wqu-econometrics-group-6-A-w7

Contents

Final Report

Group Member (in alphabetical order):

- Dylan Thorne (dylan.thorne@gmail.com)
- Pariyat Limpitheeprakan (macchiato.me@gmail.com)
- Trai Torsricharoen (traitorsricharoen@gmail.com)
- YIU LEUNG CHENG (howard.yl.cheng.hk@gmail.com)

3.3.1 Algorithmic Trading

Fenner (2012) says Design your own algorithmic trading strategy in R.

KBank SCB

pair trading by using Thai Stocks in Banking Sector, KBANK and SCB. You can search more details by using ticker KBANK.BK and SCB.BK in Yahoo Finance.

ANN model incorporate with GARCH model and Google trend input. References: 1. Volatility Forecast Based on the Hybrid Artificial Neural Network and GARCH-type Models (https://www.sciencedirect.com/science/article/pii/S1877050916313382) 2. GARCH based artificial neural networks in forecasting conditional variance of stock returns (https://hrcak.srce.hr/file/197475)

```
library("quantmod")
```

```
## Loading required package: xts

## Loading required package: zoo

##
## Attaching package: 'zoo'

## The following objects are masked from 'package:base':
##
##     as.Date, as.Date.numeric

## Registered S3 method overwritten by 'xts':
##   method     from
##   as.zoo.xts zoo

## Loading required package: TTR
```

```
## Registered S3 method overwritten by 'quantmod':
##   method            from
##   as.zoo.data.frame zoo
```

```
## Version 0.4-0 included new data defaults. See ?getSymbols.
```

```
getSymbols("SPY", scr="yahoo",from = as.Date("2007-01-04"), to = as.Date("2019-10-18"),warnings=FALSE)
```

```
## 'getSymbols' currently uses auto.assign=TRUE by default, but will
## use auto.assign=FALSE in 0.5-0. You will still be able to use
## 'loadSymbols' to automatically load data. getOption("getSymbols.env")
## and getOption("getSymbols.auto.assign") will still be checked for
## alternate defaults.
##
## This message is shown once per session and may be disabled by setting
## options("getSymbols.warning4.0"=FALSE). See ?getSymbols for details.
```

```
## [1] "SPY"
```

```
SPY500<- SPY[,"SPY.Close"]
head(SPY500)
```

```
##            SPY.Close
## 2007-01-04    141.67
## 2007-01-05    140.54
## 2007-01-08    141.19
## 2007-01-09    141.07
## 2007-01-10    141.54
## 2007-01-11    142.16
```

```
#fill NA with previous non-NA value
library(zoo)
library(dplyr)
```

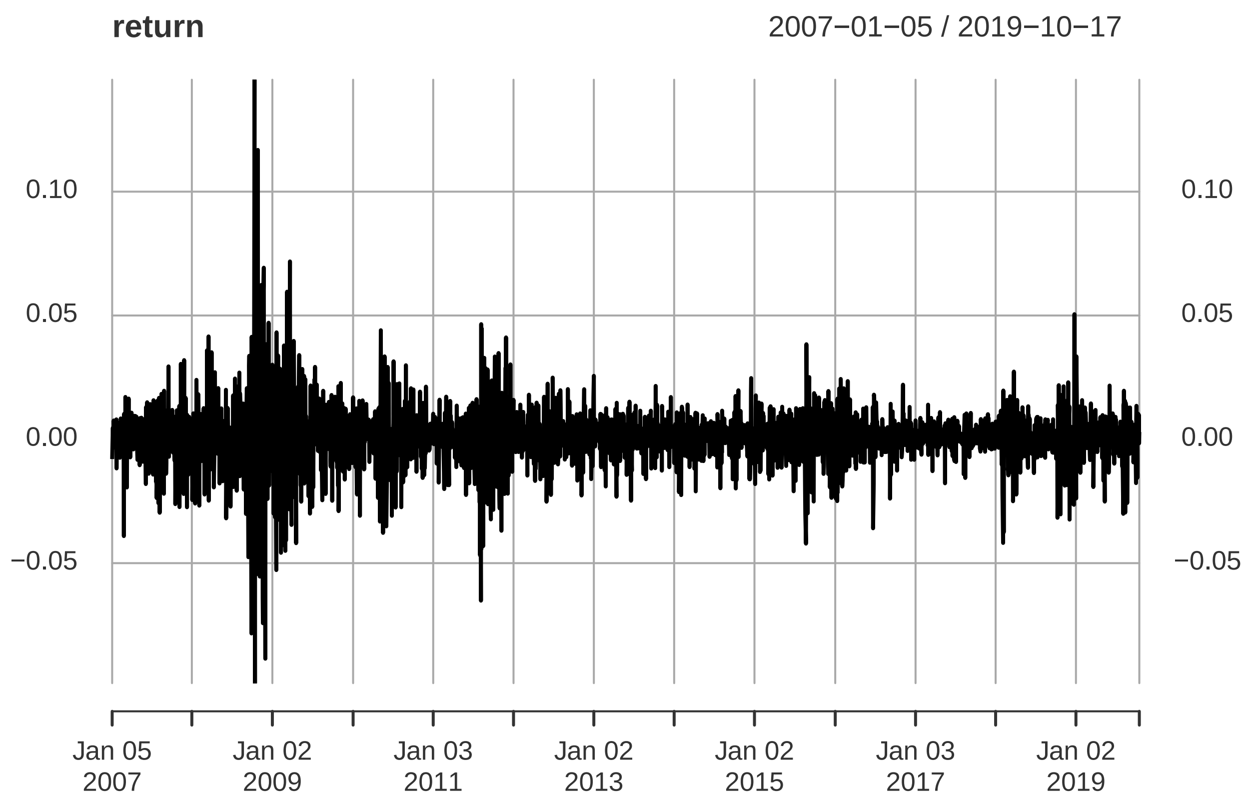
```
##
## Attaching package: 'dplyr'
```

```
## The following objects are masked from 'package:xts':
##
##     first, last
```

```
## The following objects are masked from 'package:stats':
##
##     filter, lag
```

```
## The following objects are masked from 'package:base':
##
##     intersect, setdiff, setequal, union
```

```
SPY500 <- na.locf(SPY500)
return <- Delt(SPY500)
rows = nrow(return)
return <- return[2:rows]
plot(return)
```




```r
#technical analysis indicators
average10<- rollapply(SPY500, 10, mean)
average20<-rollapply(SPY500, 20, mean)
std10<- rollapply(SPY500, 10, sd)
std20<- rollapply(SPY500, 20, sd)
rsi5<- RSI(SPY500,5,"SMA")
rsi14<- RSI(SPY500, 14, "SMA")
macd12269<- MACD(SPY500, 12, 26, 9, "SMA")
macd7205<- MACD(SPY500, 7, 20, 5, "SMA")
bollinger_bands<-BBands(SPY500,20,"SMA",2)
direction<- data.frame(matrix(NA,dim(SPY500)[1],1))
lagreturn<- (SPY500 - Lag(SPY500, 20))/Lag(SPY500, 20)
direction[lagreturn>0.02] <- "Up"
direction[lagreturn< -0.02] <- "Down"
direction[lagreturn< 0.02 &lagreturn> -0.02] <- "NoWhere"
```

```r
#GARCH Model
require(stats)
require(tseries)
```

```
## Loading required package: tseries
```

```r
require(forecast)
```

```
## Loading required package: forecast
```

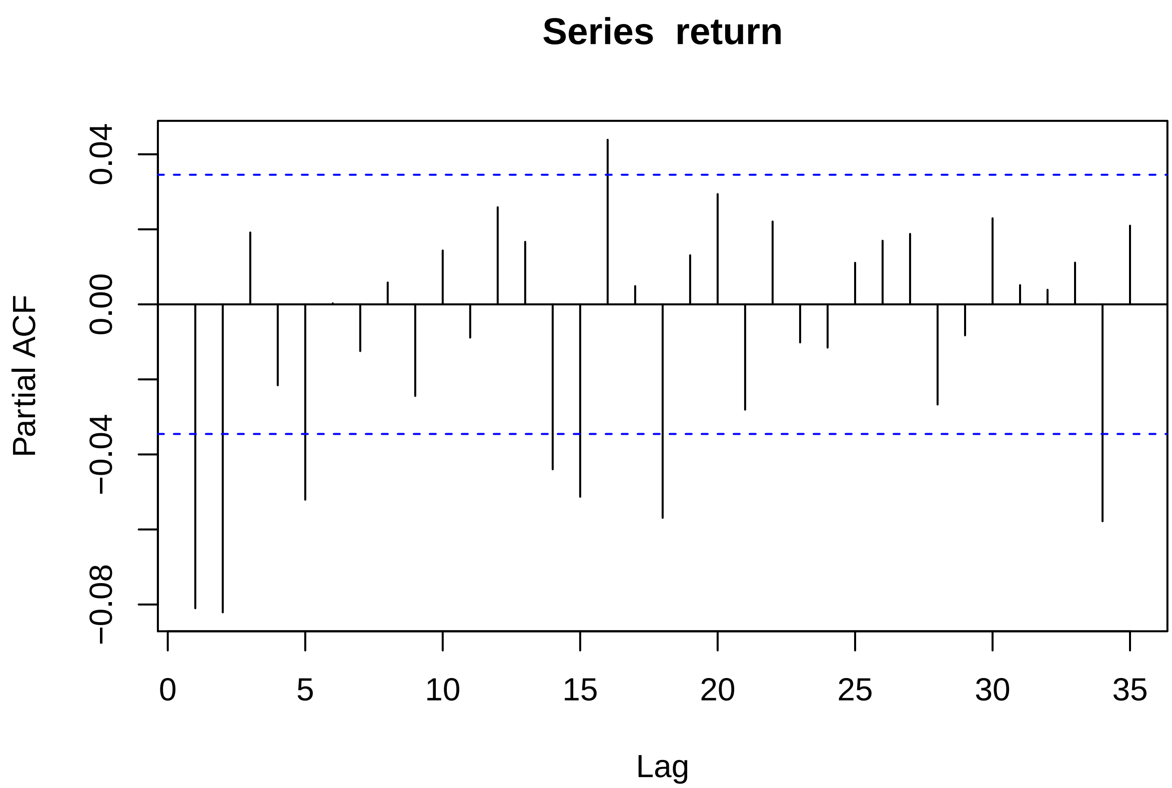
```
## Registered S3 methods overwritten by 'forecast':
##   method             from
##   fitted.fracdiff    fracdiff
##   residuals.fracdiff fracdiff
```

```r
#adf test suggesting stationarity
adf.test(return)
```

