MA 374 - Financial Engineering Lab09

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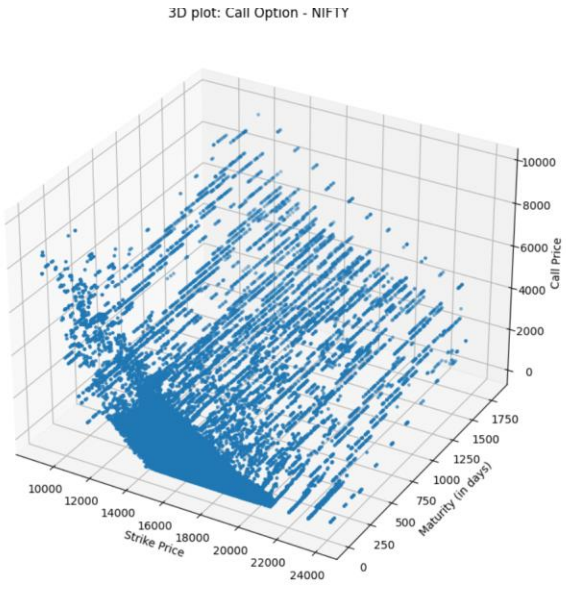
Q1

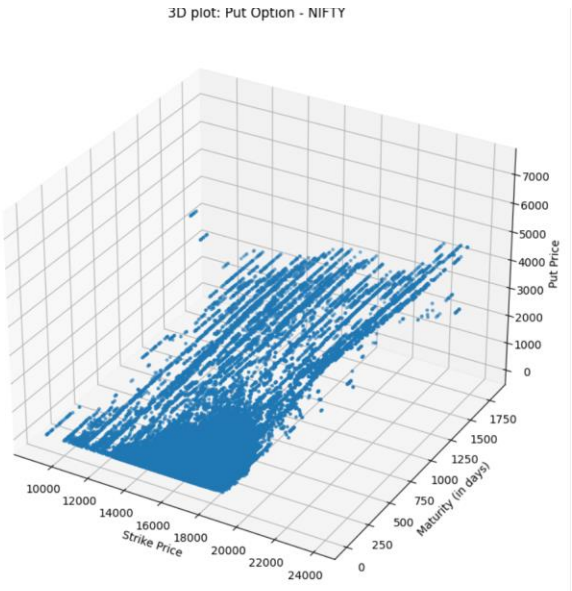
Data for following companies (from nsedata1) are taken for the analysis:

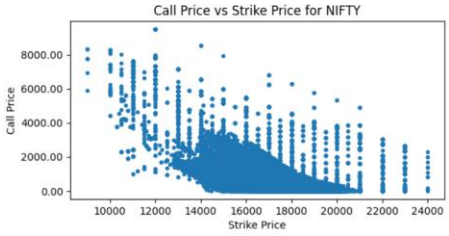
1. NSE Index (NIFTY 50)
2. HDFCBANK.NS
3. ICICIBANK.NS
4. INFY.NS
5. WIPRO.NS

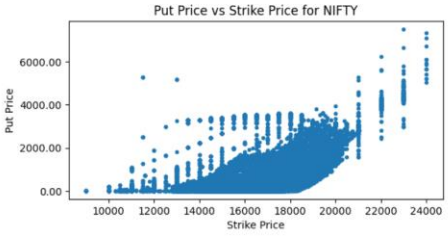
Q2 -a

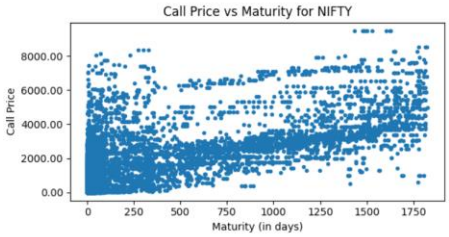
NIFTY

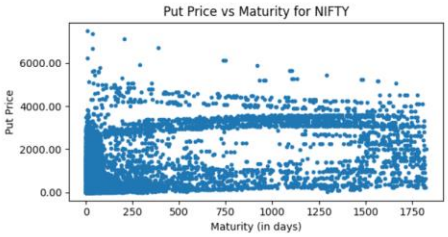




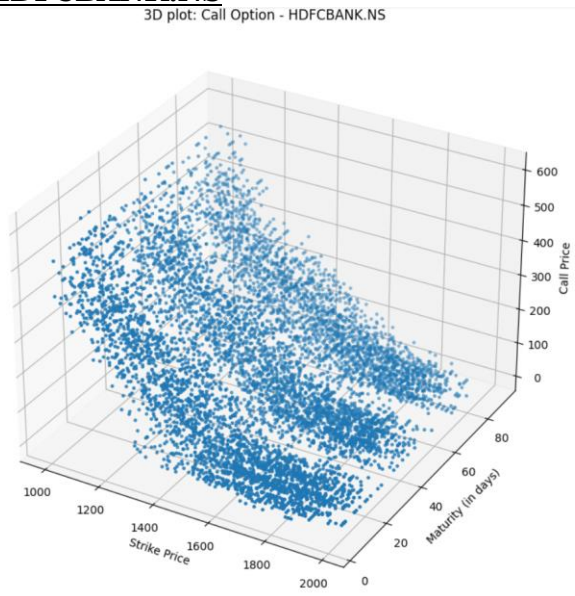

Call Price vs Strike Price for NIFTY
Call Price
Strike Price

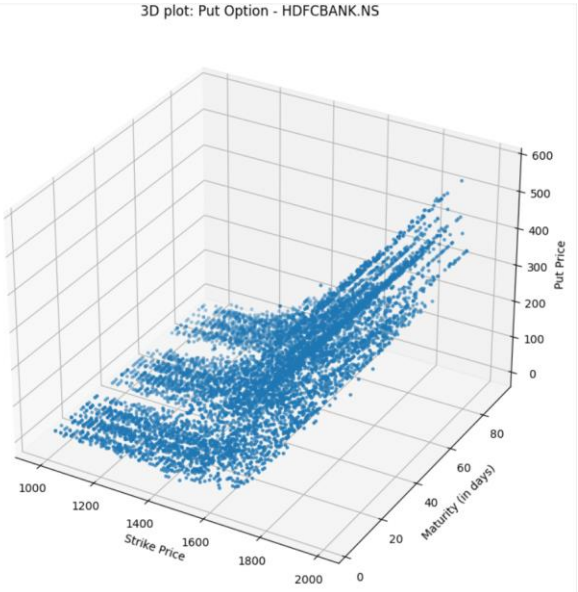

Put Price vs Strike Price for NIFTY
Put Price
Strike Price

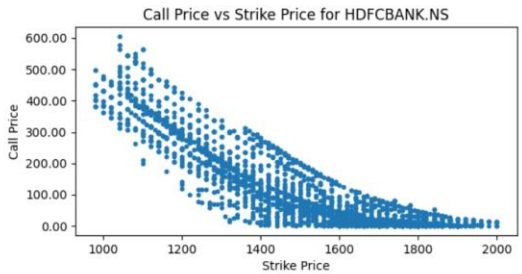

Call Price vs Maturity for NIFTY
Call Price
Maturity (in days)

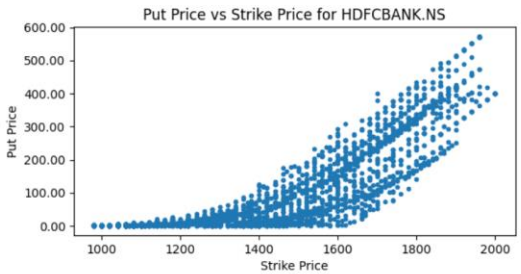

Put Price vs Maturity for NIFTY
Put Price
Maturity (in days)

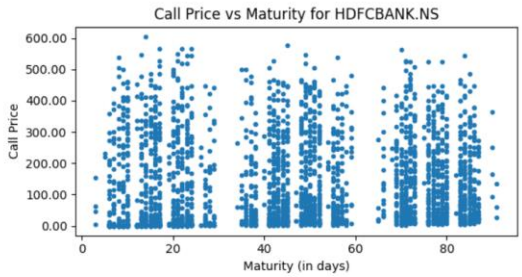
HDFCBANK.NS

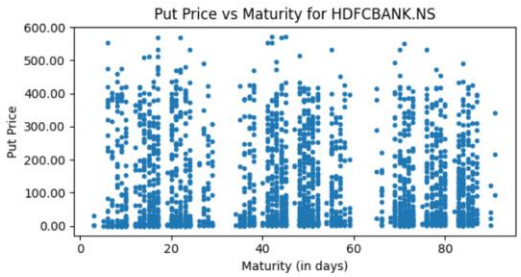

3D plot: Call Option - HDFCBANK.NS
Call Price
Strike Price
Maturity (in days)


3D plot: Put Option - HDFCBANK.NS
Put Price
Strike Price
Maturity (in days)

