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Applied Financial Econometrics

Lecturer: Axel A. Araneda, Ph.D.

About the course (1/2)

- Time table:
  - Lectures: Friday 10:00-11:50 (P106)
  - Seminars: Friday 14:00-15:50 (VT105)

- Course Rules:
  - Attendance is highly recommended but not compulsory.
  - The final grade of the course is established as:
    - Tasks on seminars (50%). The best 8 grades become the tasks grade.
    - Final Term or Exam (50%)

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About the course (2/2)

- Contact
  - Anytime by email: axelaraneda@mail.muni.cz
- Consultation (office) hours:
  - Wednesday (11:00-12:00 hrs) and Friday (13:00-14:00 hrs).
  - Preferable an email in advance.
  - Office: 408.
  - Other consultation hours (physically or virtually) per agreement by email.

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About the lecturer

- Axel A. Araneda, Ph.D.
  - Native of Chile.
  - B.Sc. Physics and B.Eng. Engineering Physics.
  - Ph.D. in Complex Systems.
  - Former postdoc at FIAS and MUNI.
  - Current position: Assistant Professor, Department of Finance, MUNI.
  - Research line:
    - Quantitative Finance
    - Econophysics
    - Economic Modelling
    - Financial Econometrics

Outline of the course

1. Introduction to financial econometrics.
2. Predictability of market returns.
3. Time-series econometric models, AR (p), MA (p), ARMA (p, q), ARIMA (p, q).
4. Unit Root Tests and invertibility.
5. ARDL models – estimation, autocorrelation tests, HAC standard errors.
6. ARCH/GARCH models.
7. Value-at-Risk models.
8. Expected shortfall.
9. Market event study – design of a market event study.
10. News driven market movements.
11. Capital asset pricing model, Fama and French model.
12. Asset allocation (portfolio).

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Lecture 1

Introduction to Financial Econometrics

- Introduction to financial markets and econometrics analysis using R.

Some Basics

- Time series: Sequence of sucesive observed points. Data indexed in time order.

$$X_{-1}, X_0, X_1, X_2, \ldots, X_t, \ldots X_n$$

```
library(quantmod)
getSymbols('^GSPC',src='yahoo', from="2010-01-01") # S&P500 since 2010
SP500=GSPC$GSPC.Adjusted # adjusted closing price
plot(SP500)
```

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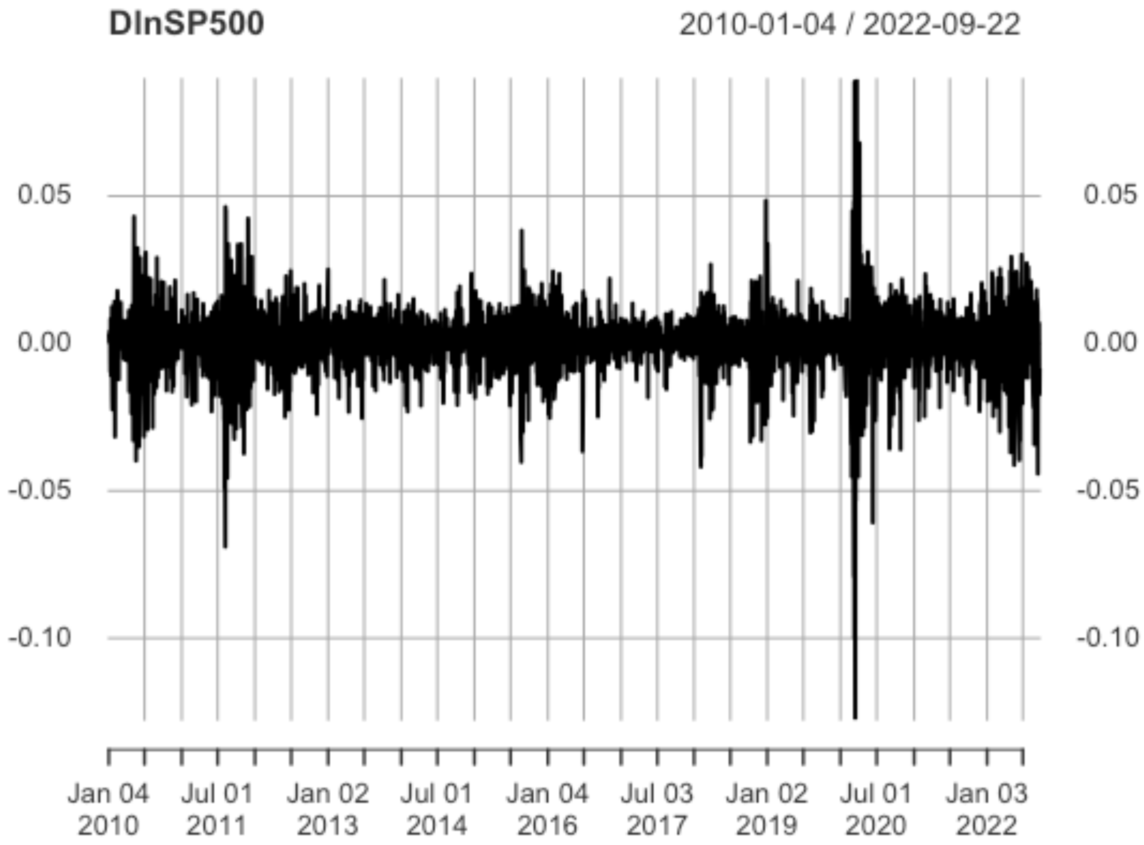
Some Basics

