Enhanced GARCH Model for SP500 Volatility

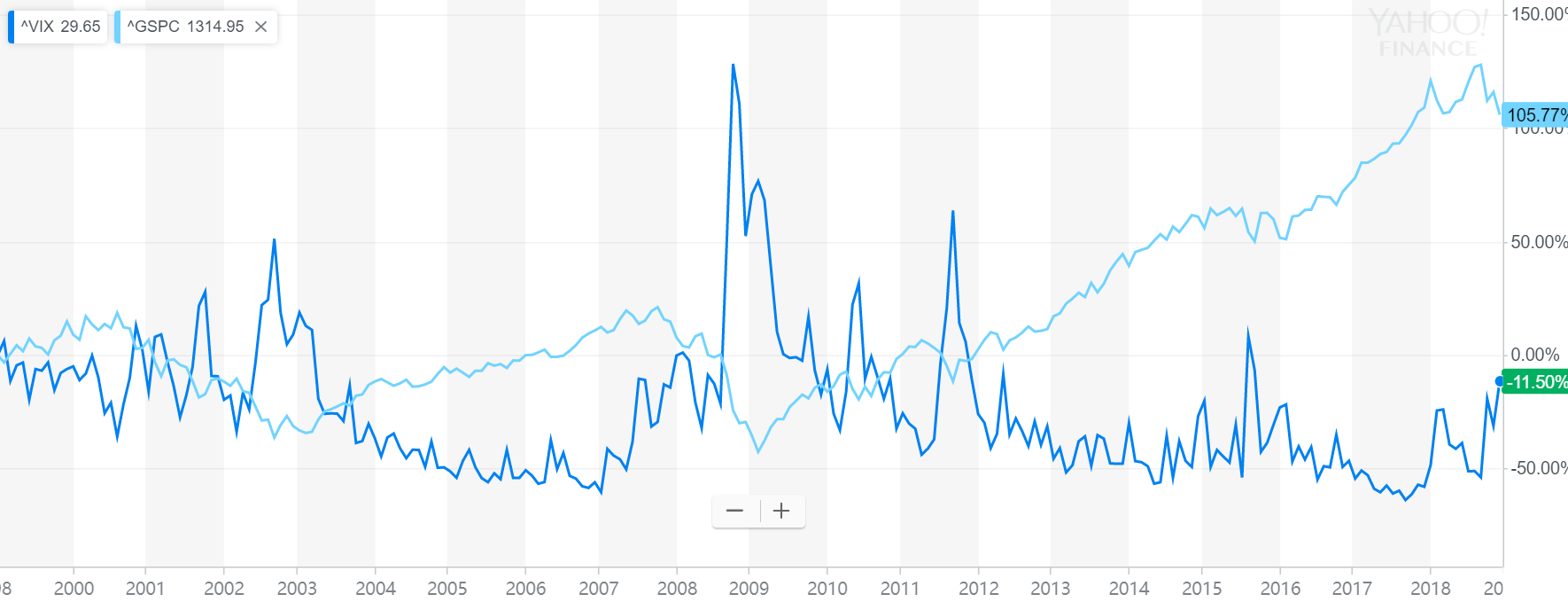
ECON/FIN250A Final Project

Yuzhou Liu, Qinghan Shen, Yukun Xia, Zihao Song, Jiaren Ma

12/8/2018

# Topic Introduction

Nowadays, volatility is widely used as a prime perimeter for financial risk management. Risk parity funds tend to hedge their exposure using derivatives when the market volatility exceeds some certain levels. The traditional GARCH model for volatility forecasting implies that Volatility will risk after a large movement in markets regardless of the direction of the movement. However, market experiences show that VIX index, which is calculated using the IV of index option, tend to rise when market crushes, and decrease when market rises. This phenomenon could be explained by the leverage effect, and our goal is to add the leverage effect to the traditional model and test whether our model is more accurate in forecasting the real volatility of the market for the period than the traditional GARCH model and the VIX index.