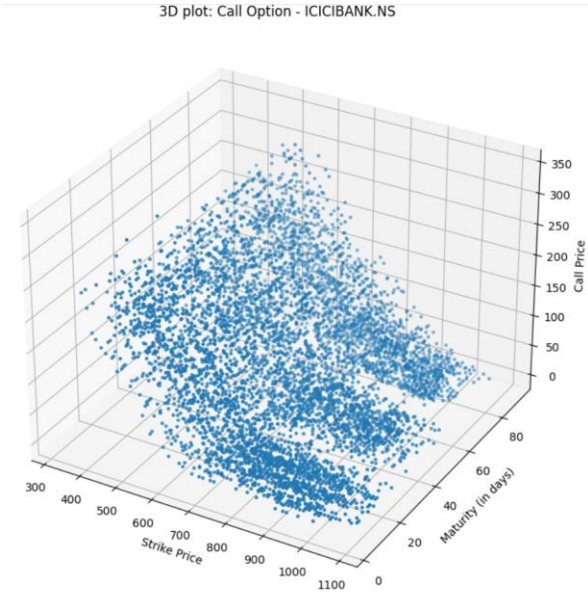

Call Price vs Strike Price for HDFCBANK.NS
Call Price
Strike Price

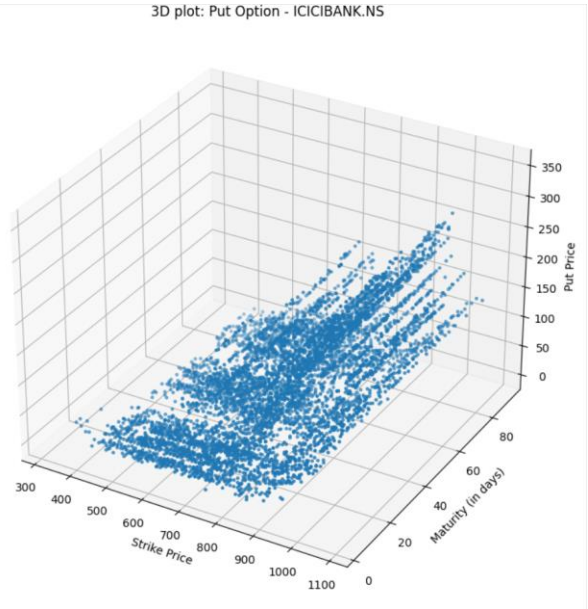

Put Price vs Strike Price for HDFCBANK.NS
Put Price
Strike Price

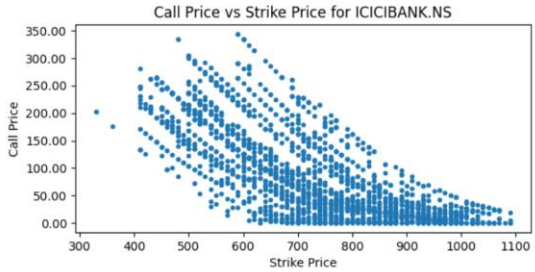

Call Price vs Maturity for HDFCBANK.NS
Call Price
Maturity (in days)

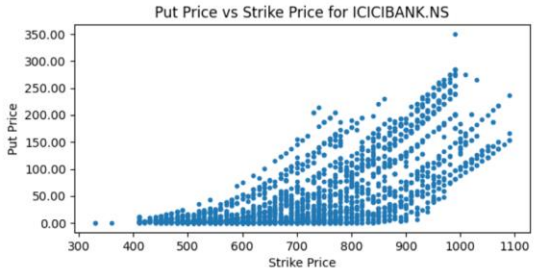

Put Price vs Maturity for HDFCBANK.NS
Put Price
Maturity (in days)

