Modelling and Prediction of Stock Market Data with GARCH Model

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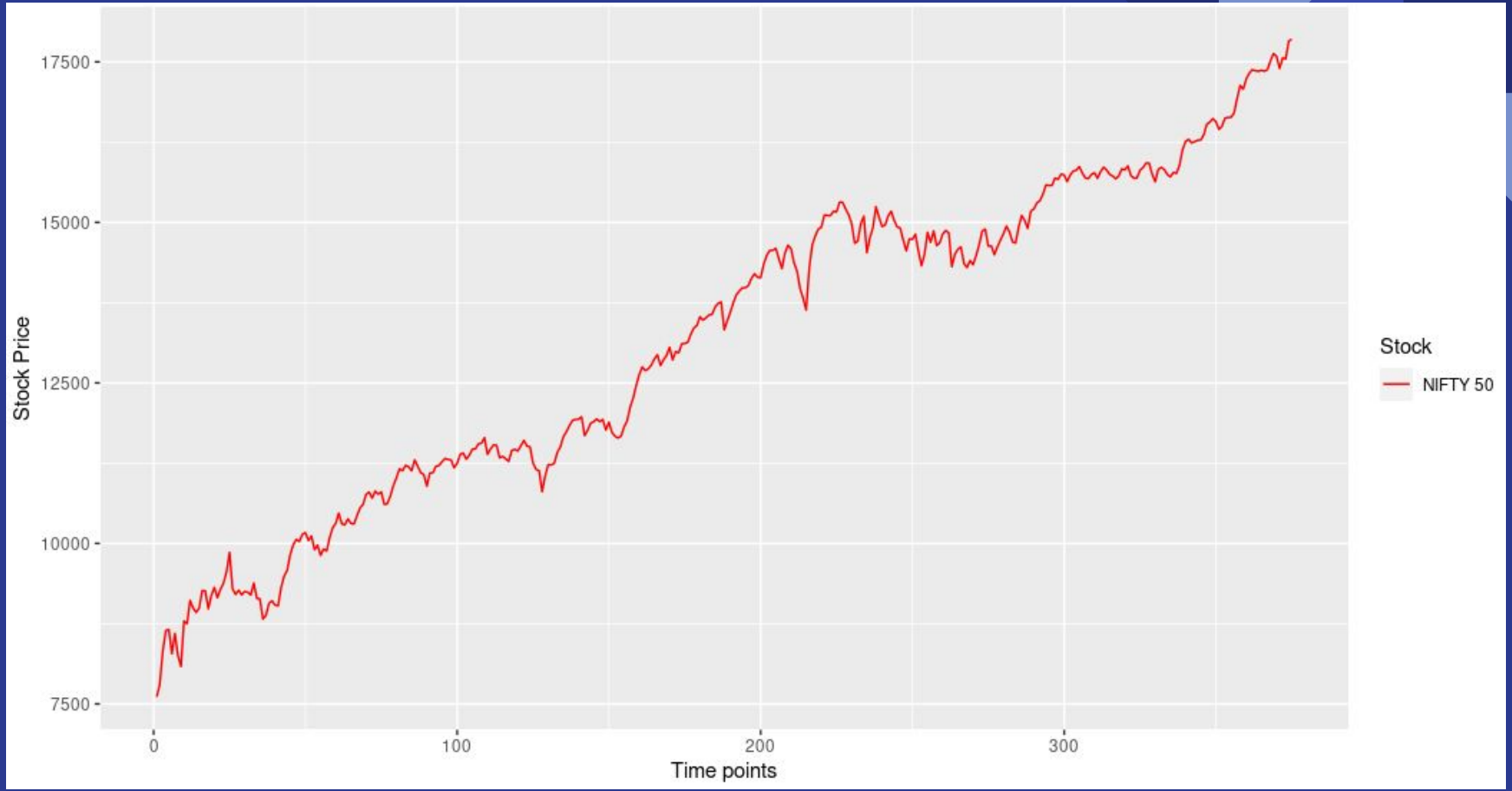
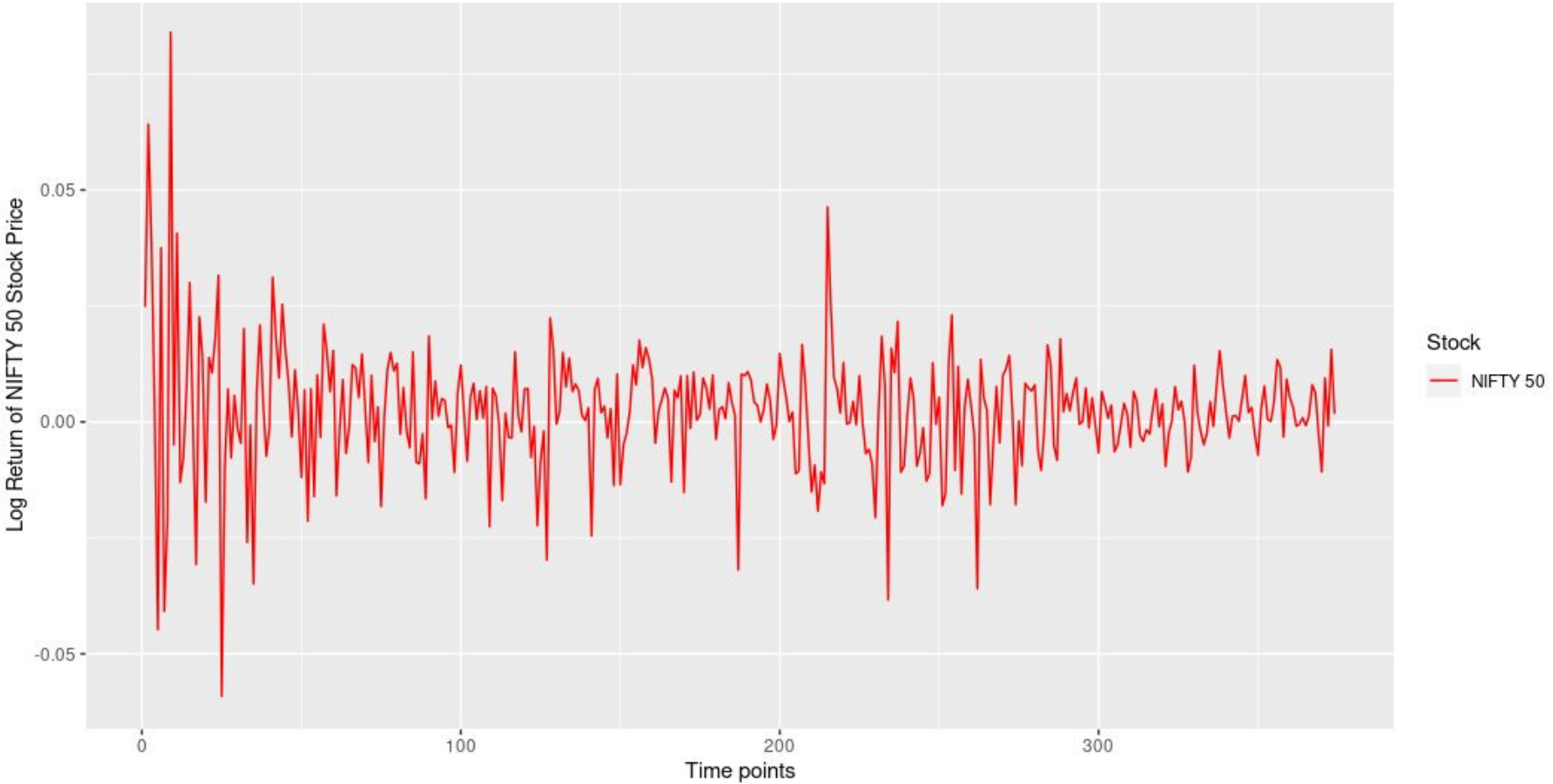
Dibyendu Das

Daily Closing Prices of Nifty 50 : from March 23, 2020 to Sep 24, 2021

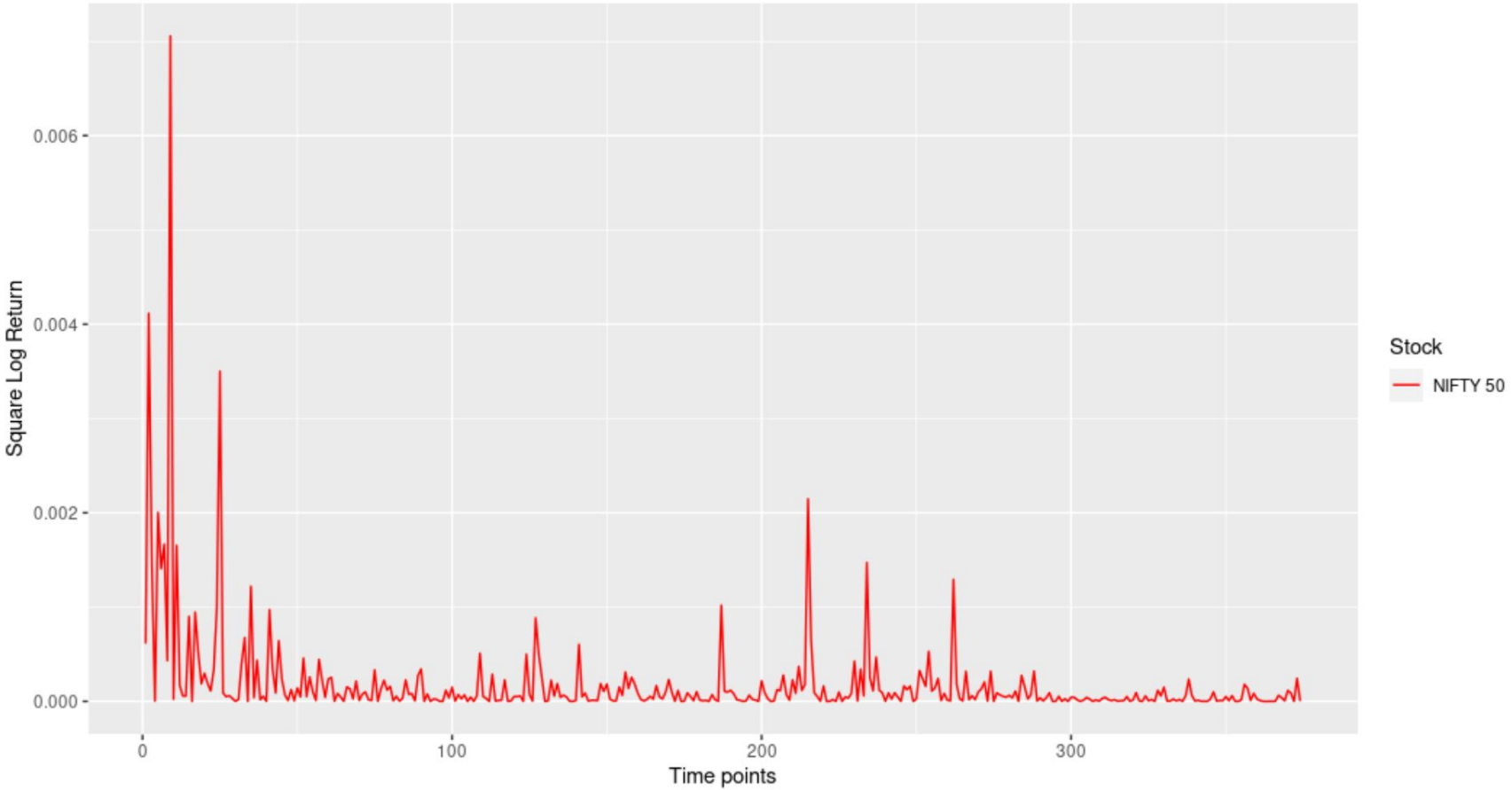


Daily Increase and Decrease in Stock Prices in NIFTY 50 Data

Log Returns of the Closing Prices of NIFTY 50



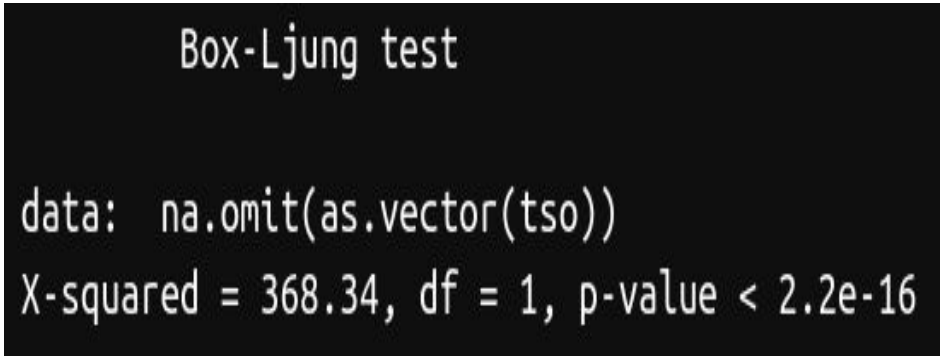
Square Log Returns of the Closing Prices of NIFTY 50



Ljung–Box Test : Test for Serial Correlation for NIFTY 50

Null Hypothesis : The X_t's are independently distributed (i.e. the correlations in the population from which the sample is taken are 0, so that any observed correlations in the data result from randomness of the sampling process).

