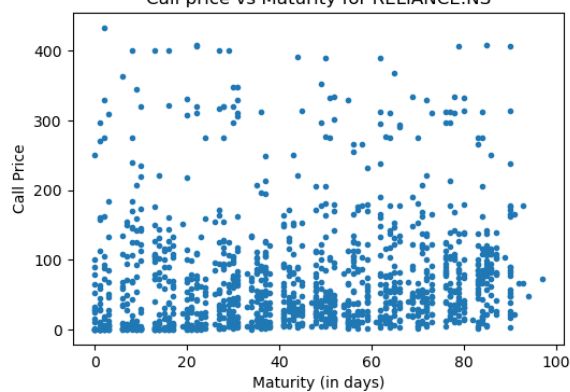
3D plot for Call Option - RELIANCE.NS



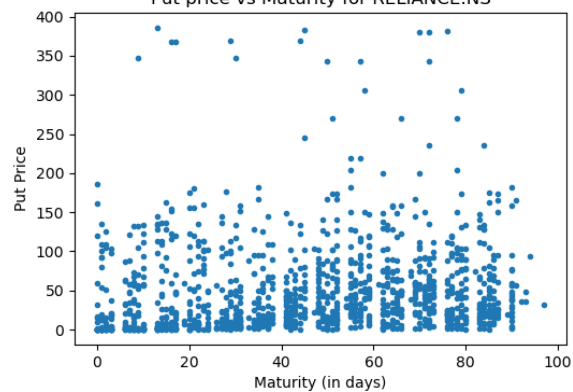
3D plot for Put Option - RELIANCE.NS



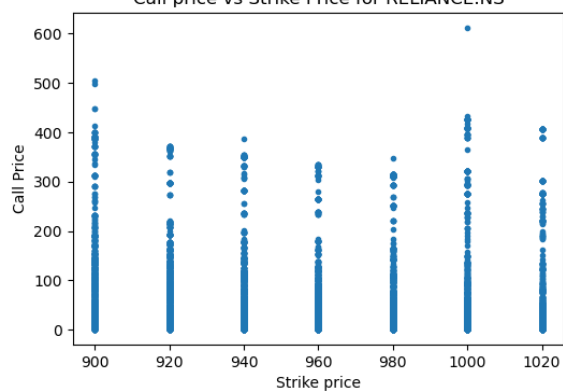
Call price vs Maturity for RELIANCE.NS



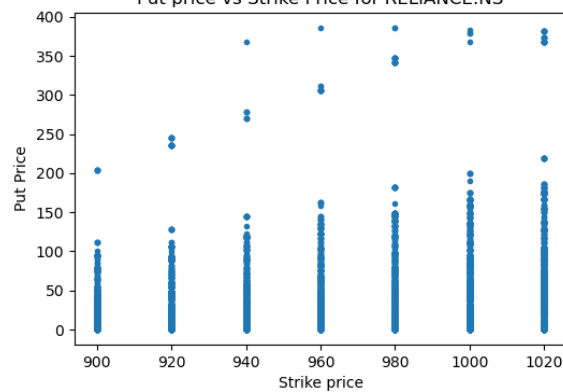
Put price vs Maturity for RELIANCE.NS



Call price vs Strike Price for RELIANCE.NS

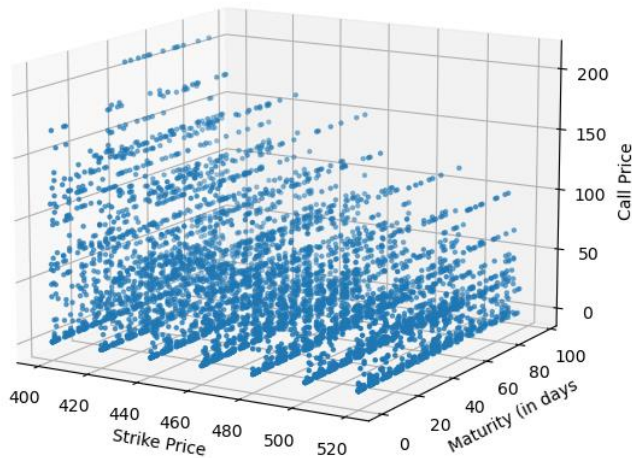


Put price vs Strike Price for RELIANCE.NS

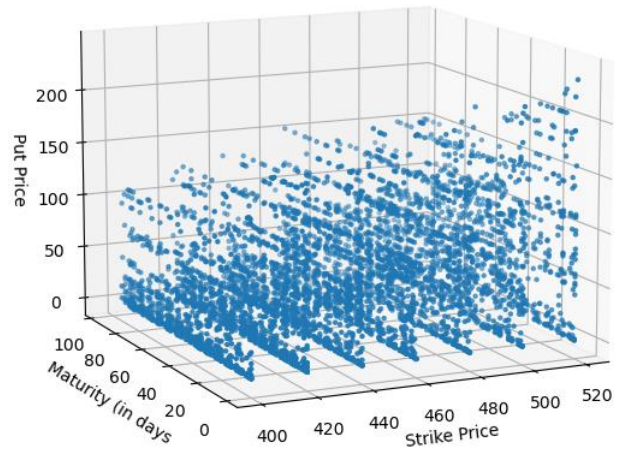


## vi. TATA Motors –

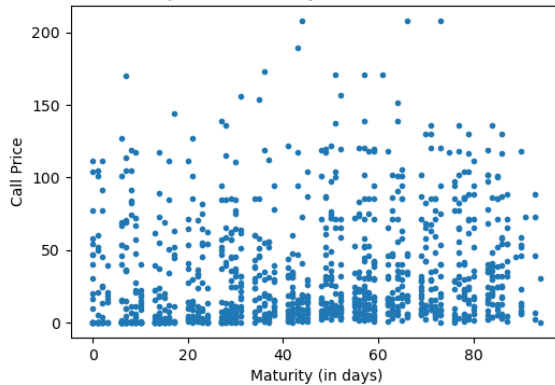
3D plot for Call Option - TATAMOTORS.NS



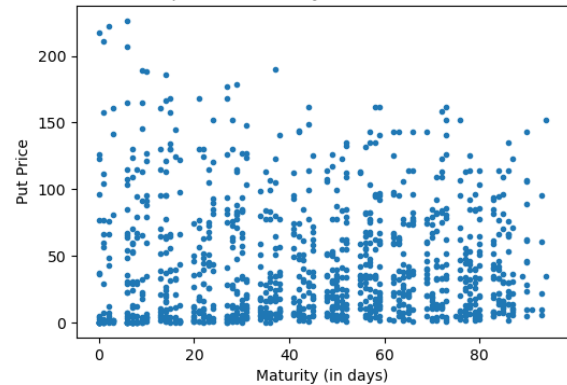
3D plot for Put Option - TATAMOTORS.NS



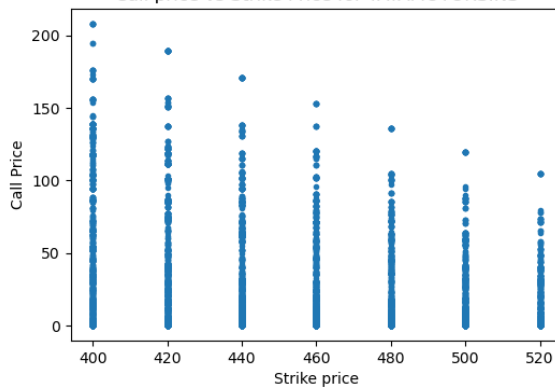
Call price vs Maturity for TATAMOTORS.NS