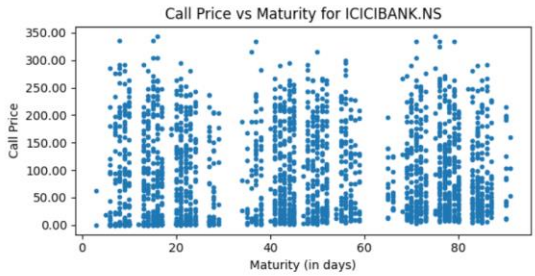
ICICIBANK.NS

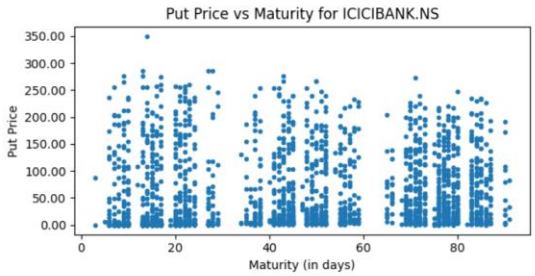




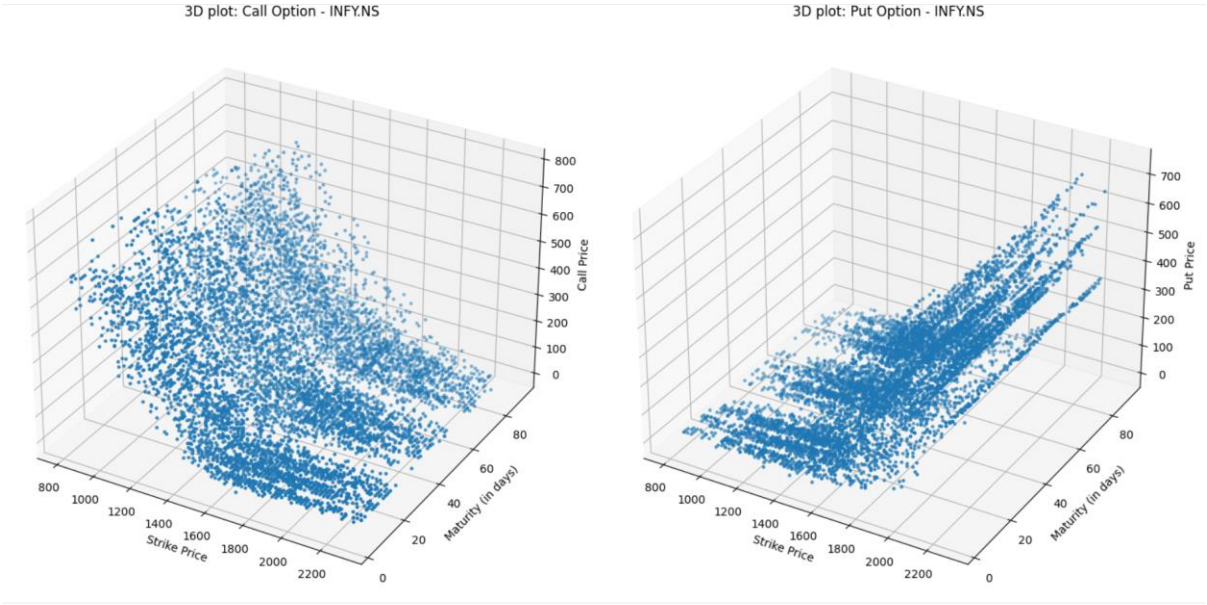


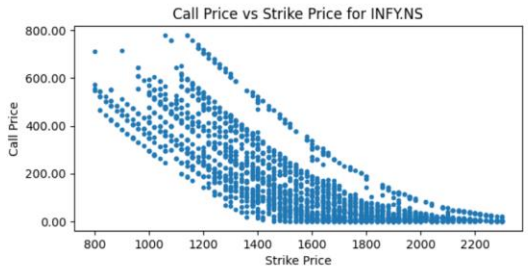


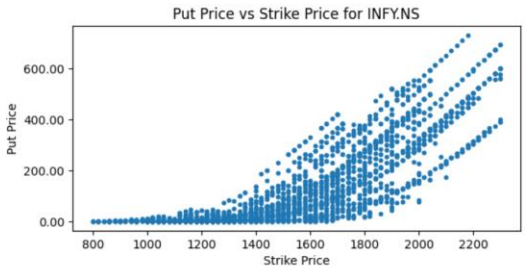


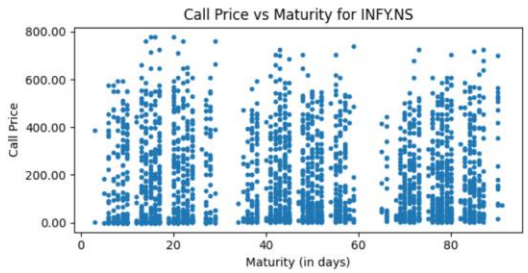


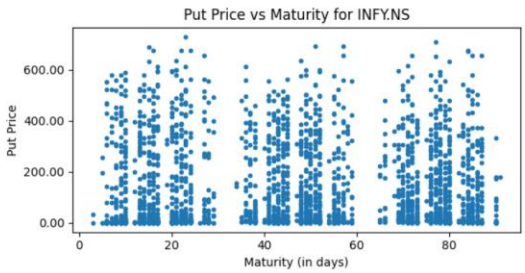
INFY.NS



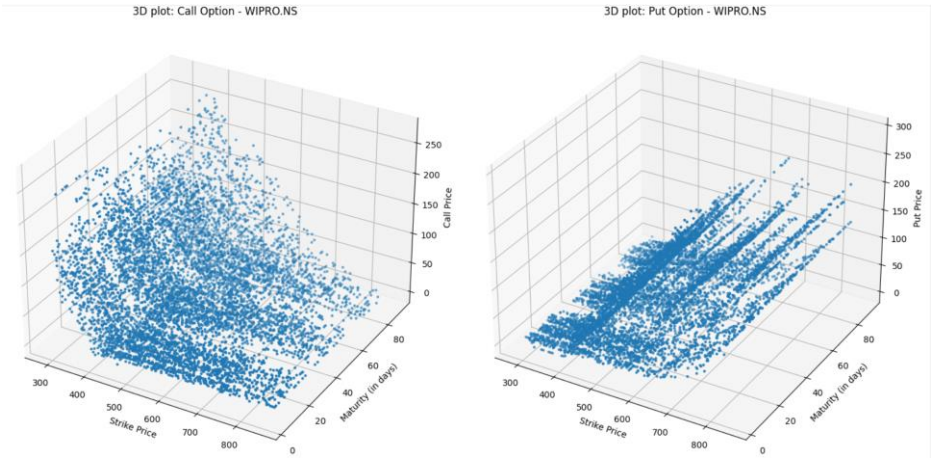


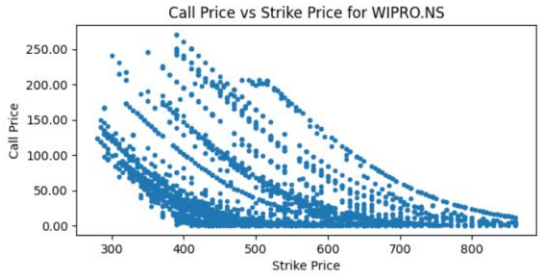


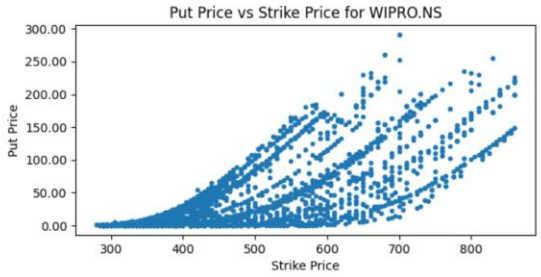


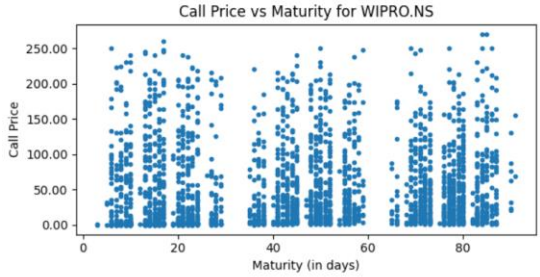


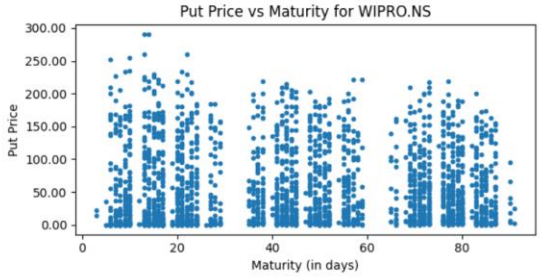
WIPRO.NS











Observations:

1. Making accurate analyses becomes challenging due to the lack of sufficient data, but it is possible to identify general trends by examining the NIFTY50 plots, which have more data points. The other plots also demonstrate similar patterns.
2. We can observe a consistent trend where the price of call options decreases while that of put options increases as the strike price rises. This pattern aligns with our expectations.
3. However, the plots for call and put options do not precisely match our expectations. In general, we expect the price of call options to increase and the price of put options to decrease with a longer maturity period.

Q2-b

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

where,

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

$F(\sigma) = C(\sigma) - C^*$
$C(\sigma) =$ BSM formula with σ 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:

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

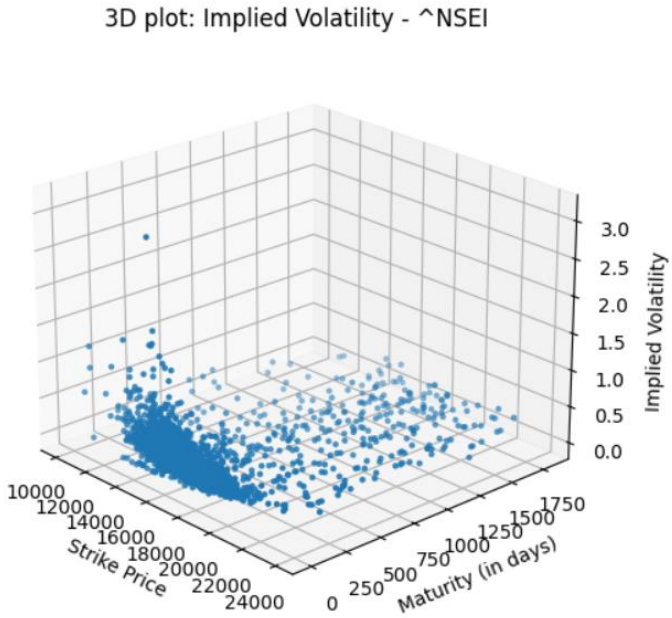
where,

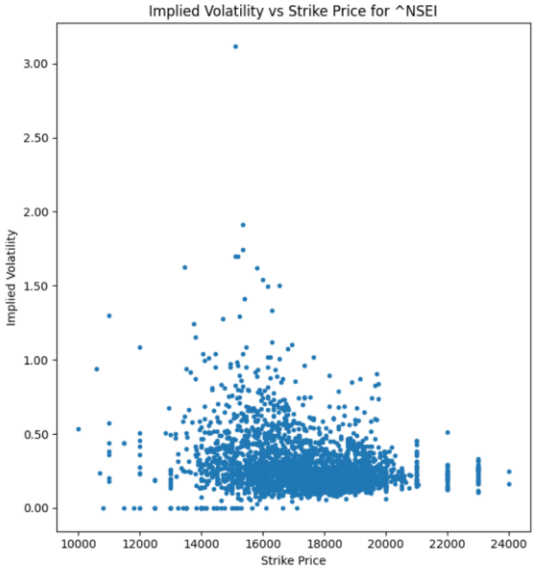
$$d_1 = \frac{\log\left(\frac{x}{K}\right) + \left(r + \frac{1}{2}\sigma^2\right)(T-t)}{\sigma\sqrt{T-t}}$$

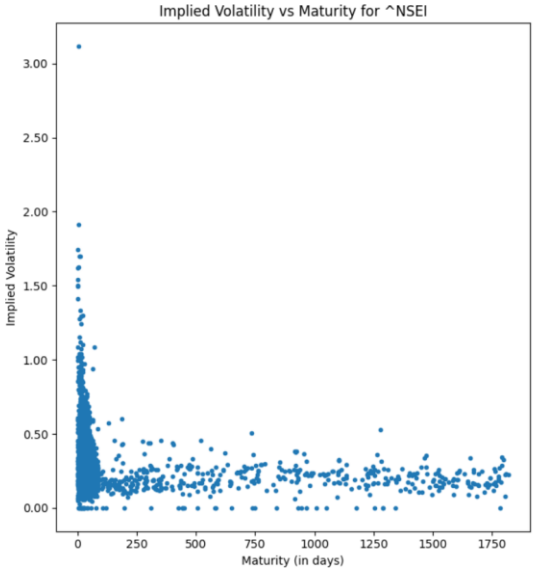
$$d_2 = \frac{\log\left(\frac{x}{K}\right) + \left(r - \frac{1}{2}\sigma^2\right)(T-t)}{\sigma\sqrt{T-t}}$$