Alternative Hypothesis :The X_t's are not independently distributed; they exhibit serial correlation.



Test Result :

Null Hypothesis is rejected

Decision :

The X_t's are not independently distributed

Ljung–Box Test : Test for Serial Correlation for NIFTY 50

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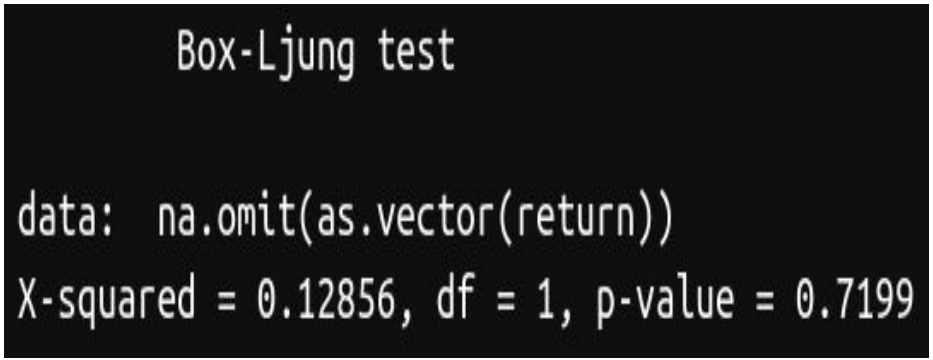


Test Result :

Null Hypothesis is failed to be rejected

Decision :

There is no proof of the presence of serial correlation

Augmented Dickey-Fuller Test : Unit Root Test for NIFTY 50

Null Hypothesis : Unit Root exists

Alternative Hypothesis : Root is outside the unit circle

ADF test for NIFTY 50 closing prices

```
Value of test-statistic is: -1.0497 6.1874

Critical values for test statistics:
      1pct  5pct 10pct
tau2 -3.44 -2.87 -2.57
phi1  6.47  4.61  3.79
```

Test Result :

Null Hypothesis is accepted

Decision :

Unit root exists

Augmented Dickey-Fuller Test : Unit Root Test for NIFTY 50

Null Hypothesis : Unit Root exists

Alternative Hypothesis : Unit root does not exist

ADF test for log returns of NIFTY 50 closing price

```
Value of test-statistic is: -15.2982 117.053

Critical values for test statistics:
      1pct  5pct 10pct
tau2 -3.44 -2.87 -2.57
phi1  6.47  4.61  3.79
```

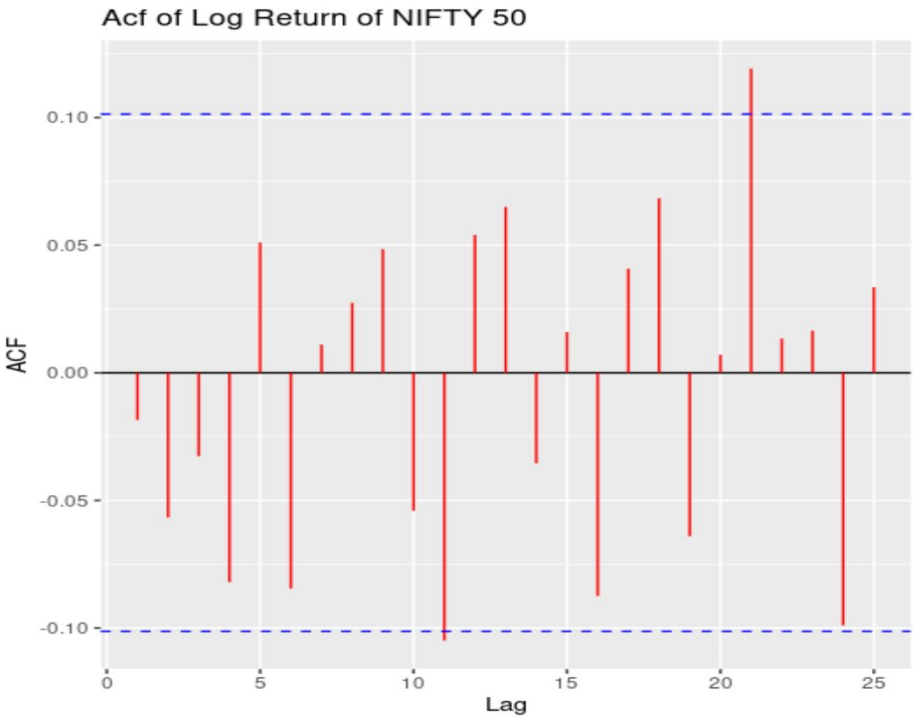
Test Result :

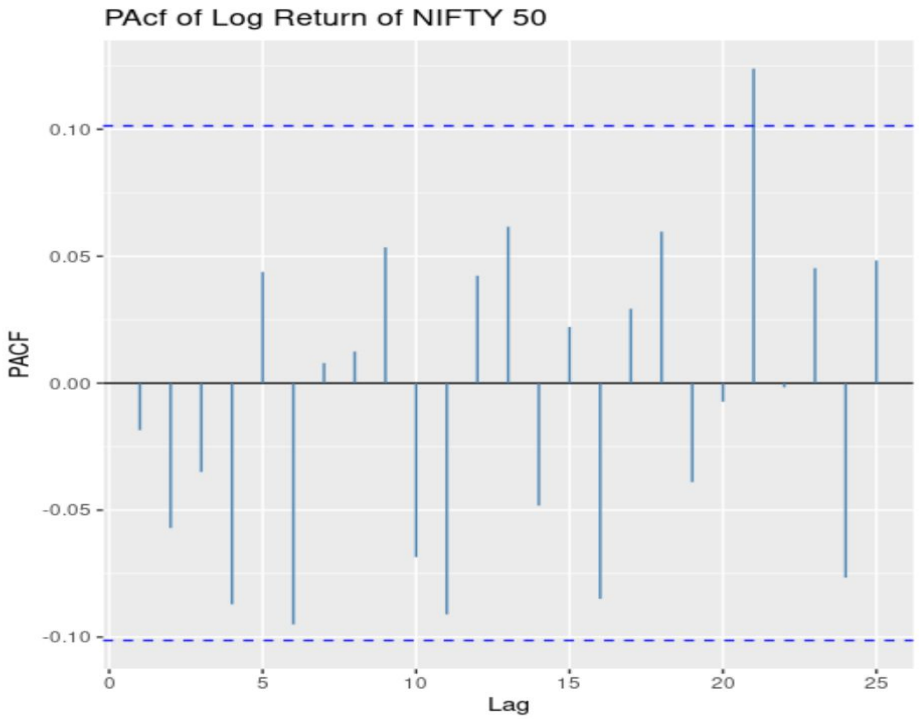
Null Hypothesis is rejected

Decision :

Unit root does not exist

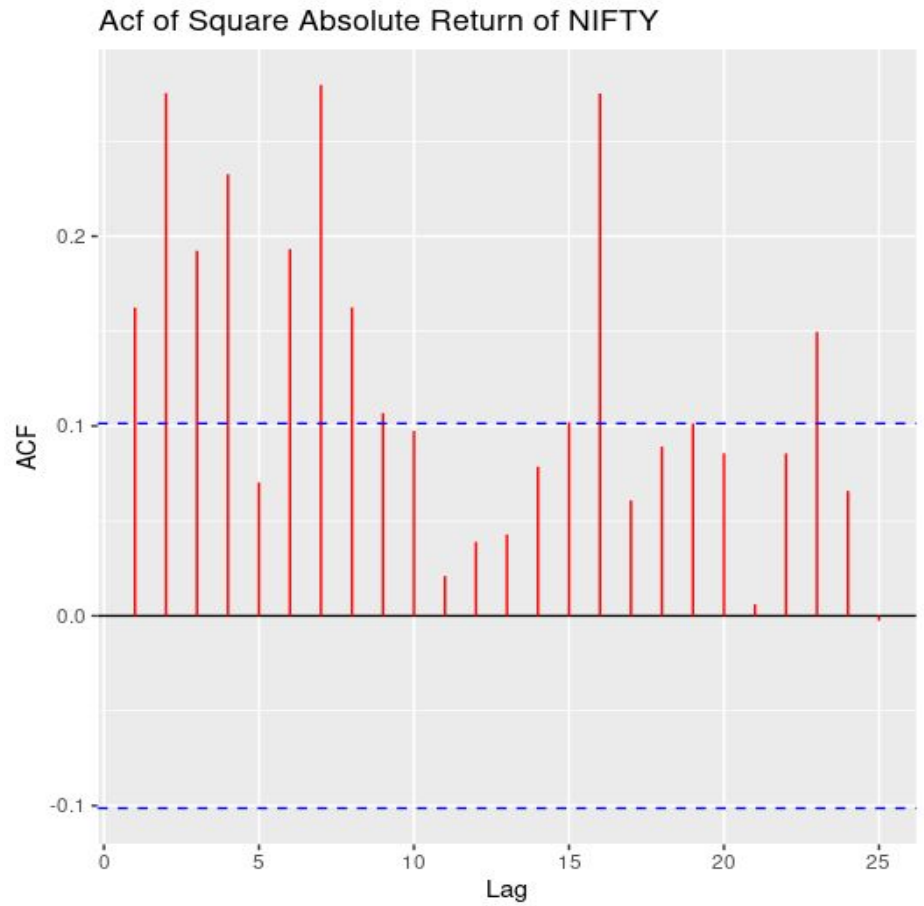
ACF and PACF of Log Return of NIFTY 50 Closing Price