- Simple return: $R_t = \frac{P_t - P_{t-1}}{P_{t-1}}$

- Log-return:

$$r_t = \ln\left(\frac{P_t}{P_{t-1}}\right) = \ln(P_t) - \ln(P_{t-1})$$

```
#log_returns
lnSP500<-log(SP500) # Natural log of SP500
DlnSP500<-diff(lnSP500) # First difference of lnSP500
plot(DlnSP500)
```



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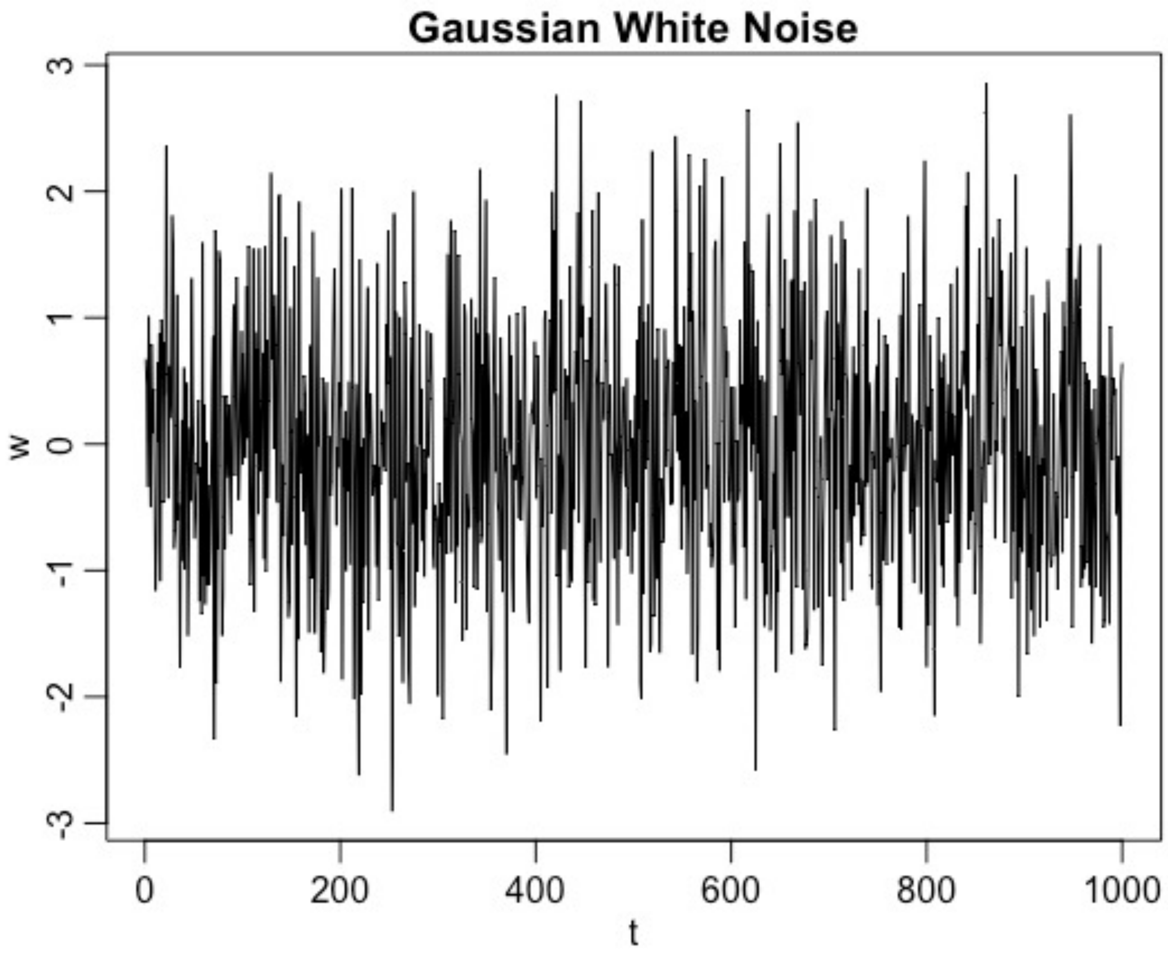
Some Basics