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

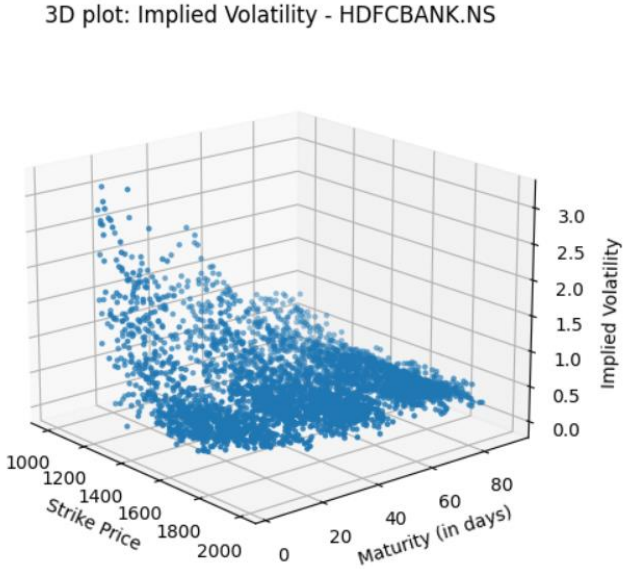
NIFTY50

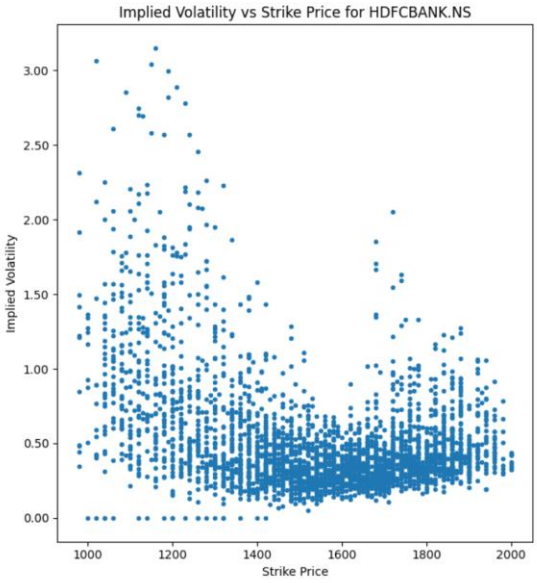


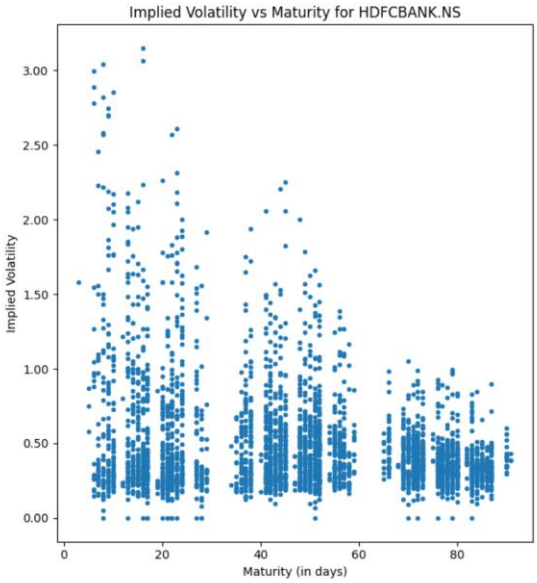




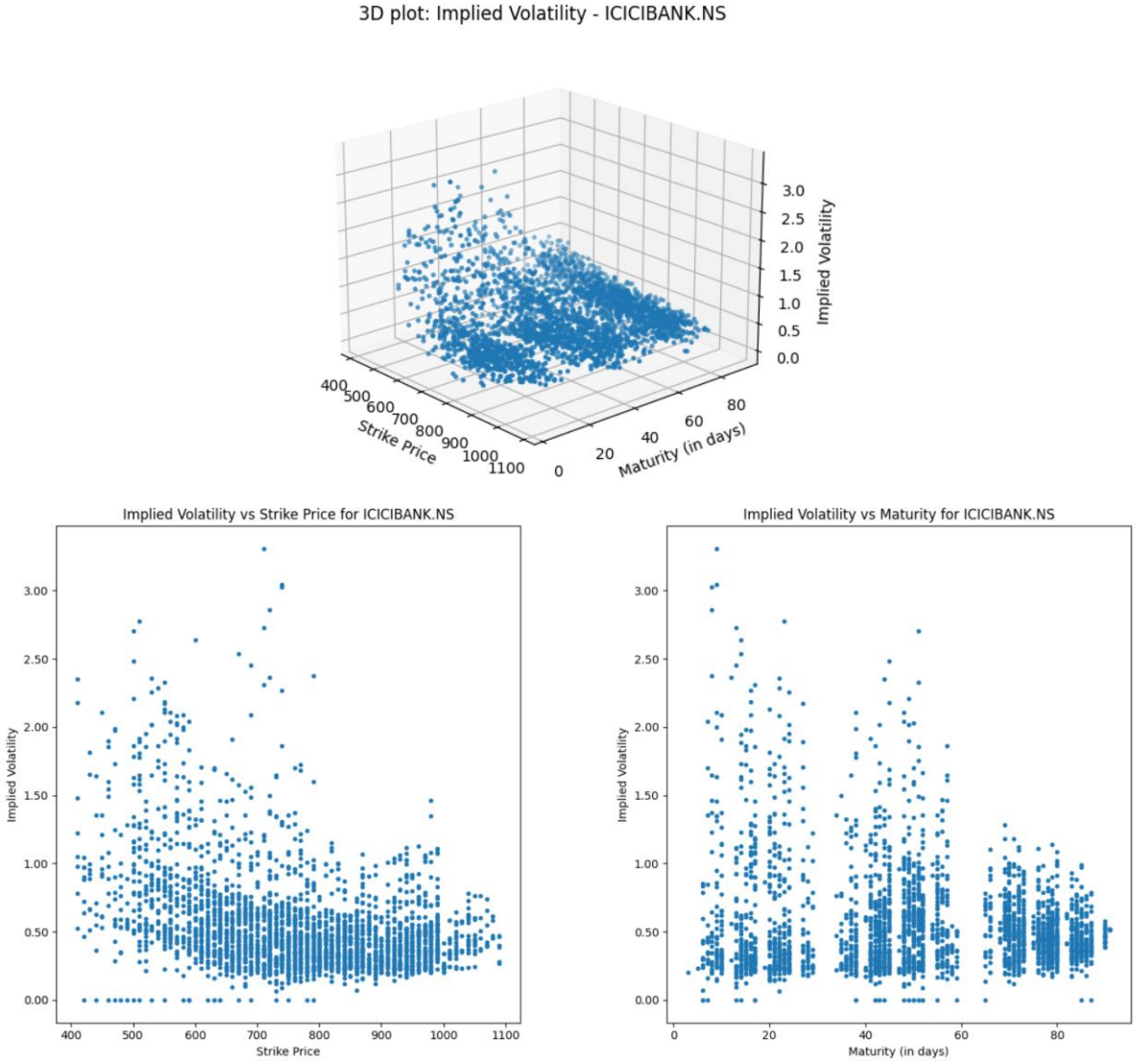
HDFCBANK.NS


3D plot: Implied Volatility - HDFCBANK.NS
Implied Volatility
Strike Price
Maturity (in days)

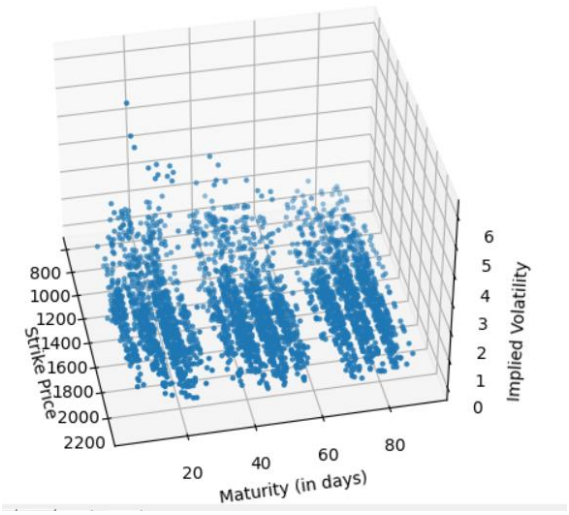

Implied Volatility vs Strike Price for HDFCBANK.NS
Implied Volatility
Strike Price

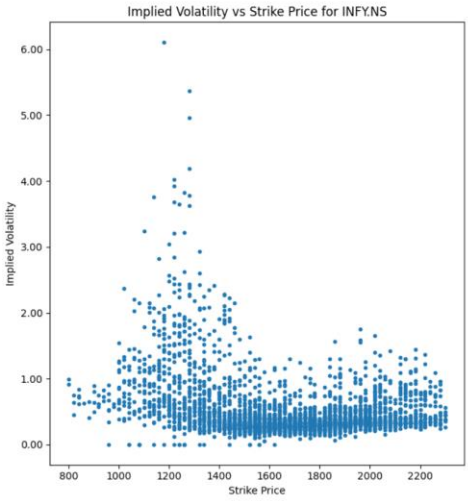

Implied Volatility vs Maturity for HDFCBANK.NS
Implied Volatility
Maturity (in days)