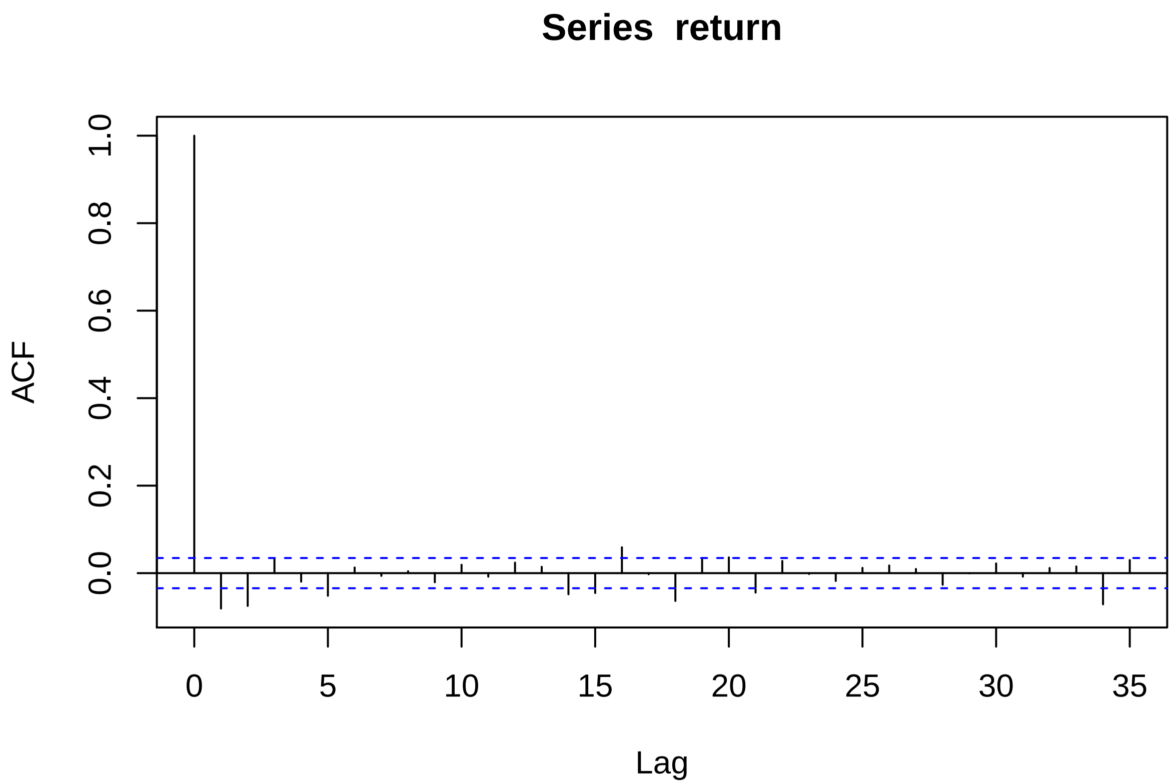
```
## Warning in adf.test(return): p-value smaller than printed p-value

##
##  Augmented Dickey-Fuller Test
##
## data:  return
## Dickey-Fuller = -16.192, Lag order = 14, p-value = 0.01
## alternative hypothesis: stationary
```

```r
#PACF plot suggests significant spike through lag 2.
pacf(return)
```

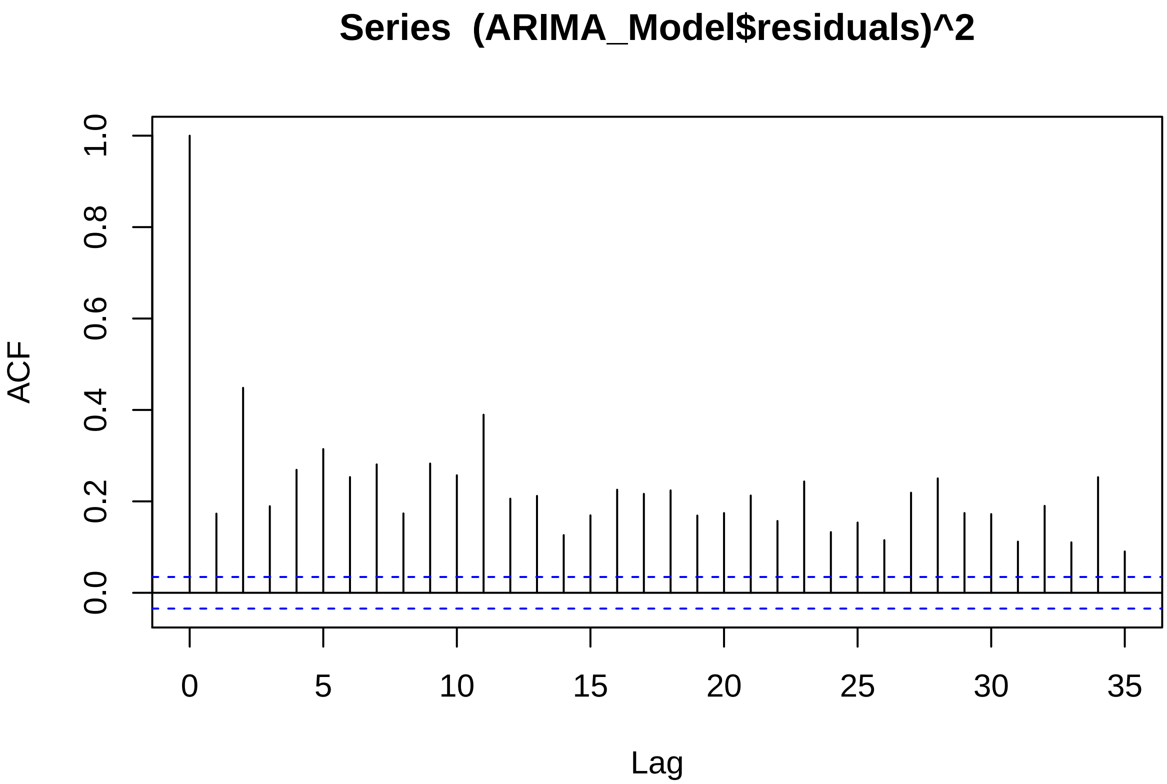



```r
#ACF plot shows exponential decay. Thus, it can be deduced AR(2) model.
acf(return)
```

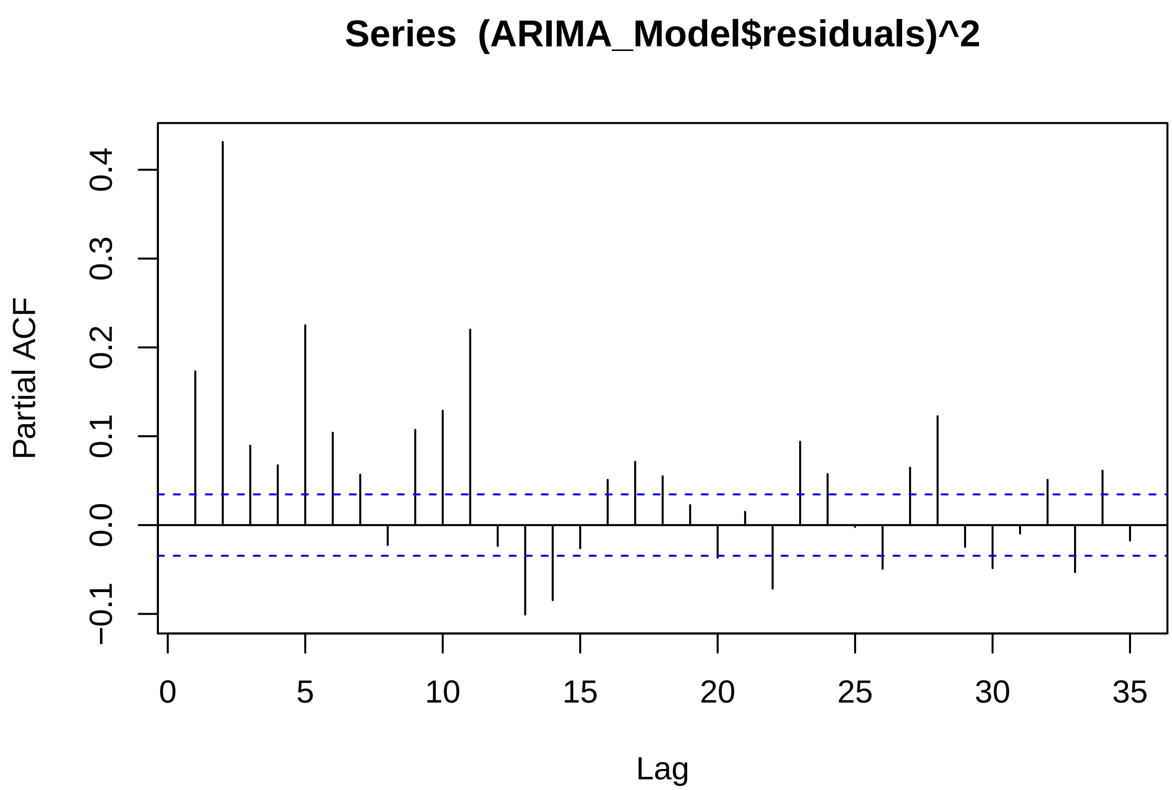



```
lengthOfReturns<-length(return)
timeseries <- ts(return)
```

```
ARIMA_Model <- arima(window(timeseries,1,lengthOfReturns), order=c(2,0,0), method = "ML")
acf((ARIMA_Model$residuals)^2)
```




```
pacf((ARIMA_Model$residuals)^2)
```




```
require(fGarch)
```

```
## Loading required package: fGarch
```

```
## Loading required package: timeDate
## Loading required package: timeSeries
##
## Attaching package: 'timeSeries'
## The following object is masked from 'package:zoo':
##
##     time<-
## Loading required package: fBasics
##
## Attaching package: 'fBasics'
## The following object is masked from 'package:TTR':
##
##     volatility
```