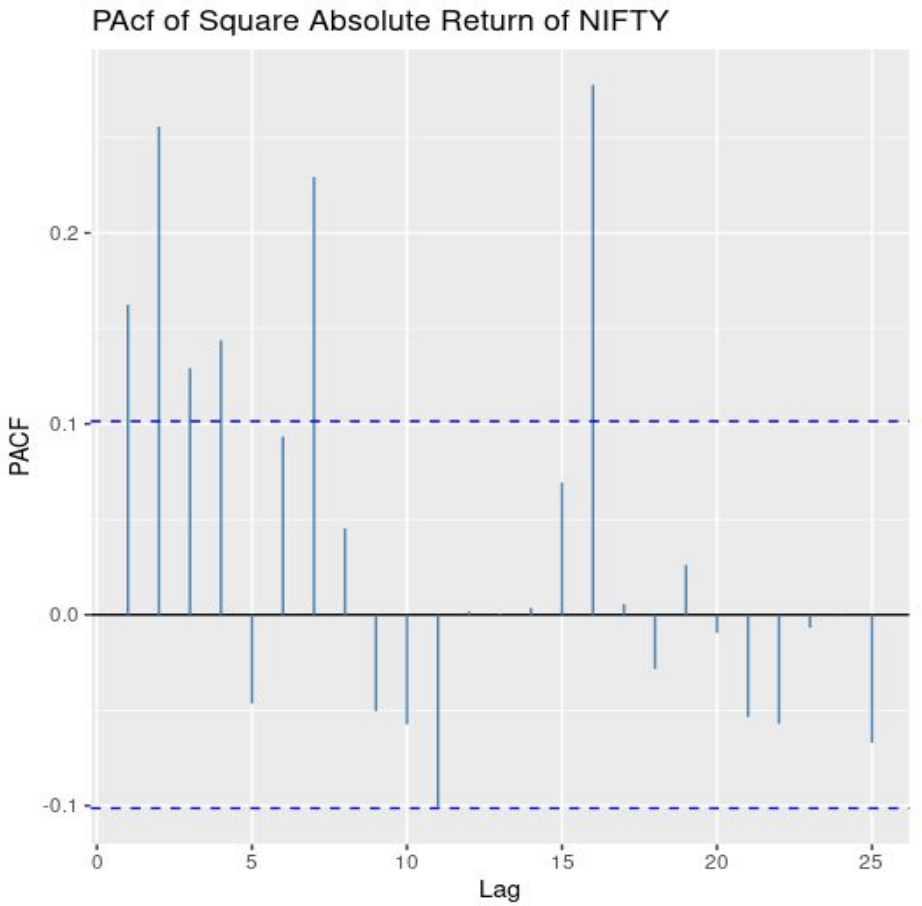




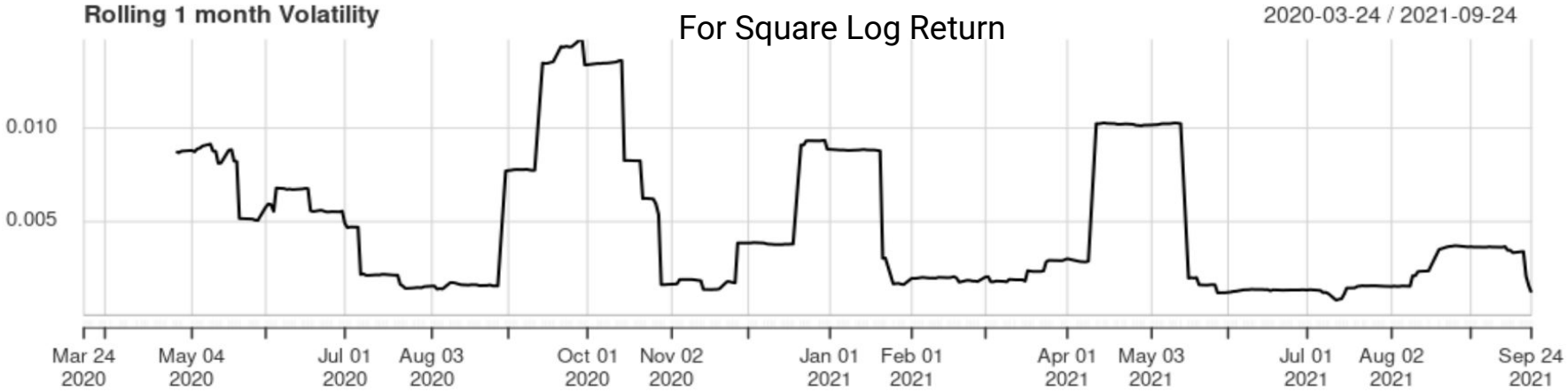
Observation : Absence of significant auto correlation in returns