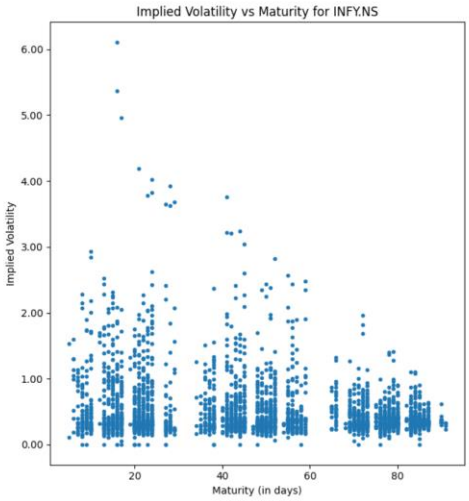
ICICIBANK.NS



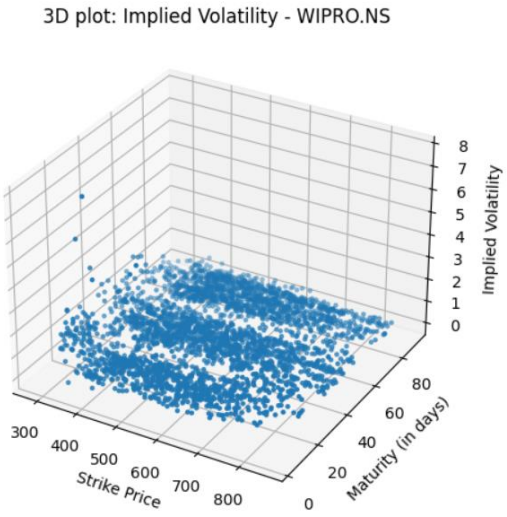
INFY.NS

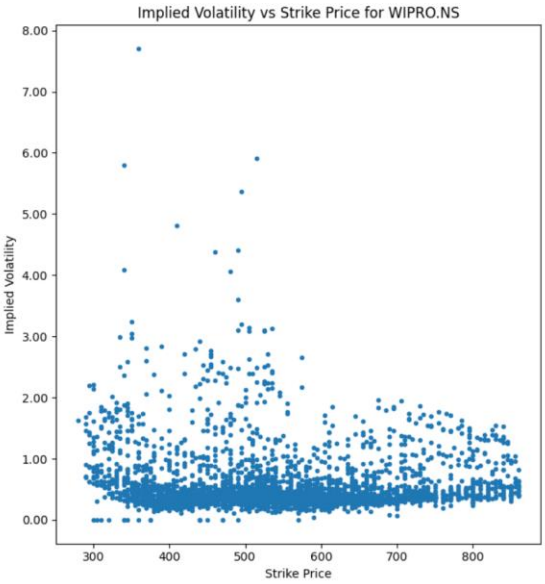


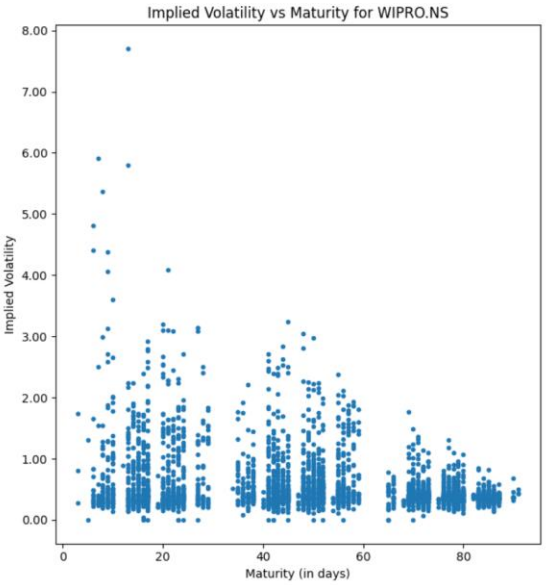

Implied Volatility vs Strike Price for INFY.NS
Implied Volatility
Strike Price


Implied Volatility vs Maturity for INFY.NS
Implied Volatility
Maturity (in days)

WIPRO.NS


3D plot: Implied Volatility - WIPRO.NS
Implied Volatility
Strike Price
Maturity (in days)


Implied Volatility vs Strike Price for WIPRO.NS
Implied Volatility
Strike Price

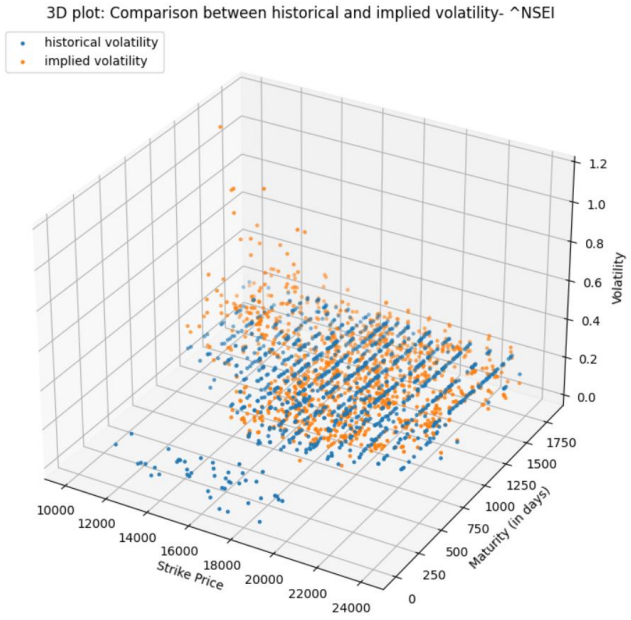

Implied Volatility vs Maturity for WIPRO.NS
Implied Volatility
Maturity (in days)

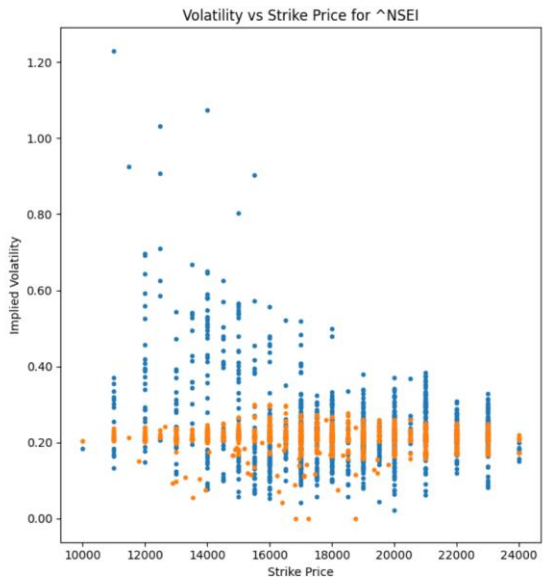
Observations:

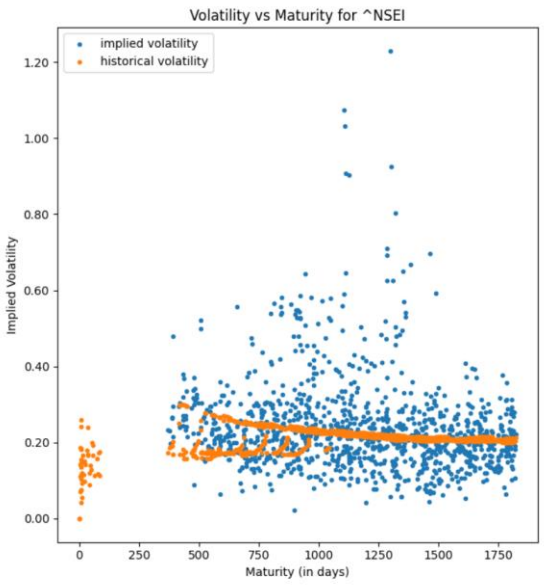
1. Inadequate data presents challenges in conducting precise analyses, but examining NIFTY50 plots, which have a larger number of data points, allows for the identification of general trends. Other plots demonstrate similar trends.
2. In theory, the Volatility Smile is a curve that exhibits a convex relationship between the implied volatility and strike price. However, this feature is not clearly evident in the plotted curves.
3. Typically, the implied volatility decreases as maturity values increase, but this pattern is not consistently observed in some of the plots mentioned above.