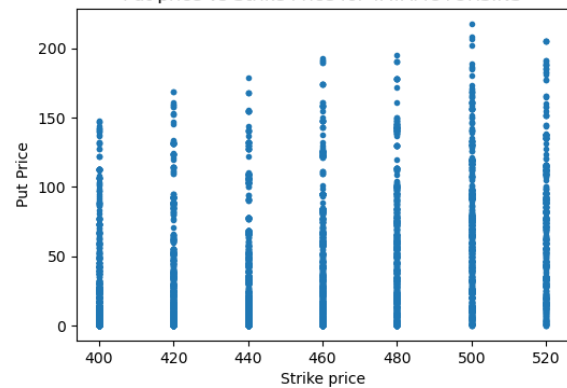
Put price vs Maturity for TATAMOTORS.NS



Call price vs Strike Price for TATAMOTORS.NS



Put price vs Strike Price for TATAMOTORS.NS



## 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 1<sup>st</sup> Jan 2014 – 31<sup>st</sup> Dec 2014 will show different price from that of 1<sup>st</sup> Jan 2015 – 31<sup>st</sup> Jan 2015 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.

### 3 QUESTION – 3 :

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,

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

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

$C^*$  = 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,

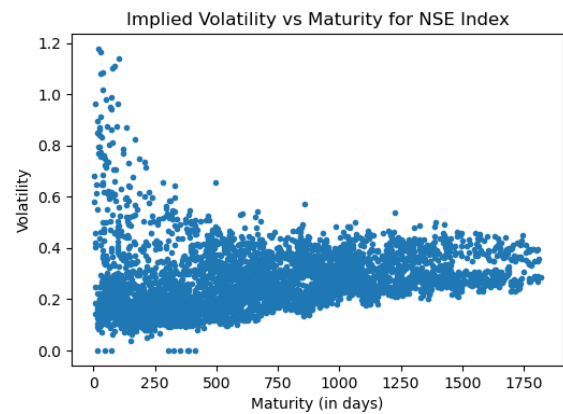
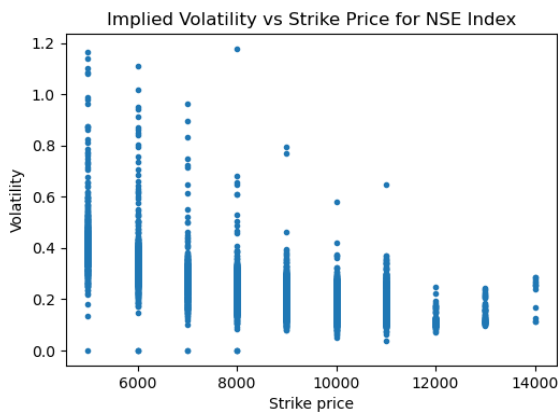
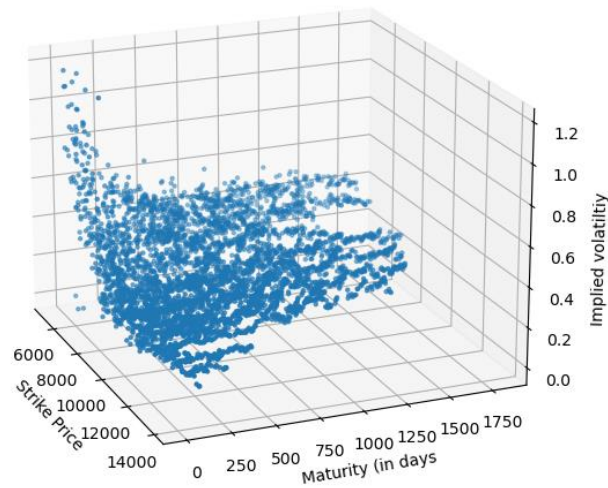
$$d_1 = \frac{\log\left(\frac{x}{K}\right) + (r + \frac{1}{2}\sigma^2)(T-t)}{\sigma\sqrt{T-t}}$$

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

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

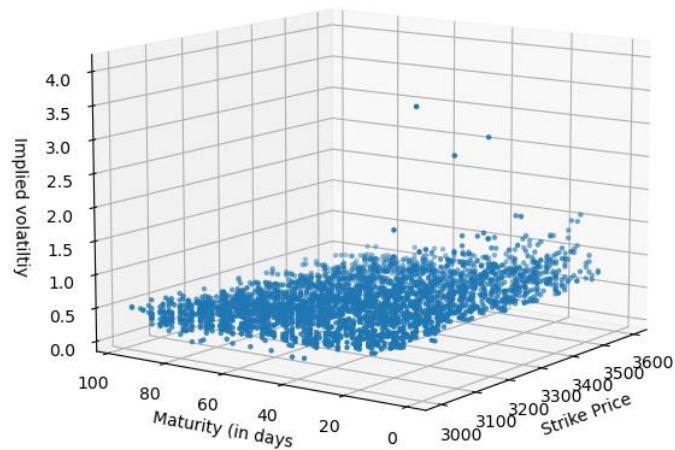
## i. NIFTY50 –

3D plot for Implied volatility - NSE Index

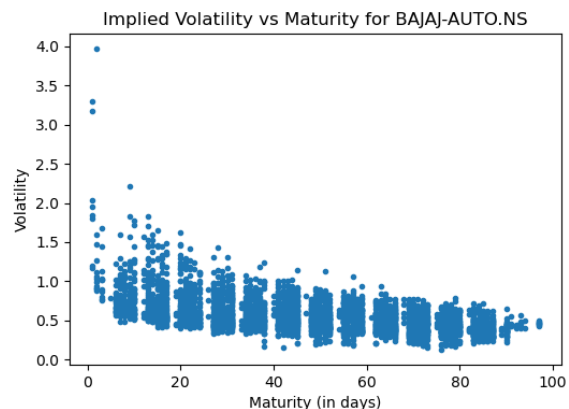
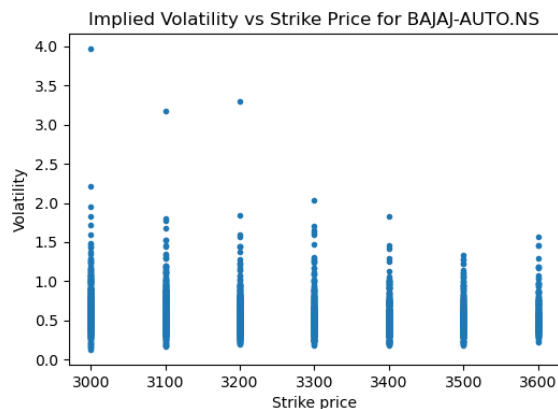