ACF and PACF of Square Log Return of NIFTY 50 Closing Price

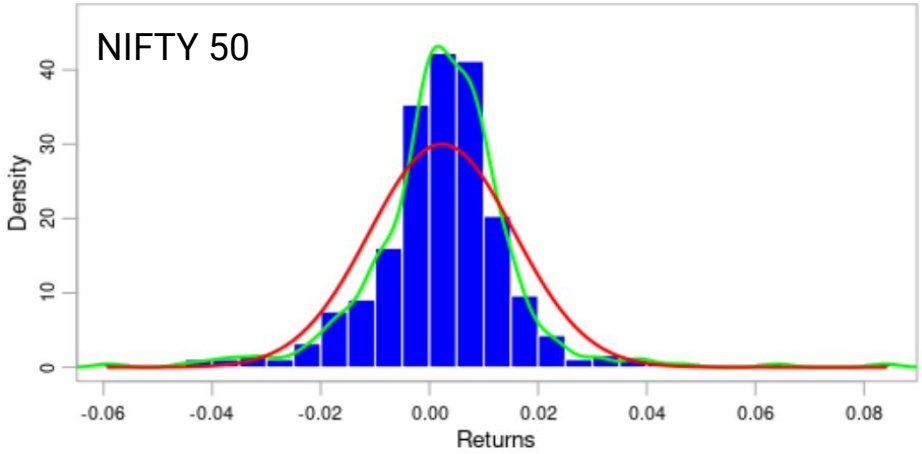


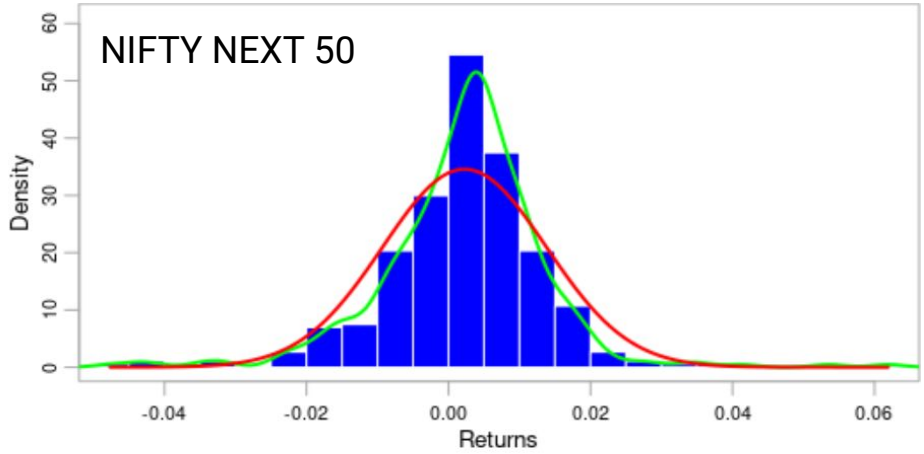


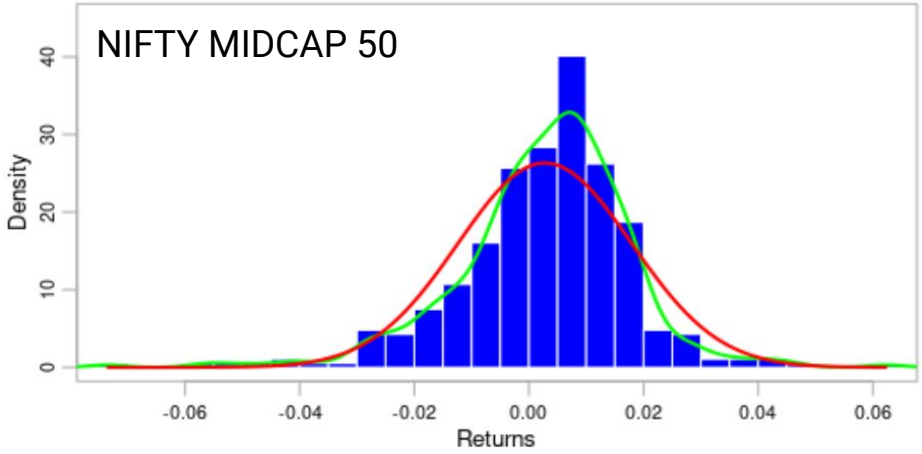
Volatility Clustering

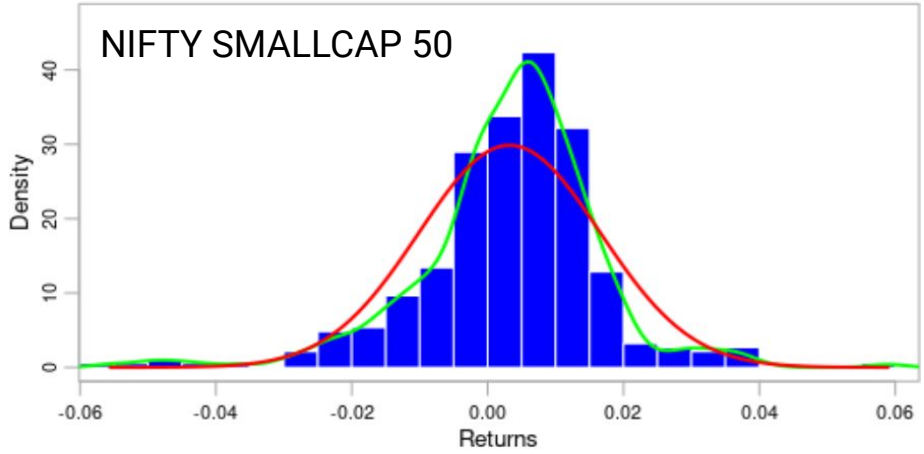


Distribution of Log Returns

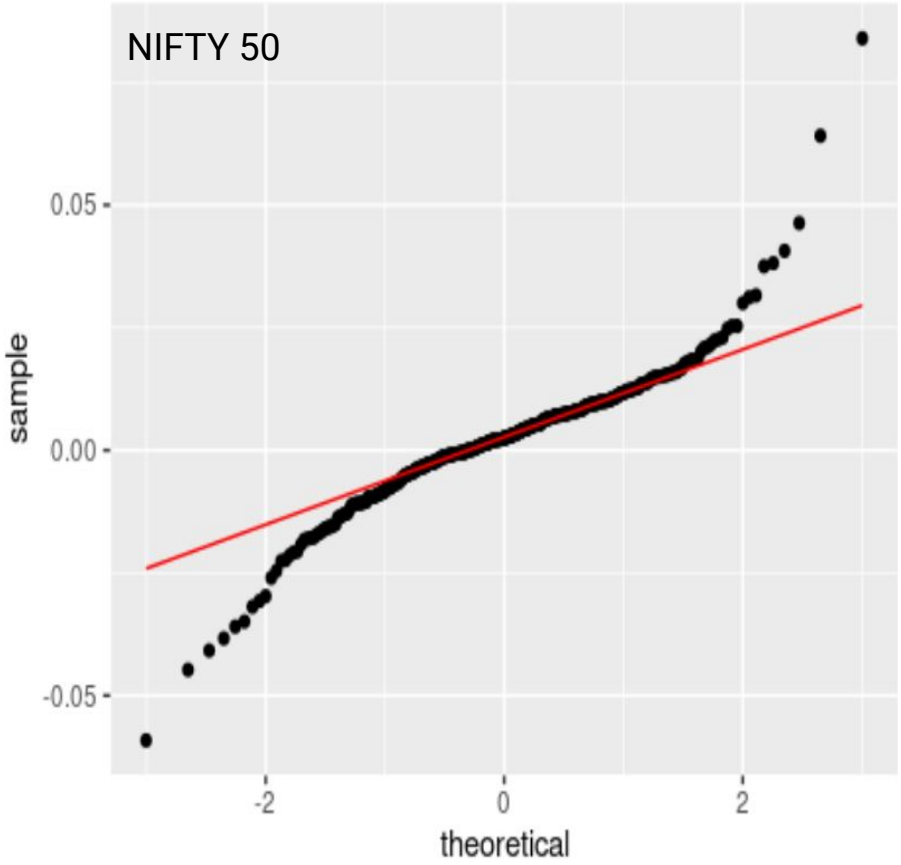


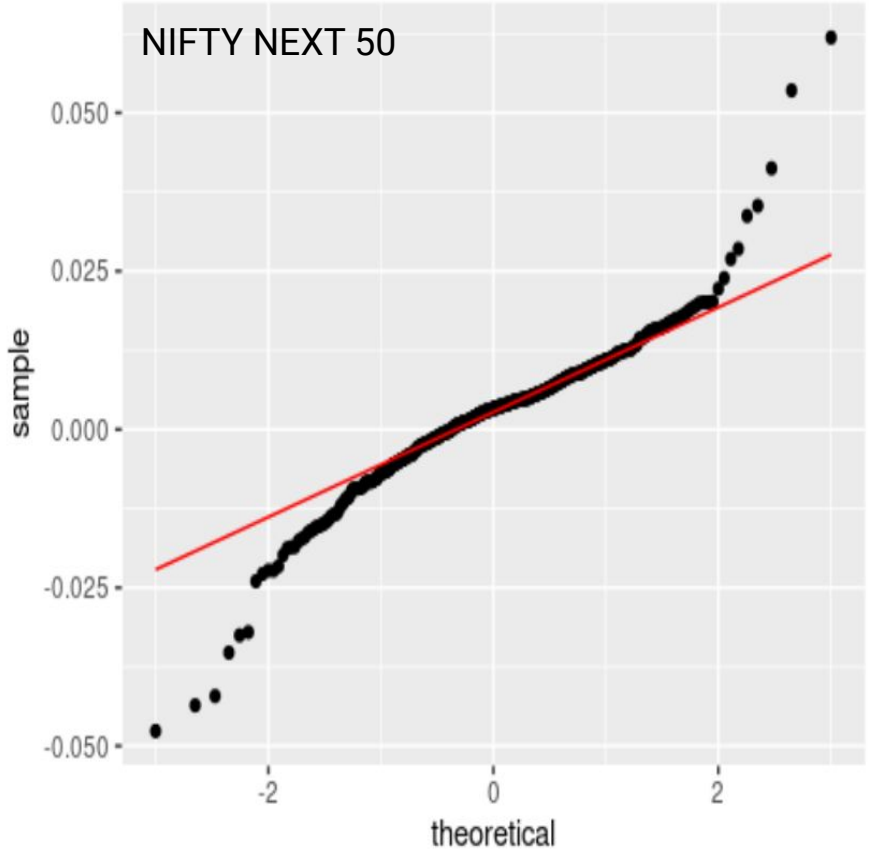




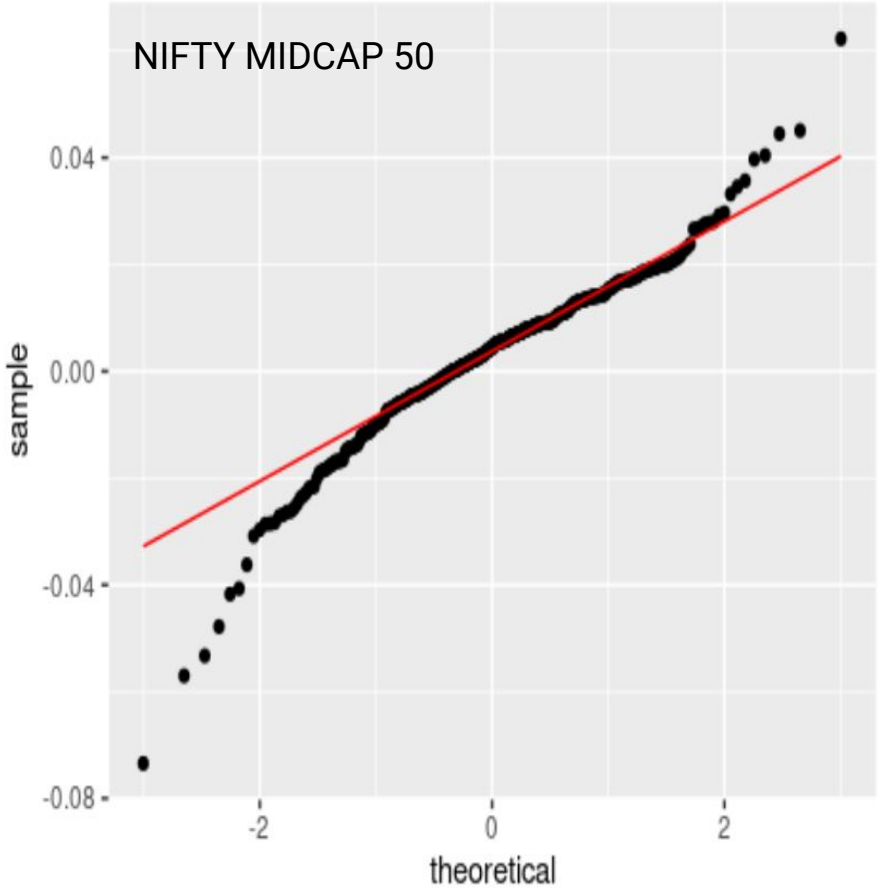


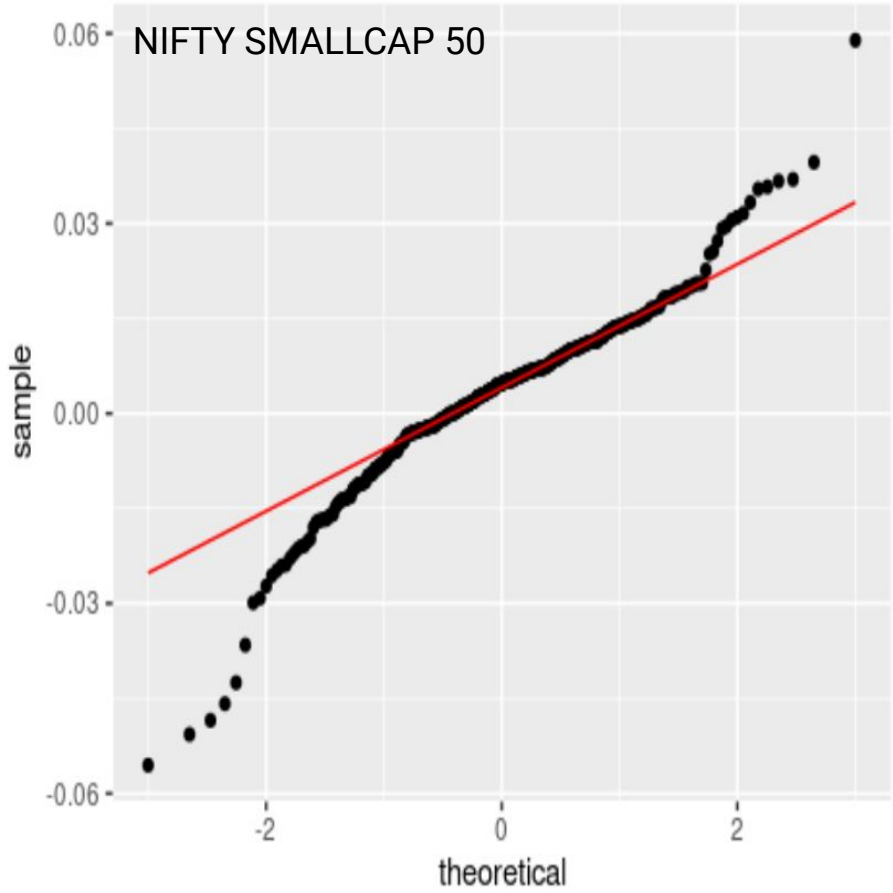
QQ plot of the Log Returns : Check for Normality





QQ plot of the Log Returns : Check for Normality





General Equation of ARMA(m,n) -GARCH(p,q) Model :

$$x_t = \mu + \sum_{i=1}^{m} a_i x_{t-i} + \sum_{j=1}^{n} b_j \epsilon_{t-j} + \epsilon_t$$

$$\epsilon_t = z_t \sigma_t$$

$$\sigma_t^2 = w + \sum_{i=1}^{p} \alpha_i \epsilon_{t-i}^2 + \sum_{i=1}^{q} \beta_j \sigma_{t-j}^2$$

Parameters of the Model for NIFTY 50 Data

ARMA(5,4) -GARCH(1,1)

mu	ar1	ar2	ar3	ar4
1.505968e-03	-7.199823e-02	1.713870e+00	-5.263776e-02	-8.456273e-01
ar5	ma1	ma2	ma3	ma4
9.211497e-02	1.357630e-01	-1.835927e+00	-1.132231e-01	9.465146e-01
omega	alpha1	beta1	skew	shape
9.542719e-07	8.793527e-02	9.098174e-01	7.462623e-01	4.704573e+00

ARMA(0,0) -GARCH(1,1)

mu	omega	alpha1	beta1	skew
1.555425e-03	1.717501e-06	1.109278e-01	8.824059e-01	7.545621e-01
shape				
5.090149e+00				

ARMA(0,0)-Garch(1,1) Model for NIFTY 50 Data

$$x_t = 1.55 * 10^{-3} + \epsilon_t$$

$$\epsilon_t = z_t \sigma_t$$

$$\sigma_t^2 = 1.71 * 10^{-6} + 1.109 * 10^{-1} \epsilon_{t-1}^2 + 8.824 * 10^{-1} \sigma_{t-1}^2$$

ARMA(5,4)-Garch(1,1) Model for NIFTY 50 Data

$$x_t = 1.50 * 10^{-3} - 7.19 * 10^{-2} x_{t-1} + 1.71 * 10^{-2} x_{t-2} - 5.263 * 10^{-2} x_{t-3} - 8.45 * 10^{-1} x_{t-4} + 9.211 * 10^{-2} x_{t-5} + 1.35 * 10^{-1} \epsilon_{t-1}$$
$$- 1.83 \epsilon_{t-2} - 1.135 * 10^{-1} \epsilon_{t-3} + 9.46 * 10^{-1} \epsilon_{t-4} + \epsilon_t$$
$$\epsilon_t = z_t \sigma_t$$

$$\sigma_t^2 = 9.54 * 10^{-7} + 8.79 * 10^{-2} \epsilon_{t-i}^2 + 9.09 * 10^{-1} \sigma_{t-j}^2$$

Parameters of the Model for NIFTY NEXT 50 Data

ARMA(2,5) -GARCH(4,0)

mu	ar1	ar2	ma1	ma2
4.932596e-03	1.597794e-02	9.860641e-01	-3.264236e-02	-1.134588e+00
ma3	**ma4**	**ma5**	**omega**	**alpha1**
-4.035971e-02	1.004738e-01	7.689682e-02	7.183544e-05	3.502931e-01
alpha2	**alpha3**	**alpha4**	**skew**	**shape**
2.778026e-01	2.071394e-03	2.837994e-01	7.612496e-01	2.949511e+00

ARMA(0,0) -GARCH(1,1)

mu	omega	alpha1	beta1	skew
1.492385e-03	2.818135e-06	1.077308e-01	8.840318e-01	8.004310e-01
shape				
3.712443e+00				

Parameters of the Model for NIFTY MIDCAP Data

ARMA(3,3) -GARCH(1,2)

mu	ar1	ar2	ar3	ma1
5.210723e-03	6.335855e-01	-6.119709e-01	9.932826e-01	-6.513966e-01
ma2	ma3	omega	alpha1	beta1
6.385309e-01	-1.039249e+00	8.754276e-06	9.323952e-02	7.582512e-01
beta2	skew	shape		
1.050537e-01	7.339262e-01	4.910806e+00		

ARMA(0,0) -GARCH(1,1)

mu	omega	alpha1	beta1	skew
2.146099e-03	1.018319e-05	9.484450e-02	8.631986e-01	7.252322e-01
shape				
4.969198e+00				

Parameters of the Model for NIFTY SMALLCAP Data

ARMA(3,3) -GARCH(5,1)

mu	ar1	ar2	ar3	ma1
3.144488e-03	-2.199037e+00	-2.143503e+00	-9.221316e-01	2.306219e+00
ma2	ma3	omega	alpha1	alpha2
2.358168e+00	1.068085e+00	8.288284e-05	1.043162e-01	6.367793e-02
alpha3	alpha4	alpha5	beta1	skew
2.164296e-14	1.321554e-01	2.094679e-01	7.780574e-08	8.536493e-01
shape				
4.704478e+00				