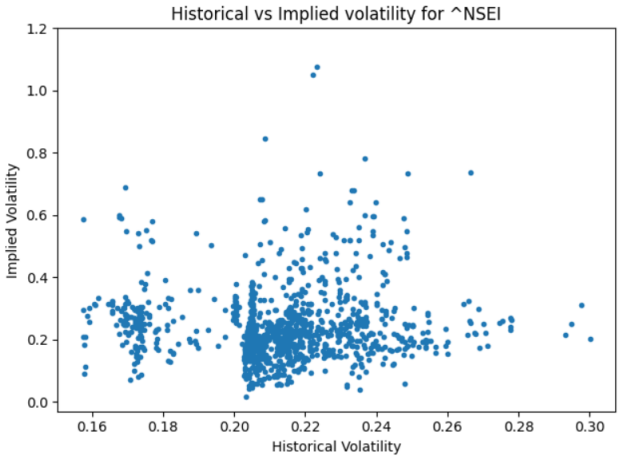
Q2-c

NIFTY50





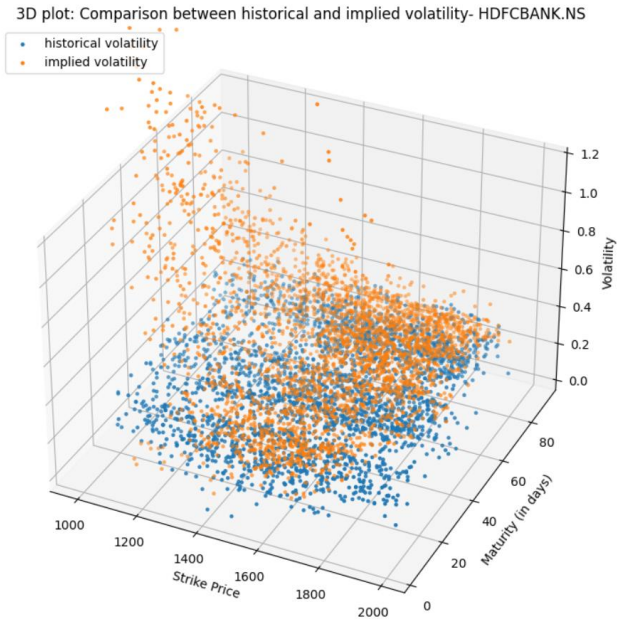


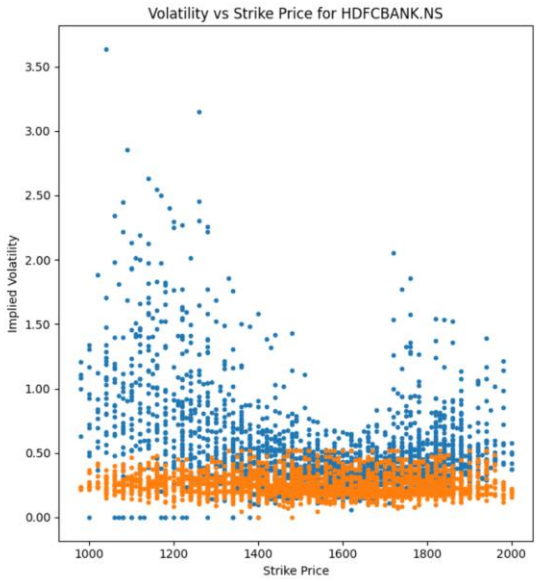


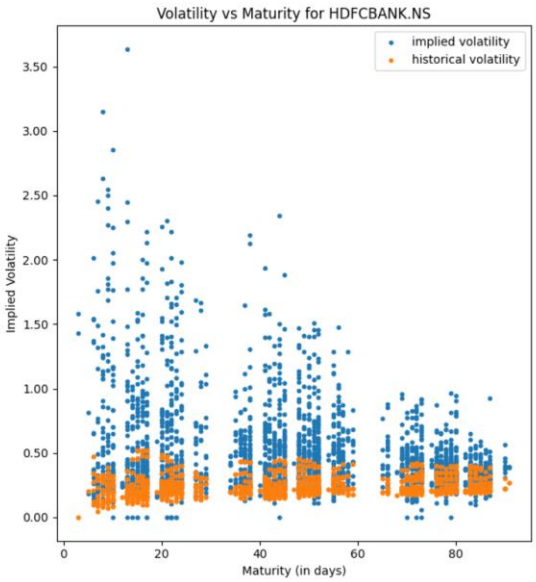
For ^NSEI

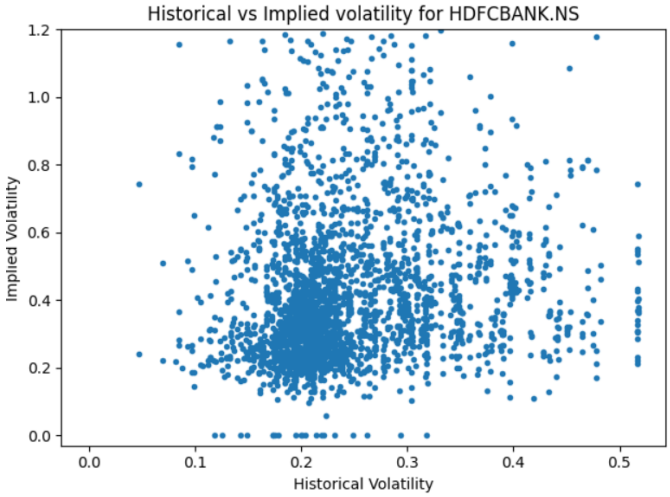
SI No.	Call Price	Stock Price (S0)	Maturity (in days)	Historical Volatility	Implied Volatility
1	3030	17383.2	1402	0.214811	0.160781
2	4908.35	17383.2	1213	0.219763	0.354123
3	3701.25	17428.6	1578	0.206957	0.185432
4	2783.5	17428.6	1578	0.206957	0.202357
5	5977.65	17428.6	1403	0.214822	0.239881
6	3701.25	17591.3	1581	0.20703	0.175777
7	3039	17591.3	1406	0.214581	0.238684
8	3704.3	17591.3	1406	0.214581	0.236452
9	6285.7	17574.7	1771	0.200593	0.32016
10	5977.65	17574.7	1407	0.214661	0.224388
11	2088.15	17574.7	854	0.167852	0.265092
12	9159.8	17755.3	1772	0.200453	0.378339
13	5450.25	17755.3	1408	0.214649	0.212997
14	7938.05	17755.3	1219	0.219274	0.255333
15	3095.8	17755.3	855	0.167681	0.598616
16	2722.55	17905.8	1220	0.219351	0.231805
17	2100	17905.8	1037	0.182682	0.153236
18	3704.3	17965.6	1410	0.214621	0.216871
19	2645.65	17965.6	1221	0.219366	0.24675
20	4908.35	17965.6	1221	0.219366	0.318258

