Configuration Manual

MSc Research Project
Masters in Fintech

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School of Computing
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Supervisor: Noel Cosgrave

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MSc Project Submission Sheet

School of Computing

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Supervisor:	Noel Cosgrave
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Configuration Manual

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1 Introduction

This configuration manual consists of the computer system, **R** programming software, **R** programming packages, **R** programming codes and graphical illustration of datasets which was used to compare the stock market volatility, using the developed stock market index such as S & P 500, Nasdaq Composites and Dow Jones Industrial Average as a case study.

2 Computer System

The specification of the computer system used to carry out the research studies are listed below:

(i). Windows edition: Windows 10
(ii). Processor: intel (R) core (TM) i5 3320m CPU @ 2.60GHz 2.60GHz
(iii). Installed memory (RAM): 8.00 GB (7.70 GB usable)
(iv). System type: 64-bit Operating System, x64 based processor
(v). pen and touch: Touch Support with 2 touch points
(vi). Computer name: DESKTOP-RKOJC3P
(vii). Windows Product ID: 00326- 10000- 00000- AA242

3 R programming Software

The r programming software comprises of RStudio and **R** software, the RStudio is a set of integrated tools designed to help **R** be more productive for analytics. The R software version is 3.5.1: 62 megabytes and 64 bits

4 R code

```
##Loading Data from yahoo Finance:
## Deveoped Stock Market Index
## GSPC = S & P 500
## IXIC = NASDAQ
## DJI = Dow Jones Industrial Average
getSymbols("^GSPC", from="2015-01-01", to="2019-06-30")
getSymbols("^IXIC", from="2015-01-01", to="2019-06-30")
getSymbols("^DJI", from="2015-01-01", to="2019-06-30")
##DATASET ONE S&P 500 (GSPC)
##FEATURE ENGINEERING OF S&P 500 (GSPC)
## PART ONE: Finding mising values
z <- c(1:3,NA)
is.na(z)
```

```
sum(is.na(z))
sapply(GSPC, FUN = function(x) {sum(is.na(x))})
unique(z)
length(unique(z))
##PART Two: Showing the Trending analysis and descriptive statistics of the Close price of the stock
market index
## The Data is the Daily close price
barplot(GSPC$GSPC.Close)
hist(GSPC$GSPC.Close,
   main="Distribution of GSPC.Close",
   xlab="GSPC.Close")
qqnorm(GSPC$GSPC.Close,
     main="Distribution of GSPC.Close",
     xlab="GSPC.Close")
sd(GSPC$GSPC.Close)
skewness(GSPC$GSPC.Close)
kurtosis(GSPC$GSPC.Close)
##Chat Series of the Dataset(GSPC)
chartSeries(GSPC)
## When we are estimating volatility, we work with returns either daily or monthly
## Estimating Volatility Models
##Chart Series of Daily Return (GSPC)
S.P500 <- dailyReturn(GSPC)
chartSeries(S.P500)
acf(S.P500)
pacf(S.P500)
###Descriptive Statistics of Daily Returns of S & P 500
min(S.P500)
max(S.P500)
mean(S.P500)
median(S.P500)
var(S.P500)
sd(S.P500)
skewness(S.P500)
kurtosis(S.P500)
##Stationarity test: Augment Dickey-Fuller test
adf.test(S.P500)
##BOX-LJUNG TEST
Box.test(S.P500, lag=10, type="Ljung")
##ARCH TEST
ArchTest(S.P500)
##Model Specification