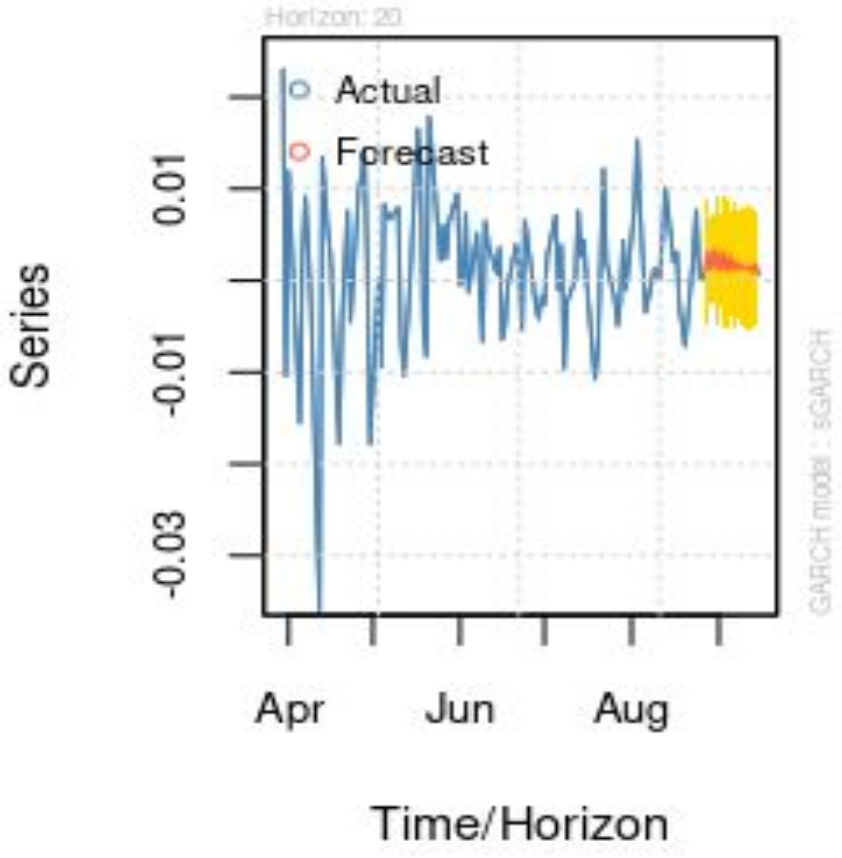
ARMA(0,0) -GARCH(1,1)

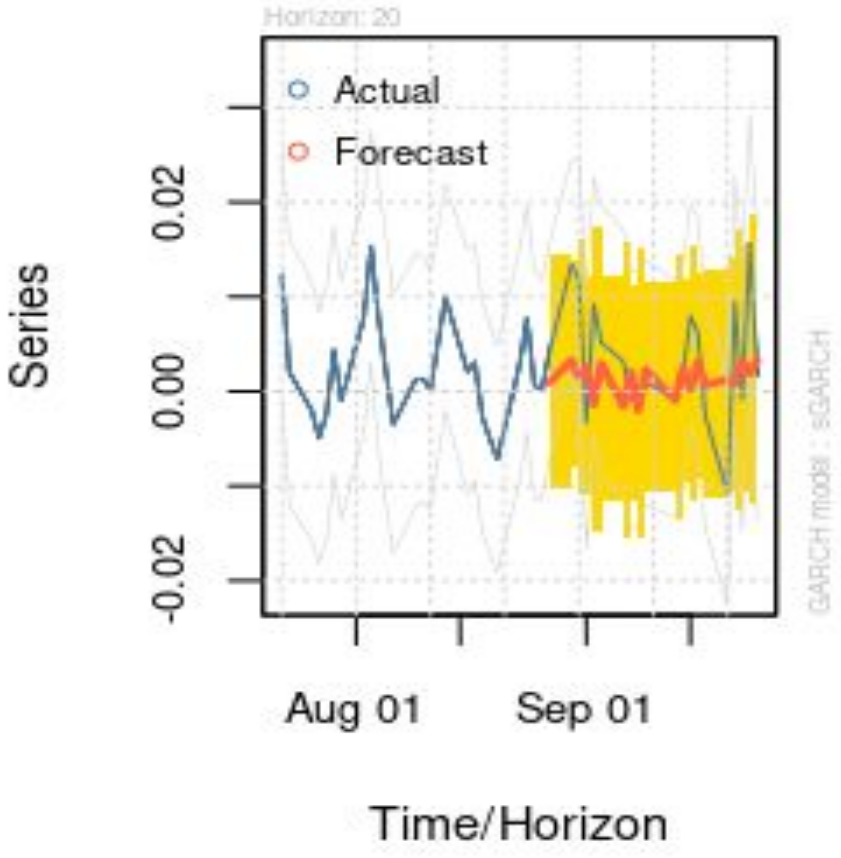
mu	omega	alpha1	beta1	skew
3.098175e-03	2.373183e-05	1.203816e-01	7.583815e-01	8.094982e-01
shape				
4.232789e+00				

Optimal Models w.r.t Different Information Criteria

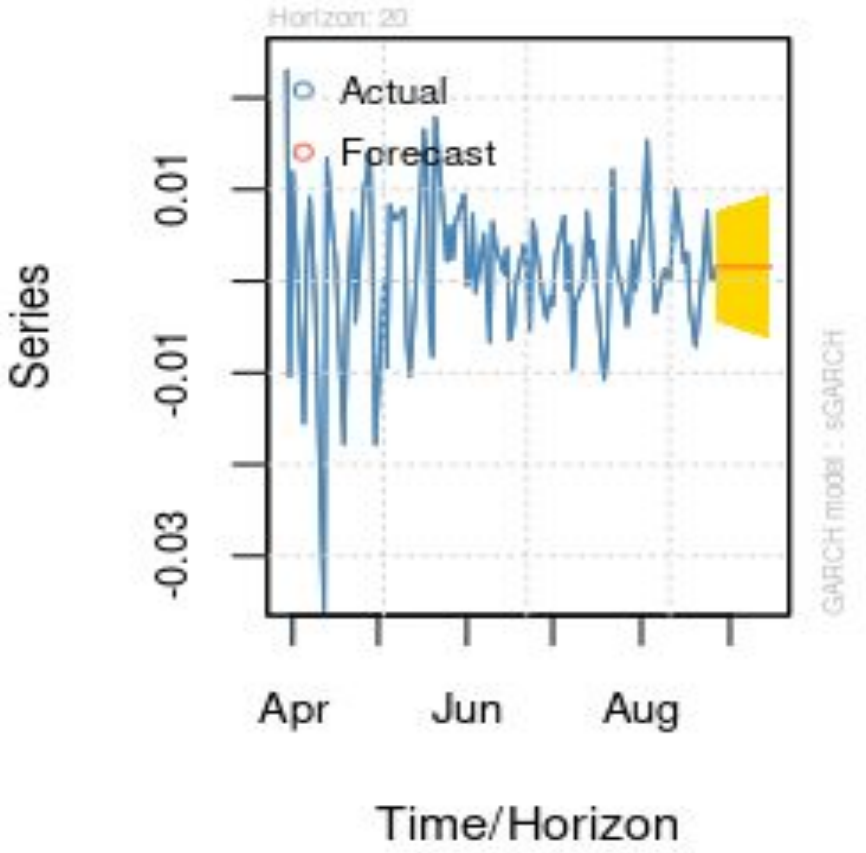
DATA	Model	AIC	BIC	AICc
NIFTY 50	ARMA(5,4)-GARCH(1,1)	-6.207122	-6.043169	-5.477840
	ARMA(0,0)-GARCH(1,1)	-6.190454	-6.124873	-6.158109
NIFTY NEXT 50	ARMA(2,5)-GARCH(4,0)	-6.395097	-6.231144	-5.665815
	ARMA(0,0)-GARCH(1,1)	-6.357362	-6.291781	-6.325017
NIFTY MIDCAP	ARMA(3,3)-GARCH(1,2)	-5.756788	-5.614695	-5.262282
	ARMA(0,0)-GARCH(1,1)	-5.715612	-5.650031	-5.683267
NIFTY SMALL CAP	ARMA(3,3)-GARCH(5,1)	-6.011425	-5.836174	-5.147159
	ARMA(0,0)-GARCH(1,1)	-5.934790	-5.869071	-5.902445

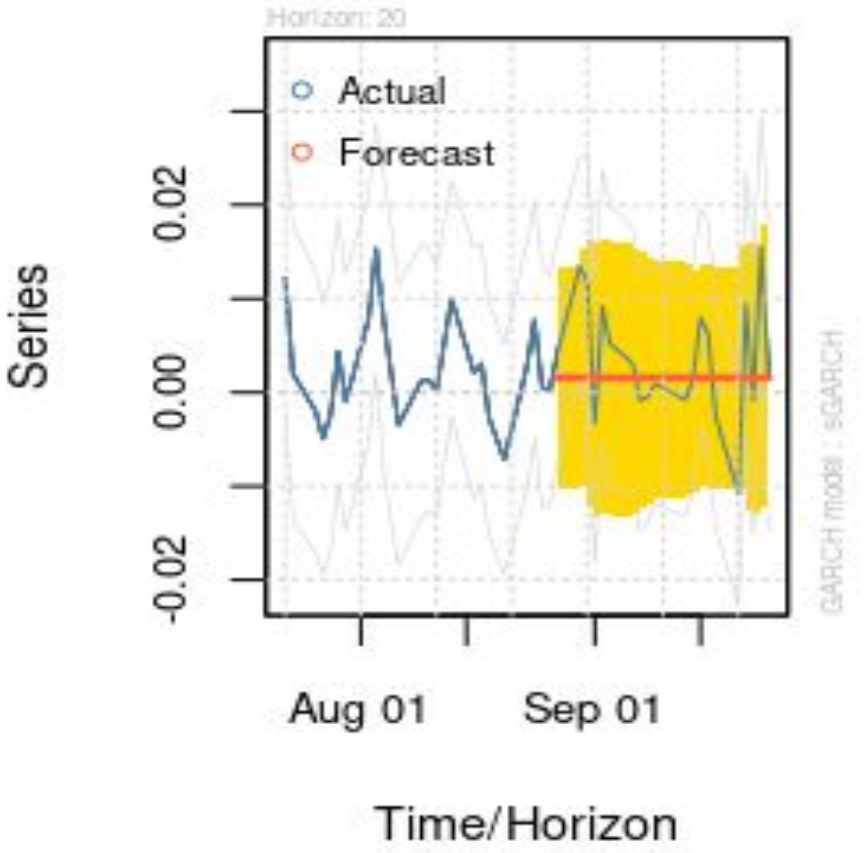
Prediction for NIFTY 50 Data ARMA(5,4)-GARCH(1,1)



