QAF-Assignment

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Contents

1 The Data

Data consist of the prices and volume of **ACC Stocks**. ACC stocks are traded in the CNX_NIFTY 50. We use 5 minutes frequency data collected from the Bloomberg Terminal.

The head of the data is as follows:

R Terminal

```
> headdata
              Date     TIME    OPEN    HIGH     LOW LAST_PRICE NUMBER_TICKS VOLUME
1 11-01-2016 00:00 09:15:00 1279.02 1283.94 1269.01    1271.75          120   4157
2 11-01-2016 00:00 09:20:00 1272.80 1275.14 1271.05    1271.85           82   1789
3 11-01-2016 00:00 09:25:00 1274.34 1277.37 1273.05    1273.05           98   1468
4 11-01-2016 00:00 09:30:00 1273.05 1276.33 1271.00    1274.94           78   2297
5 11-01-2016 00:00 09:35:00 1273.99 1274.14 1271.25    1273.34           54   1048
6 11-01-2016 00:00 09:40:00 1273.14 1273.34 1272.00    1273.24           41    414
>
```

The rows containing zero in any column has been removed prior processing. About 257 rows containing zeros were discovered, all in the VOLUME column. Additionally, the data points corresponding to the opening and closing of markets, i.e. before 09:15 hrs and after 15:25 hrs are ignored.

2 Question 1

Calculate logarithmic returns for the entire period.

Logarithmic returns were caluculated by the following formula:

$$log\_returns = \log \frac{S_t}{S_{t-1}} \tag{1}$$

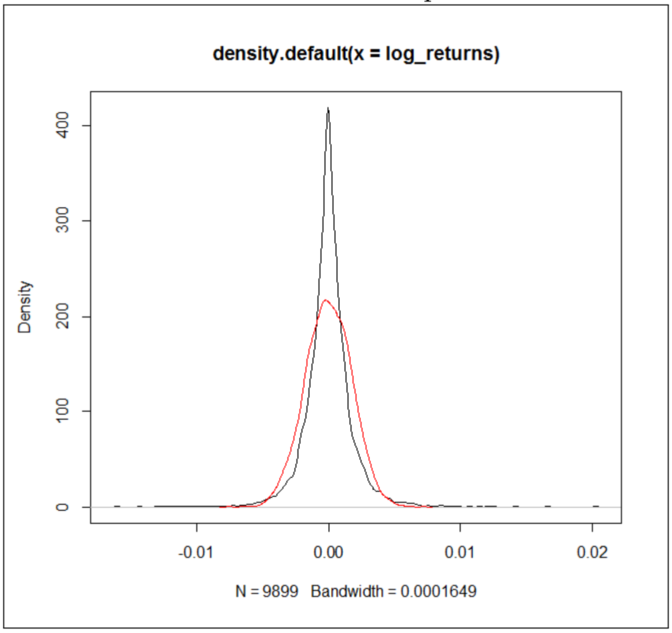
R Terminal

```
log_returns <- difflogdata$LAST_PRICE, lag=1;
```

3 Question 2

Test normality of the data (returns) by testing significance of its Kurtosis, Skewness, and joint hypothesis using Jarque-Bera statistics. Additionally, plot density of the returns and superimpose density of a normal distribution with the same mean and the same standard deviation (as that of the data).

Plot of the log-returns is as follows. A normal density function estimated by r-norm with the same mean and variance has been superimposed. The density plot shows the presence of kurtosis. We test the same with Jarque-Bera test.



R Terminal

```
> jb

        Jarque Bera Test

data:  log_returns
X-squared = 34902, df = 2, p-value < 2.2e-16

> skewnesslog_returns
[1] 0.165029
> kurtosislog_returns
[1] 9.193
>
```

JB test result results in rejection of the null hypothesis, thus distribution of the data does not jointly have skewness=0 & kurtosis=3. Conducting the D'A test for skewness, we get the following:

R Terminal

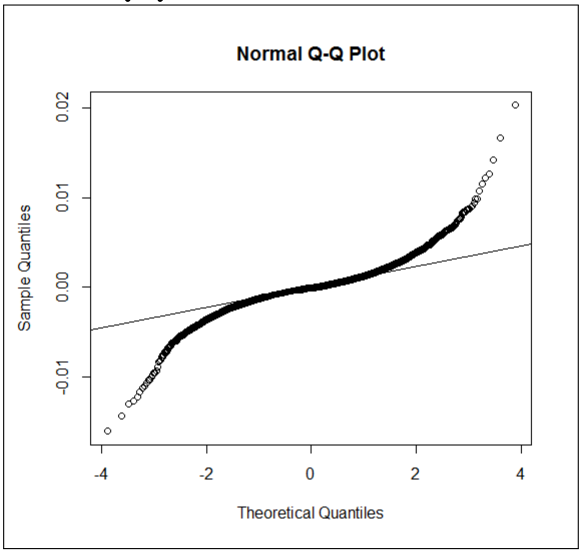
```
> agostino.testlog_returns

        D'Agostino skewness test

data:  log_returns
skew = 0.16503, z = 6.66350, p-value = 2.674e-11
alternative hypothesis: data have a skewness

>
```