Modelspec <- auto.arima(S.P500, trace = TRUE, test = "kpss", ic= "bic")
S.P500ug_spec = ugarchspec()
S.P500ug_spec
## Model Estimation
S.P500ugfit = ugarchfit(spec = S.P500ug_spec, data = S.P500)
S.P500ugfit
names(S.P500ugfit@model)
names(S.P500ugfit@fit)
summary(S.P500ugfit)
plot(S.P500ugfit)
```

```
##Measurement of Value at Risk
ctrl = list(tol = 1e-7, delta = 1e-9)
S.P500ugfit_roll <- ugarchroll(S.P500ug_spec, S.P500, n.start = 250, refit.every = 1,
                        refit.window = "moving", solver = "hybrid", calculate.VaR = TRUE,
                        VaR.alpha = 0.01, keep.coef = TRUE, solver.control = ctrl,
                        fit.control = list(scale = 1))
report(S.P500ugfit_roll, type = "VaR", VaR.alpha = 0.01, conf.level =0.99)
plot(S.P500ugfit)
## Extraction of Estimated Coefficients
S.P500ugfit@fit$coef
## Extraction of Estimated Conditional Variances
S.P500ug_var <- S.P500ugfit@fit$var
## Extraction of Estimated Squared residuals
S.P500ug_res2 <- (S.P500ugfit@fit$residuals)^2
##Plotting the squared residuals and the estimated conditional variances
plot(S.P500ug_res2, type ="c")
lines(S.P500ug_var, col = "green")
## Model Forecasting
S.P500ugfore <- ugarchforecast(S.P500ugfit, n.ahead = 10, data = S.P500)
plot(S.P500ugfore)
S.P500ugfore
S.P500ug_f <- S.P500ugfore@forecast$sigmaFor
plot(S.P500ug_f, type = "c")
##Note that volatility is the square root of the conditional variance
S.P500ug_var_t <- c(tail(S.P500ug_var,20), rep(NA,10)) #get the last 20 observations
S.P500ug_res2_t <- c(tail(S.P500ug_res2,20), rep(NA,10)) #get the last 20 observations
S.P500ug_f <- c(rep(NA,20),(S.P500ug_f)^2)
plot(S.P500ug_res2_t, type ="c")
lines(S.P500ug_f, col ="orange")
lines(S.P500ug_var_t, col ="green")
plot(S.P500ugfit)
##GJRGARCH
S.P500.gjrgarch.spec <- ugarchspec(variance.model = list(model="gjrGARCH",
garchOrder=c(1,1)),distribution.model = "norm")
S.P500.gjrgarch.fit = ugarchfit(S.P500.gjrgarch.spec, S.P500)
S.P500.gjrgarch.fit
coef(S.P500.gjrgarch.fit)
##GJRGARCH FORECASTING
S.P500.gjrgarch_Pred <- ugarchforecast(S.P500.gjrgarch.fit, n.ahead = 20, plot = TRUE)
plot(S.P500.gjrgarch_Pred)
##EGARCH
S.P500.egarch.spec = ugarchspec(variance.model=list(model="eGARCH",garchOrder=c(1,1)),
mean.model=list(armaOrder=c(0,0)))
S.P500.egarch.fit = ugarchfit(S.P500.egarch.spec, S.P500)
S.P500.egarch.fit
coef(S.P500.egarch.fit)
##EGARCH FORECASTING
S.P500.egarch_Pred <- ugarchforecast(S.P500.egarch.fit, n.ahead = 20, plot = TRUE)
plot(S.P500.egarch_Pred)
##DATASET TWO NASDAQ (IXIC)
##FEATURE ENGINEERING OF NASDAQ (IXIC)
## PART ONE: Finding mising values
```

```
z <- c(1:3,NA)
is.na(z)
sum(is.na(z))
sapply(IXIC, FUN = function(x) {sum(is.na(x))})
unique(z)
length(unique(z))
##PART Two: Showing the Trending analysis and descriptive statistics of the Close price of the stock market index
## The Data is the Daily close price
barplot(IXIC$IXIC.Close)
hist(IXIC$IXIC.Close,
    main="Distribution of IXIC.Close",
    xlab="IXIC.Close")
qqnorm(IXIC$IXIC.Close,
      main="Distribution of IXIC.Close",
      xlab="IXIC.Close")
sd(IXIC$IXIC.Close)
skewness(IXIC$IXIC.Close)
kurtosis(IXIC$IXIC.Close)
##Chat Series of the Dataset(IXIC)
chartSeries(IXIC)