Source: Yahoo Finance

# Data Description

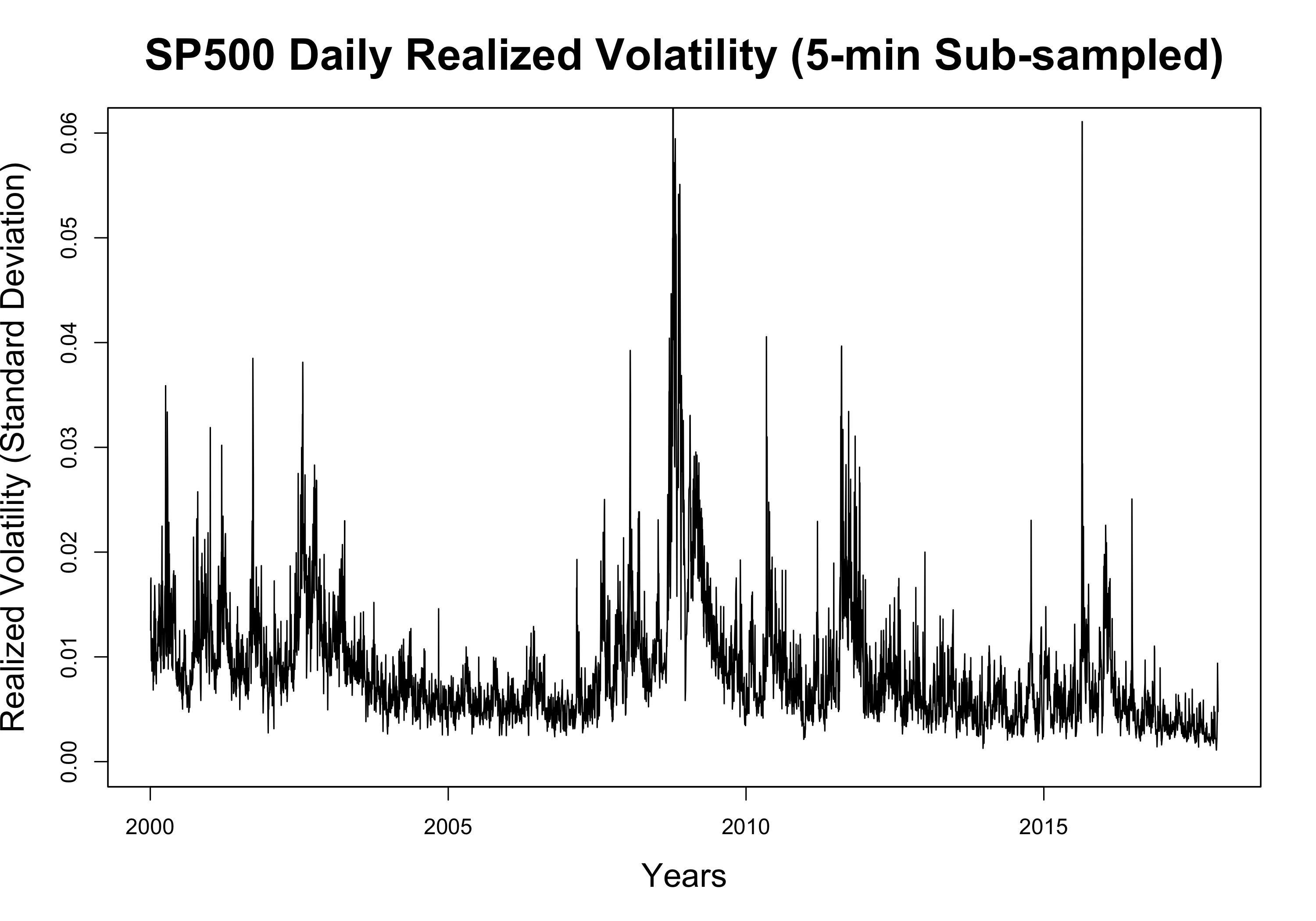
&&&1 First, we use the daily open and close quote for S&P500 ETF from yahoo finance to generate the SP500 return time series. The plot of data is as follows. From the graph, we can see there is no obvious trend or seasonality.

Second, we use the daily realized volatility SP500 data from Oxford-Man institute of quantitative Finance library to get the realized volatility of SP500 from 2000.

Finally, we use the daily open and close data of VIX index from yahoo finance to get the market implied volatility of the SP500 index. ?