Therefore the data is not normal due to both skewness and kurtosis. Additionally, we also construct a Q-Q Plot.



4 Question 3

Calculate the volume-cum-returns-based technical indicator as discussed in the course.

The indiacator is given by:

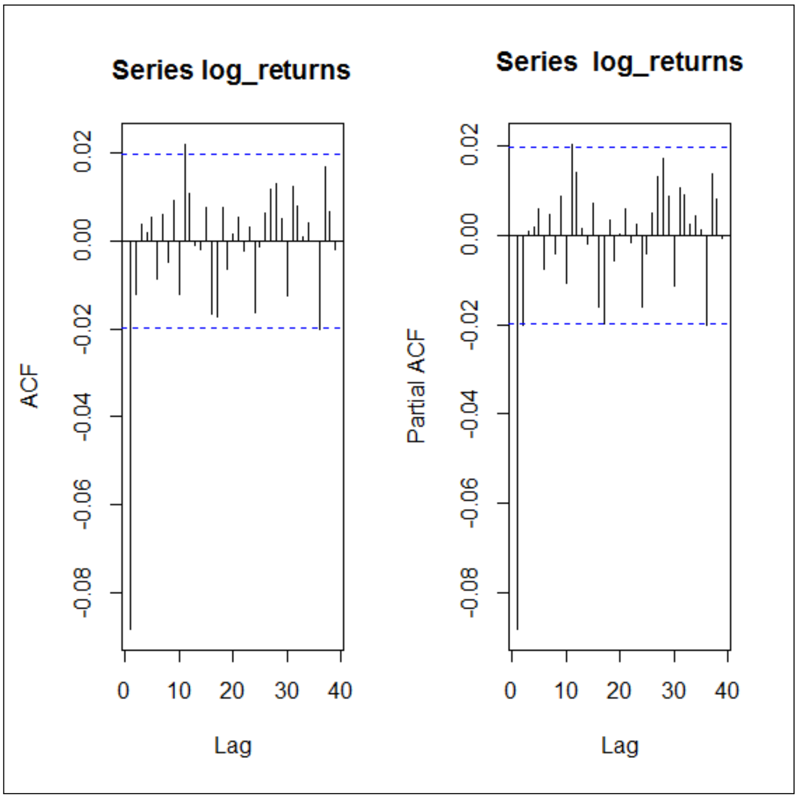
$$VolRet = \log \frac{V_t}{V_{t-1}} \log \frac{S_t}{S_{t-1}} \tag{2}$$

5 Question 4

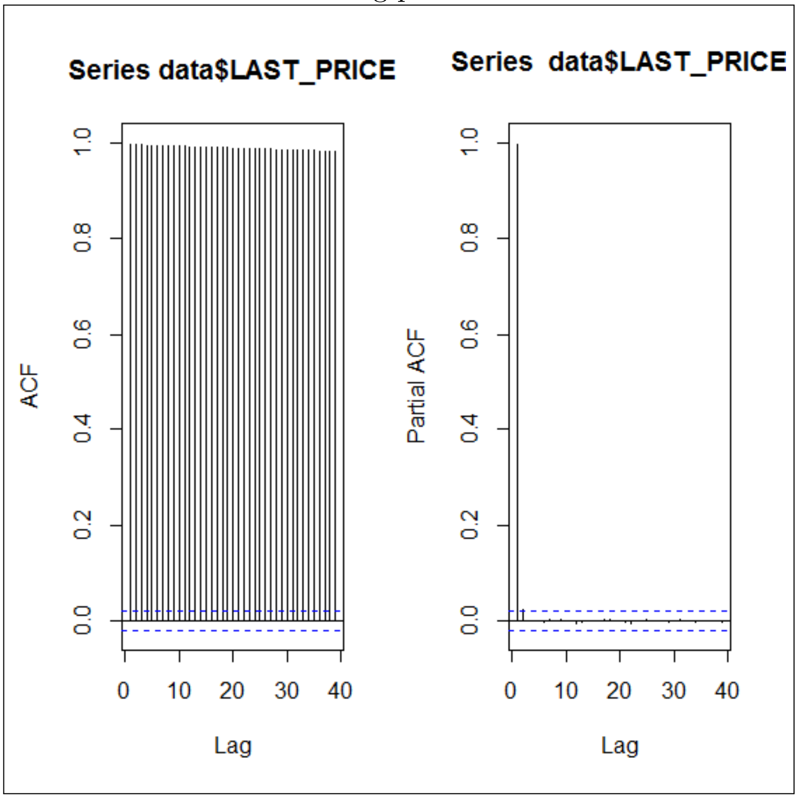
Test the stationarity of the prices and returns by using ACF, PACF, and the ADF test. Further, fit a regression model (ARMAX) to examine whether the returns of a security are explained by the volume-cum-returns-based technical indicator contemporaneously as well as with a lag.