## When we are estimating volatility, we work with returns either daily or monthly
## Estimating Volatility Models
##Chart Series of Daily Return (IXIC)
NASDAQ <- dailyReturn(IXIC)
chartSeries(NASDAQ)
acf(NASDAQ)
pacf(NASDAQ)
###Descriptive Statistics of Daily Returns of NASDAQ
min(NASDAQ)
max(NASDAQ)
mean(NASDAQ)
median(NASDAQ)
skewness(NASDAQ)
kurtosis(NASDAQ)
var(NASDAQ)
sd(NASDAQ)
##Stationarity test: Augment Dickey-Fuller test
adf.test(NASDAQ)
##BOX-LJUNG TEST
Box.test(NASDAQ, lag=10, type="Ljung")
##ARCH TEST
ArchTest(NASDAQ)
Modelspec <- auto.arima(NASDAQ, trace = TRUE, test = "kpss", ic= "bic")
##Model Specification
NASDAQug_spec = ugarchspec()
NASDAQug_spec
##Measurement of Value at Risk
ctrl = list(tol = 1e-7, delta = 1e-9)
NASDAQugfit_roll <- ugarchroll(NASDAQug_spec, S.P500, n.start = 250, refit.every = 1,
                        refit.window = "moving", solver = "hybrid", calculate.VaR = TRUE,
                        VaR.alpha = 0.01, keep.coef = TRUE, solver.control = ctrl,
```

```
                    fit.control = list(scale = 1))
report(NASDAQugfit_roll, type = "VaR", VaR.alpha = 0.01, conf.level =0.99)
## Model Estimation
NASDAQugfit = ugarchfit(spec = NASDAQug_spec, data = NASDAQ)
NASDAQugfit
names(NASDAQugfit@model)
names(NASDAQugfit@fit)
summary(NASDAQugfit)
plot(NASDAQugfit)
## Extraction of Estimated Coefficients
NASDAQugfit@fit$coef
## Extraction of Estimated Conditional Variances
NASDAQug_var <- NASDAQugfit@fit$var
## Extraction of Estimated Squared residuals
NASDAQug_res2 <- (NASDAQugfit@fit$residuals)^2
##Plotting the squared residuals and the estimated conditional variances
plot(NASDAQug_res2, type ="c")
lines(NASDAQug_var, col = "green")
## Model Forecasting
NASDAQugfore <- ugarchforecast(NASDAQugfit, n.ahead = 10)
NASDAQugfore
NASDAQug_f <- NASDAQugfore@forecast$sigmaFor
plot(NASDAQug_f, type = "c")
plot(NASDAQugfore)
##GJRGARCH
NASDAQgjrgarch.spec <- ugarchspec(variance.model = list(model="gjrGARCH",
garchOrder=c(1,1)),distribution.model = "norm")
NASDAQgjrgarch.fit = ugarchfit(NASDAQgjrgarch.spec, NASDAQ)
NASDAQgjrgarch.fit
coef(NASDAQgjrgarch.fit)
##GJRGARCH FORECASTING
NASDAQgjrgarch_Pred <- ugarchforecast(NASDAQgjrgarch.fit, n.ahead = 10, plot = TRUE)
plot(NASDAQgjrgarch_Pred)
##EGARCH
NASDAQ.egarch.spec = ugarchspec(variance.model=list(model="eGARCH",garchOrder=c(1,1)),
mean.model=list(armaOrder=c(0,0)))
NASDAQ.egarch.fit = ugarchfit(NASDAQ.egarch.spec, NASDAQ)
NASDAQ.egarch.fit
coef(NASDAQ.egarch.fit)
##EGARECH FORECASTING
NASDAQ.egarch_Pred <- ugarchforecast(NASDAQ.egarch.fit, n.ahead = 10, plot = TRUE)
plot(NASDAQ.egarch_Pred)
##DATASET THREE DOW JONE INDUSTRIAL AVERAGE (DJI)
##FEATURE ENGINEERING OF DOW JONE INDUSTRIAL AVERAGE (DJI)
## PART ONE: Finding mising values
z <- c(1:3,NA)
is.na(z)
sum(is.na(z))
sapply(DJI, FUN = function(x) {sum(is.na(x))})
unique(z)
length(unique(z))
```

```
##PART Two: Showing the Trending analysis and descriptive statistics of the Close price of the stock
market index
## The Data is the Daily close price
barplot(DJI$DJI.Close)
hist(DJI$DJI.Close,
   main="Distribution of DJI.Close",
   xlab="DJI.Close")
qqnorm(DJI$DJI.Close,
     main="Distribution of DJI.Close",
     xlab="DJI.Close")
sd(DJI$DJI.Close)
skewness(DJI$DJI.Close)
kurtosis(DJI$DJI.Close)
##Chat Series of the Dataset(DJI)