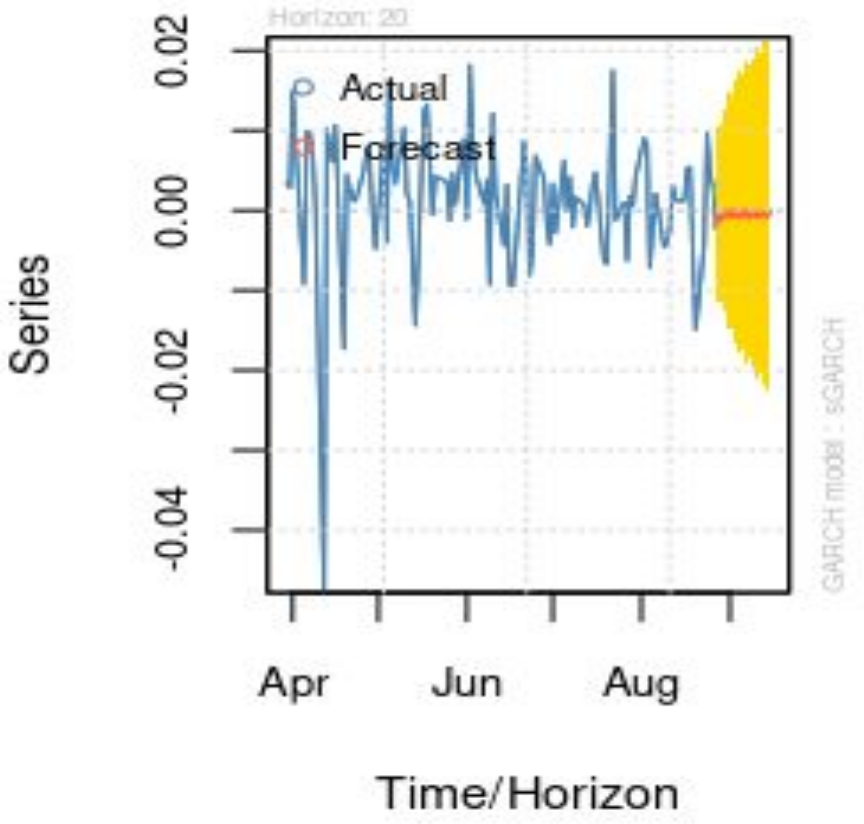


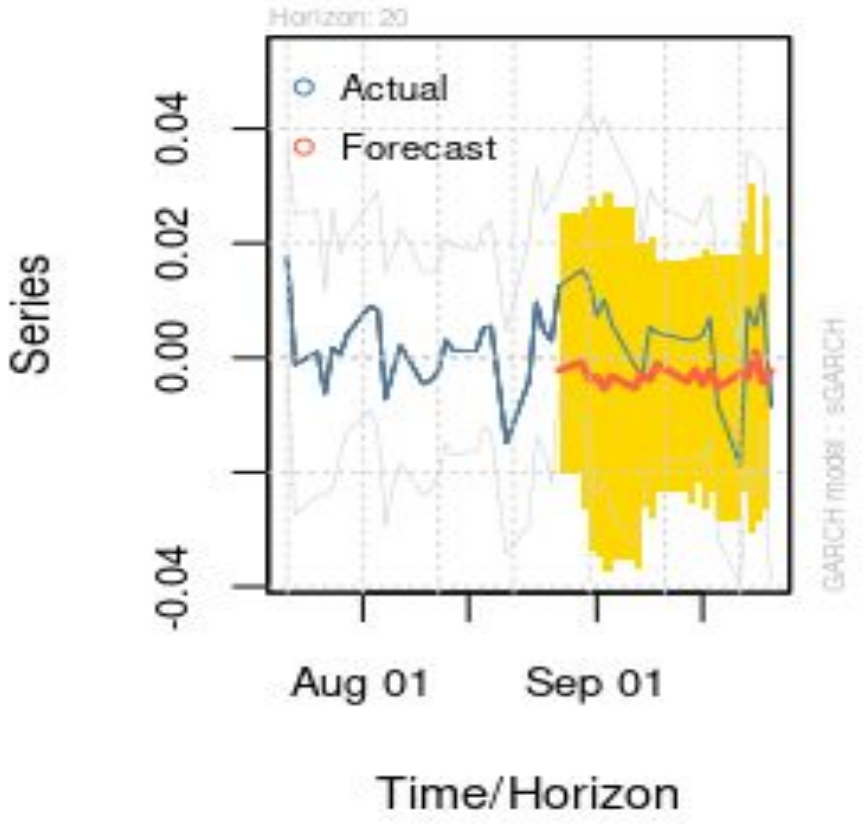
Prediction for NIFTY 50 Data ARMA(0,0)-GARCH(1,1)



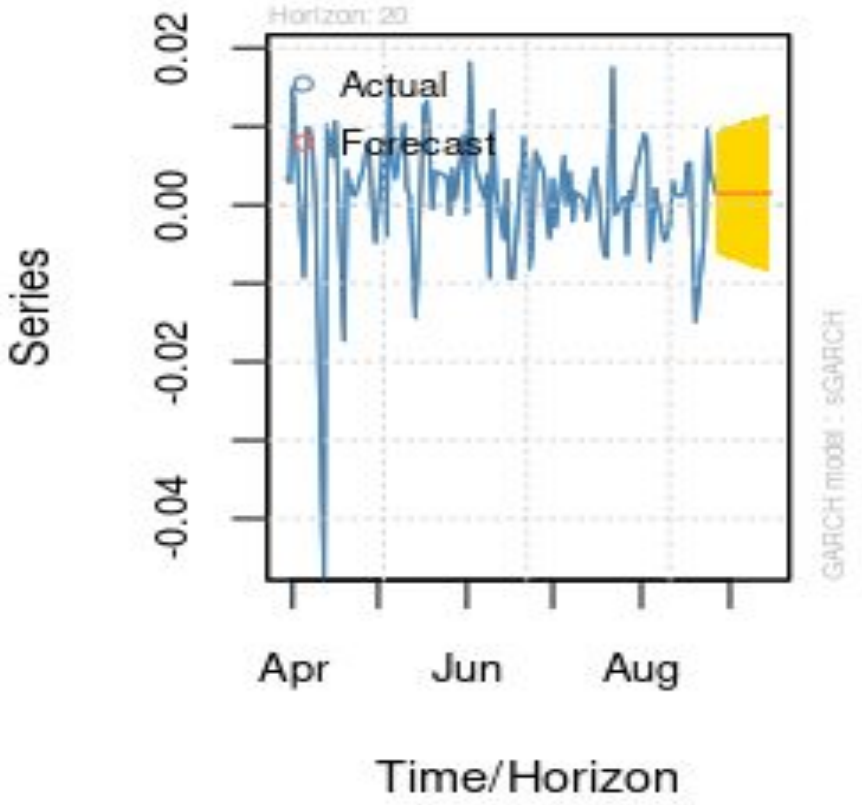


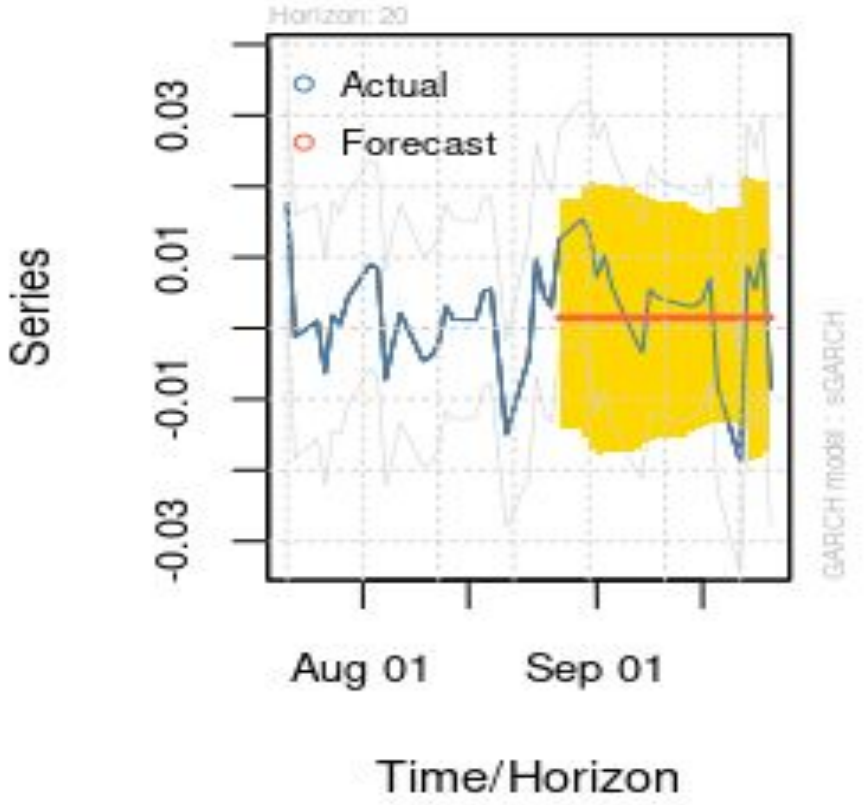
Prediction for NIFTY NEXT 50 Data ARMA(2,5)-GARCH(4,0)



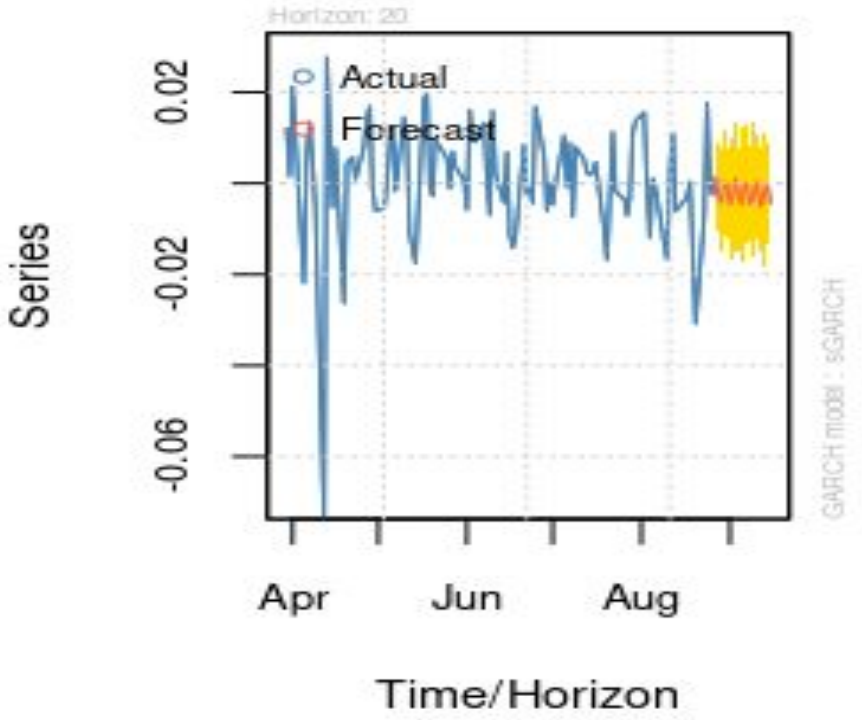


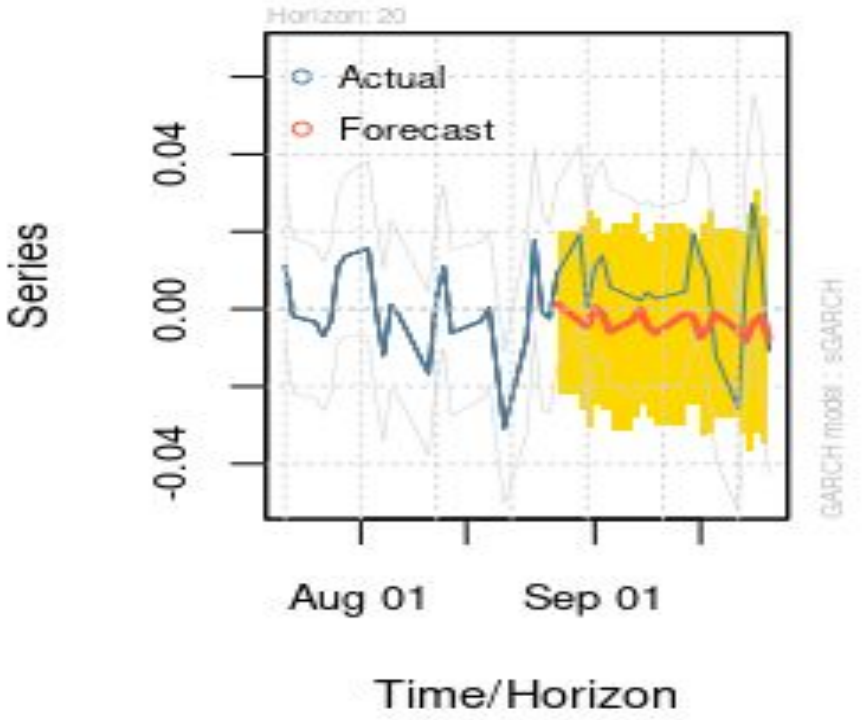
Prediction for NIFTY NEXT 50 Data ARMA(0,0)-GARCH(1,1)