## ii. BAJAJ-AUTO –

3D plot for Implied volatility - BAJAJ-AUTO.NS

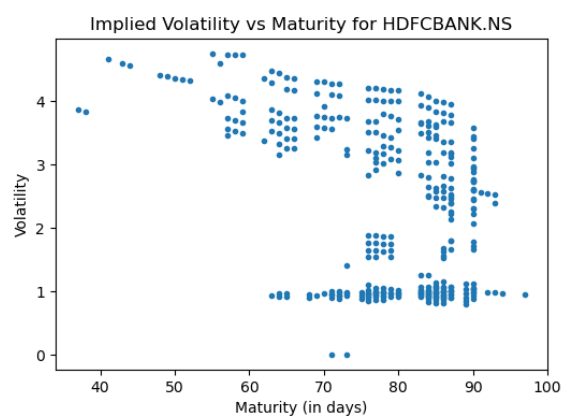
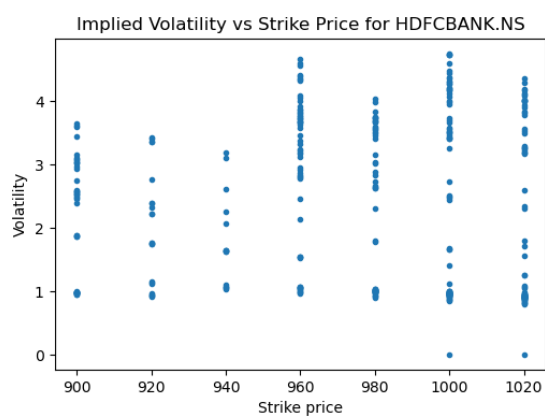
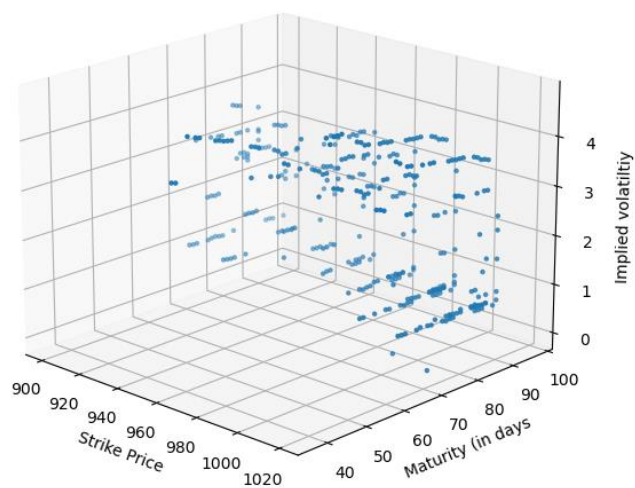