# Relized Volatility Forecasting

### Basic check for Relized Vol series

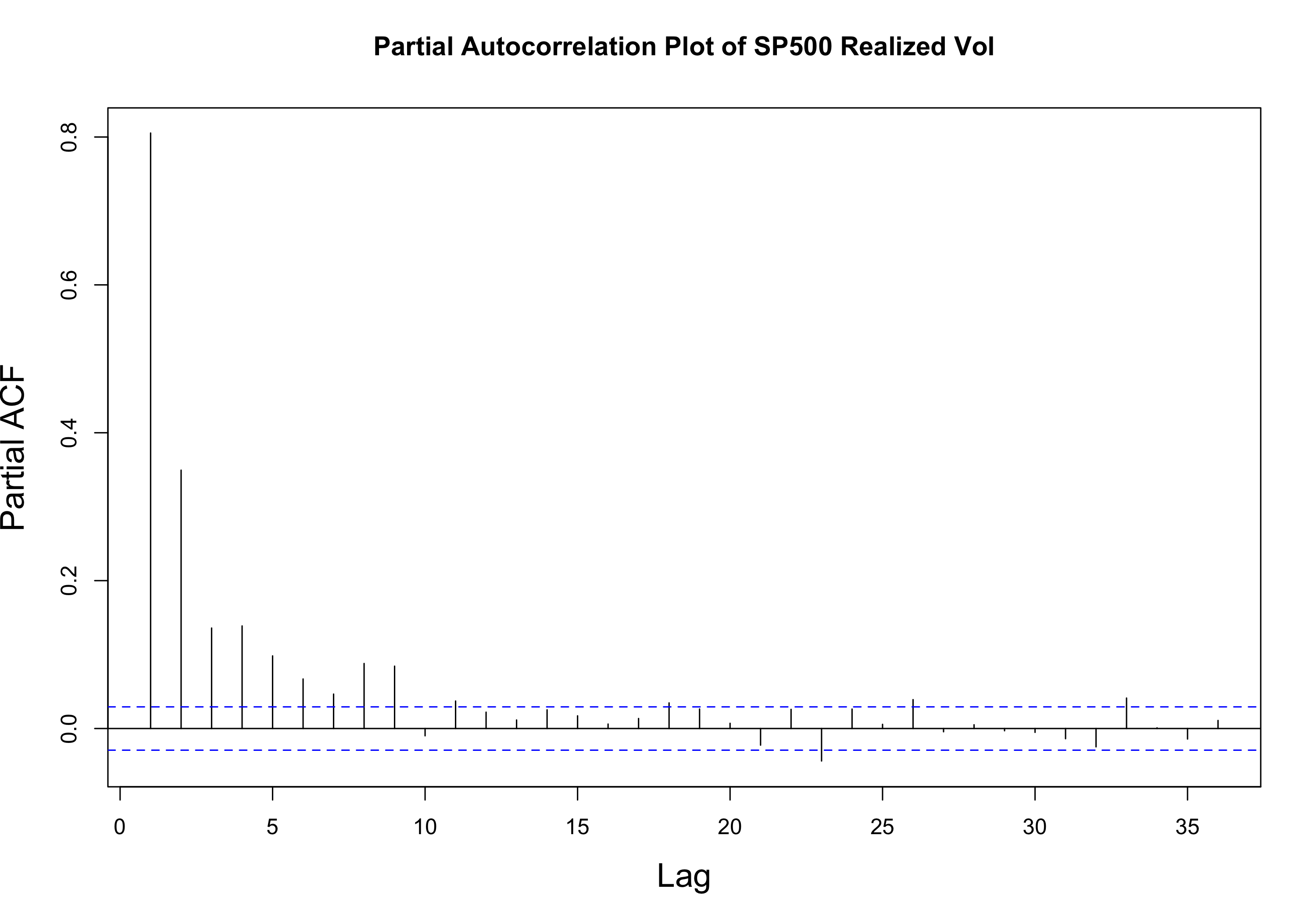