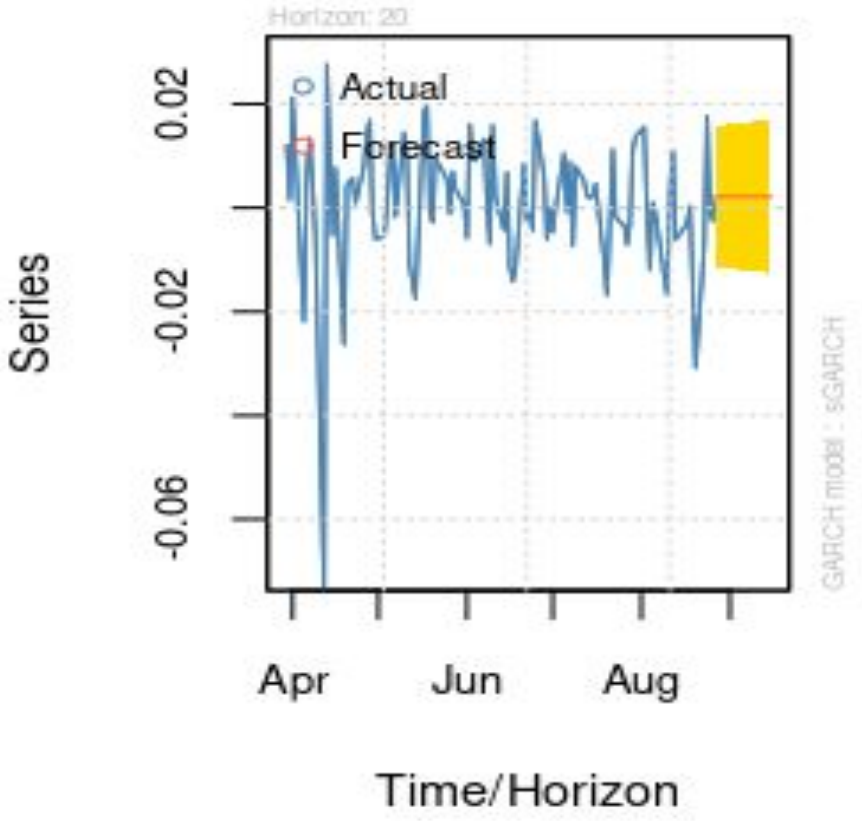


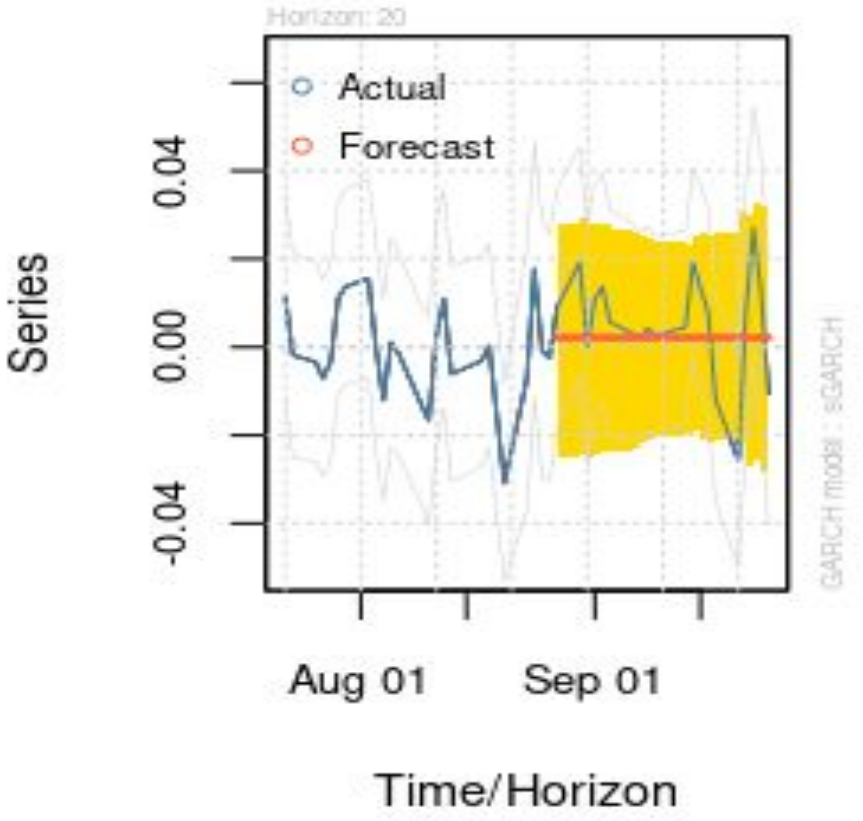
Prediction for NIFTY MIDCAP Data ARMA(3,3)-GARCH(1,2)



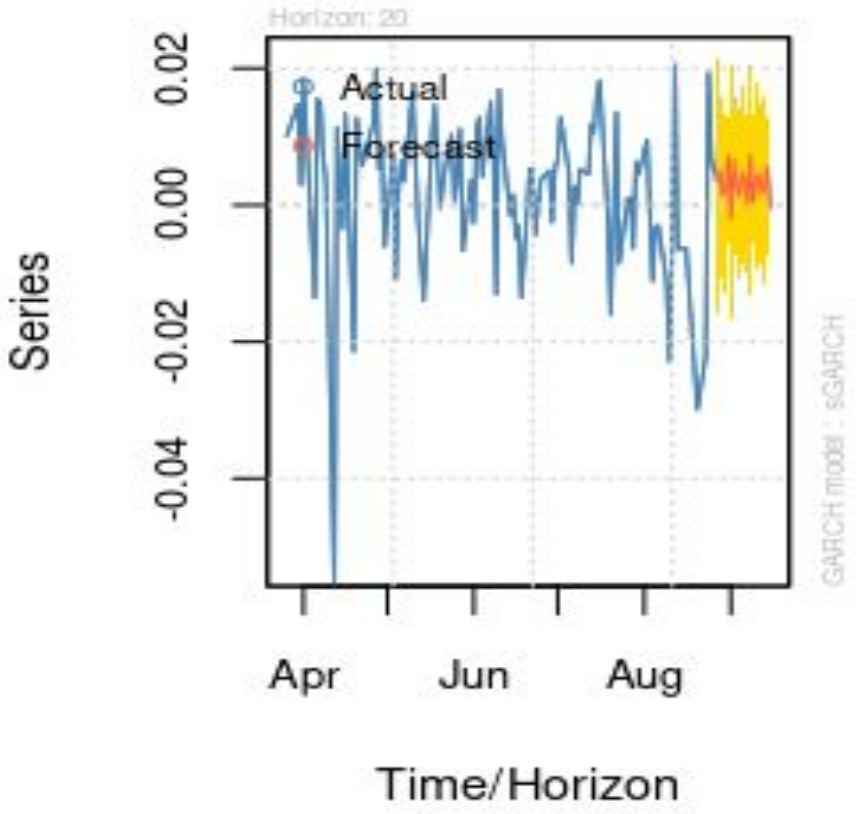


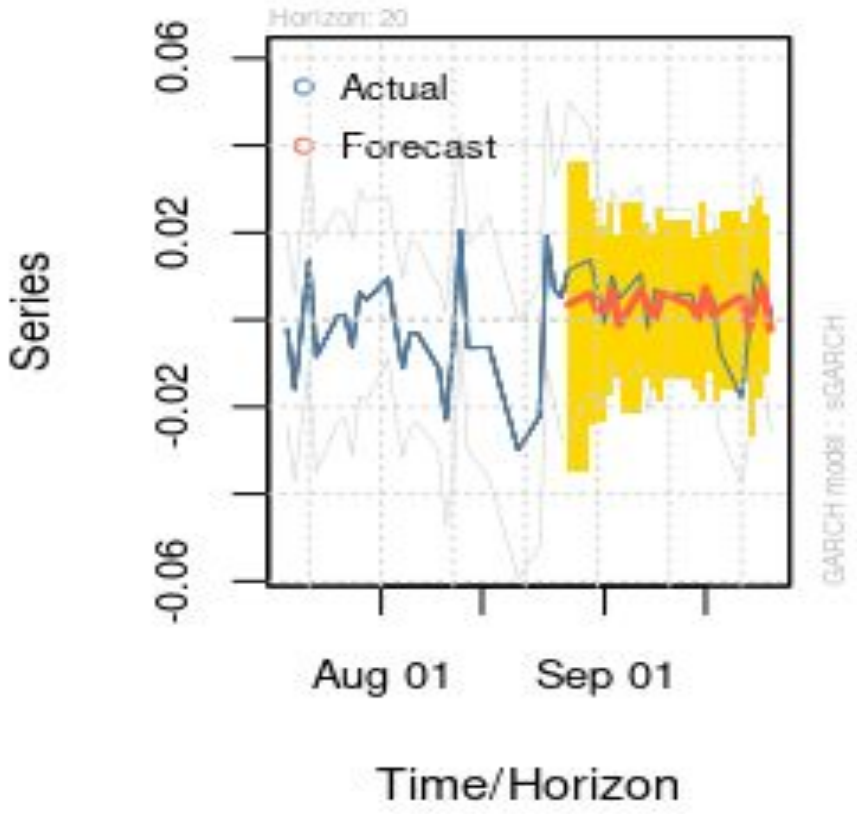
Prediction for NIFTY MIDCAP Data ARMA(0,0)-GARCH(1,1)



