Time Series Analysis (I)
Lecture 1: An Introduction to Time Series

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Sep. 10, 2015

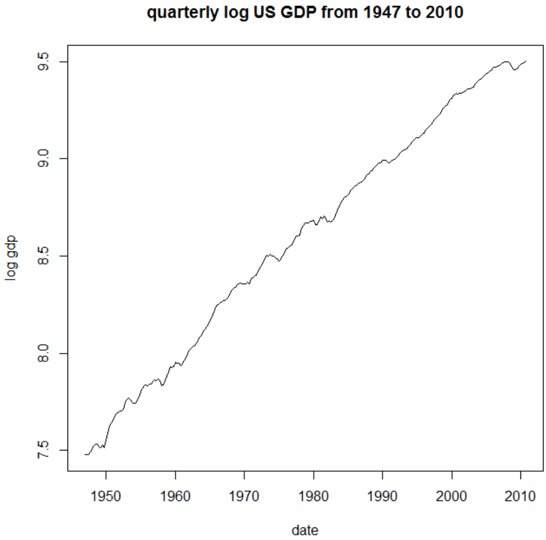
Today's Lecture

1. An Introduction to Time Series
2. Materials Review

What is Time Series Analysis?

- A time series is a sequence of data points, measured typically at successive points in time spaced at uniform time intervals;
- Examples of time series include tick data of stock prices, daily exchange rates, monthly interest rates, annual GDP growth rate etc.;
- Time series analysis provides statistical\econometrics tools for those time series data;
- Famous time series models/tools: ARIMA model, random walk, cointegration, error correction model, vector autoregressive model and ARCH/GARCH etc..

Some examples of time series data



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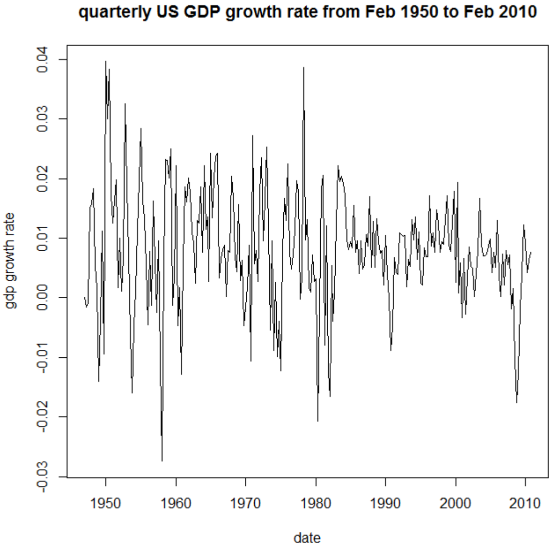

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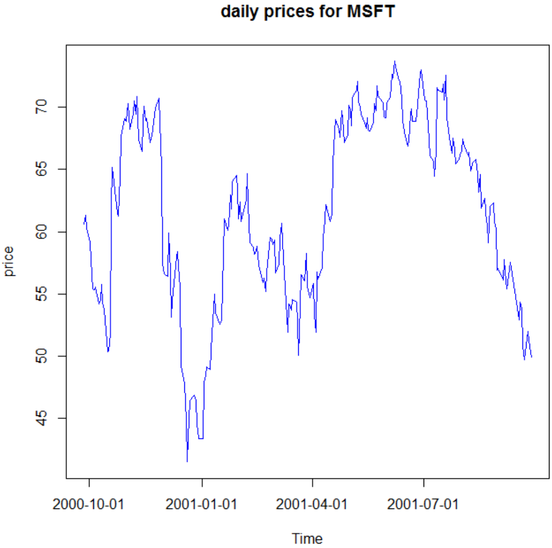

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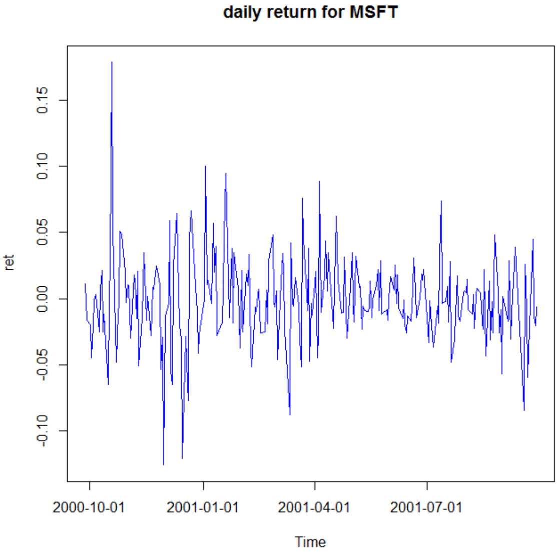
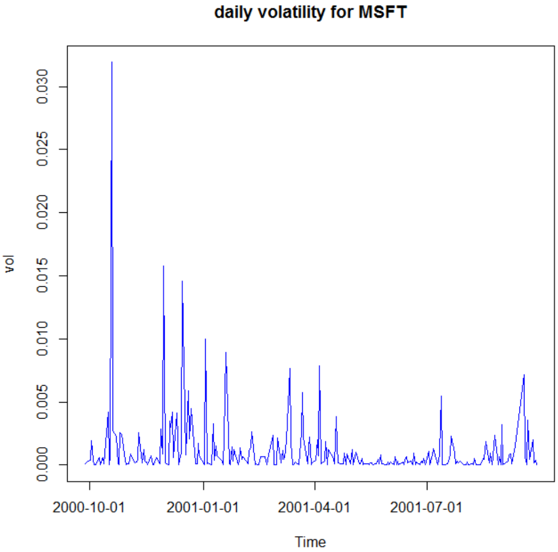