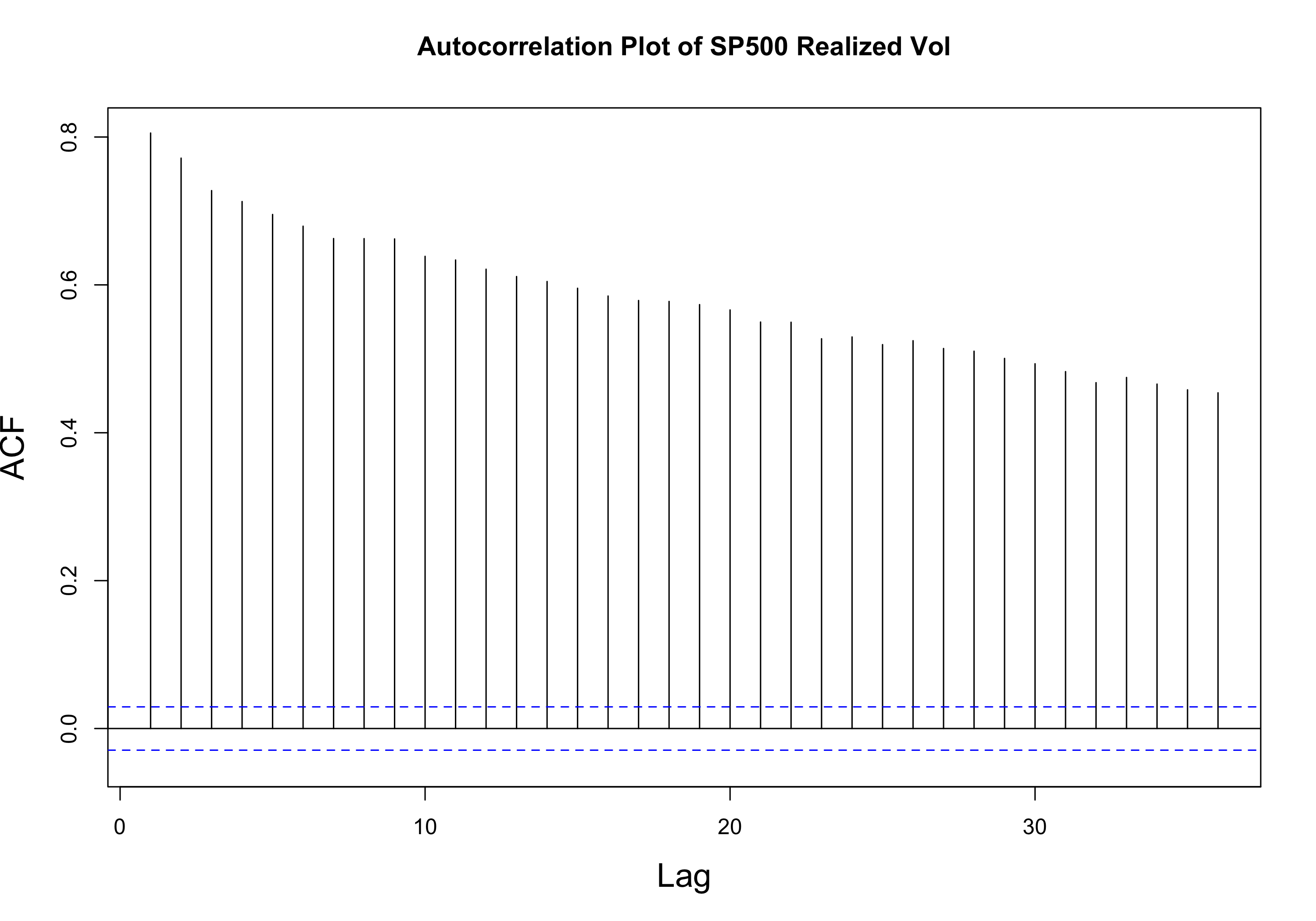
&&&2 The seasonal and trend or stationary from its plot? 