HDFCBANK.NS





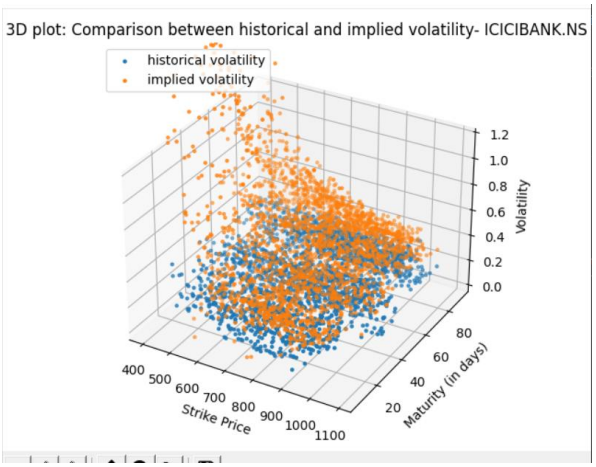


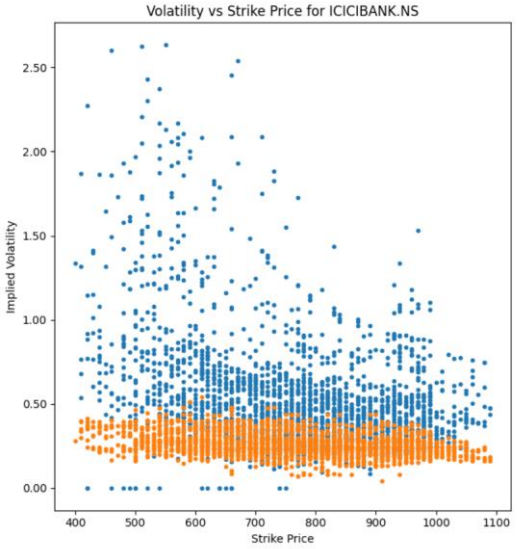


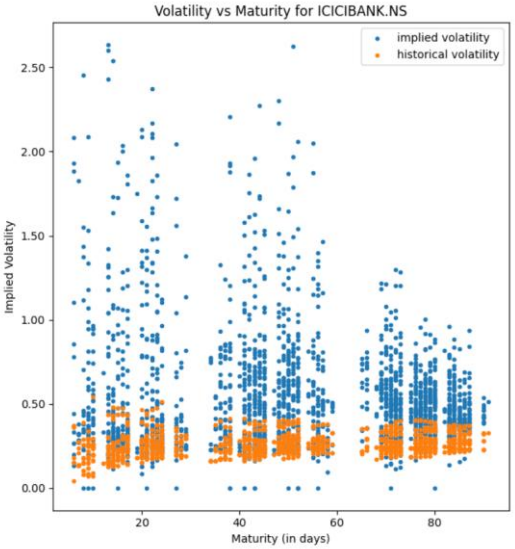
For HDFCBANK.NS

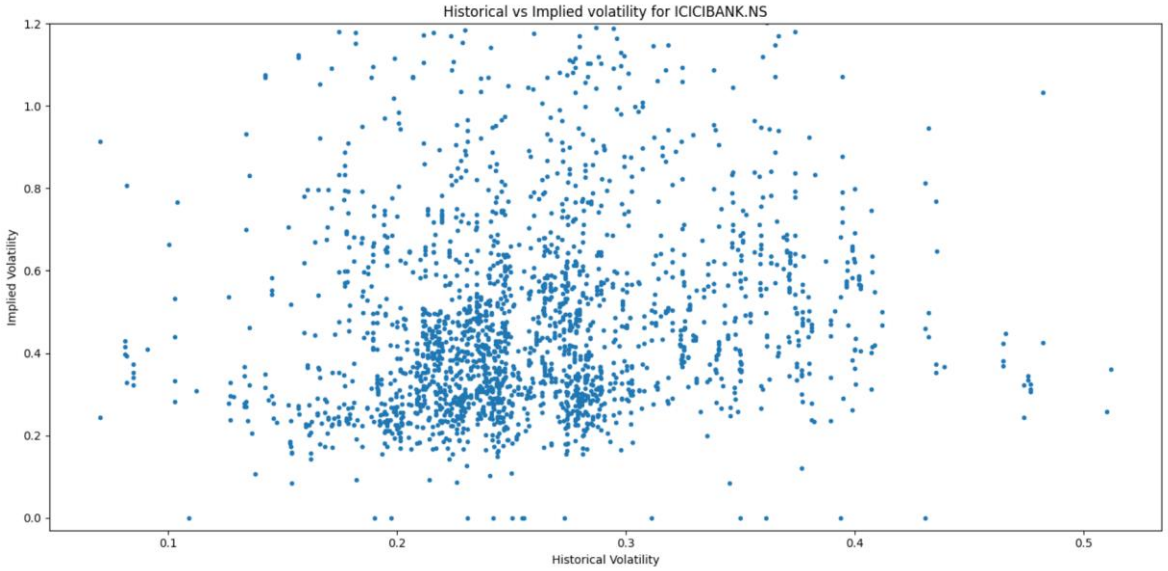
SI No.	Call Price	Stock Price (S0)	Maturity (in days)	Historical Volatility	Implied Volatility
1	173.75	1620.2	9	0.222516	0.640548
2	8.25	1620.2	36	0.150577	0.308779
3	41.25	1620.2	65	0.193305	0.380438
4	36.8	1620.2	65	0.193305	0.379743
5	280.85	1620.2	65	0.193305	0.448094
6	147.8	1620.2	65	0.193305	0.40097
7	135.95	1620.2	65	0.193305	0.3982
8	19.2	1452	10	0.197162	1.38811
9	24.75	1452	38	0.188126	0.220733
10	22.5	1452	38	0.188126	0.701561
11	524.45	1452	38	0.188126	1.87736
12	504.85	1452	38	0.188126	1.81796
13	389.4	1452	38	0.188126	1.49015
14	5.7	1452	66	0.190836	0.431023
15	380.35	1452	66	0.190836	0.881488
16	192.15	1452	66	0.190836	0.61269
17	127.4	1452	66	0.190836	0.544964
18	41.1	1452	66	0.190836	0.227532
19	10	1452	66	0.190836	0.284555
20	4.6	1444	70	0.212398	0.308803

ICICIBANK.NS





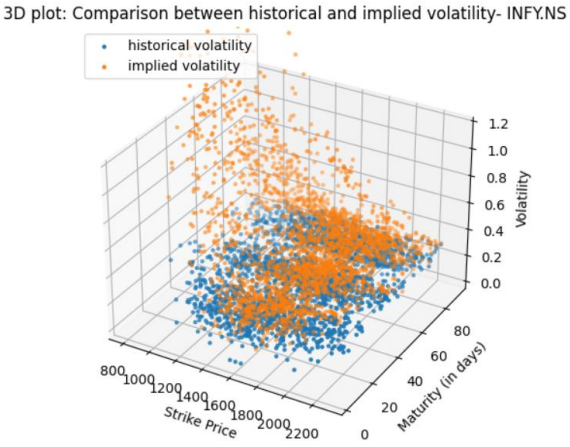


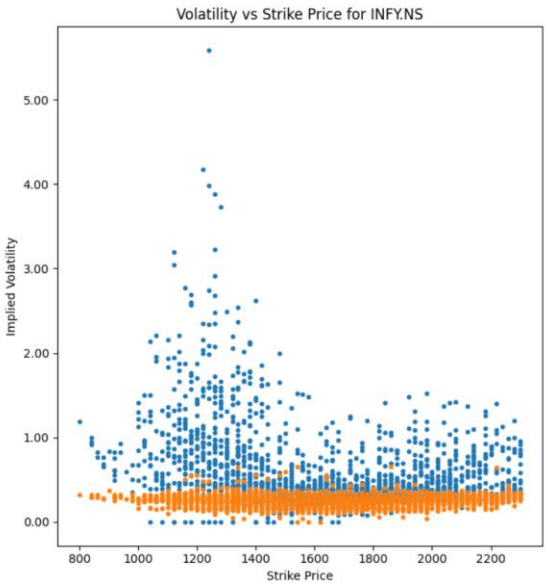


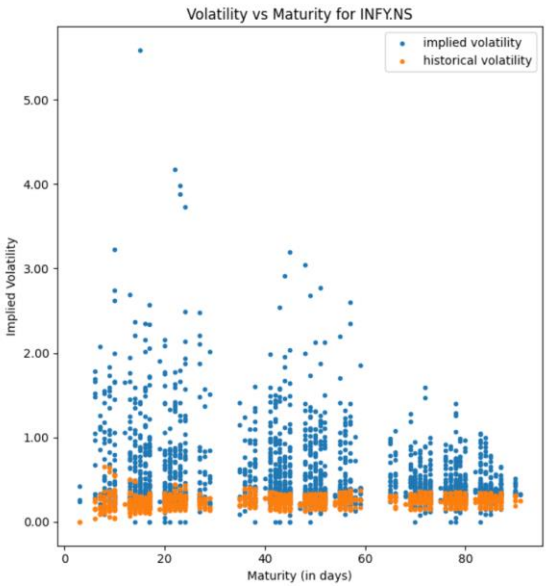
For ICICIBANK.NS

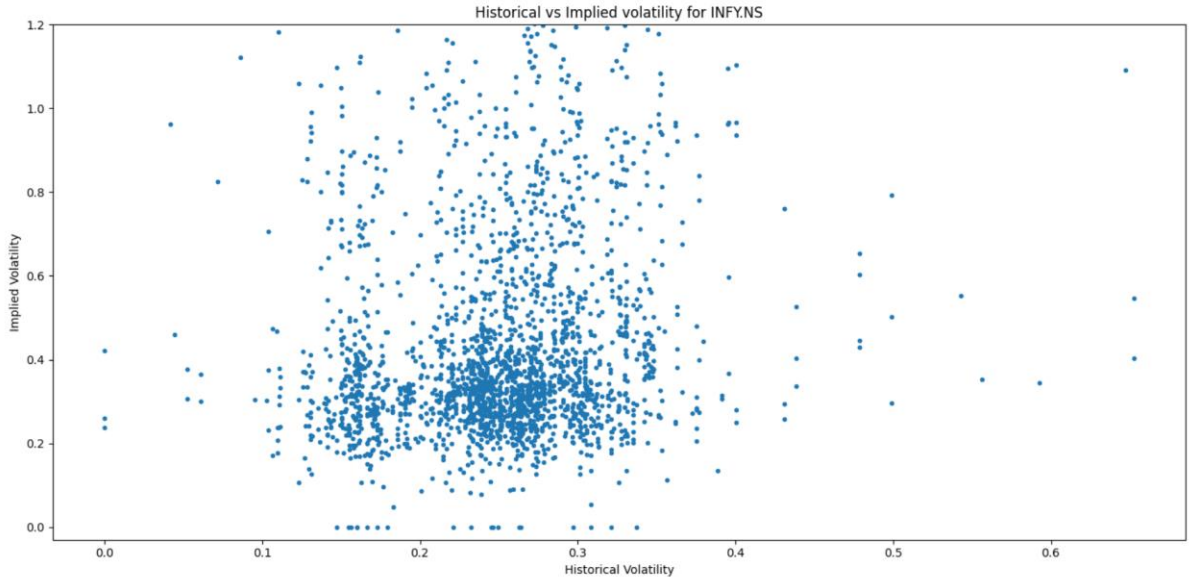
SI No.	Call Price	Stock Price (S0)	Maturity (in days)	Historical Volatility	Implied Volatility
1	48	906	9	0.160237	0.227629
2	1.4	906	9	0.160237	0.222214
3	88.4	906	36	0.17783	0.694467
4	4.1	906	65	0.218687	0.290425
5	50	906	65	0.218687	0.374357
6	50.75	906	65	0.218687	0.502048
7	46.9	906	65	0.218687	0.497655
8	7.1	718.1	38	0.259556	0.329125
9	47.65	718.1	38	0.259556	1.04148
10	2.05	718.1	38	0.259556	0.484806
11	285.15	718.1	38	0.259556	2.14543
12	275.65	718.1	38	0.259556	2.08501
13	60.35	718.1	66	0.288073	0.645773
14	28.35	718.1	66	0.288073	0.605795
15	257.4	718.1	66	0.288073	1.11937
16	121.85	718.1	66	0.288073	0.743084
17	44.7	889.7	70	0.237808	0.26172
18	41.05	889.7	70	0.237808	0.269459
19	21.85	889.7	70	0.237808	0.306407
20	21.1	889.7	35	0.237626	0.255837