chartSeries(DJI)
## When we are estimating volatility, we work with returns either daily or monthly
## Estimating Volatility Models
##Chart Series of Daily Return (DJI)
DOWJONES <- dailyReturn(DJI)
chartSeries(DOWJONES)
acf(DOWJONES)
pacf(DOWJONES)
###Descriptive Statistics of Daily Returns of DOWJONES
min(DOWJONES)
max(DOWJONES)
mean(DOWJONES)
median(DOWJONES)
skewness(DOWJONES)
kurtosis(DOWJONES)
var(DOWJONES)
sd(DOWJONES)
##Stationarity test: Augment Dickey-Fuller test
adf.test(DOWJONES)
##BOX-LJUNG TEST
Box.test(DOWJONES, lag=10, type="Ljung")
##ARCH TEST
ArchTest(DOWJONES)
##Model Specification
Modelspec <- auto.arima(DOWJONES, trace = TRUE, test = "kpss", ic= "bic")
DOWJONESug_spec = ugarchspec()
DOWJONESug_spec
##Measurement of Value at Risk
ctrl = list(tol = 1e-7, delta = 1e-9)
DOWJONESugfit_roll <- ugarchroll(DOWJONESug_spec, S.P500, n.start = 250, refit.every = 1,
                        refit.window = "moving", solver = "hybrid", calculate.VaR = TRUE,
                        VaR.alpha = 0.01, keep.coef = TRUE, solver.control = ctrl,
                        fit.control = list(scale = 1))
report(DOWJONESugfit_roll, type = "VaR", VaR.alpha = 0.01, conf.level =0.99)
## Model Estimation
DOWJONESugfit = ugarchfit(spec = DOWJONESug_spec, data = DOWJONES)
DOWJONESugfit
names(DOWJONESugfit@model)
```

```
names(DOWJONESugfit@fit)
plot(DOWJONESugfit)
## Extraction of Estimated Coefficients
DOWJONESugfit@fit$coef
## Extraction of Estimated Conditional Variances
DOWJONESug_var <- DOWJONESugfit@fit$var
## Extraction of Estimated Squared residuals
DOWJONESug_res2 <- (DOWJONESugfit@fit$residuals)^2
##Plotting the squared residuals and the estimated conditional variances
plot(DOWJONESug_res2, type ="c")
lines(DOWJONESug_var, col = "green")
## Model Forecasting
DOWJONESugfore <- ugarchforecast(DOWJONESugfit, n.ahead = 10)
DOWJONESugfore
DOWJONESug_f <- DOWJONESugfore@forecast$sigmaFor
plot(DOWJONESug_f, type = "c")
plot(DOWJONESugfore)
##GJRGARCH
DOWJONESgjrgarch.spec <- ugarchspec(variance.model = list(model="gjrGARCH",
garchOrder=c(1,1)),distribution.model = "norm")
DOWJONESgjrgarch.fit = ugarchfit(DOWJONESgjrgarch.spec, DOWJONES)
DOWJONESgjrgarch.fit
coef(DOWJONESgjrgarch.fit)
##GJRGARCH FORECASTING
NASDAQgjrgarch_Pred <- ugarchforecast(NASDAQgjrgarch.fit, n.ahead = 10, plot = TRUE)
plot(NASDAQgjrgarch_Pred)
##EGARCH
DOWJONES.egarch.spec = ugarchspec(variance.model=list(model="eGARCH",garchOrder=c(1,1)),
mean.model=list(armaOrder=c(0,0)))
DOWJONES.egarch.fit = ugarchfit(DOWJONES.egarch.spec, DOWJONES)
DOWJONES.egarch.fit
coef(DOWJONES.egarch.fit)
##EGARECH FORECASTING
DOWJONES.egarch_Pred <- ugarchforecast(DOWJONES.egarch.fit, n.ahead = 20, plot = TRUE)
plot(DOWJONES.egarch_Pred)
##Volatility Estimators for Datasetone: S & P 500
NGSPC <- GSPC
NGSPC
##Yang and Zhang volatility estimators
GSPCtest5 <- volatility(NGSPC, n = 30, calc = "yang.zhang", N = 256)
GSPCtest5
plot(GSPCtest5,
   main="Yang and Zhang Estimator: S & P 500",
   xlab="GSPCtest5")
##Volatility Estimators for Dataset two; NASDAQ
NIXIC <- IXIC
NIXIC
##Yang and Zhang volatility estimators
IXICtest5 <- volatility(NIXIC, n = 30, calc = "yang.zhang", N = 365)
IXICtest5
plot(IXICtest5,
   main="Yang and Zhang Estimator: NASDAQ",
```