&&&3 Unit Root Test check stationary?

##   
## ###############################################################   
## # Augmented Dickey-Fuller Test Unit Root / Cointegration Test #   
## ###############################################################   
##   
## The value of the test statistic is: -7.9543

## [1] "Critical Value Table"

## 1pct 5pct 10pct  
## tau1 -2.58 -1.95 -1.62

&&&4 ACF and PACF ?  ###Data Preprocessing

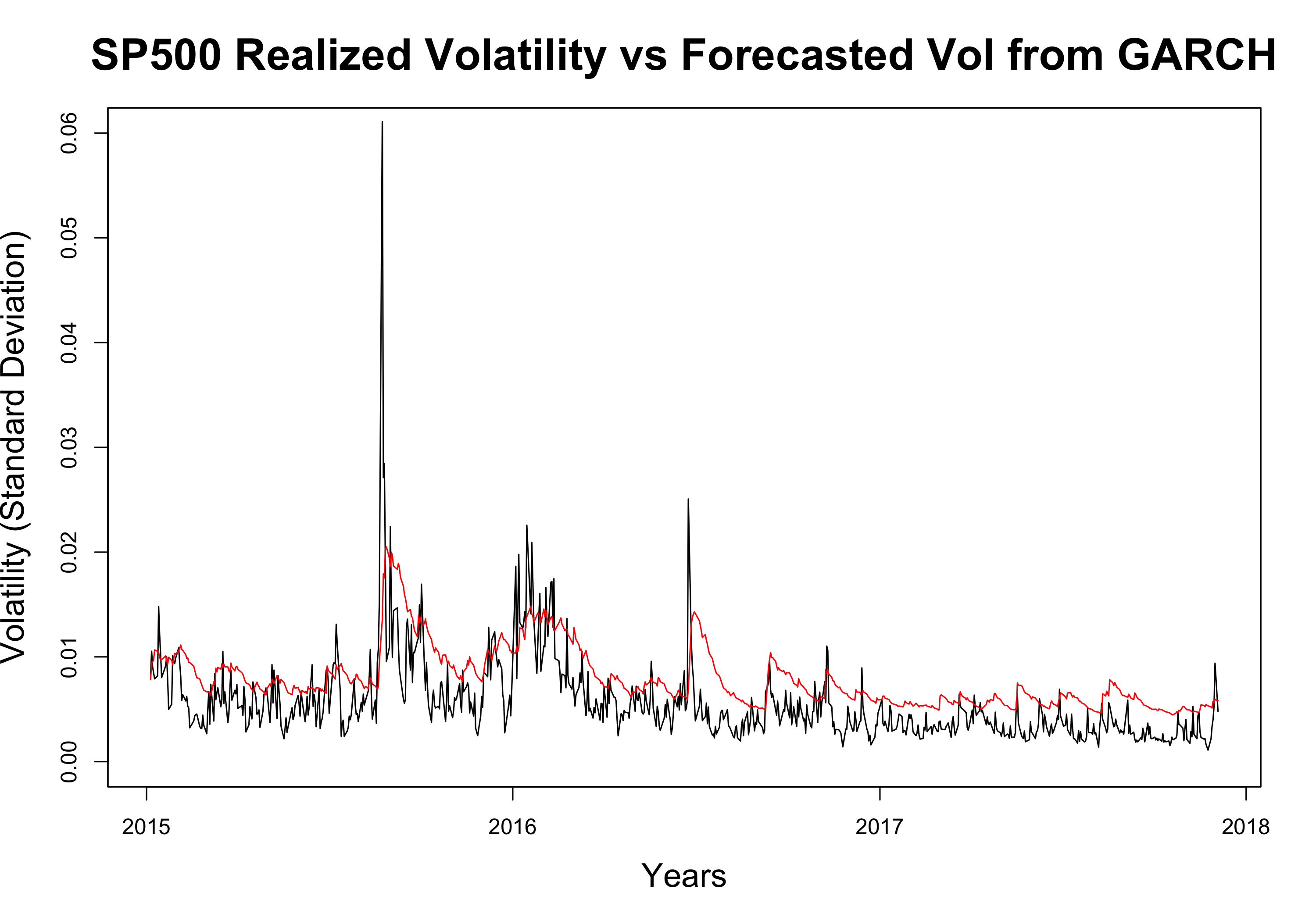
&&&5 some descripe of the process and train and validation ?

### GRACH Model as Benchmark

&&&6 GARCH Model used here and its forecast result?

## [1] "Validation set Forecasting errors of GARCH Model"

## ME RMSE MAE MPE MAPE ACF1  
## Test set 0.002350199 0.003908771 0.003023468 31.3564 38.58287 0.6173118  
## Theil's U  
## Test set 7.43692

&&&7 Explain the fit, not very good outcome from GARCH Model 

### Benchmark Model For Relized Volatility

&&&8 Explain how the two benchmark works and a little explaination of realized vol ?