INFY.NS





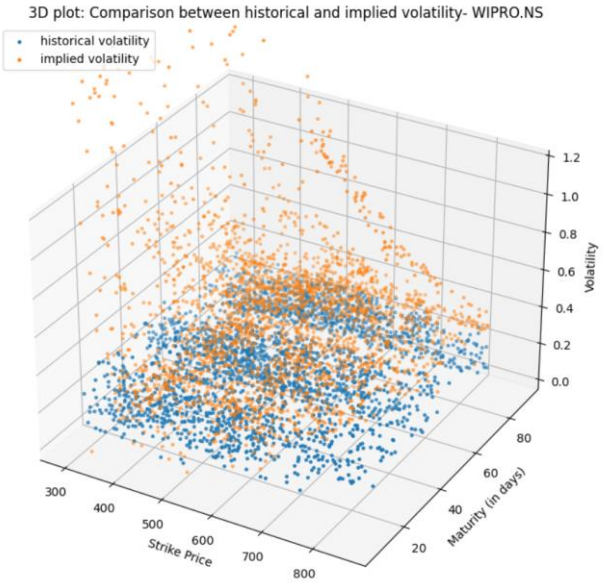


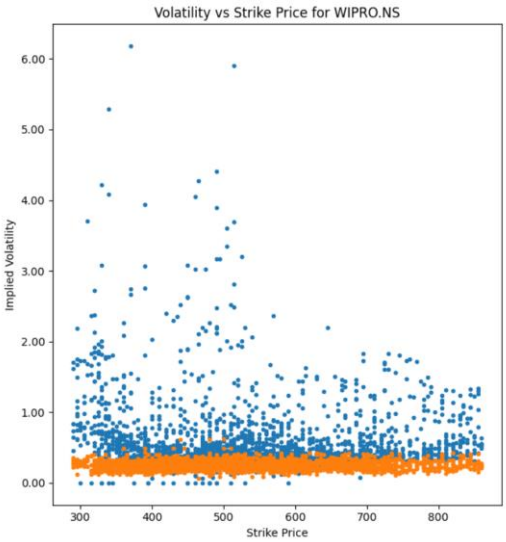


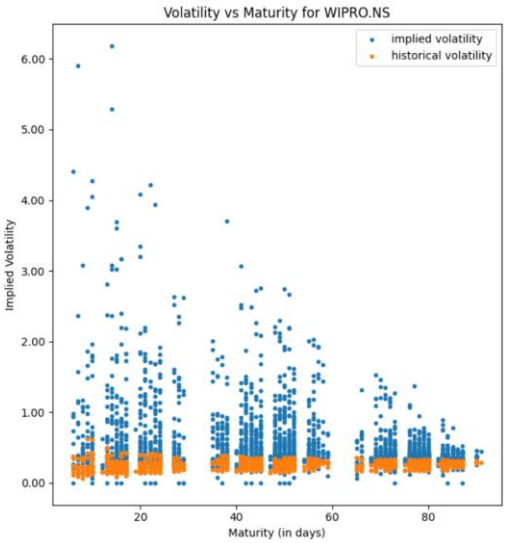
For INFY.NS

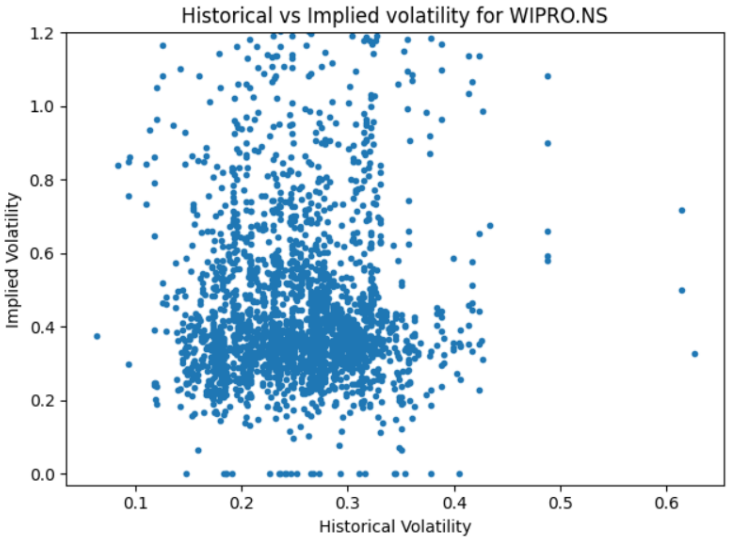
SI No.	Call Price	Stock Price (S0)	Maturity (in days)	Historical Volatility	Implied Volatility
1	1.65	1501	36	0.240636	0.367494
2	322.65	1501	65	0.25407	0.955598
3	157.55	1501	65	0.25407	0.701357
4	10.75	1501	65	0.25407	0.377954
5	18.7	1801.7	10	0.262948	0.216244
6	2	1801.7	10	0.262948	0.305043
7	13.95	1801.7	10	0.262948	0.733652
8	10.85	1801.7	38	0.249106	0.408002
9	13.35	1801.7	66	0.246119	0.30981
10	8.1	1475	70	0.277162	0.322887
11	12.35	1475	70	0.277162	0.316776
12	3.35	1475	70	0.277162	0.332437
13	4.5	1475	70	0.277162	0.329279
14	287.4	1475	7	0.325698	2.07783
15	5.35	1475	35	0.28313	0.595065
16	416.2	1475	35	0.28313	1.15147
17	89.85	1475	35	0.28313	0.299248
18	532.55	1475	35	0.28313	1.41529
19	71.65	1829.4	71	0.231732	0.081313
20	3.3	1829.4	8	0.285403	0.361948

WIPRO.NS


3D plot: Comparison between historical and implied volatility- WIPRO.NS
historical volatility
implied volatility
Volatility
Strike Price
Maturity (in days)


Volatility vs Strike Price for WIPRO.NS
Implied Volatility
Strike Price


Volatility vs Maturity for WIPRO.NS
implied volatility
historical volatility
Implied Volatility
Maturity (in days)


Historical vs Implied volatility for WIPRO.NS
Implied Volatility
Historical Volatility

For WIPRO.NS

SI No.	Call Price	Stock Price (S0)	Maturity (in days)	Historical Volatility	Implied Volatility
1	84.9	388.8	9	0.173844	1.66266
2	15.4	388.8	9	0.173844	0.234516
3	1.15	388.8	9	0.173844	0.289702
4	45.2	388.8	36	0.176417	0.500567
5	1.75	388.8	36	0.176417	0.272126
6	1.1	388.8	36	0.176417	0.314379
7	1.7	388.8	36	0.176417	0.29025
8	3.5	388.8	36	0.176417	0.53913
9	4.25	388.8	65	0.176515	0.296562
10	60.55	388.8	65	0.176515	0.579527
11	8	388.8	65	0.176515	0.274702
12	2.95	667.55	10	0.147636	0.345377
13	91	667.55	38	0.21084	0.468934
14	31.8	667.55	38	0.21084	0.364548
15	5.85	667.55	38	0.21084	0.554982
16	47.2	667.55	66	0.197768	0.248151
17	56.2	377	70	0.277589	0.621992
18	63.85	377	70	0.277589	0.653982
19	20.15	377	70	0.277589	0.50299
20	3.65	377	70	0.277589	0.331077

Observations:

1. Historical volatility refers to the measurement of volatility over a previous period, whereas implied volatility estimates the volatility for the upcoming months.
2. Approximately, historical volatility should equal implied volatility which is somehow visible from the table but there are some differences also.
3. Implied volatility tends to be higher for stocks like NIFTY50 and RELIANCE, while historical volatility tends to be higher for stocks like BAJAJ-AUTO and TATAMOTORS. The significant difference between these two values arises due to several factors present in the real market.
4. The plot that compares historical and implied volatility effectively captures this relationship, while other plots illustrate the dependency of different types of volatility on varying strike price and maturity.