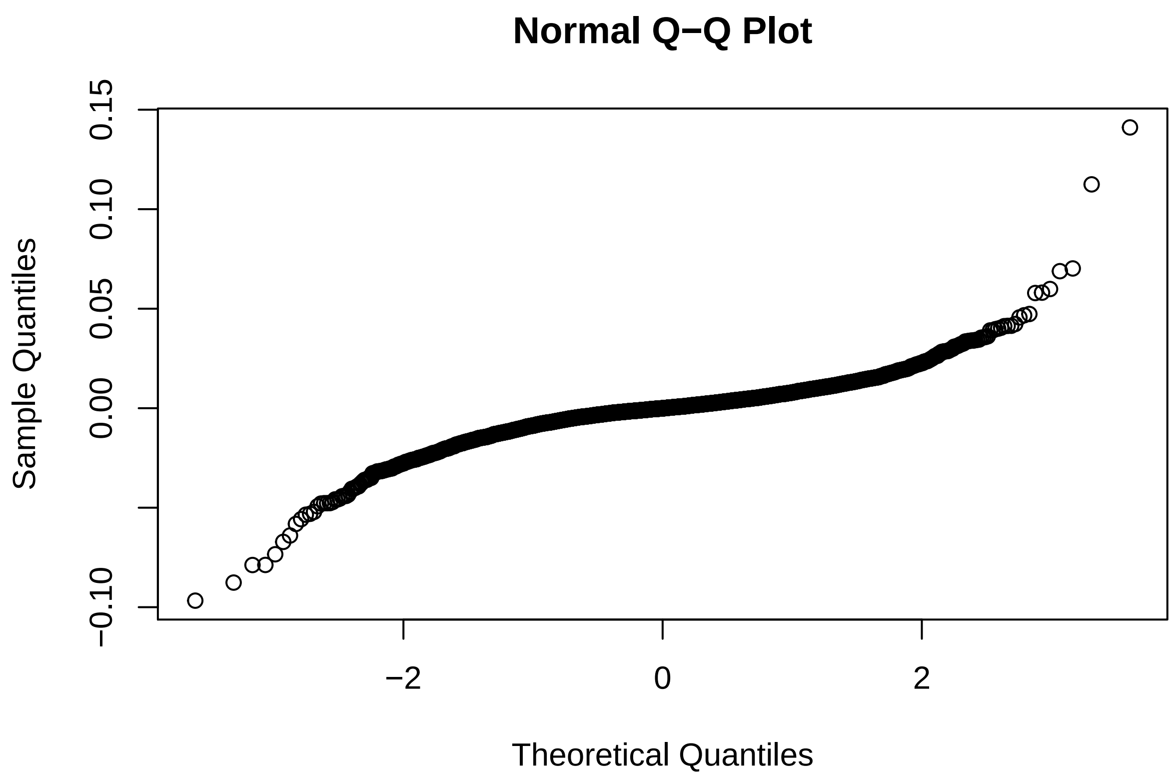
```r
model <- garchFit(formula = ~ arma(2,0) + garch(11,0) , data = timeseries, trace = F)
summary(model)
```

```
##
## Title:
##  GARCH Modelling
##
## Call:
##  garchFit(formula = ~arma(2, 0) + garch(11, 0), data = timeseries,
##     trace = F)
##
## Mean and Variance Equation:
##  data ~ arma(2, 0) + garch(11, 0)
## <environment: 0xbdd4a40>
##  [data = timeseries]
##
## Conditional Distribution:
##  norm
##
## Coefficient(s):
##          mu          ar1          ar2        omega       alpha1
##  8.1551e-04  -6.5797e-02  -2.4323e-02   1.8515e-05   7.6807e-02
##      alpha2       alpha3       alpha4       alpha5       alpha6
##  1.5374e-01   9.8210e-02   1.3536e-01   6.3122e-02   5.9403e-02
##      alpha7       alpha8       alpha9      alpha10      alpha11
##  5.4562e-02   5.9989e-02   5.9964e-02   6.7037e-02   4.2801e-02
##
## Std. Errors:
##  based on Hessian
##
## Error Analysis:
##           Estimate  Std. Error  t value Pr(>|t|)
## mu       8.155e-04   1.360e-04    5.997 2.01e-09 ***
## ar1     -6.580e-02   1.836e-02   -3.583 0.000339 ***
## ar2     -2.432e-02   1.936e-02   -1.256 0.209051
## omega    1.852e-05   1.747e-06   10.595  < 2e-16 ***
## alpha1   7.681e-02   1.794e-02    4.280 1.87e-05 ***
## alpha2   1.537e-01   2.475e-02    6.212 5.22e-10 ***
```

```
## alpha3   9.821e-02   2.234e-02    4.396 1.11e-05 ***
## alpha4   1.354e-01   2.603e-02    5.200 2.00e-07 ***
## alpha5   6.312e-02   1.846e-02    3.419 0.000628 ***
## alpha6   5.940e-02   1.861e-02    3.191 0.001416 **
## alpha7   5.456e-02   1.725e-02    3.162 0.001565 **
## alpha8   5.999e-02   1.885e-02    3.183 0.001460 **
## alpha9   5.996e-02   2.092e-02    2.867 0.004149 **
## alpha10  6.704e-02   1.907e-02    3.516 0.000438 ***
## alpha11  4.280e-02   1.716e-02    2.494 0.012641 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Log Likelihood:
##  10521.29    normalized:  3.268496
##
## Description:
##  Tue Oct 22 10:11:35 2019 by user:
##
##
## Standardised Residuals Tests:
##                                 Statistic p-Value
##  Jarque-Bera Test   R    Chi^2  766.633   0
##  Shapiro-Wilk Test  R    W      0.9749061 0
##  Ljung-Box Test     R    Q(10)  12.21964  0.2706257
##  Ljung-Box Test     R    Q(15)  23.61286  0.07196621
##  Ljung-Box Test     R    Q(20)  27.28147  0.1275291
##  Ljung-Box Test     R^2  Q(10)  3.15208   0.977615
##  Ljung-Box Test     R^2  Q(15)  8.047753  0.9218539
##  Ljung-Box Test     R^2  Q(20)  10.68428  0.9540028
##  LM Arch Test       R    TR^2   5.127157  0.9535963
##
## Information Criterion Statistics:
##       AIC       BIC       SIC      HQIC
## -6.527673 -6.499356 -6.527716 -6.517524
```

```r
res = residuals(model)
```

```r
#qq-plot of residual between GARCH model and actual data
qqnorm(res)
```




```r
library("rugarch")
```

```
## Loading required package: parallel
##
## Attaching package: 'rugarch'
## The following object is masked from 'package:stats':
##
##     sigma
```

```r
garch11_spec <- ugarchspec(variance.model = list(garchOrder = c(11, 0)),mean.model = list(armaOrder = c
garch11_fit<-ugarchfit(spec=garch11_spec, data=timeseries)
```

```
## Warning in .sgarchfit(spec = spec, data = data, out.sample = out.sample, :
## ugarchfit-->warning: solver failer to converge.
```