- White noise: Random variable u_t with zero unconditional mean, constant variance, and uncorrelated.
  - $\mathbb{E}(u_t) = 0$
  - $\text{Var}(u_t) = \sigma^2$
  - $\text{Cov}(u_s, u_t) = 0$
- In case $u_t \sim N(0,\sigma^2)$: Gaussian WN

```
set.seed(120)
w=rnorm(1000,0,1)
plot(w,type="l", main = 'Gaussian White Noise',xlab='t')
```



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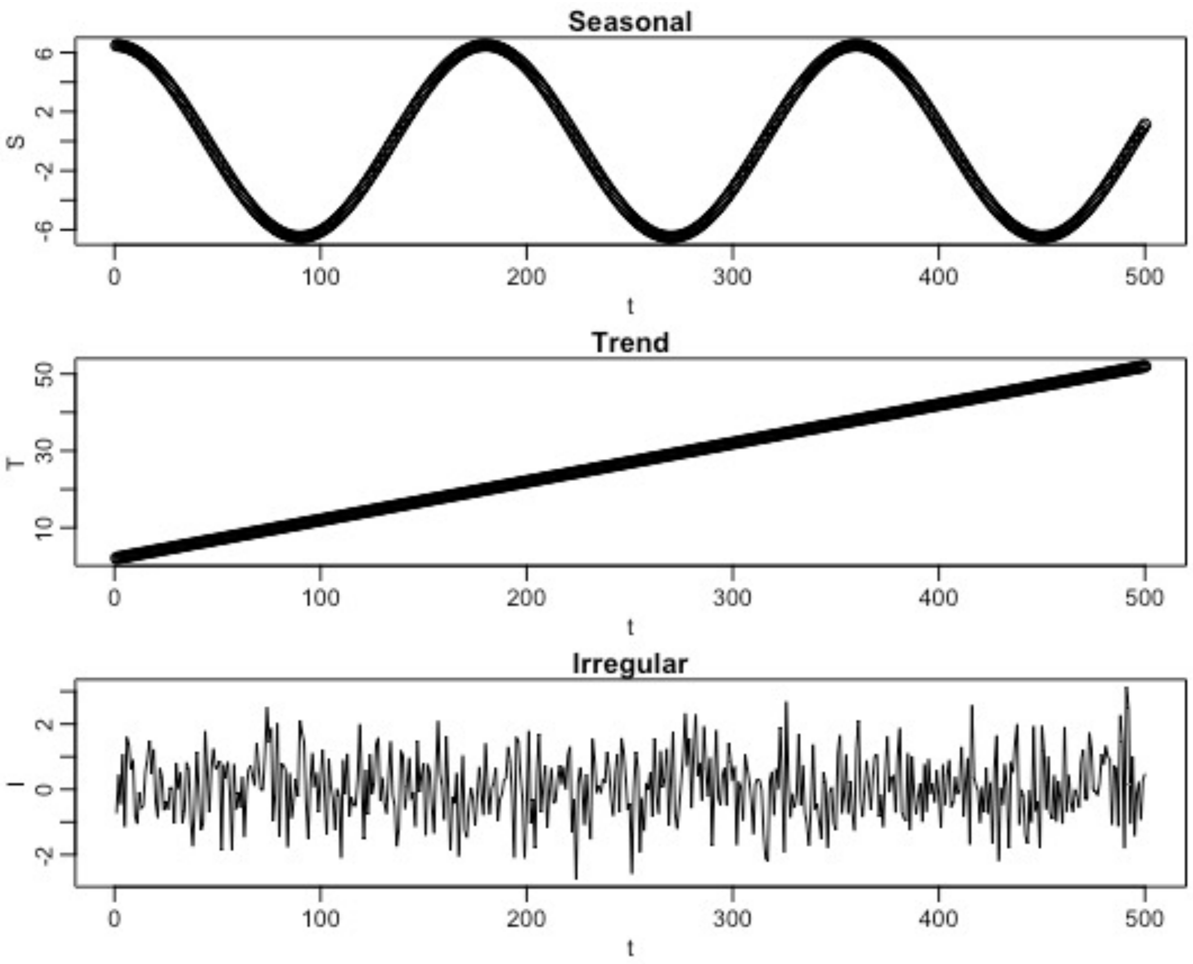
Time-series decomposition