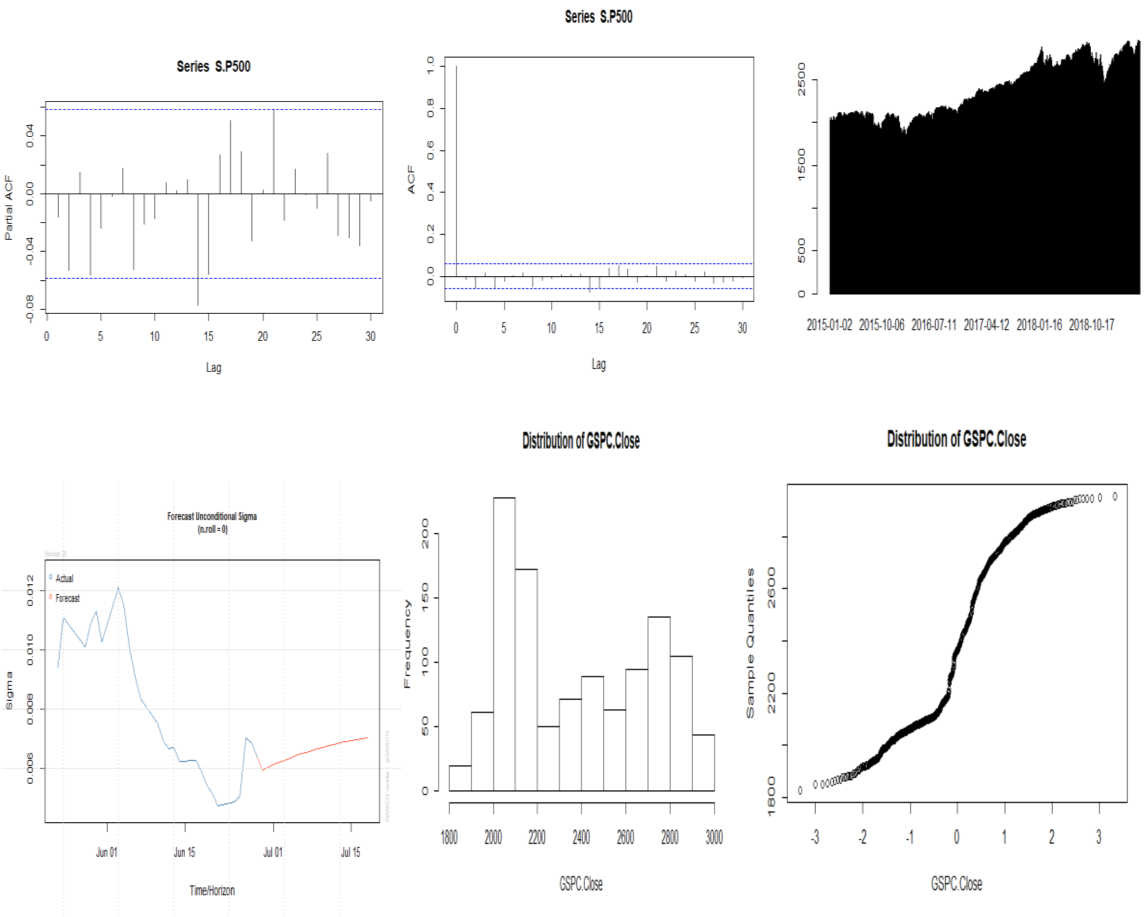
```
    xlab="IXICtest5")
##Volatility Estimators for Dataset three: DOWJONES
NDJI <- DJI
NDJI
##Yang and Zhang volatility estimators
DJItest5 <- volatility(NDJI, n = 30, calc = "yang.zhang", N = 365)
DJItest5
plot(DJItest5,
    main="Yang and Zhang Estimator: DOWJONES",
    xlab="DJItest5")
```