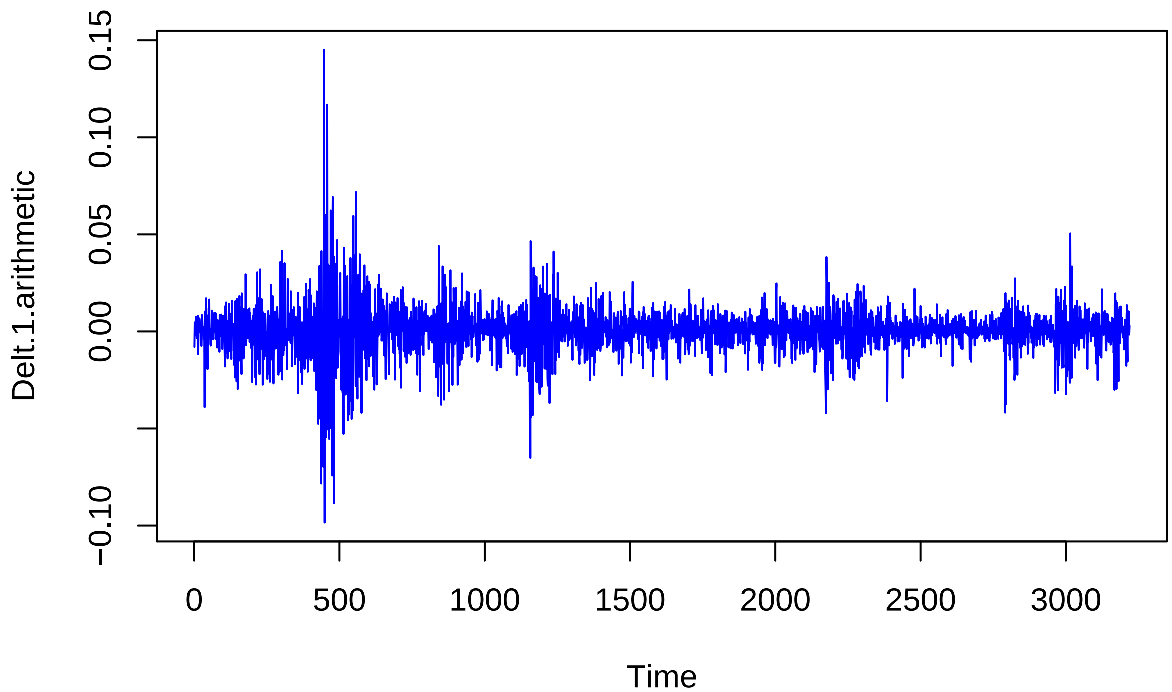
```r
garch11_fit
```

```
##
## *---------------------------------*
## *          GARCH Model Fit        *
## *---------------------------------*
##
## Conditional Variance Dynamics
## -----------------------------------
## GARCH Model  : sGARCH(11,0)
## Mean Model   : ARFIMA(2,0,0)
## Distribution : norm
##
## Convergence Problem:
## Solver Message:
```

```r
garch11_fit@fit$fitted.values
```

```
## NULL
```

```r
#visualize how well GARCH itself fit the data
plot(timeseries, type="l", col="blue")
lines(garch11_fit@fit$fitted.values, col="green")
```




```r
#binding closing price and technical analysis indicators into a variable SPY500
SPY500 <- cbind(SPY500[2:nrow(SPY500)], average10[2:nrow(average10)], average20[2:nrow(average20)], std
```

```r
#integrate GARCH model rolling window prediction output into variable
SPY500 <- cbind(SPY500,garch11_fit@fit$fitted.values)
```

```r
#Import Google trend data regarding trend of recession and expansion
recessiondata<-read.csv("Recession_gtrends.csv",header=F)$V2
expansiondata<-read.csv("Expansion_gtrends.csv",header=F)$V2
#integrate Google trend data into variable
SPY500 <- cbind(SPY500,recessiondata,expansiondata)
```

```r
#indicate end and start dates for train, validating and testing period
train_sdate<- "2007-03-01"
train_edate<- "2017-03-01"
vali_sdate<- "2017-03-02"
vali_edate<- "2018-03-02"
test_sdate<- "2018-03-03"
test_edate<- "2019-10-18"
```

```r
#constructing data ranges for the three datasets
trainrow<- which(index(SPY500) >= train_sdate& index(SPY500) <= train_edate)
valirow<- which(index(SPY500) >= vali_sdate& index(SPY500) <= vali_edate)
testrow<- which(index(SPY500) >= test_sdate& index(SPY500) <= test_edate)
```

```r
#extract data fpr training, validating and testing periods
train<- SPY500[trainrow,]
vali<- SPY500[valirow,]
test<- SPY500[testrow,]
trainme<-apply(train,2,mean)
trainstd<-apply(train,2,sd)

#training, validating and testing data dimensions
trainidn<- (matrix(1,dim(train)[1],dim(train)[2]))
valiidn<- (matrix(1,dim(vali)[1],dim(vali)[2]))
testidn<- (matrix(1,dim(test)[1],dim(test)[2]))

#normalize the three datasets
norm_train<- (train-t(trainme*t(trainidn)))/t(trainstd*t(trainidn))
norm_vali<- (vali-t(trainme*t(valiidn)))/t(trainstd*t(valiidn))
norm_test<- (test-t(trainme*t(testidn)))/t(trainstd*t(testidn))

#define training, validating and testing period
traindir<- direction[trainrow,1]
validir<- direction[valirow,1]
testdir<- direction[testrow,1]

#implement ANN
library(nnet)
set.seed(1)
neural_network<- nnet(norm_train, class.ind(traindir), size=4, trace=T)
```

```
## # weights:  87
## initial  value 2046.443499
## iter  10 value 856.398611
## iter  20 value 666.873545
## iter  30 value 630.913796
## iter  40 value 599.414176
## iter  50 value 562.914859
## iter  60 value 545.981441
## iter  70 value 538.057476
## iter  80 value 534.228500
## iter  90 value 529.830311
## iter 100 value 527.163171
## final  value 527.163171
## stopped after 100 iterations
```

```r
#obtain data dimension
dim(norm_train)
```

```
## [1] 2519   17
```

```r
#make prediction
vali_pred<-predict(neural_network, norm_vali)
head(vali_pred)
```

```
##                  Down     NoWhere        Up
## 2017-03-02 0.01051211 0.001628957 0.9978049
## 2017-03-03 0.01007747 0.001287799 0.9982364
## 2017-03-06 0.01317520 0.005836338 0.9928284
```

```
## 2017-03-07 0.01391204 0.007970571 0.9904222
## 2017-03-08 0.02628690 0.143936354 0.8426444
## 2017-03-09 0.02283733 0.081539201 0.9038932
```

```r
#calculate the predicted direction using the information obtained above
vali_pred_class<- data.frame(matrix(NA,dim(vali_pred)[1],1))
vali_pred_class[vali_pred[,"Down"] > 0.5,1]<- "Down"
vali_pred_class[vali_pred[,"NoWhere"] > 0.5,1]<- "NoWhere"
vali_pred_class[vali_pred[,"Up"] > 0.5,1]<- "Up"
vali_pred_class[is.na(vali_pred_class)]<- "NoWhere"

#check forecast accuracy
library(caret)
```

```
## Loading required package: lattice
## Loading required package: ggplot2
```

```r
u<- union(vali_pred_class[,1],validir)
t<-table(factor(vali_pred_class[,1],u),factor(validir,u))
confusionMatrix(t)
```

```
## Confusion Matrix and Statistics
##
##
##            Up NoWhere Down
##   Up       67      25    0
##   NoWhere  21     120    6
##   Down      0       1   13
##
## Overall Statistics
##
##                Accuracy : 0.7905
##                  95% CI : (0.7351, 0.839)
##     No Information Rate : 0.5771
##     P-Value [Acc > NIR] : 6.531e-13
##
##                   Kappa : 0.6078
##
##  Mcnemar's Test P-Value : NA
##
## Statistics by Class:
##
##                      Class: Up Class: NoWhere Class: Down
## Sensitivity             0.7614         0.8219     0.68421
## Specificity             0.8485         0.7477     0.99573
## Pos Pred Value          0.7283         0.8163     0.92857
## Neg Pred Value          0.8696         0.7547     0.97490
## Prevalence              0.3478         0.5771     0.07510
## Detection Rate          0.2648         0.4743     0.05138
## Detection Prevalence    0.3636         0.5810     0.05534
## Balanced Accuracy       0.8049         0.7848     0.83997
```

```r
#check accuracy on testing data
test_pred<- predict(neural_network, norm_test)
test_pred
```

```
##                  Down     NoWhere           Up
## 2018-03-05 0.183357235 6.564762e-01 0.0052489332
## 2018-03-06 0.050737861 9.135963e-01 0.0084945613
## 2018-03-07 0.034055294 9.370218e-01 0.0116446949
## 2018-03-08 0.017907481 8.331590e-01 0.1635788293
## 2018-03-09 0.010497377 9.714202e-04 0.9984643629
## 2018-03-12 0.004814221 1.913241e-05 0.9999643674
## 2018-03-13 0.007094653 1.096155e-04 0.9998056459
## 2018-03-14 0.013208037 4.370332e-03 0.9941480205
## 2018-03-15 0.018583365 2.997261e-02 0.9643509099
## 2018-03-16 0.043126981 3.707012e-01 0.5323167980
## 2018-03-19 0.030471852 8.664017e-01 0.0794152874
## 2018-03-20 0.027339338 9.448381e-01 0.0129365274
## 2018-03-21 0.775905848 3.592525e-03 0.0299051214
## 2018-03-22 0.976331756 4.492896e-04 0.0058513045
## 2018-03-23 0.992088965 1.669573e-04 0.0029006852
## 2018-03-26 0.930592766 1.216710e-03 0.0118878810
## 2018-03-27 0.991016491 1.870533e-04 0.0031465735
## 2018-03-28 0.994934275 1.115180e-04 0.0021906646
## 2018-03-29 0.987873139 2.447817e-04 0.0038133562
## 2018-04-02 0.995916750 9.187234e-05 0.0019114504
## 2018-04-03 0.995016983 1.099094e-04 0.0021675548
## 2018-04-04 0.919166154 1.435839e-03 0.0130055084
## 2018-04-05 0.624168024 7.949893e-03 0.0425586707
## 2018-04-06 0.979235022 4.021632e-04 0.0053466953
## 2018-04-09 0.992237551 2.140369e-04 0.0022326584
## 2018-04-10 0.846517896 1.783749e-01 0.0003380597
## 2018-04-11 0.750428031 2.793809e-01 0.0004789883
## 2018-04-12 0.828969383 2.006875e-01 0.0003562084
## 2018-04-13 0.709004675 3.158755e-01 0.0005517534
## 2018-04-16 0.632278710 3.772265e-01 0.0007071621
## 2018-04-17 0.270187078 6.756941e-01 0.0020534452
## 2018-04-18 0.022502534 9.171161e-01 0.0360721015
## 2018-04-19 0.064775126 5.552919e-01 0.2317686014
## 2018-04-20 0.037559906 8.793059e-01 0.0441559492
## 2018-04-23 0.038678063 9.074189e-01 0.0206972980
## 2018-04-24 0.116735450 6.604302e-01 0.0441357167
## 2018-04-25 0.100502192 5.758906e-01 0.1228459513
## 2018-04-26 0.028337540 8.481131e-01 0.0803418326
## 2018-04-27 0.035265637 6.196896e-01 0.2858593934
## 2018-04-30 0.036303010 7.197210e-01 0.1856448372
## 2018-05-01 0.008584614 8.621195e-01 0.1864802194
## 2018-05-02 0.009462422 9.211766e-01 0.1189477079
## 2018-05-03 0.009435433 9.733644e-01 0.0298672304
## 2018-05-04 0.005368766 8.862977e-01 0.1510582881
## 2018-05-07 0.003560896 6.014242e-01 0.4885796402
## 2018-05-08 0.006535963 8.440220e-01 0.1465852464
## 2018-05-09 0.003949110 4.077621e-01 0.5813350354
## 2018-05-10 0.002157956 3.605941e-02 0.9680018218
## 2018-05-11 0.006533204 5.459693e-04 0.9991677636
## 2018-05-14 0.006458653 6.740972e-03 0.9906979971
## 2018-05-15 0.026256644 8.204917e-02 0.7574333526
## 2018-05-16 0.023091888 1.169555e-01 0.8478507323
## 2018-05-17 0.036382909 3.525368e-01 0.5255604257
```

```
## 2018-05-18 0.035543242 6.654083e-01 0.2077066380
## 2018-05-21 0.028741874 1.959807e-01 0.7448400535
## 2018-05-22 0.014664298 5.487638e-01 0.4657046299
## 2018-05-23 0.015077632 3.280769e-01 0.6770242393
## 2018-05-24 0.022276041 9.205770e-02 0.9001257233
## 2018-05-25 0.020936823 7.195009e-02 0.9240678218
## 2018-05-29 0.037657823 5.575861e-01 0.4215320050
## 2018-05-30 0.018559052 3.595300e-02 0.9577900399
## 2018-05-31 0.021792064 2.426545e-01 0.7388608444
## 2018-06-01 0.010344592 6.096450e-03 0.9911535563
## 2018-06-04 0.008890774 1.411440e-03 0.9976000570
## 2018-06-05 0.004761002 6.271996e-04 0.9990783524
## 2018-06-06 0.005693197 3.460117e-05 0.9999250862
## 2018-06-07 0.004538612 1.300833e-05 0.9999731439
## 2018-06-08 0.004831588 2.051284e-05 0.9999589773
## 2018-06-11 0.005459971 3.553826e-05 0.9999316425
## 2018-06-12 0.007206131 3.083546e-04 0.9994876834
## 2018-06-13 0.016140788 2.661029e-02 0.9619073179
## 2018-06-14 0.014404247 1.559194e-02 0.9785572918
## 2018-06-15 0.021887694 5.184141e-01 0.4020897946
## 2018-06-18 0.012029704 9.013304e-01 0.0850123997
## 2018-06-19 0.024489497 8.211835e-01 0.1169795489
## 2018-06-20 0.010979678 9.348960e-01 0.0550502268
## 2018-06-21 0.021207748 9.147597e-01 0.0458610212
## 2018-06-22 0.014728794 9.204256e-01 0.0573956342
## 2018-06-25 0.019517162 9.623856e-01 0.0148453866
## 2018-06-26 0.015446308 9.613144e-01 0.0197750002
## 2018-06-27 0.034560553 9.460110e-01 0.0086806869
## 2018-06-28 0.023205709 9.536517e-01 0.0129106560
## 2018-06-29 0.028299723 9.467955e-01 0.0110783634
## 2018-07-02 0.016215298 9.562150e-01 0.0194853046
## 2018-07-03 0.041097790 9.318077e-01 0.0082195395
## 2018-07-05 0.012124806 9.548630e-01 0.0286230465
## 2018-07-06 0.011714134 9.250085e-01 0.0430651081
## 2018-07-09 0.008176398 8.173048e-01 0.1267887256
## 2018-07-10 0.009229918 8.090151e-01 0.1146105314
## 2018-07-11 0.018409578 9.151760e-01 0.0270221849
## 2018-07-12 0.016003123 8.485445e-01 0.0504479512
## 2018-07-13 0.012523384 8.571514e-01 0.0722592211
## 2018-07-16 0.015706342 9.061710e-01 0.0400604380
## 2018-07-17 0.016376618 7.431758e-01 0.1654809310
## 2018-07-18 0.006831903 7.340731e-01 0.2979327920
## 2018-07-19 0.020593766 7.708527e-01 0.1731052867
## 2018-07-20 0.034171632 4.683568e-01 0.4593986068
## 2018-07-23 0.026957458 1.818845e-01 0.7986424002
## 2018-07-24 0.017966946 2.844188e-02 0.9657304594
## 2018-07-25 0.008986871 5.523439e-04 0.9991533306
## 2018-07-26 0.008227293 3.612380e-04 0.9994388190
## 2018-07-27 0.012264448 3.471376e-03 0.9954570614
## 2018-07-30 0.017567442 2.355524e-02 0.9724587510
## 2018-07-31 0.012899866 4.584807e-03 0.9937719138
## 2018-08-01 0.015821980 9.369466e-03 0.9865471298
## 2018-08-02 0.008746699 5.933573e-04 0.9989538211
## 2018-08-03 0.003975614 4.003202e-04 0.9993524002
```

```