– Time-series are usually decomposed into:
  a) A trend T_t
  b) A seasonal component S_t
  c) An irregular element I_t
– For example:

$$T_t = 2 + 0.1t;\ \ S_t = \cos\left(\pi \frac{t}{90}\right);\ \ I_t \sim N(0,1)$$

```
t<-seq(1,500)
T<-2+0.1*t
S<-6.5*cos(pi*t/90)
I<-rnorm(500,0,1)
par(mfrow=c(3,1))
plot(S,xlab='t',main='Seasonal')
plot(T,xlab='t',main='Trend')
plot(I,type='l',xlab='t',main='Irregular')
par(mfrow=c(1,1))
plot.ts(S + T + I)
```



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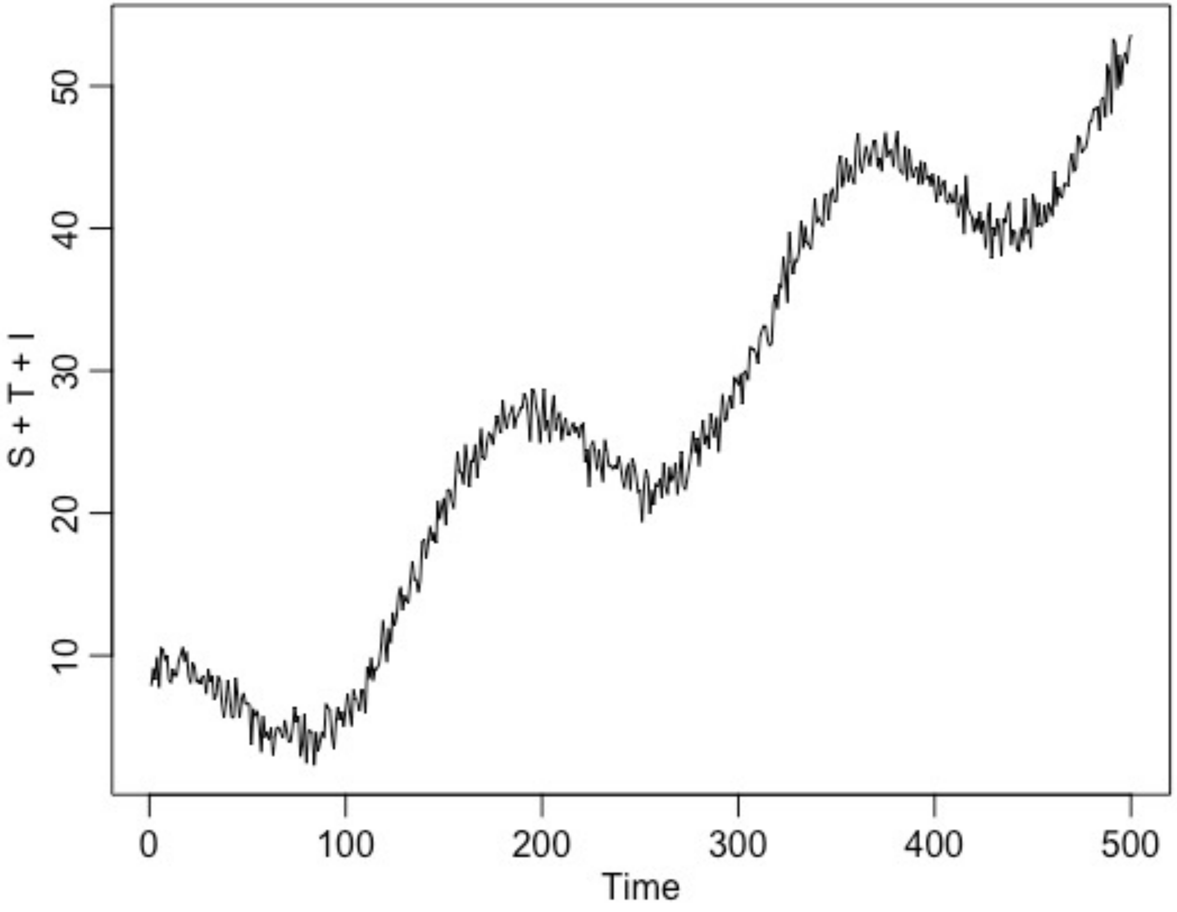