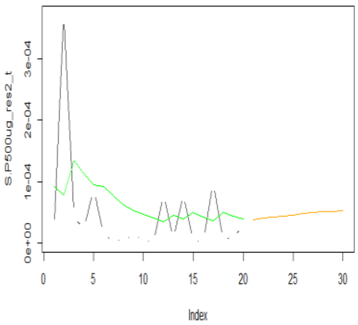
5 R Packages

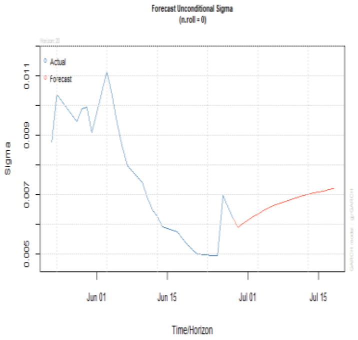
The following are the packages used for to enables data exploration, analysis, interpretation and evaluation: ("zoo"), ("xts"), (curl), (TTR), (quantmod), (lattice), (timeDate), (timeSeries), (parallel), (rugarch), (aTSA), (forecast), (ggplot2), (FinTS), (pdfetch), (rmgarch),(e1071), (MLmetrics), (tseries), (psycho) and (Metrics).

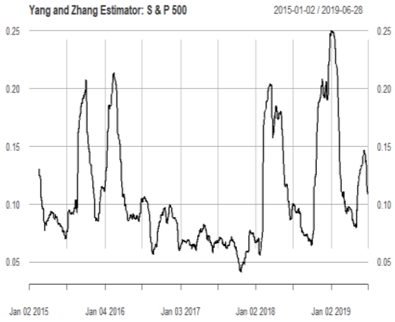