## 2018-08-06 0.003321925 7.811552e-05 0.9998634623
## 2018-08-07 0.004606051 3.457970e-05 0.9999301682
## 2018-08-08 0.003694481 2.865752e-05 0.9999471012
## 2018-08-09 0.003558780 2.970458e-04 0.9995739387
## 2018-08-10 0.005776729 2.768170e-01 0.7297735728
## 2018-08-13 0.010751583 8.470885e-01 0.0948349972
## 2018-08-14 0.009195737 5.096771e-01 0.3455900250
## 2018-08-15 0.013897182 8.852851e-01 0.0547241495
## 2018-08-16 0.013018705 7.010710e-01 0.1154667849
## 2018-08-17 0.007847905 4.892813e-01 0.3169067591
## 2018-08-20 0.004379346 2.409943e-01 0.6917562870
## 2018-08-21 0.003899405 1.937025e-01 0.7728614622
## 2018-08-22 0.002235625 2.110042e-02 0.9816177266
## 2018-08-23 0.003314674 8.704825e-02 0.9232830360
## 2018-08-24 0.003100942 1.068468e-02 0.9882140493
## 2018-08-27 0.002922966 1.102941e-03 0.9983517389
## 2018-08-28 0.003514691 1.445096e-03 0.9978989654
## 2018-08-29 0.004740466 1.700780e-04 0.9996858726
## 2018-08-30 0.005749448 7.419063e-03 0.9904432683
## 2018-08-31 0.007900349 8.296688e-03 0.9892906187
## 2018-09-04 0.020592708 4.339959e-02 0.9401674699
## 2018-09-05 0.013984228 5.654665e-01 0.4145184541
## 2018-09-06 0.034399711 7.409361e-01 0.1163795109
## 2018-09-07 0.031107108 8.647384e-01 0.0417240634
## 2018-09-10 0.020733543 8.980976e-01 0.0359794455
## 2018-09-11 0.009255412 7.760881e-01 0.1826024807
## 2018-09-12 0.006225780 7.023969e-01 0.3101854756
## 2018-09-13 0.001967463 4.242486e-02 0.9654956572
## 2018-09-14 0.001631546 5.563708e-03 0.9952571069
## 2018-09-17 0.006077178 4.068165e-02 0.9590607052
## 2018-09-18 0.003666692 1.420725e-02 0.9850151854
## 2018-09-19 0.004572205 7.364660e-03 0.9909823112
## 2018-09-20 0.002533646 8.593660e-03 0.9889258353
## 2018-09-21 0.004874428 2.169238e-01 0.7335978465
## 2018-09-24 0.005234094 5.217114e-01 0.4332988079
## 2018-09-25 0.009007497 7.653685e-01 0.1442863554
## 2018-09-26 0.012425005 8.797163e-01 0.0583533114
## 2018-09-27 0.033852503 8.272855e-01 0.0222834674
## 2018-09-28 0.023835369 8.338608e-01 0.0336390617
## 2018-10-01 0.014964835 7.579895e-01 0.0813245298
## 2018-10-02 0.016465177 7.891078e-01 0.0640727356
## 2018-10-03 0.004968424 5.583174e-01 0.4224096512
## 2018-10-04 0.012828711 9.202535e-01 0.0432765763
## 2018-10-05 0.014174210 9.493565e-01 0.0259837050
## 2018-10-08 0.031197799 9.216699e-01 0.0131809126
## 2018-10-09 0.043120227 9.091529e-01 0.0096470778
## 2018-10-10 0.863534055 2.522959e-03 0.0180156712
## 2018-10-11 0.994466856 1.208928e-04 0.0023143116
## 2018-10-12 0.995494959 1.003341e-04 0.0020343463
## 2018-10-15 0.996933323 7.096492e-05 0.0015963906
## 2018-10-16 0.993133112 1.463866e-04 0.0026591067
## 2018-10-17 0.982889870 3.349406e-04 0.0047451510
## 2018-10-18 0.992770234 1.538300e-04 0.0027411307
## 2018-10-19 0.992471540 1.596072e-04 0.0028116156
```

```
## 2018-10-22 0.976452844 4.512586e-04 0.0057950938
## 2018-10-23 0.992790748 1.535822e-04 0.0027343787
## 2018-10-24 0.997991655 4.848127e-05 0.0012230921
## 2018-10-25 0.998232836 4.320432e-05 0.0011286380
## 2018-10-26 0.998362284 4.034534e-05 0.0010759399
## 2018-10-29 0.998366940 4.024206e-05 0.0010740172
## 2018-10-30 0.998295900 4.181405e-05 0.0011031525
## 2018-10-31 0.997774083 5.317697e-05 0.0013049495
## 2018-11-01 0.997390990 6.131832e-05 0.0014425652
## 2018-11-02 0.995704127 9.610083e-05 0.0019746333
## 2018-11-05 0.919661478 2.541089e-02 0.0008484489
## 2018-11-06 0.595103523 4.176804e-01 0.0007658052
## 2018-11-07 0.773059338 3.287980e-03 0.0324778452
## 2018-11-08 0.499061638 9.504174e-03 0.0695381279
## 2018-11-09 0.341483769 1.921787e-02 0.0965328182
## 2018-11-12 0.854786806 2.569114e-03 0.0196904161
## 2018-11-13 0.819258775 3.235664e-03 0.0232477725
## 2018-11-14 0.855682420 1.967808e-03 0.0351131526
## 2018-11-15 0.612555407 4.406762e-03 0.1541595301
## 2018-11-16 0.675614100 5.319407e-03 0.0521225645
## 2018-11-19 0.925517106 1.301240e-03 0.0126027518
## 2018-11-20 0.987089146 2.598808e-04 0.0039619651
## 2018-11-21 0.843019248 2.789343e-03 0.0208243127
## 2018-11-23 0.749721437 4.727895e-03 0.0296406876
## 2018-11-26 0.340751291 2.091585e-02 0.0885112917
## 2018-11-27 0.372185292 1.764415e-02 0.0844892761
## 2018-11-28 0.106089314 1.357094e-02 0.4577584369
## 2018-11-29 0.100594614 2.599744e-02 0.3657683444
## 2018-11-30 0.066469930 8.431086e-03 0.7205901493
## 2018-12-03 0.186586976 6.600891e-06 0.9991875441
## 2018-12-04 0.154231929 2.918247e-02 0.3777726472
## 2018-12-06 0.279857642 2.750807e-02 0.1033597508
## 2018-12-07 0.934717627 1.169850e-03 0.0112582665
## 2018-12-10 0.992057291 1.672443e-04 0.0029119654
## 2018-12-11 0.996896491 7.162803e-05 0.0016100919
## 2018-12-12 0.996544484 7.877652e-05 0.0017247730
## 2018-12-13 0.996628602 7.700165e-05 0.0016989073
## 2018-12-14 0.995945373 9.123522e-05 0.0019038267
## 2018-12-17 0.997118925 6.709891e-05 0.0015346512
## 2018-12-18 0.991222906 1.835650e-04 0.0030958199
## 2018-12-19 0.996012906 8.995367e-05 0.0018824708
## 2018-12-20 0.998128581 4.549417e-05 0.0011700062
## 2018-12-21 0.998376670 4.002612e-05 0.0010699924
## 2018-12-24 0.998401001 3.948559e-05 0.0010598889
## 2018-12-26 0.998381937 3.990918e-05 0.0010678102
## 2018-12-27 0.998293437 4.186928e-05 0.0011041385
## 2018-12-28 0.998147742 4.507476e-05 0.0011624596
## 2018-12-31 0.997806028 5.249973e-05 0.0012929619
## 2019-01-02 0.997825611 5.207689e-05 0.0012857057
## 2019-01-03 0.998334680 4.095709e-05 0.0010872977
## 2019-01-04 0.997444421 6.022969e-05 0.0014231889
## 2019-01-07 0.997697927 5.480746e-05 0.0013329336
## 2019-01-08 0.997751659 5.363315e-05 0.0013136462
## 2019-01-09 0.997506522 5.886081e-05 0.0014021601
```

```
## 2019-01-10 0.976758805 4.436265e-04 0.0057671191
## 2019-01-11 0.329885787 1.570360e-02 0.1891895634
## 2019-01-14 0.597166501 1.553768e-03 0.7096599880
## 2019-01-15 0.482114967 1.890657e-03 0.8069473995
## 2019-01-16 0.418095030 1.754446e-03 0.8597237089
## 2019-01-17 0.381867679 1.164725e-03 0.9082138156
## 2019-01-18 0.244470961 4.087473e-05 0.9957835206
## 2019-01-22 0.282196878 1.362640e-04 0.9875304920
## 2019-01-23 0.175084342 3.961221e-06 0.9995184653
## 2019-01-24 0.093996811 0.000000e+00 0.9999893021
## 2019-01-25 0.051599145 0.000000e+00 0.9999996535
## 2019-01-28 0.077030378 0.000000e+00 0.9999966295
## 2019-01-29 0.004352858 7.526289e-06 0.9999840772
## 2019-01-30 0.002598562 4.874818e-07 0.9999987774
## 2019-01-31 0.031583922 0.000000e+00 1.0000000000
## 2019-02-01 0.026226689 0.000000e+00 1.0000000000
## 2019-02-04 0.037428786 0.000000e+00 1.0000000000
## 2019-02-05 0.037426864 0.000000e+00 1.0000000000
## 2019-02-06 0.039381967 0.000000e+00 1.0000000000
## 2019-02-07 0.058325254 0.000000e+00 0.9999993190
## 2019-02-08 0.059226809 0.000000e+00 0.9999992606
## 2019-02-11 0.116394619 0.000000e+00 0.9999661663
## 2019-02-12 0.004044669 6.755082e-06 0.9999862585
## 2019-02-13 0.003832935 5.097601e-06 0.9999894697
## 2019-02-14 0.003435670 2.910731e-06 0.9999938187
## 2019-02-15 0.002860823 1.014366e-06 0.9999976645
## 2019-02-19 0.036909020 0.000000e+00 0.9999996458
## 2019-02-20 0.047885332 0.000000e+00 1.0000000000
## 2019-02-21 0.061083047 0.000000e+00 0.9999991263
## 2019-02-22 0.050000330 0.000000e+00 0.9999995400
## 2019-02-25 0.009075703 1.046452e-06 0.9999923347
## 2019-02-26 0.004845835 2.013956e-05 0.9999627506
## 2019-02-27 0.005140837 2.742544e-05 0.9999501105
## 2019-02-28 0.006253599 8.429172e-05 0.9998585305
## 2019-03-01 0.005661658 4.613493e-05 0.9999185656
## 2019-03-04 0.010353536 1.339208e-03 0.9981244113
## 2019-03-05 0.011403032 2.388200e-03 0.9968212886
## 2019-03-06 0.021411568 6.524234e-02 0.9284361547
## 2019-03-07 0.033718075 4.910513e-01 0.4756523660
## 2019-03-08 0.046088365 5.703468e-01 0.2923831059
## 2019-03-11 0.013577070 5.510178e-02 0.9279729396
## 2019-03-12 0.008097841 2.779384e-02 0.9616176732
## 2019-03-13 0.005213548 4.180118e-03 0.9938605417
## 2019-03-14 0.006710727 9.896129e-04 0.9984471510
## 2019-03-15 0.006367349 3.365949e-04 0.9994467135
## 2019-03-18 0.006774400 1.683028e-04 0.9997026864
## 2019-03-19 0.007391581 3.840157e-04 0.9993726285
## 2019-03-20 0.014155273 1.327975e-01 0.8290246564
## 2019-03-21 0.009602750 2.276552e-03 0.9959563921
## 2019-03-22 0.016899233 9.267569e-01 0.0409565710
## 2019-03-25 0.021610341 9.315053e-01 0.0247751128
## 2019-03-26 0.018085688 8.285398e-01 0.1020731073
## 2019-03-27 0.014608647 9.419449e-01 0.0329485062
## 2019-03-28 0.020050604 9.203134e-01 0.0285745365
```

```
## 2019-03-29 0.010559345 5.410597e-01 0.4281075251
## 2019-04-01 0.011227072 1.157982e-02 0.9809040049
## 2019-04-02 0.014145157 4.061738e-03 0.9934990214
## 2019-04-03 0.009261755 5.785366e-04 0.9990747359
## 2019-04-04 0.006301860 7.246289e-05 0.9998695042
## 2019-04-05 0.004897824 1.654826e-05 0.9999669671
## 2019-04-08 0.005850702 4.472735e-05 0.9999165268
## 2019-04-09 0.013231085 3.819291e-03 0.9946373153
## 2019-04-10 0.010950625 1.480655e-03 0.9978436582
## 2019-04-11 0.019579775 4.218074e-02 0.9465269746
## 2019-04-12 0.014484344 6.847705e-03 0.9904369832
## 2019-04-15 0.015862799 1.131752e-02 0.9852253729
## 2019-04-16 0.011031546 3.422552e-03 0.9955379659
## 2019-04-17 0.017435638 5.270976e-02 0.9413770491
## 2019-04-18 0.015366683 1.842370e-02 0.9783102583
## 2019-04-22 0.017124284 2.094474e-02 0.9743513028
## 2019-04-23 0.005991129 6.357729e-05 0.9998872564
## 2019-04-24 0.009053463 6.272530e-04 0.9990361045
## 2019-04-25 0.007925166 3.628223e-04 0.9994221166
## 2019-04-26 0.005848601 4.840584e-05 0.9999092306
## 2019-04-29 0.004985682 1.887074e-05 0.9999625904
## 2019-04-30 0.007148448 1.943644e-04 0.9996645605
## 2019-05-01 0.013868744 7.882191e-03 0.9887241239
## 2019-05-02 0.011880698 1.058291e-01 0.8767494722
## 2019-05-03 0.007891404 5.117748e-03 0.9916866571
## 2019-05-06 0.010020241 1.496140e-01 0.8076135016
## 2019-05-07 0.011238639 9.405136e-01 0.0513532536
## 2019-05-08 0.012885339 9.512150e-01 0.0292774073
## 2019-05-09 0.028925418 9.347612e-01 0.0125740777
## 2019-05-10 0.054635136 8.806945e-01 0.0087125634
## 2019-05-13 0.719072801 5.279376e-03 0.0332947428
## 2019-05-14 0.733512051 4.691828e-03 0.0330287258
## 2019-05-15 0.819354599 2.901188e-03 0.0249202928
## 2019-05-16 0.658719420 5.379150e-03 0.0458230886
## 2019-05-17 0.070265077 8.995134e-01 0.0054459488
## 2019-05-20 0.023261804 9.630493e-01 0.0109135667
## 2019-05-21 0.053068093 9.183105e-01 0.0067349941
## 2019-05-22 0.092988419 8.783230e-01 0.0043068631
## 2019-05-23 0.332502283 6.580105e-01 0.0014932634
## 2019-05-24 0.281370821 7.019856e-01 0.0017538569
## 2019-05-28 0.854330972 1.755491e-01 0.0003144394
## 2019-05-29 0.979276411 1.069423e-02 0.0002407269
## 2019-05-30 0.996209407 1.033305e-04 0.0015320781
## 2019-05-31 0.996994464 6.964641e-05 0.0015769529
## 2019-06-03 0.997805439 5.247642e-05 0.0012938036
## 2019-06-04 0.995596321 9.763102e-05 0.0020112851
## 2019-06-05 0.746281003 2.699470e-01 0.0005089167
## 2019-06-06 0.178523931 7.612709e-01 0.0029727043
## 2019-06-07 0.028651645 8.971795e-01 0.0178904962
## 2019-06-10 0.197227752 7.267299e-03 0.3451945745
## 2019-06-11 0.102441240 5.217077e-03 0.7046371319
## 2019-06-12 0.207378830 1.468045e-03 0.8793730695
## 2019-06-13 0.224706815 5.621271e-04 0.9447130151
## 2019-06-14 0.394213626 6.142312e-04 0.9179189917
```

```