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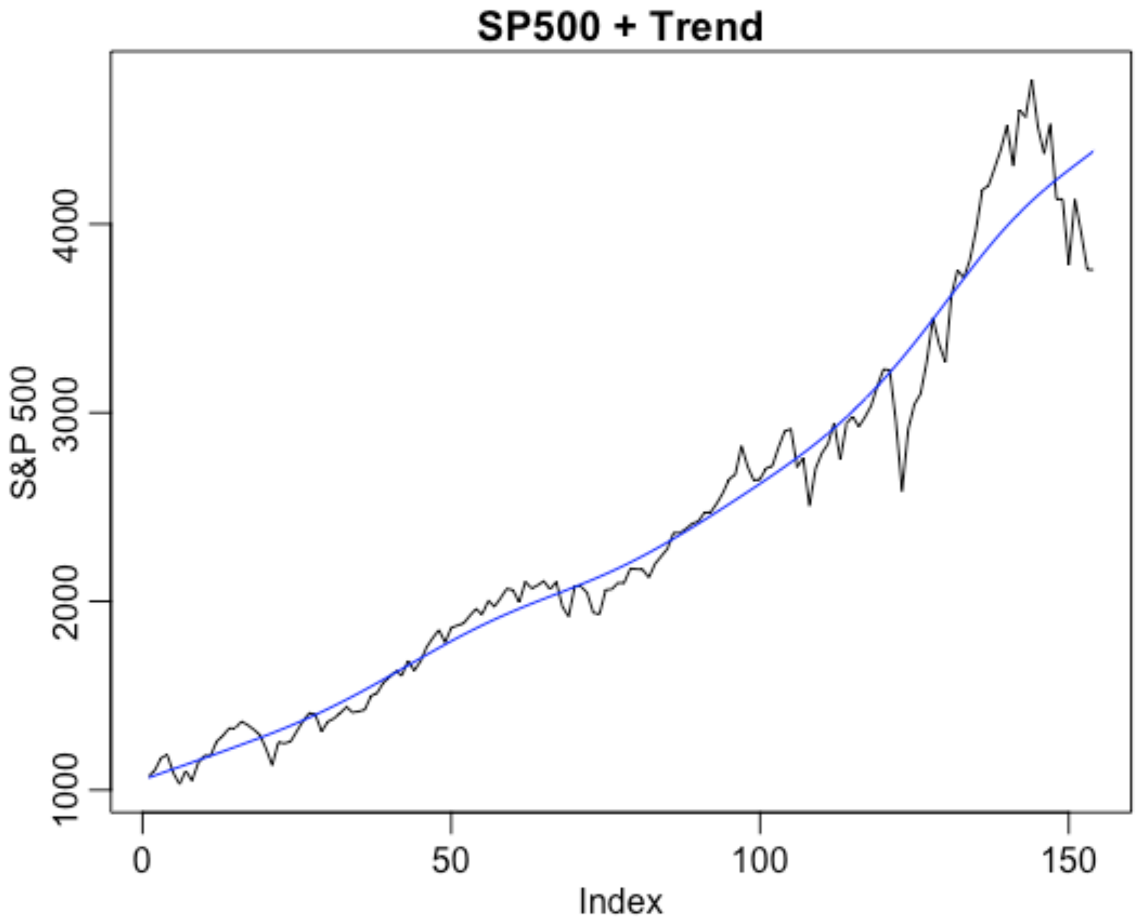
Time-series decomposition: Hodrick-Prescott Filter