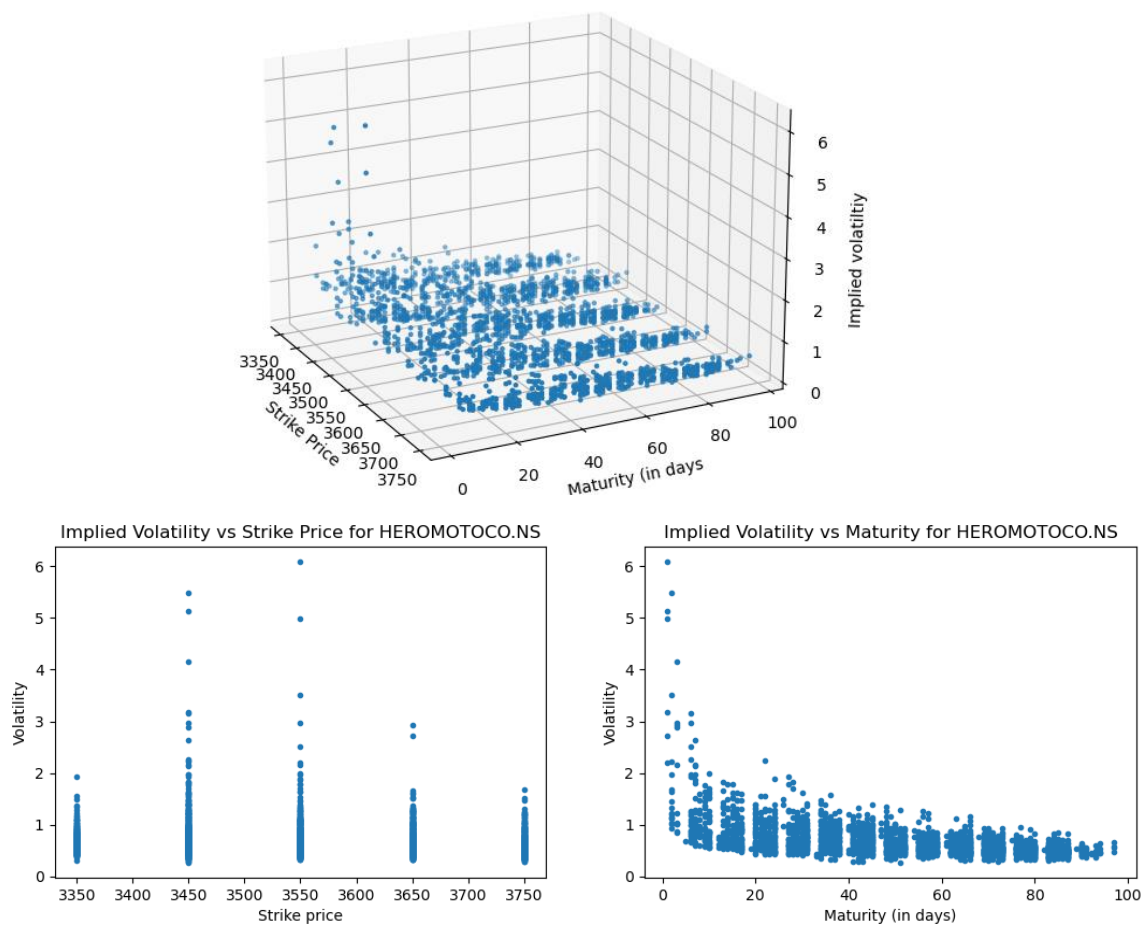
### iii. HDFC Bank –

3D plot for Implied volatility - HDFCBANK.NS



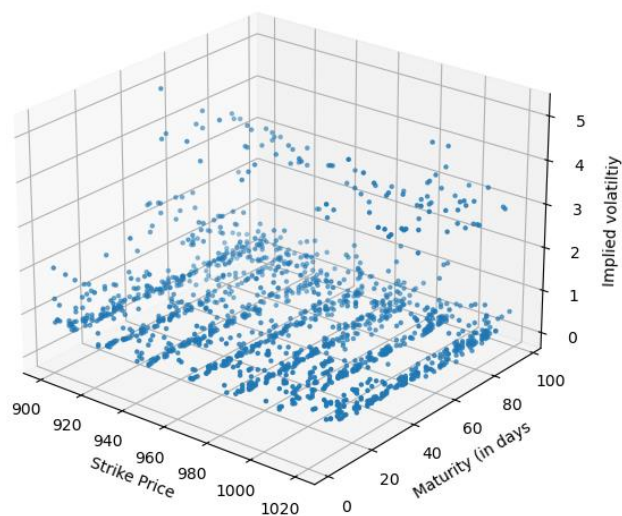
#### iv. HEROMOTOCO –

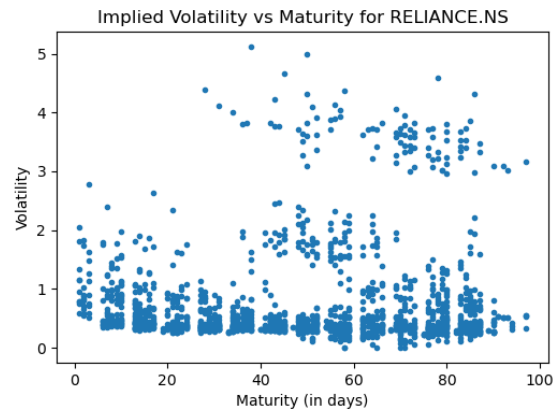
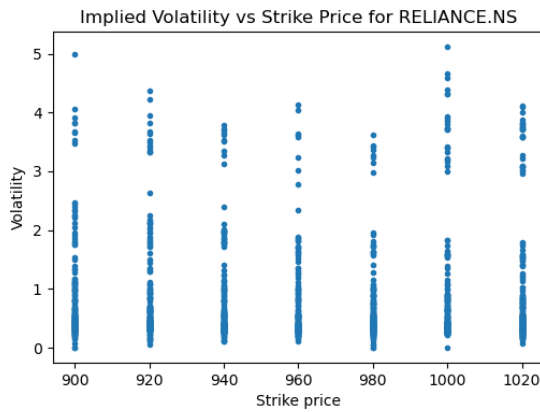
3D plot for Implied volatility - HEROMOTOCO.NS



#### v. RELIANCE –

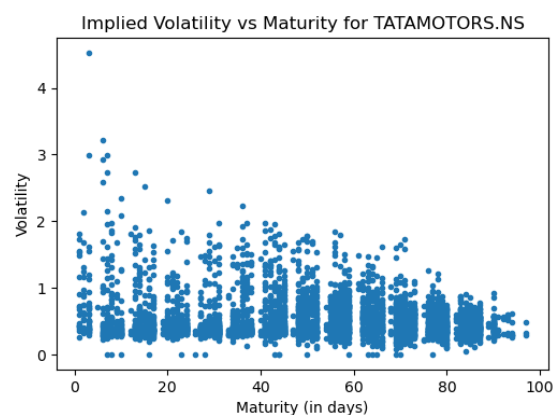
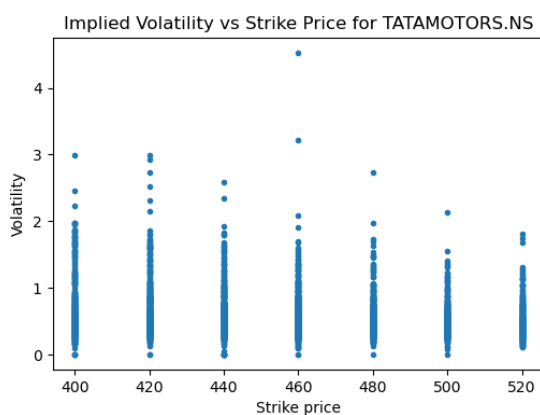
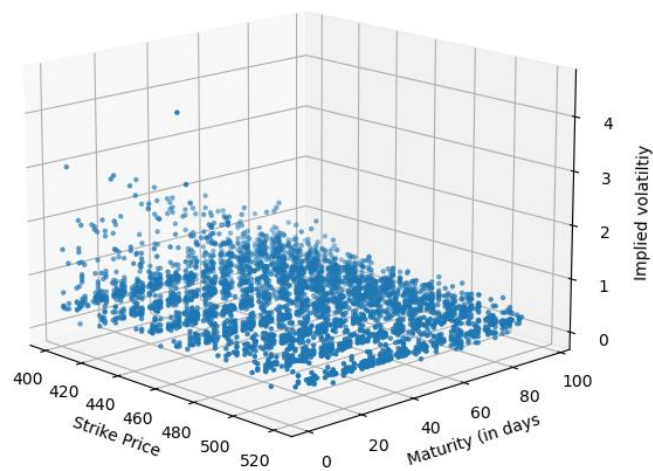
3D plot for Implied volatility - RELIANCE.NS





## vi. TATAMOTORS –

3D plot for Implied volatility - TATAMOTORS.NS



## Observations –

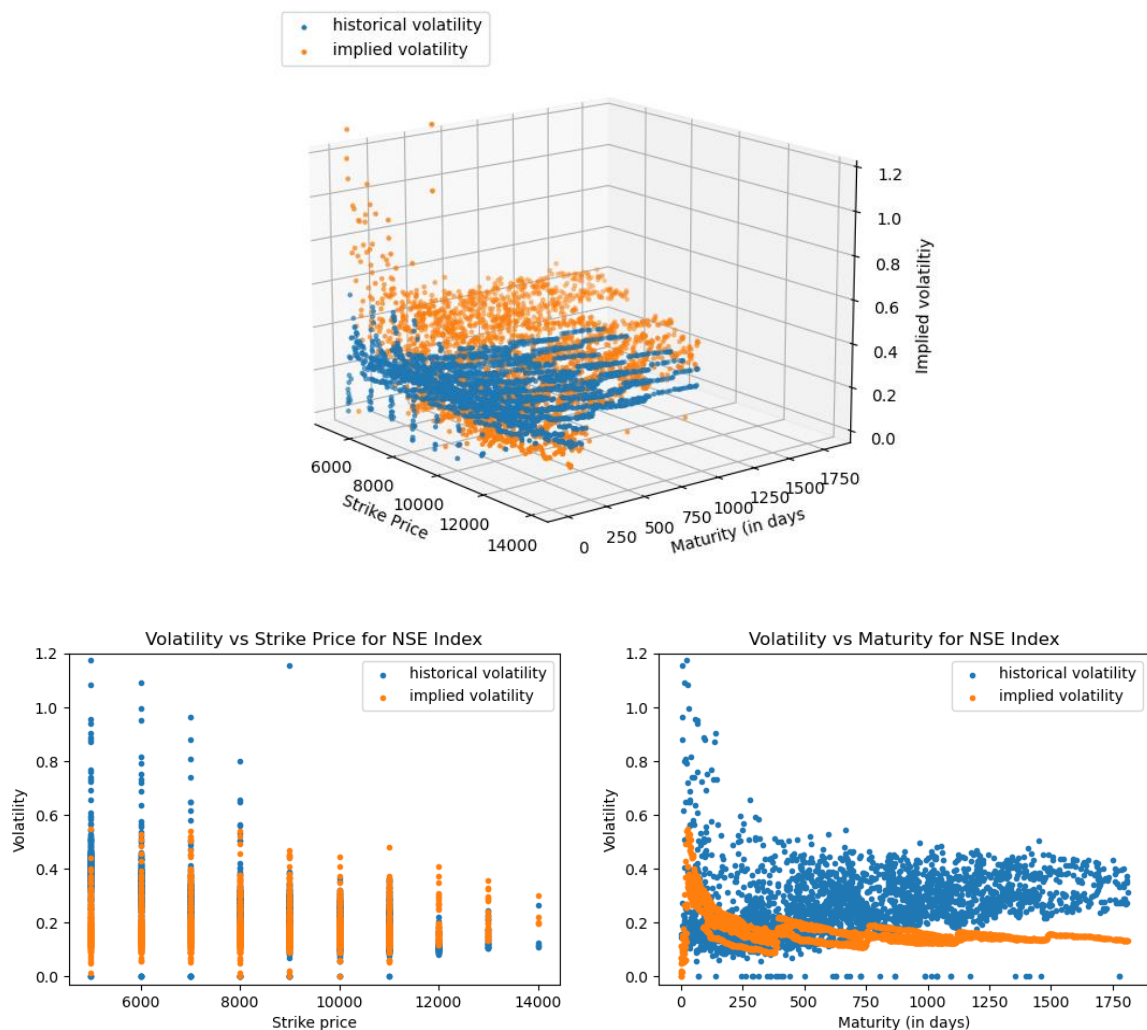
1. The lack of sufficient data adds difficulty in making proper analysis, but general trends can be figured out by considering the plots for NIFTY50 since it has larger data-points. The other plots also show similar trends.
2. Theoretically, the implied volatility is generally a convex function of strike 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 1<sup>st</sup> Jan 2014 – 31<sup>st</sup> Dec 2014 will show different price from that of 1<sup>st</sup> Jan 2015 – 31<sup>st</sup> Jan 2015 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.