## [1] "Validation set Forecasting errors of AR2 Model"

## ME RMSE MAE MPE MAPE  
## Test set -0.0004759644 0.002883321 0.001658777 -21.81033 33.52743

## [1] "Validation set Forecasting errors of MIDAS Model"

## ME RMSE MAE MPE MAPE  
## Test set -0.00027188 0.002862302 0.0015601 -17.26183 30.55538

## [1] "Diebold/Mariano AR2 versus MIDAS"

##   
## Diebold-Mariano Test  
##   
## data: na.locf(as.ts(arima.ben.res))na.locf(as.ts(midas.ben.res))  
## DM = 0.56721, Forecast horizon = 1, Loss function power = 2,  
## p-value = 0.5707  
## alternative hypothesis: two.sided

### Leverage Effect as Dummy

&&&9 Explain the result?

## [1] "Validation set Forecasting errors of MIDAS Model with Dummy Leverage Effect"

## ME RMSE MAE MPE MAPE  
## Test set -0.0002959763 0.002811812 0.00152233 -16.75068 29.45156

## [1] "Diebold/Mariano MIDAS Model with Dummy Leverage Effect versus MIDAS Benchmark"

##   
## Diebold-Mariano Test  
##   
## data: na.locf(as.ts(midas.dummy.res))na.locf(as.ts(midas.ben.res))  
## DM = -3.9266, Forecast horizon = 1, Loss function power = 2,  
## p-value = 9.169e-05  
## alternative hypothesis: two.sided

### Leaverage Effect as Return

&&&11 Explain the result?

## [1] "Validation set Forecasting errors of MIDAS Model with Return"

## ME RMSE MAE MPE MAPE  
## Test set -0.0002618941 0.002753947 0.001496064 -16.51067 29.30235

## [1] "Diebold/Mariano MIDAS Model with Return versus MIDAS with dummy leverage effect"

##   
## Diebold-Mariano Test  
##   
## data: na.locf(as.ts(midas.return.res))na.locf(as.ts(midas.dummy.res))  
## DM = -2.4586, Forecast horizon = 1, Loss function power = 2,  
## p-value = 0.01411  
## alternative hypothesis: two.sided

### Return and Dummy

&&&10 Explain the result?

## [1] "Validation set Forecasting errors of MIDAS Model with Return and Dummy"

## ME RMSE MAE MPE MAPE  
## Test set -0.0003111873 0.002511126 0.001404977 -16.45516 27.87236

## [1] "Diebold/Mariano MIDAS Model with Return and Dummy versus MIDAS with Return"

##   
## Diebold-Mariano Test  
##   
## data: na.locf(as.ts(midas.ret\_sign.res))na.locf(as.ts(midas.return.res))  
## DM = -3.2588, Forecast horizon = 1, Loss function power = 2,  
## p-value = 0.001154  
## alternative hypothesis: two.sided

### Model Selection/Evaluation

&&&13 Explain which model is best, and look deep into the model, and some things to notice