- The Hodrick-Prescott (HP) filter allows to separate the trend and cyclic components for x_t.

```
#install.packages("mFilter")
library(mFilter)
HPF<-hpfilter(SP500,freq=14400,type="lambda")
plot(HPF$cycle,type = 'l')
plot(HPF$trend,type = 'l')
plot(HPF$x,type = 'l',ylab='S&P 500',main='SP500 + Trend')
lines(HPF$trend,col='blue')
```



Time-series differences

- First difference:

$$\Delta x_t = x_t - x_{t-1}$$

- Second difference:

$$\Delta^2 x_t = (x_t - x_{t-1}) - (x_{t-1} - x_{t-2})$$

Difference transformations are used to capture the seasonal component of the series

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Dummy variables

- D is a binary variable such that:
  - $D=1$ if the observation has specific characteristics.
  - $D=0$ if it does not have them.
- For example: $x_t = \beta_0 + \beta_1 z_t + \beta_2 D + \beta_3 D z_t$

$$D = 1 => x_t = (\beta_0 + \beta_2) + (\beta_1 + \beta_3) z_t$$

$$D = 0 => x_t = \beta_0 + \beta_1 z_t$$

Dummy variables can be used to change the slope and/or intercept in a linear model, which allows capturing seasonality namely (quarter or season)

Statistics and dependency measures

- Mean: $$\mu_x = \mathbb{E}\left(x_t\right) = \int_{-\infty}^{\infty} x f\left(x_t\right) \mathrm{d}x$$

- Autocovariance: $$\gamma_x\left(s,t\right) = \operatorname{cov}\left(x_t, x_s\right) = \mathbb{E}\left(x_t - \mu_{x_t}, x_s - \mu_{s_t}\right)$$

- Autocorrelation: $$-1 \leq \rho\left(s,t\right) = \frac{\gamma\left(s,t\right)}{\sqrt{\gamma\left(s,s\right)\gamma\left(t,t\right)}} \leq 1$$

ACF, measures the linear predictability of the series at time t; i.e., we predict x_t using only the value x_s.