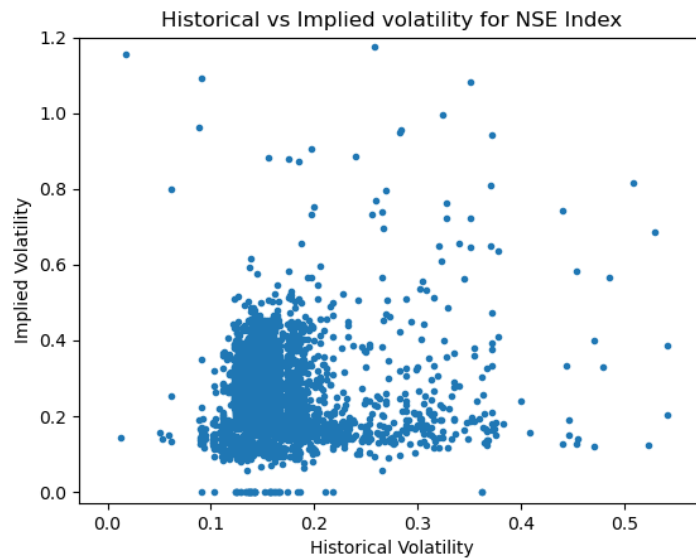
## 4 QUESTION – 4 :

### i. NIFTY50 -

Comparison between historical and implied volatility - NSE Index





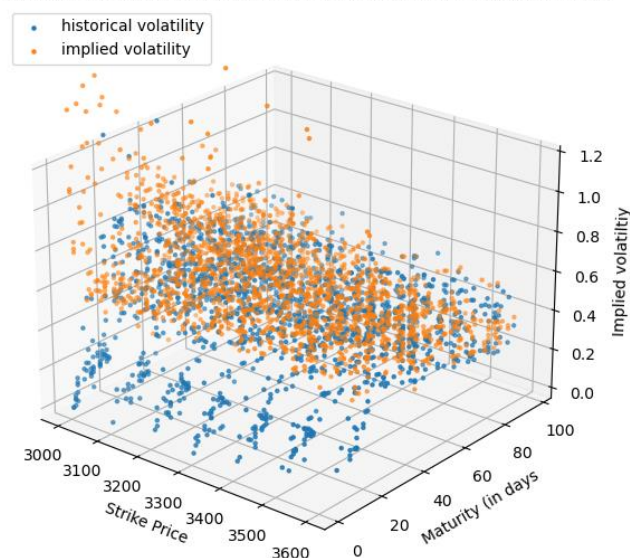


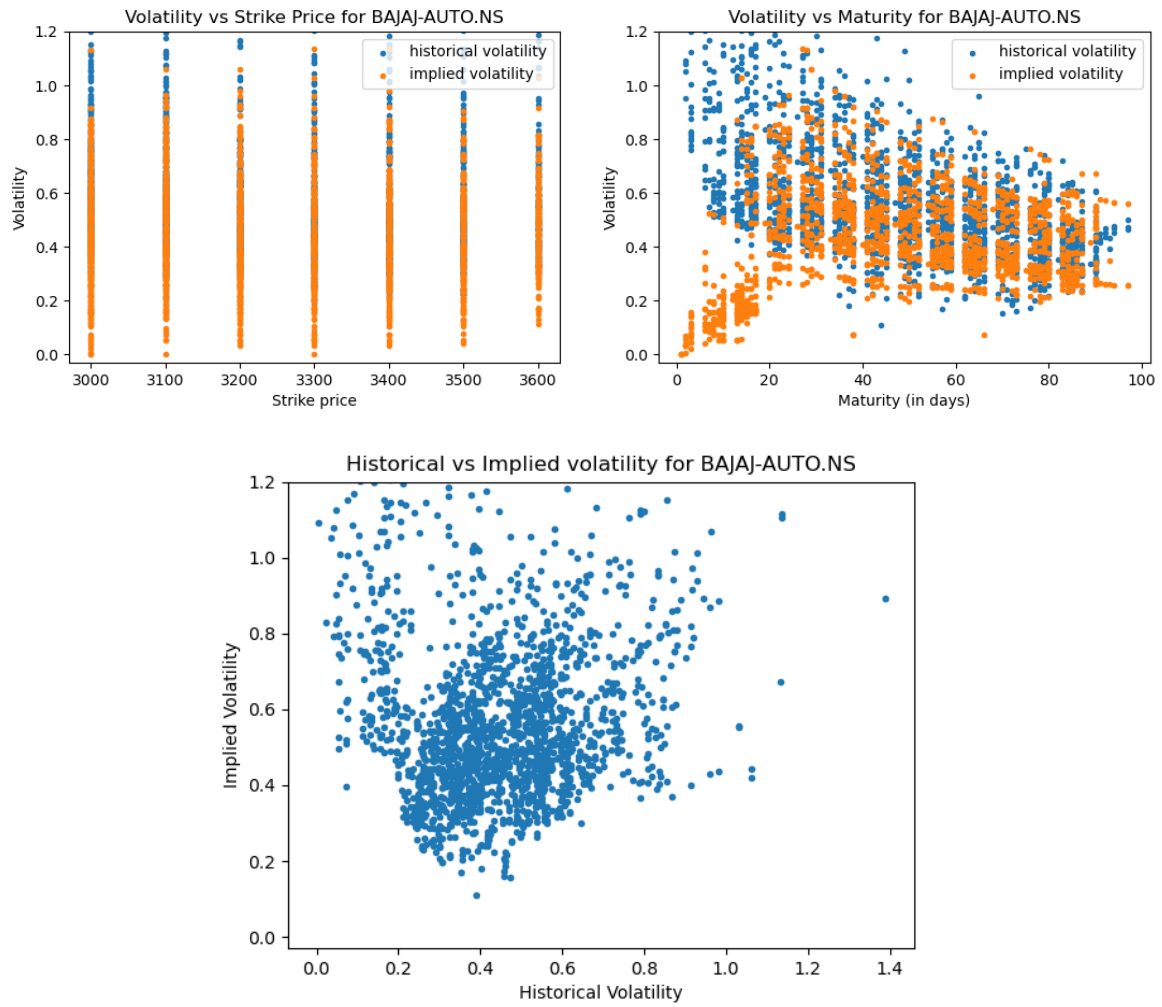
The tabular data (only few data-points) is as follows:

***** For NSE Index *****					
SI No.	Call Price	Stock Price (₹)	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	0.358896
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	0.260744
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

## ii. BAJAJ-AUTO -

Comparison between historical and implied volatility - BAJAJ-AUTO.NS



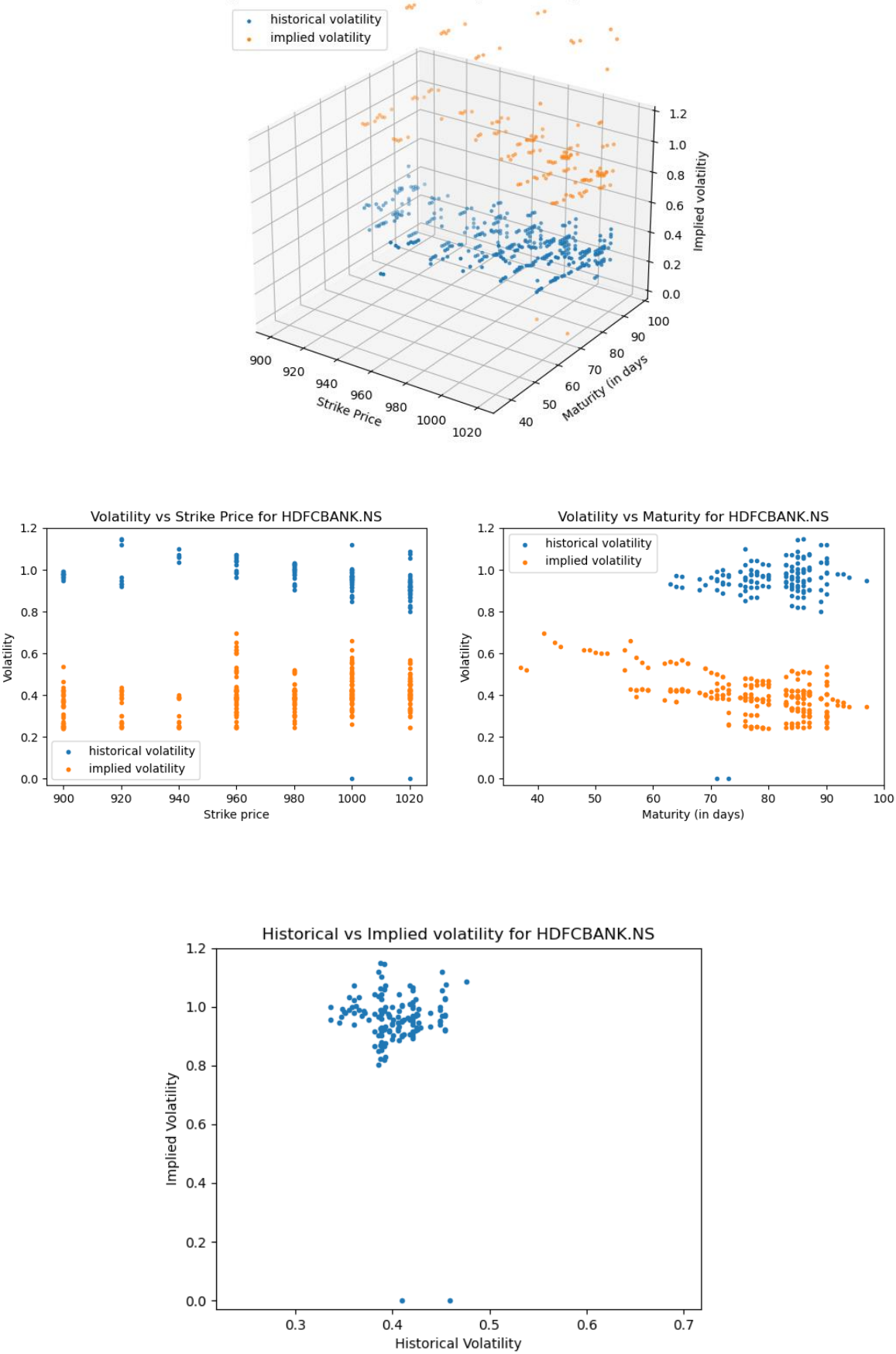


The tabular data (only few data-points) is as follows:

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

iii. HDFC Bank -

Comparison between historical and implied volatility - HDFCBANK.NS

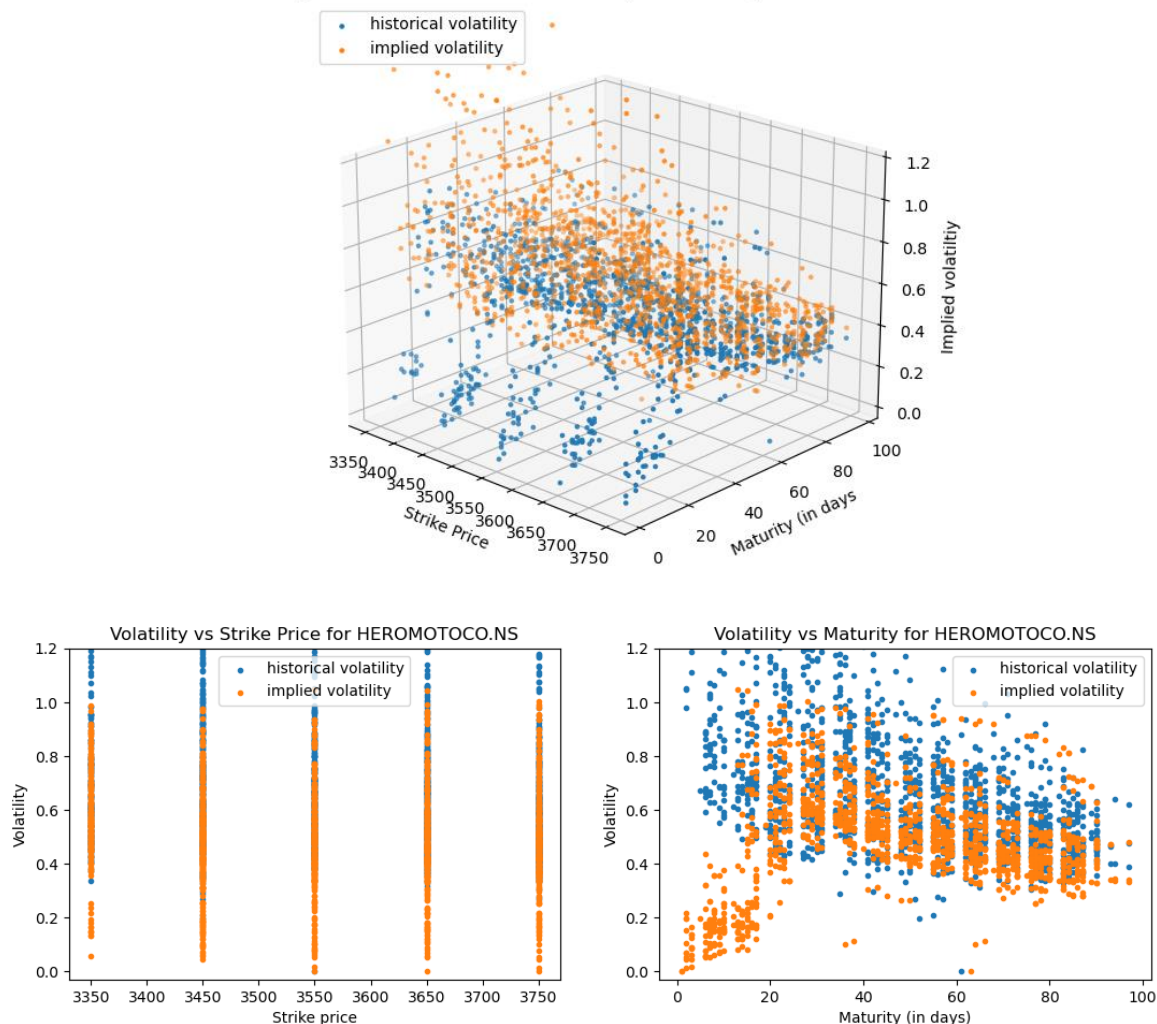


The tabular data (only few data-points) is as follows:

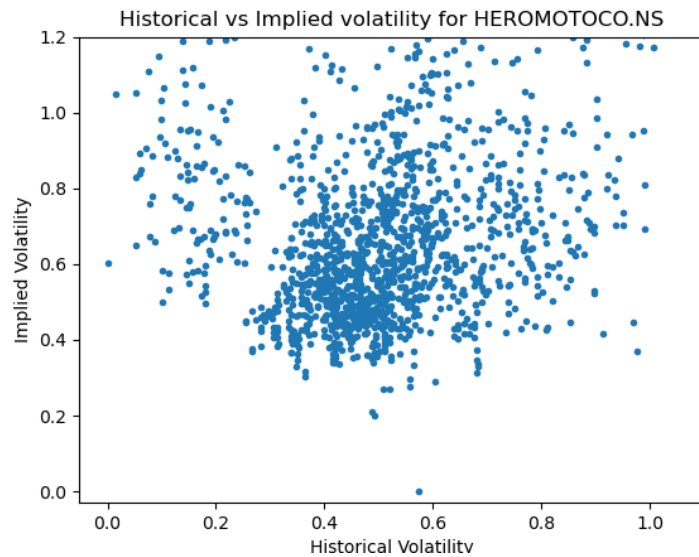
***** For HDFCBANK.NS *****						
SI No.	Call Price	Stock Price (S0)	Maturity (in days)	Historical Volatility	Implied Volatility	
1	2.75	341.983	93	0.349957	0.981824	
2	1.8	389.878	72	0.438511	0.93215	
3	2.75	386.749	71	0.427235	0.993337	
4	4.9	412.737	83	0.360245	1.02353	
5	12.3	419.964	89	0.385825	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	

#### iv. HEROMOTOCO –

Comparison between historical and implied volatility - HEROMOTOCO.NS





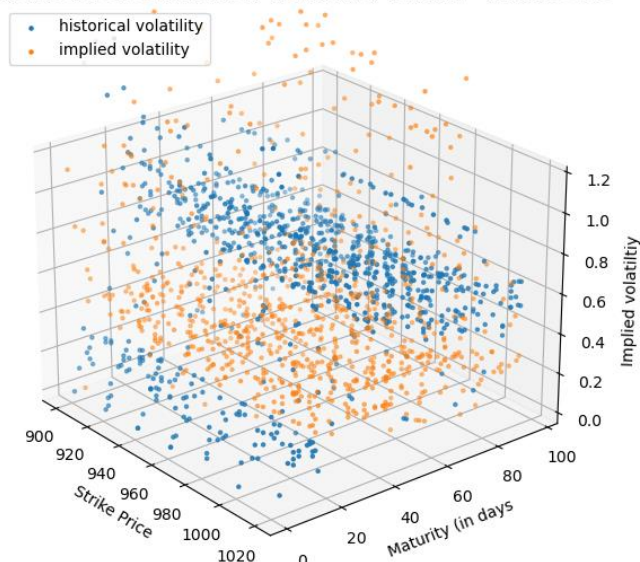


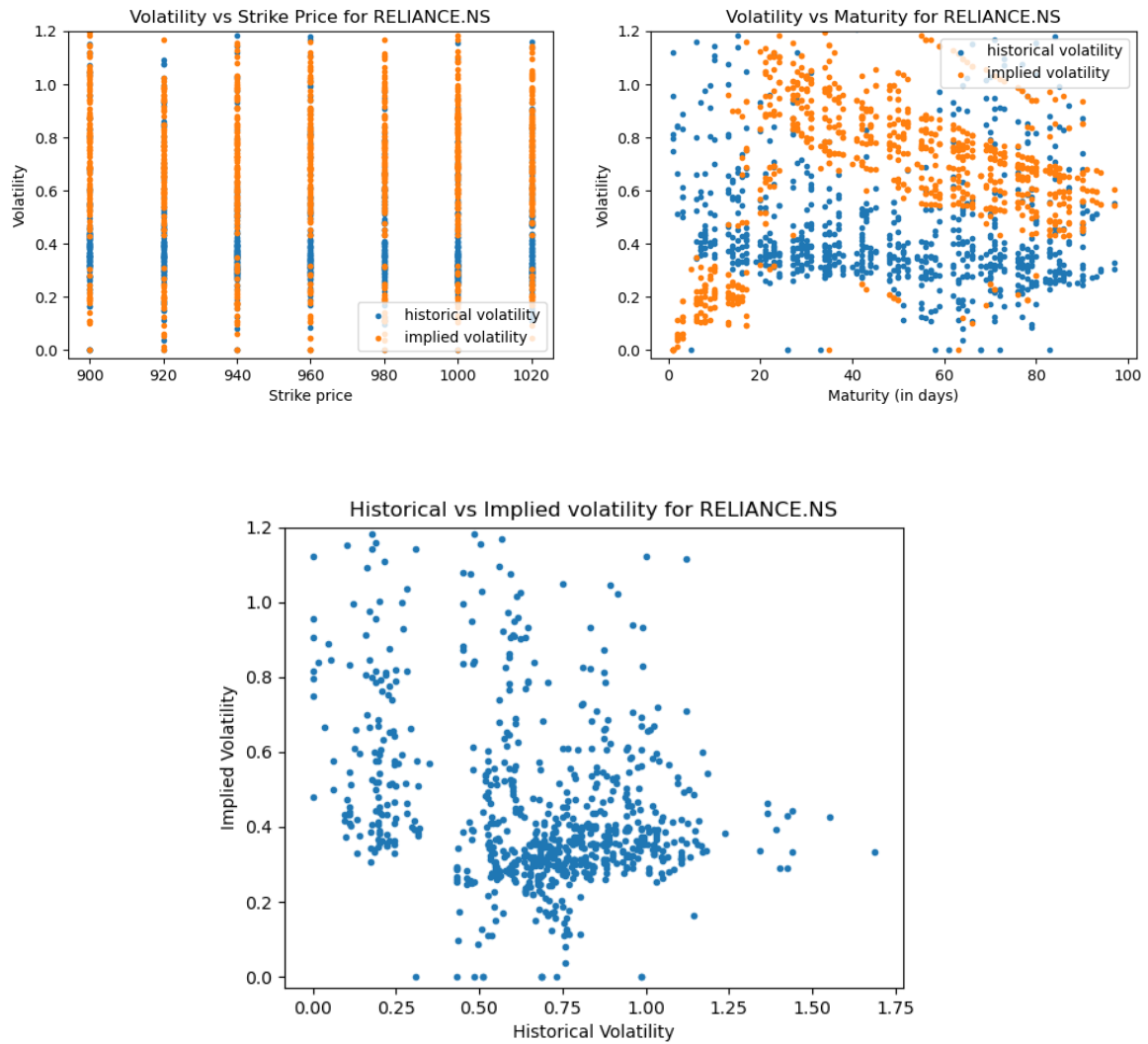
The tabular data (only few data-points) is as follows:

***** For HEROMOTOCO.NS *****					
SI No.	Call Price	Stock Price (50)	Maturity (in days)	Historical Volatility	Implied Volatility
1	11.95	2698.32	22	0.857818	0.632383
2	44.85	2673.46	57	0.783986	0.64401
3	80.5	2673.46	57	0.783986	0.687165
4	22.75	2673.46	21	0.886932	0.710124
5	80.5	2693.3	56	0.74071	0.67947
6	77.45	2693.3	84	0.566754	0.541661
7	105.4	2693.3	84	0.566754	0.569853
8	39.45	2667.35	83	0.566754	0.513328
9	39.45	2644.88	80	0.424646	0.534513
10	53.4	2644.88	16	0.485621	1.25346
11	44.85	2625.17	51	0.576572	0.712875
12	5.2	2625.17	15	0.449644	0.715393
13	105.65	2652.08	50	0.544443	0.781724
14	77.45	2606.76	77	0.372749	0.619284
15	105.4	2606.76	77	0.372749	0.653898
16	53.4	2615.38	12	0.172289	1.48999
17	27.4	2632.57	73	0.358146	0.546195
18	39.45	2632.57	73	0.358146	0.567152
19	60.45	2621.95	44	0.546426	0.796813
20	80.5	2562.44	43	0.553289	0.885481

## v. RELIANCE –

Comparison between historical and implied volatility - RELIANCE.NS



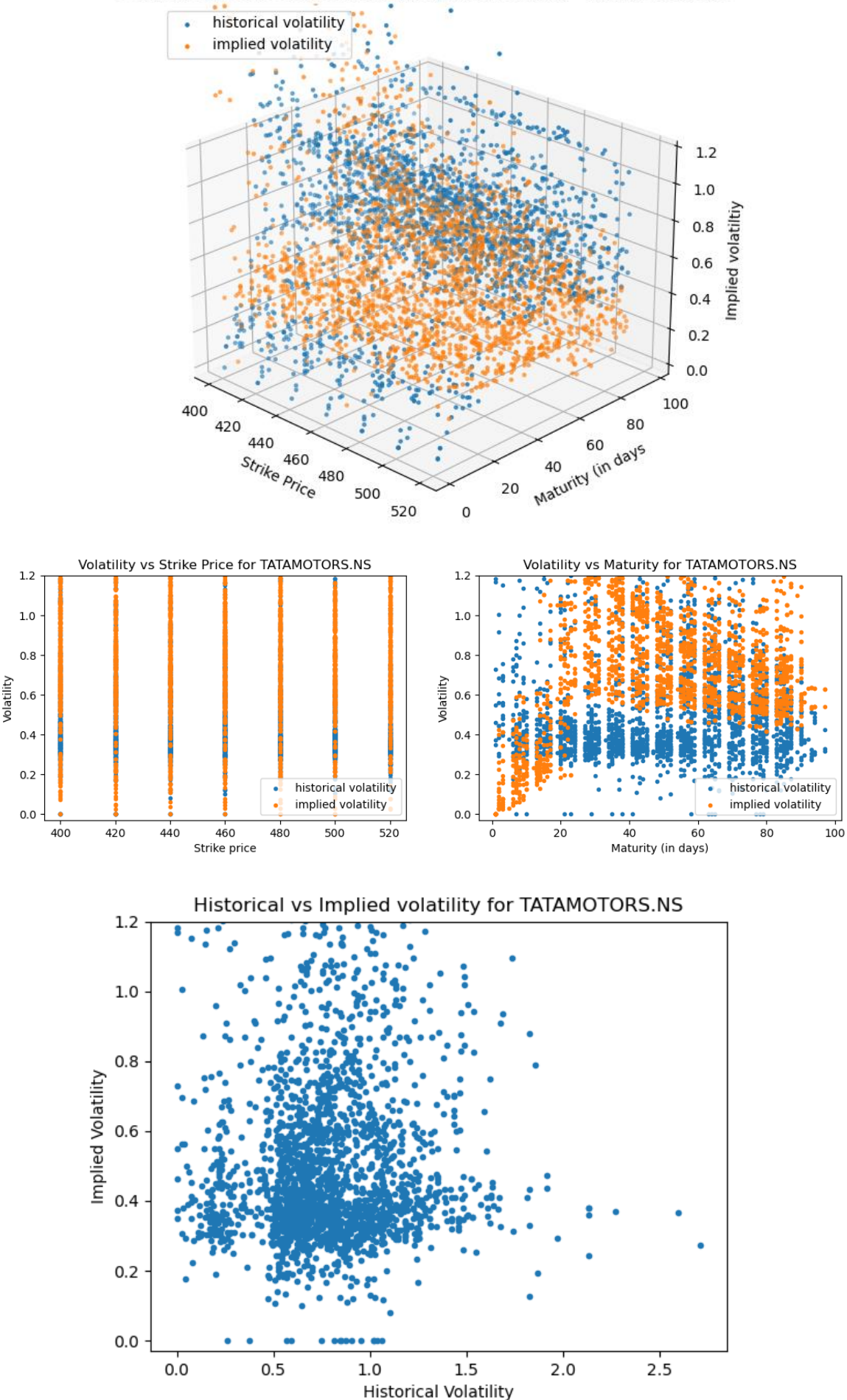


The tabular data (only few data-points) is as follows:

***** For RELIANCE.NS *****					
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

vi. TATAMOTORS –

Comparison between historical and implied volatility - TATAMOTORS.NS



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

***** For TATAMOTORS.NS *****						
SI No.	Call Price	Stock Price (S0)	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 RELIANCE, implied volatility is generally higher while for stocks like BAJAJ-AUTO and TATAMOTORS, 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.