6 Graphical Illustration of Datasets

(a). S & P 500

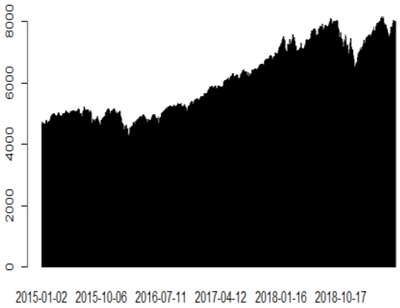


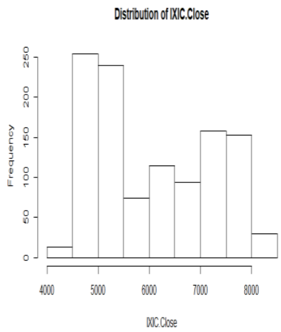


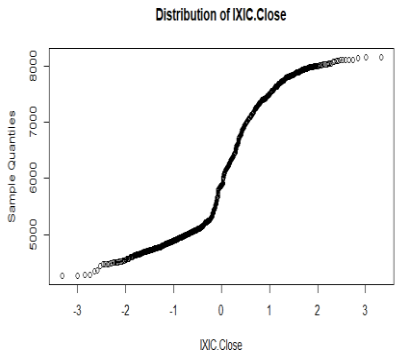


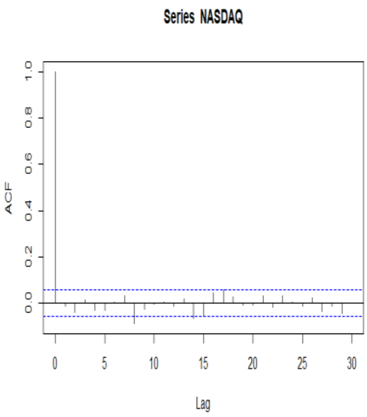


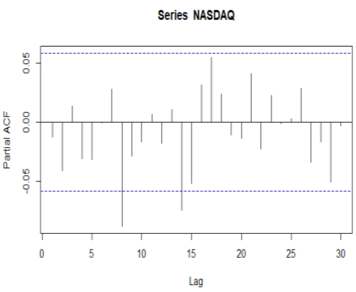
(b). NASDAQ Composites

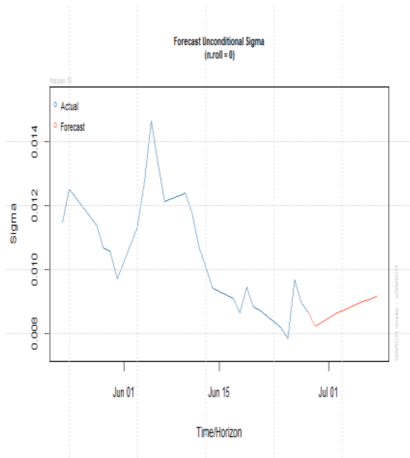


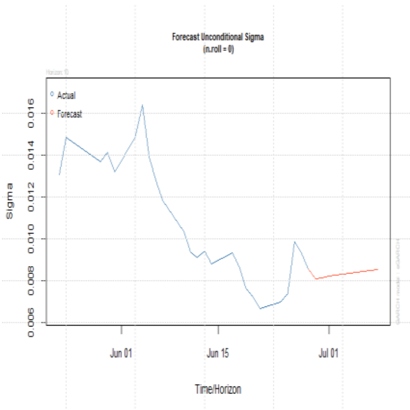


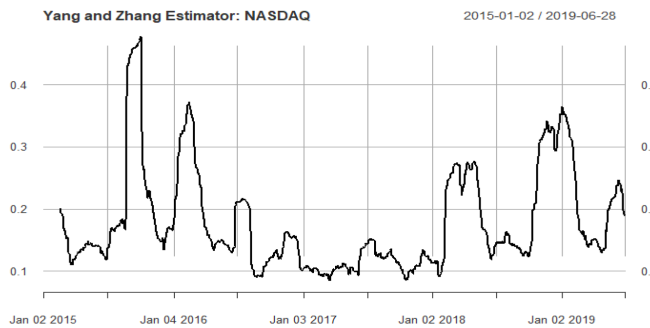












(c). Dow Jones Industrial Average