## 2019-06-17 0.050307304 5.062319e-01 0.2591780295
## 2019-06-18 0.025158142 1.028092e-01 0.8771997220
## 2019-06-19 0.017160650 2.154364e-02 0.9750177706
## 2019-06-20 0.149444281 1.477844e-06 0.9998069146
## 2019-06-21 0.227006675 2.051617e-05 0.9976976356
## 2019-06-24 0.204143871 1.046004e-05 0.9987902598
## 2019-06-25 0.321402701 3.212452e-04 0.9716298681
## 2019-06-26 0.320591732 3.081769e-04 0.9724694501
## 2019-06-27 0.295498148 1.779678e-04 0.9835099946
## 2019-06-28 0.011057666 2.106588e-03 0.9972044963
## 2019-07-01 0.004351476 9.141221e-06 0.9999813404
## 2019-07-02 0.002951478 1.130196e-06 0.9999973768
## 2019-07-03 0.002485301 4.397713e-07 0.9999989139
## 2019-07-05 0.002541483 5.089538e-07 0.9999987618
## 2019-07-08 0.003293901 2.211716e-06 0.9999951694
## 2019-07-09 0.003986589 6.056602e-06 0.9999875039
## 2019-07-10 0.004344142 8.484823e-06 0.9999822785
## 2019-07-11 0.006218533 4.557286e-05 0.9999082499
## 2019-07-12 0.005669886 3.188693e-05 0.9999343620
## 2019-07-15 0.004570073 1.519951e-05 0.9999693172
## 2019-07-16 0.006497985 1.082106e-03 0.9984577382
## 2019-07-17 0.019351960 7.774945e-02 0.9050095672
## 2019-07-18 0.014968622 1.536529e-02 0.9794952487
## 2019-07-19 0.027813618 2.233792e-01 0.7242884216
## 2019-07-22 0.023928961 1.999067e-01 0.7396147836
## 2019-07-23 0.010358250 5.611933e-02 0.9274360335
## 2019-07-24 0.006464273 1.120965e-03 0.9982106065
## 2019-07-25 0.009034118 1.993120e-02 0.9723147711
## 2019-07-26 0.003268405 3.373812e-04 0.9994861885
## 2019-07-29 0.004395747 3.398385e-04 0.9994507010
## 2019-07-30 0.007520782 1.765361e-03 0.9971827171
## 2019-07-31 0.009364688 6.125877e-01 0.3931948321
## 2019-08-01 0.045563396 6.117840e-01 0.3528721904
## 2019-08-02 0.139816214 3.452754e-01 0.2180111264
## 2019-08-05 0.931135377 8.001698e-04 0.0306862296
## 2019-08-06 0.926010472 1.219782e-03 0.0146075431
## 2019-08-07 0.924167071 1.301614e-03 0.0135433614
## 2019-08-08 0.739513354 4.389742e-03 0.0386780029
## 2019-08-09 0.640999621 6.973561e-03 0.0470704938
## 2019-08-12 0.410498384 1.701935e-02 0.0738484328
## 2019-08-13 0.224899537 3.368145e-02 0.1364025865
## 2019-08-14 0.559596421 1.024700e-02 0.0494694376
## 2019-08-15 0.789323514 3.902842e-03 0.0257003879
## 2019-08-16 0.527725130 1.141847e-02 0.0536111432
## 2019-08-19 0.672967214 6.568683e-03 0.0374119859
## 2019-08-20 0.945930194 9.768483e-04 0.0099459477
## 2019-08-21 0.367187844 1.827738e-02 0.0970703573
## 2019-08-22 0.348546562 1.514060e-02 0.2028474305
## 2019-08-23 0.721122669 5.036574e-03 0.0381332607
## 2019-08-26 0.839445368 1.690649e-03 0.0673879042
## 2019-08-27 0.675011008 2.595765e-02 0.0133683098
## 2019-08-28 0.651690832 1.687519e-01 0.0072067833
## 2019-08-29 0.779030723 6.108464e-02 0.0160102035
## 2019-08-30 0.238488876 2.953715e-01 0.1104328095
```

```
## 2019-09-03 0.054192580 8.989306e-01 0.0089461187
## 2019-09-04 0.025541597 6.314917e-01 0.2538999055
## 2019-09-05 0.017191394 8.472539e-03 0.9868490353
## 2019-09-06 0.161718946 1.517631e-06 0.9997819085
## 2019-09-09 0.167623330 5.481642e-06 0.9994070995
## 2019-09-10 0.176204974 5.620111e-06 0.9993576495
## 2019-09-11 0.045030433 1.120440e-05 0.9997648151
## 2019-09-12 0.009151266 5.370529e-05 0.9998522552
## 2019-09-13 0.129465428 4.099745e-07 0.9999376069
## 2019-09-16 0.177631904 3.541542e-06 0.9995449775
## 2019-09-17 0.016362789 2.858733e-03 0.9947905946
## 2019-09-18 0.015671706 1.607602e-02 0.9818740656
## 2019-09-19 0.015372496 1.574124e-02 0.9825713184
## 2019-09-20 0.028763619 3.439918e-01 0.6835090194
## 2019-09-23 0.031737561 3.524058e-01 0.6484671717
## 2019-09-24 0.045011699 5.517544e-01 0.3959062842
## 2019-09-25 0.027261353 1.495237e-01 0.8327506807
## 2019-09-26 0.027099256 1.326447e-01 0.8462088841
## 2019-09-27 0.031066937 2.674601e-01 0.7079455127
## 2019-09-30 0.023023934 1.443282e-01 0.8323979128
## 2019-10-01 0.009771510 9.064495e-01 0.1327475529
## 2019-10-02 0.159906866 6.919338e-02 0.1168137130
## 2019-10-03 0.174950529 6.057580e-02 0.1108302166
## 2019-10-04 0.021172344 9.320244e-01 0.0207789091
## 2019-10-07 0.040221857 9.347331e-01 0.0082300887
## 2019-10-08 0.792218563 3.836010e-03 0.0253200731
## 2019-10-09 0.147549934 8.198938e-01 0.0031121667
## 2019-10-10 0.109337868 8.591332e-01 0.0038659475
## 2019-10-11 0.040977380 9.255918e-01 0.0088102731
## 2019-10-14 0.024211640 9.513037e-01 0.0126735398
## 2019-10-15 0.009145773 9.280675e-01 0.0565279989
## 2019-10-16 0.029474955 9.181412e-01 0.0145177479
## 2019-10-17 0.021814083 9.205676e-01 0.0214635023
```

```r
#indicate the classes for the testing data
test_pred_class<- data.frame(matrix(NA,dim(test_pred)[1],1))
test_pred_class[test_pred[,"Down"] > 0.5,1]<- "Down"
test_pred_class[test_pred[,"NoWhere"] > 0.5,1]<- "NoWhere"
test_pred_class[test_pred[,"Up"] > 0.5,1]<- "Up"
test_pred_class[is.na(test_pred_class)]<- "NoWhere"
```

```r
#Check the accuracy of the forecasts
u<- union(test_pred_class[,1],testdir)
t<-table(factor(test_pred_class[,1],u),factor(testdir,u))
confusionMatrix(t)
```

```
## Confusion Matrix and Statistics
##
##
##           NoWhere  Up Down
##   NoWhere      93  18   16
##   Up           36 147    2
##   Down         16   0   82
##
## Overall Statistics
```

```
##
##                Accuracy : 0.7854
##                  95% CI : (0.7424, 0.8241)
##     No Information Rate : 0.4024
##     P-Value [Acc > NIR] : < 2e-16
##
##                   Kappa : 0.6701
##
##  Mcnemar's Test P-Value : 0.04601
##
## Statistics by Class:
##
##                      Class: NoWhere Class: Up Class: Down
## Sensitivity                  0.6414    0.8909      0.8200
## Specificity                  0.8717    0.8449      0.9484
## Pos Pred Value               0.7323    0.7946      0.8367
## Neg Pred Value               0.8163    0.9200      0.9423
## Prevalence                   0.3537    0.4024      0.2439
## Detection Rate               0.2268    0.3585      0.2000
## Detection Prevalence         0.3098    0.4512      0.2390
## Balanced Accuracy            0.7565    0.8679      0.8842
```

```
#generate trade signals using the same pattern as human psychology
signal<-ifelse(test_pred_class=="Up",1,ifelse(test_pred_class=="Down",-1, 0))
signal
```

```
##       matrix.NA..dim.test_pred..1...1.
##   [1,]                                0
##   [2,]                                0
##   [3,]                                0
##   [4,]                                0
##   [5,]                                1
##   [6,]                                1
##   [7,]                                1
##   [8,]                                1
##   [9,]                                1
##  [10,]                                1
##  [11,]                                0
##  [12,]                                0
##  [13,]                               -1
##  [14,]                               -1
##  [15,]                               -1
##  [16,]                               -1
##  [17,]                               -1
##  [18,]                               -1
##  [19,]                               -1
##  [20,]                               -1
##  [21,]                               -1
##  [22,]                               -1
##  [23,]                               -1
##  [24,]                               -1
##  [25,]                               -1
##  [26,]                               -1
##  [27,]                               -1
##  [28,]                               -1
```

```
## [29,] -1
## [30,] -1
## [31,]  0
## [32,]  0
## [33,]  0
## [34,]  0
## [35,]  0
## [36,]  0
## [37,]  0
## [38,]  0
## [39,]  0
## [40,]  0
## [41,]  0
## [42,]  0
## [43,]  0
## [44,]  0
## [45,]  0
## [46,]  0
## [47,]  1
## [48,]  1
## [49,]  1
## [50,]  1
## [51,]  1
## [52,]  1
## [53,]  1
## [54,]  0
## [55,]  1
## [56,]  0
## [57,]  1
## [58,]  1
## [59,]  1
## [60,]  0
## [61,]  1
## [62,]  1
## [63,]  1
## [64,]  1
## [65,]  1
## [66,]  1
## [67,]  1
## [68,]  1
## [69,]  1
## [70,]  1
## [71,]  1
## [72,]  1
## [73,]  0
## [74,]  0
## [75,]  0
## [76,]  0
## [77,]  0
## [78,]  0
## [79,]  0
## [80,]  0
## [81,]  0
## [82,]  0
```

```
##  [83,]                                  0
##  [84,]                                  0
##  [85,]                                  0
##  [86,]                                  0
##  [87,]                                  0
##  [88,]                                  0
##  [89,]                                  0
##  [90,]                                  0
##  [91,]                                  0
##  [92,]                                  0
##  [93,]                                  0
##  [94,]                                  0
##  [95,]                                  0
##  [96,]                                  0
##  [97,]                                  0
##  [98,]                                  1
##  [99,]                                  1
## [100,]                                  1
## [101,]                                  1
## [102,]                                  1
## [103,]                                  1
## [104,]                                  1
## [105,]                                  1
## [106,]                                  1
## [107,]                                  1
## [108,]                                  1
## [109,]                                  1
## [110,]                                  1
## [111,]                                  1
## [112,]                                  1
## [113,]                                  0
## [114,]                                  0
## [115,]                                  0
## [116,]                                  0
## [117,]                                  0
## [118,]                                  1
## [119,]                                  1
## [120,]                                  1
## [121,]                                  1
## [122,]                                  1
## [123,]                                  1
## [124,]                                  1
## [125,]                                  1
## [126,]                                  1
## [127,]                                  1
## [128,]                                  1
## [129,]                                  0
## [130,]                                  0
## [131,]                                  0
## [132,]                                  0
## [133,]                                  0
## [134,]                                  0
## [135,]                                  1
## [136,]                                  1
```

```
## [137,]                                    1
## [138,]                                    1
## [139,]                                    1
## [140,]                                    1
## [141,]                                    1
## [142,]                                    0
## [143,]                                    0
## [144,]                                    0
## [145,]                                    0
## [146,]                                    0
## [147,]                                    0
## [148,]                                    0
## [149,]                                    0
## [150,]                                    0
## [151,]                                    0
## [152,]                                    0
## [153,]                                    0
## [154,]                                   -1
## [155,]                                   -1
## [156,]                                   -1
## [157,]                                   -1
## [158,]                                   -1
## [159,]                                   -1
## [160,]                                   -1
## [161,]                                   -1
## [162,]                                   -1
## [163,]                                   -1
## [164,]                                   -1
## [165,]                                   -1
## [166,]                                   -1
## [167,]                                   -1
## [168,]                                   -1
## [169,]                                   -1
## [170,]                                   -1
## [171,]                                   -1
## [172,]                                   -1
## [173,]                                   -1
## [174,]                                   -1
## [175,]                                    0
## [176,]                                    0
## [177,]                                   -1
## [178,]                                   -1
## [179,]                                   -1
## [180,]                                   -1
## [181,]                                   -1
## [182,]                                   -1
## [183,]                                   -1
## [184,]                                   -1
## [185,]                                   -1
## [186,]                                    0
## [187,]                                    0
## [188,]                                    0
## [189,]                                    0
## [190,]                                    1
```