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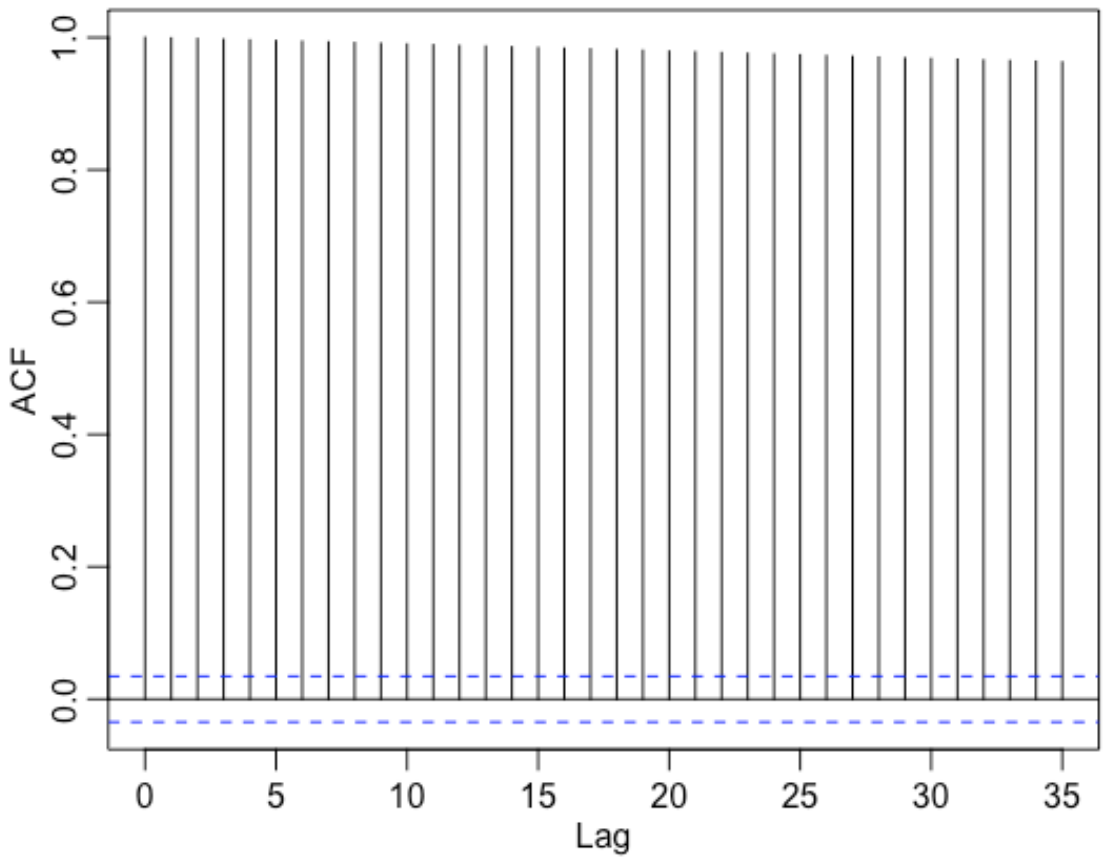
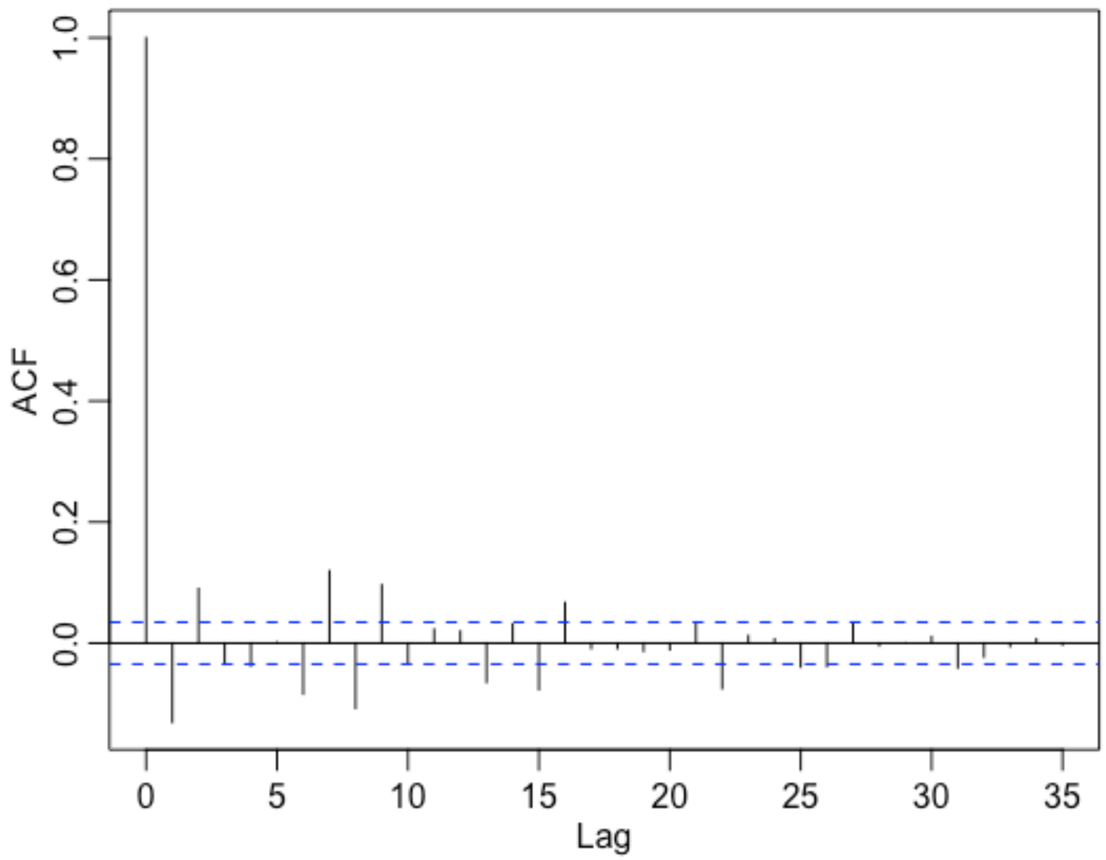



```
acf(SP500,na.rm = TRUE,na.action = na.pass)
```




```
acf(DlnSP500,na.rm = TRUE,na.action = na.pass)
```