5.1 ACF, PACF and ADF tests

ACF and PACF of the log-returns are as follows:



ACF and PACF of the closing prices are as follows:



We also conduct the ADF test on both the series. Placing special emphasis the result obtained in the case of log returns. The log-returns are stationary.

R Terminal

```
> a
```

```
        Augmented Dickey-Fuller Test

data:  log_returns
Dickey-Fuller = -21.312, Lag order = 21, p-value = 0.01
alternative hypothesis: stationary

> b

        Augmented Dickey-Fuller Test

data:  data$LAST_PRICE
Dickey-Fuller = -3.0563, Lag order = 21, p-value = 0.1308
alternative hypothesis: stationary

>
```

5.2 ARMAX Fitting

Looking at the ACF and PACF of the log-returns, best guess would be a $MA(1)$ model. However, we run a arima estimate to figure put the best estimate. Our guess is very close (look at the auto.arima result). Now, we formulate a ARIMAX with the $VolRet_t$ & $VolRet_{t-1}$ calculated in Section 4. Therefore the models in question are:

$$log - returns_t = \phi_0 + \phi_1 \epsilon_{t-1} + \epsilon_t \quad (3)$$

$$log - returns_t = \phi_0 + \phi_1 \epsilon_{t-1} + \beta vr\_ratio_t + \epsilon_t \quad (4)$$

$$log - returns_t = \phi_0 + \phi_1 \epsilon_{t-1} + \beta vr\_ratio_{t-1} + \epsilon_t \quad (5)$$

R Terminal

```
> auto.arimalog_returns
Series: log_returns
ARIMA0,0,1 with non-zero mean

Coefficients:
          ma1  intercept
      -0.0913          0
s.e.   0.0101          0

sigma^2 estimated as 3.097e-06:  log likelihood=48740.21
AIC=-97474.41   AICc=-97474.41   BIC=-97452.81
> m1<-arimaxlog_returns, c0,0,1, xreg=lagvr_ratio,1;
> m1

Call:
arimaxx = log_returns, order = c0, 0, 1, xreg = lagvr_ratio, 1

Coefficients:
          ma1  intercept    xreg
      -0.1218          0  0.3136
s.e.   0.0102          0  0.0094

sigma^2 estimated as 2.787e-06:  log likelihood = 49260.46,  aic = -98514.92
> m3<-arimaxlog_returns, c0,0,1, xreg=vr_ratio;
> m3

Call:
arimaxx = log_returns, order = c0, 0, 1, xreg = vr_ratio
```

```
Coefficients:
          ma1  intercept    xreg
      -0.1218          0  0.3136
s.e.   0.0102          0  0.0094

sigma^2 estimated as 2.787e-06:  log likelihood = 49260.46,  aic = -98514.92
```

---

6 Question 5

Draw inferences.

Based on the information criteria, AIC, the ARIMAX model is better. There is no difference between the two ARIMAX models, ones with and without the lag. But, we also consider the LR test, via which the difference between the log-likelihood of the two models appears to be insignificant.

R Terminal

```
Likelihood ratio test

Model 1: arimaxx = log_returns, order = c0, 0, 1, xreg = lagvr_ratio,    1
Model 2: arimax = log_returns, order = c0, 0, 1
  #Df LogLik Df  Chisq Pr>Chisq
1   4  49260
2   3  48740 -1 1040.5  < 2.2e-16
```

Therefore, the estimated model is:

$$log - returns_t = \phi_1 \epsilon_{t-1} + \epsilon_t \tag{6}$$

A pure MA(1) model. $\phi_1 = -0.0913$