```
## [191,]                                        1
## [192,]                                        0
## [193,]                                        0
## [194,]                                       -1
## [195,]                                       -1
## [196,]                                       -1
## [197,]                                       -1
## [198,]                                       -1
## [199,]                                       -1
## [200,]                                       -1
## [201,]                                       -1
## [202,]                                       -1
## [203,]                                       -1
## [204,]                                       -1
## [205,]                                       -1
## [206,]                                       -1
## [207,]                                       -1
## [208,]                                       -1
## [209,]                                       -1
## [210,]                                       -1
## [211,]                                       -1
## [212,]                                       -1
## [213,]                                       -1
## [214,]                                       -1
## [215,]                                       -1
## [216,]                                       -1
## [217,]                                        0
## [218,]                                        1
## [219,]                                        1
## [220,]                                        1
## [221,]                                        1
## [222,]                                        1
## [223,]                                        1
## [224,]                                        1
## [225,]                                        1
## [226,]                                        1
## [227,]                                        1
## [228,]                                        1
## [229,]                                        1
## [230,]                                        1
## [231,]                                        1
## [232,]                                        1
## [233,]                                        1
## [234,]                                        1
## [235,]                                        1
## [236,]                                        1
## [237,]                                        1
## [238,]                                        1
## [239,]                                        1
## [240,]                                        1
## [241,]                                        1
## [242,]                                        1
## [243,]                                        1
## [244,]                                        1
```

```
## [245,]                                  1
## [246,]                                  1
## [247,]                                  1
## [248,]                                  1
## [249,]                                  1
## [250,]                                  1
## [251,]                                  1
## [252,]                                  1
## [253,]                                  1
## [254,]                                  0
## [255,]                                  0
## [256,]                                  1
## [257,]                                  1
## [258,]                                  1
## [259,]                                  1
## [260,]                                  1
## [261,]                                  1
## [262,]                                  1
## [263,]                                  1
## [264,]                                  1
## [265,]                                  0
## [266,]                                  0
## [267,]                                  0
## [268,]                                  0
## [269,]                                  0
## [270,]                                  0
## [271,]                                  1
## [272,]                                  1
## [273,]                                  1
## [274,]                                  1
## [275,]                                  1
## [276,]                                  1
## [277,]                                  1
## [278,]                                  1
## [279,]                                  1
## [280,]                                  1
## [281,]                                  1
## [282,]                                  1
## [283,]                                  1
## [284,]                                  1
## [285,]                                  1
## [286,]                                  1
## [287,]                                  1
## [288,]                                  1
## [289,]                                  1
## [290,]                                  1
## [291,]                                  1
## [292,]                                  1
## [293,]                                  1
## [294,]                                  1
## [295,]                                  1
## [296,]                                  0
## [297,]                                  0
## [298,]                                  0
```

```
## [299,]                                 0
## [300,]                                -1
## [301,]                                -1
## [302,]                                -1
## [303,]                                -1
## [304,]                                 0
## [305,]                                 0
## [306,]                                 0
## [307,]                                 0
## [308,]                                 0
## [309,]                                 0
## [310,]                                -1
## [311,]                                -1
## [312,]                                -1
## [313,]                                -1
## [314,]                                -1
## [315,]                                -1
## [316,]                                -1
## [317,]                                 0
## [318,]                                 0
## [319,]                                 0
## [320,]                                 1
## [321,]                                 1
## [322,]                                 1
## [323,]                                 1
## [324,]                                 0
## [325,]                                 1
## [326,]                                 1
## [327,]                                 1
## [328,]                                 1
## [329,]                                 1
## [330,]                                 1
## [331,]                                 1
## [332,]                                 1
## [333,]                                 1
## [334,]                                 1
## [335,]                                 1
## [336,]                                 1
## [337,]                                 1
## [338,]                                 1
## [339,]                                 1
## [340,]                                 1
## [341,]                                 1
## [342,]                                 1
## [343,]                                 1
## [344,]                                 1
## [345,]                                 1
## [346,]                                 1
## [347,]                                 1
## [348,]                                 1
## [349,]                                 1
## [350,]                                 1
## [351,]                                 1
## [352,]                                 1
```

```
## [353,]                                        1
## [354,]                                        1
## [355,]                                        0
## [356,]                                        0
## [357,]                                        0
## [358,]                                       -1
## [359,]                                       -1
## [360,]                                       -1
## [361,]                                       -1
## [362,]                                       -1
## [363,]                                        0
## [364,]                                        0
## [365,]                                       -1
## [366,]                                       -1
## [367,]                                       -1
## [368,]                                       -1
## [369,]                                       -1
## [370,]                                        0
## [371,]                                        0
## [372,]                                       -1
## [373,]                                       -1
## [374,]                                       -1
## [375,]                                       -1
## [376,]                                       -1
## [377,]                                        0
## [378,]                                        0
## [379,]                                        0
## [380,]                                        1
## [381,]                                        1
## [382,]                                        1
## [383,]                                        1
## [384,]                                        1
## [385,]                                        1
## [386,]                                        1
## [387,]                                        1
## [388,]                                        1
## [389,]                                        1
## [390,]                                        1
## [391,]                                        1
## [392,]                                        1
## [393,]                                        0
## [394,]                                        1
## [395,]                                        1
## [396,]                                        1
## [397,]                                        1
## [398,]                                        0
## [399,]                                        0
## [400,]                                        0
## [401,]                                        0
## [402,]                                        0
## [403,]                                       -1
## [404,]                                        0
## [405,]                                        0
## [406,]                                        0
```

```
## [407,]                              0
## [408,]                              0
## [409,]                              0
## [410,]                              0
```

```
test_return_SPY<- return[(index(return)>= test_sdate & index(return)<= test_edate), ]
test_return<- test_return_SPY*(signal)
```

```
library(PerformanceAnalytics)
```

```
##
## Attaching package: 'PerformanceAnalytics'

## The following objects are masked from 'package:timeDate':
##
##     kurtosis, skewness

## The following object is masked from 'package:graphics':
##
##     legend
```