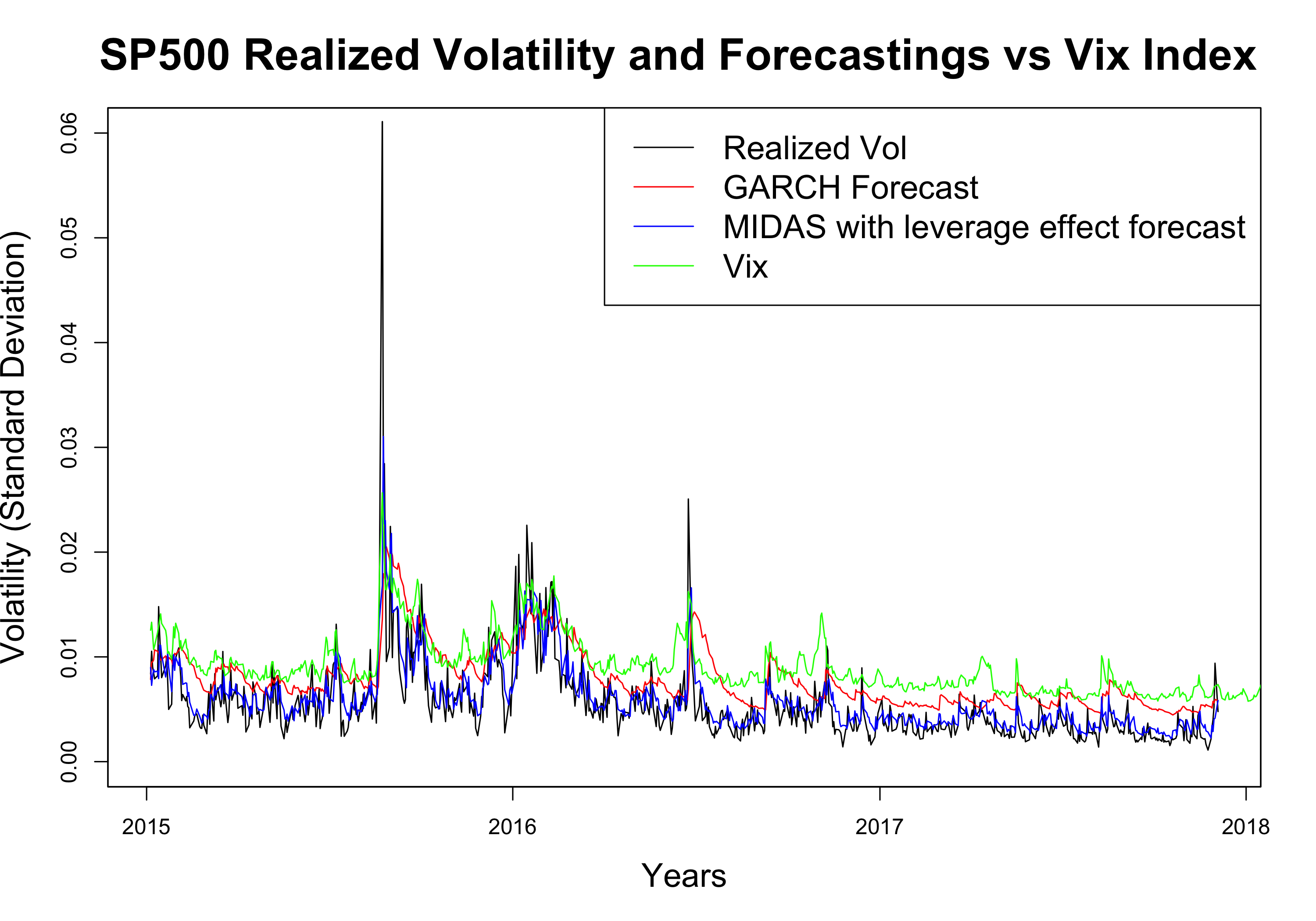
## RMSE  
## AR2 Benchmark 0.002883321  
## MIDAS Benchmark 0.002862302  
## Leverage Effect as Dummy Model 0.002811812  
## Leverage Effect as Return Model 0.002753947  
## Leverage Effect with Return and Dummy Model 0.002511126

&&&13 ?

##   
## Call:  
## lm(formula = vol ~ volL1 + ma6L2 + Return + `Return\*Sign`, data = ReVol.tra)  
##   
## Residuals:  
## Min 1Q Median 3Q Max   
## -0.022113 -0.001516 -0.000351 0.001093 0.055451   
##   
## Coefficients:  
## Estimate Std. Error t value Pr(>|t|)   
## (Intercept) 0.0007296 0.0001022 7.141 1.11e-12 \*\*\*  
## volL1 0.4038146 0.0148035 27.278 < 2e-16 \*\*\*  
## ma6L2 0.3836716 0.0165200 23.225 < 2e-16 \*\*\*  
## Return -0.1834257 0.0075254 -24.374 < 2e-16 \*\*\*  
## `Return\*Sign` 0.2942447 0.0132994 22.125 < 2e-16 \*\*\*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## Residual standard error: 0.003191 on 3733 degrees of freedom  
## Multiple R-squared: 0.7425, Adjusted R-squared: 0.7422   
## F-statistic: 2691 on 4 and 3733 DF, p-value: < 2.2e-16

# Applicaiton

### Vix comparation

&&&12 Explaination of the strategies ? 

### Control Vol

&&&14 The Logic of this stategies

## [1] "Standard deviations and sd(standard deviations)"

## [,1] [,2]  
## [1,] 0.09332141 0.02921505

## [,1] [,2]  
## [1,] 0.08960835 0.06479388

## [1] "mean and standard deviations for returns (annualized)"

## [,1] [,2]  
## [1,] 0.1444307 1.631293

## [,1] [,2]  
## [1,] 0.08516469 1.979575

## [1] "Sharpe ratios (annualized)"

## [1] 0.07014726

## [1] 0.02786694