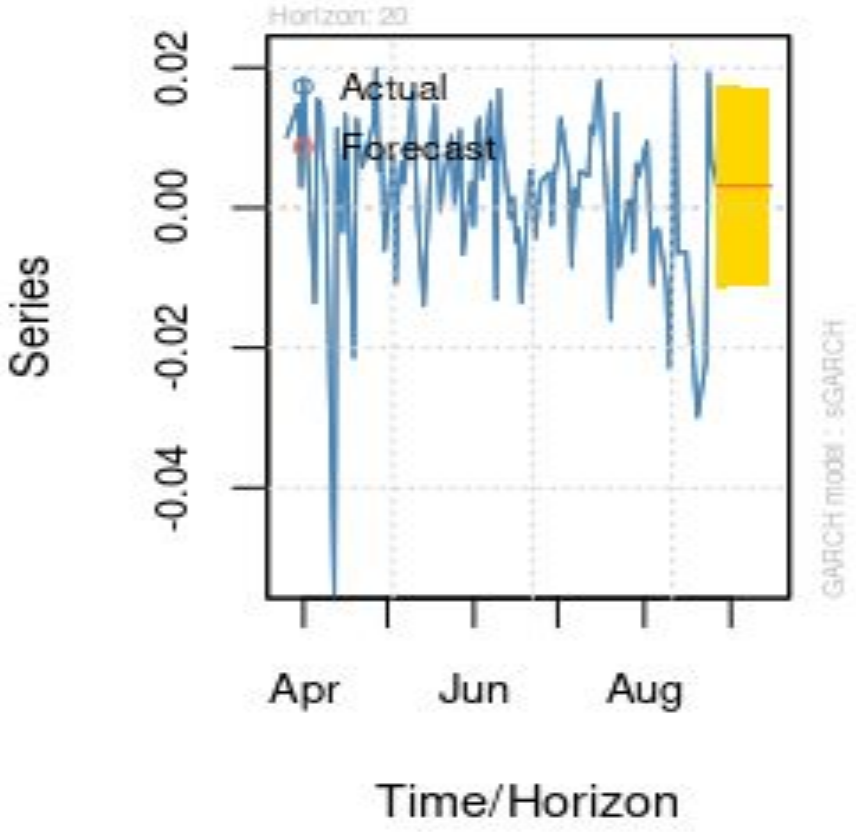


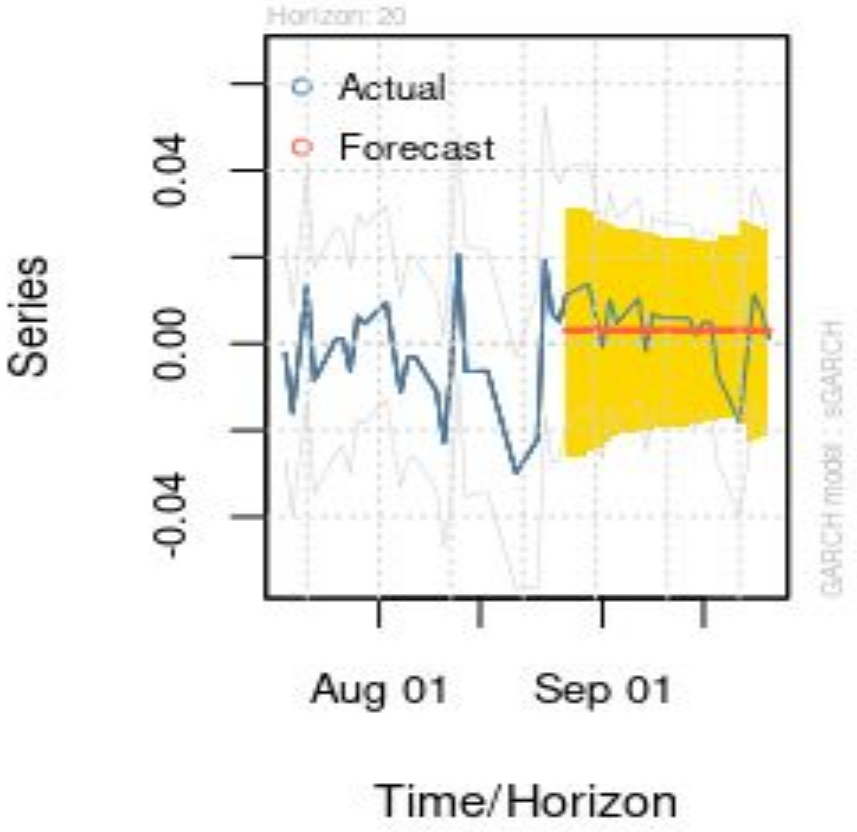
Prediction for NIFTY SMALL CAP Data ARMA(3,3)-GARCH(5,1)





Prediction for NIFTY SMALL CAP Data ARMA(0,0)-GARCH(1,1)





Various Models With MSEs

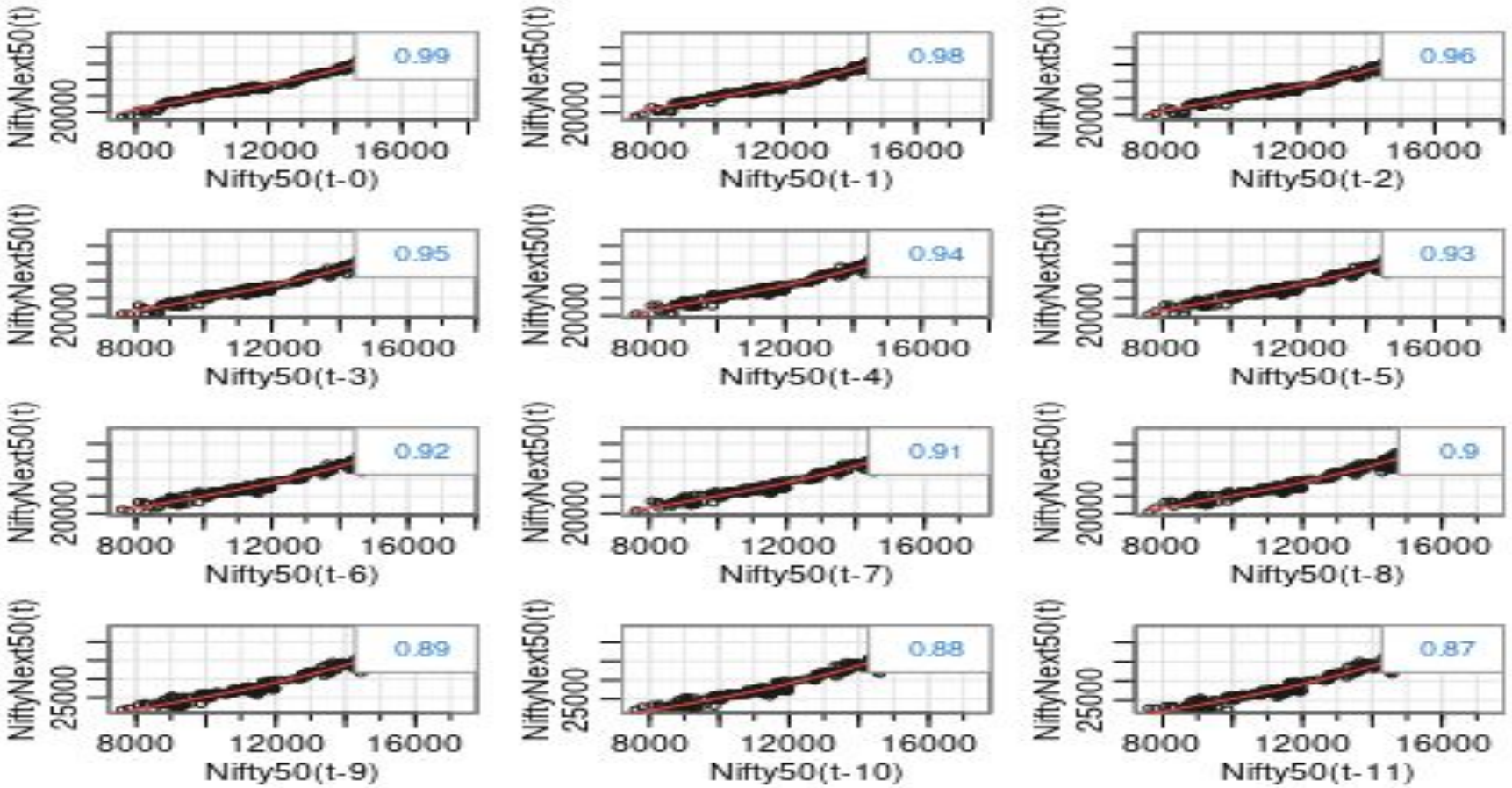
DATA	Model	Selection Method	MSE
NIFTY 50	ARMA(5,4)-GARCH(1,1)	AIC	$4.257733*e^{-05}$
	ARMA(0,0)-GARCH(1,1)	AICC and BIC	$4.321273*e^{-05}$
NIFTY NEXT 50	ARMA(2,5)-GARCH(4,0)	AIC	$9.034761*e-^{05}$
	ARMA(0,0)-GARCH(1,1)	AICC and BIC	$7.220151*e^{-05}$
NIFTY MIDCAP	ARMA(3,3)-GARCH(1,2)	AIC	0.0001937722
	ARMA(0,0)-GARCH(1,1)	AICC and BIC	0.0001463646
NIFTY SMALL CAP	ARMA(3,3)-GARCH(5,1)	AIC	$5.335918*e^{-05}$
	ARMA(0,0)-GARCH(1,1)	AICC and BIC	$5.34846*e^{-05}$

Correlation Between The Stocks

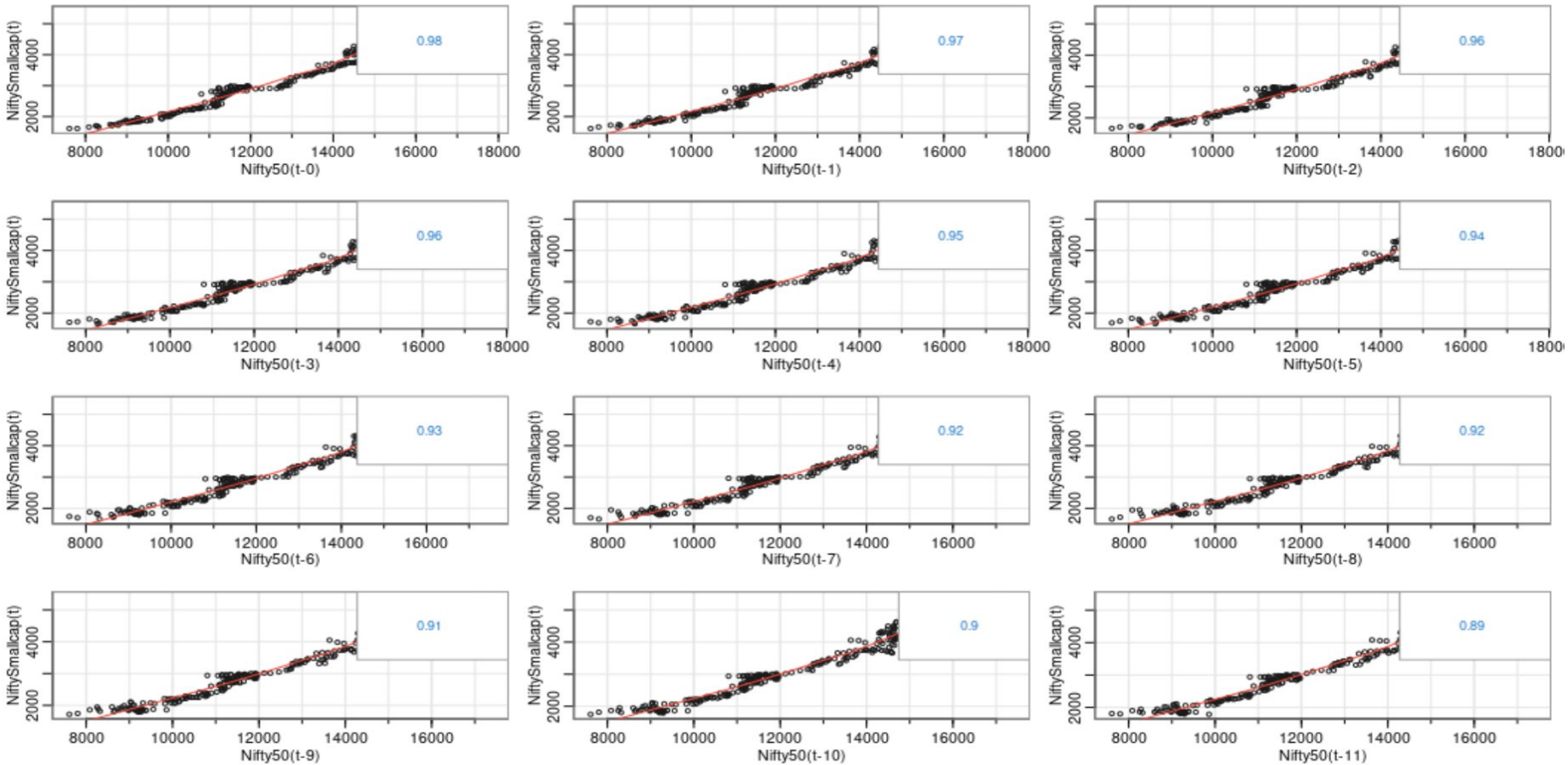
	1	2	3	4
1	1.00	0.99	0.99	0.96
2	0.99	1.00	0.99	0.97
3	0.99	0.99	1.00	0.97
4	0.96	0.97	0.97	1.00

1 = NIFTY 50
2 = NIFTY NEXT 50
3 = NIFTY MIDCAP
4 = NIFTY SMALL CAP

Lag Correlation Between Nifty 50 and Nifty Next 50



Lag Correlation Between Nifty 50 and Nifty Smallcap



Mean and Variance of the log returns of different data

MEAN	VAR	DATA
1.555*10^-3	1.71*10^-6	NIFTY 50
1.49*10^-3	2.81*10^-6	NIFTY NEXT 50
2.14*10^-3	1.02*10^-5	NIFTY MIDCAP
3.09*10^-3	2.37*10^-5	NIFTY SMALL CAP

Thank You