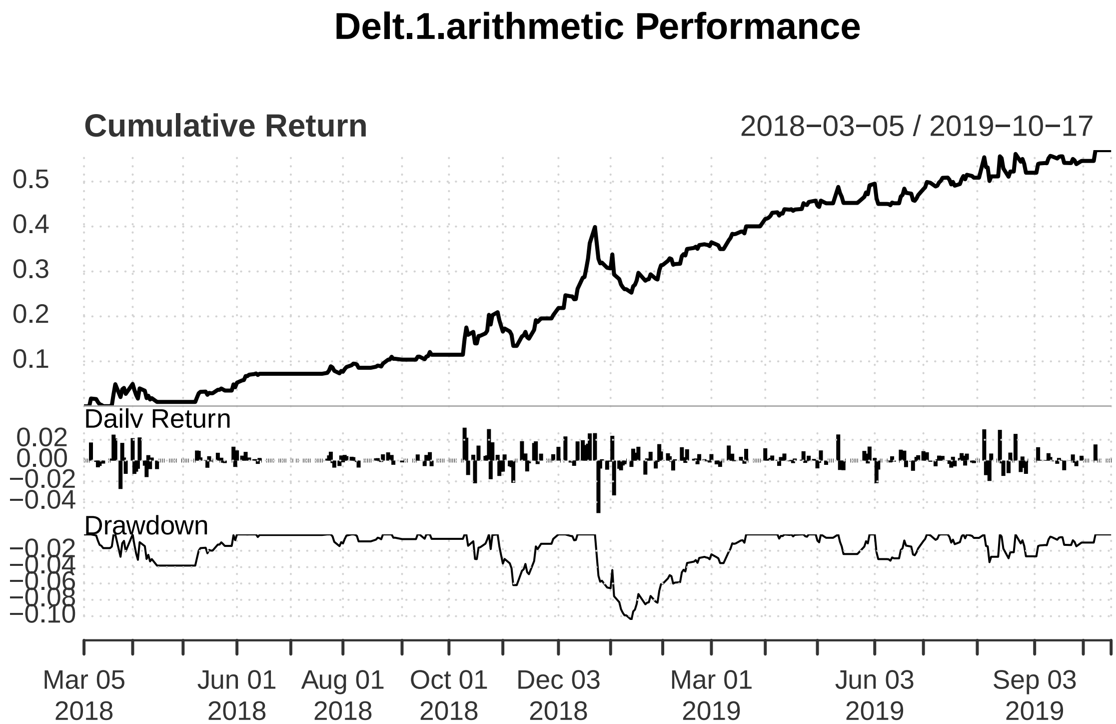
```
#calculate cummulative return
cumm_return<- Return.cumulative(test_return)
cumm_return
```

```
##                   Delt.1.arithmetic
## Cumulative Return         0.5698866
```

```
#calculate annual return
annual_return<- Return.annualized(test_return)
annual_return
```

```
##                   Delt.1.arithmetic
## Annualized Return          0.319433
```

```
charts.PerformanceSummary(test_return)
```




```
VaR(test_return, p=0.95)
```

```
##     Delt.1.arithmetic
## VaR       -0.01182357
```

```
SharpeRatio(as.ts(test_return), Rf = 0, p=0.95, FUN = "StdDev")
```

```
##                                    [,1]
## StdDev Sharpe (Rf=0%, p=95%): 0.1343047
```

```
SharpeRatio.annualized(test_return, Rf=0)
```

```
##                                 Delt.1.arithmetic
## Annualized Sharpe Ratio (Rf=0%)           2.37838
```

References

Fenner, Martin. 2012. "One-Click Science Marketing." *Nature Materials* 11 (4). Nature Publishing Group: 261–63. https://doi.org/10.1038/nmat3283.