Some examples of time series data



The Importance of Time Series to Economics

- Time and uncertainty are two most important factors when economic agents make a decision;
- Time series econometrics provides statistical methods and tools to investigate dynamic relations in econonics/finance;
- Time series data are attractive to researchers as they show many interesting phenomena: asymmetry, time irreversibility, regime-shifts, volatility clustering, and jumps or outliers;
- In past two decades, a fast development of Time series from linear to nonlinear, stationary to nonstationary, univariate to multivariate.

The objective of time series econometrics

1. Examine how well economic and financial theory/models can explain the stylized facts of economic/financial phenomena (e.g., volatility clustering, seasonal effects)
2. Test the validity of economic and financial hypotheses (e.g., market Efficient Hypothesis)
3. Predict the future evolution of economic systems and financial markets using historical data (e.g., the prediction of business cycle turning points).
4. Make policy recommendations (e.g., program evaluations)

Time Series Modeling Procedures

- Step 1: Plot the time series, find trends, seasonal components, structural changes, outliers;
- Step 2: Transform data so that residuals are **stationary**
  - a) estimate and subtract the trend T_t and seasonal components S_t
  - b) differencing
  - c) Nonlinear transformations: take log or square root
- Step 3: Fit model to residuals

An example of time series analysis

```
rm(list = ls()) # remove everything in working environment.
setwd("E:/courses/time_series_2013fall/data"); # set working
directory
da=read.table("q-gdpc96.txt",header=T); #Load data with
header
dim(da) # Check dimension of the data (row=sample size,
col=number of variables)
head(da) # Print out the first 6 rows of the data object "da".
tail(da) # Print out the last 6 rows of the data object "da".
gdp=da[,4] #Select gdp value stored in Column 4.
lgdp=log(gdp);
require(graphics)
x <- ts(lgdp, start = c(1947, 1), end = c(2010, 4), frequency = 4)
# define a time series
m=decompose(x, type = c("additive"), filter = NULL)
m$figure
```

```
plot(m,xlab="date",ylab="lgdp")
plot.ts(x)
#cite packages for economics and finance data sources:
library(Ecdat)
# some popular packages for time series analysis functions
library(fBasics)
library(stats)
library(tseries)
```

Review of Probability and Statistics

See textbook page 704-750.

- Random Variables: discrete and continuous, density, distributions
- Population moments: mean and variance
- Sample moments
- Bias and efficiency
- Joint distribution
- Conditional distribution
- Law of Iterated Expectations

Review of Probability and Statistics

- Independence
- Correlation
- Relation between independence and correlation
- Orthogonality
- Normal distribution
- Likelihood function
- MLE

Review of Algebra and Calculus

- Trace and Determinant
- Inverse of a Matrix
- Linear Dependence
- Eigenvalues and Eigenvectors
- Jordan Decomposition
- Kronecker Products
- Positive Definite Matrix
- Partial Derivatives and gradient
- Second-order derivatives
- Taylor's Theorem with Multiple Arguments

Next Lecture: Basic Definitions

- **Time series data:** $\{y_t\}_{t=1}^{T}$; or $\{y_1, y_2, ..., y_T\}$ is a collection of observations indexed by the date of each observation
- eg: daily price sequence between 2000 Jan.1st and 2000 Dec.31st; daily temperature, yearly GDP growth rate, monthly CPI;
- some simple time series:
  - a time trend : $y_t = t$ or $y_t = a + bt$
  - a constant: $y_t = c$
  - a Gaussian white noise process: $y_t = \varepsilon_t$, where ε_t is $i.i.d$ N(0,1).

Lag Operators

- Lag Operator: $L: \ L(y_t) = y_{t-1}$; and $L^k(y_t) = y_{t-k}$
  Linear Operator: $L(ay_t + w_t) = ay_{t-1} + w_{t-1}$
- Difference equations:

$$\begin{aligned}
\text{First order} \quad &: \quad y_t = \phi y_{t-1} + w_t = \phi L y_t + w_t; \\
\text{Second order} \quad &: \quad y_t = \phi_1 y_{t-1} + \phi_2 y_{t-2} + w_t; \\
\text{P-th order} \quad &: \quad y_t = \phi_1 y_{t-1} + \phi_2 y_{t-2} +, \dots, + \phi_p y_{t-p} + w_t;
\end{aligned}$$