R

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To R is Human

1 R

R is a computing environment specially made for doing statistics/econometrics.
It is becoming the standard for advanced dealing with empirical data, also in finance.
Good parts

- It is freely available for download from the internet, and can be installed on a wide range of operating systems, such as Windows, Mac OS, Unix, etc.
- There is a large number of packages available for specialized purposes, also freely dowloadable from the web.

Some issues with R

- It is command-driven, and learning to use it to its full extent takes some time and effort.
- The documentation is comprehensive, but not always easy to navigate. It is sometimes necessary to do a bit of googling before one finds examples of how somebody else has peformed a particular task.
- Since anybody can contribute their own specialized packages, there are several packages doing the same (or similar) things, leading to some confusion among the potential package users.
  – Over time may expect to see some convergence to "standard" packages for various things.
  Example: Time series handlers.

2 Introduction

Look at the simple introduction to using R

2.1 Input

Data is usually read in, but can also be specified in R:

```
> data <- c(1, 2, 3, 4, 5, 4, 3, 2, 1)
```

Note the $<-$, which is the assignment operator in R. An equality sign can be used in some cases, but to be on the safe side, stick to $<-$.

To get data in otherwise, typically read into tables from text files, see later examples

```
> data <- read.table(file,...)
> data <- read.csv(file,...)
```

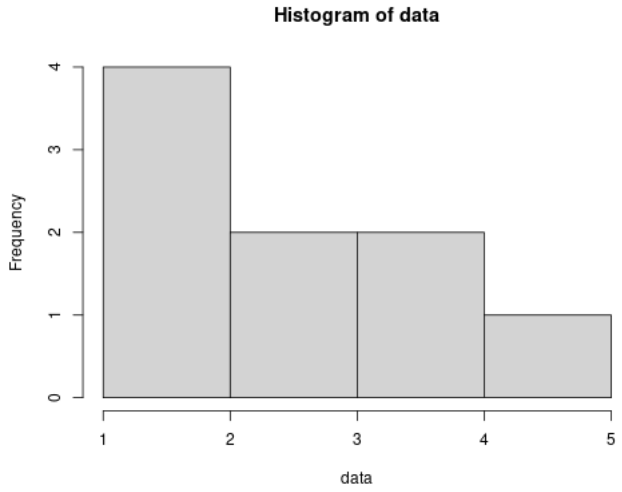
2.2 Basic Statistics

```
> data <- c(1, 2, 3, 4, 5, 4, 3, 2, 1)
> mean(data)
[1] 2.777778
> summary(data)
   Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
  1.000   2.000   3.000   2.778   4.000   5.000
```

2.3 Describing data

Pictures always nice, e.g. Histogram

```
> hist(data)
```

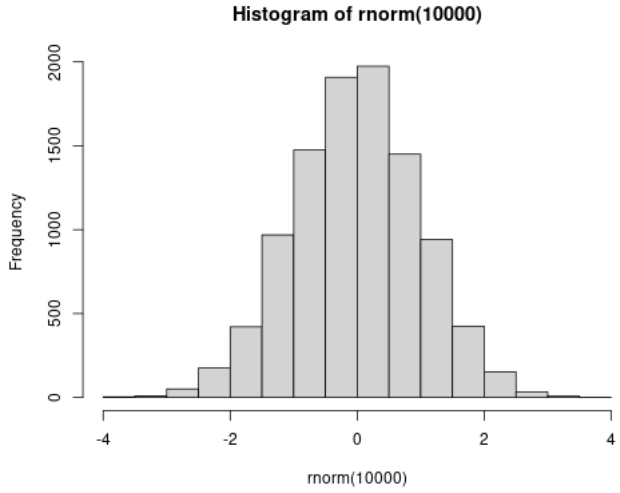


2.4 Simulating data

Specify probability distribution, e.g. normal
Simulate 1000 random N(0,1) numbers

```
> rnorm(1000)
```

Let us show the restult of the simulation in a histogram



2.5 Regression

Consider the standard regression equition

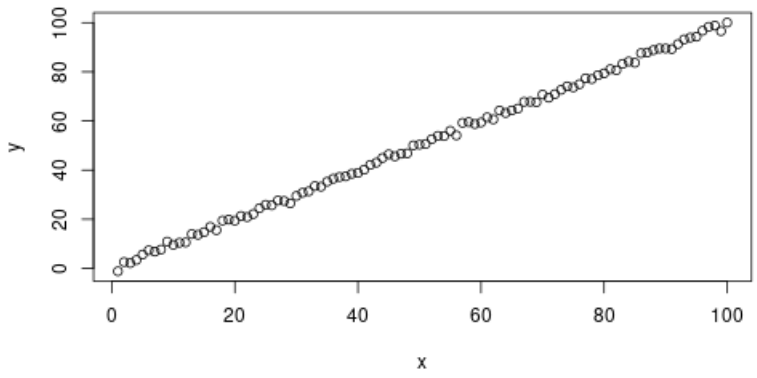
$$y = a + bx + \varepsilon$$

Let us simulate this regression with $a = 0, b = 1$ and $\varepsilon \sim N(0, 1)$, where $x = 1, 2, \cdot 100$:

```
> x <- 1:100
> y=x+rnorm(100)
```

Plot the resulting simulated values

```
> plot(x,y)
```



Perform the regression

```
> regr <- lm(y~x)
```

To actually get the results specify what you want
Summary:

```
> summary(regr)

Call:
lm(formula = y ~ x)

Residuals:
     Min       1Q   Median       3Q      Max
-1.93989 -0.54106  0.03258  0.43836  2.25277

Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept) -0.065595   0.172075  -0.381    0.704
x            1.000924   0.002958 338.351   <2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.8539 on 98 degrees of freedom
Multiple R-squared: 0.9991,Adjusted R-squared: 0.9991
F-statistic: 1.145e+05 on 1 and 98 DF,  p-value: < 2.2e-16
```

Lots of other interesting output, such as variance covariance matrix

```
> vcov(regr)
              (Intercept)             x
(Intercept)  0.0425121439 -6.345096e-04
x           -0.0006345096  1.256455e-05
```

and ANOVA analysis

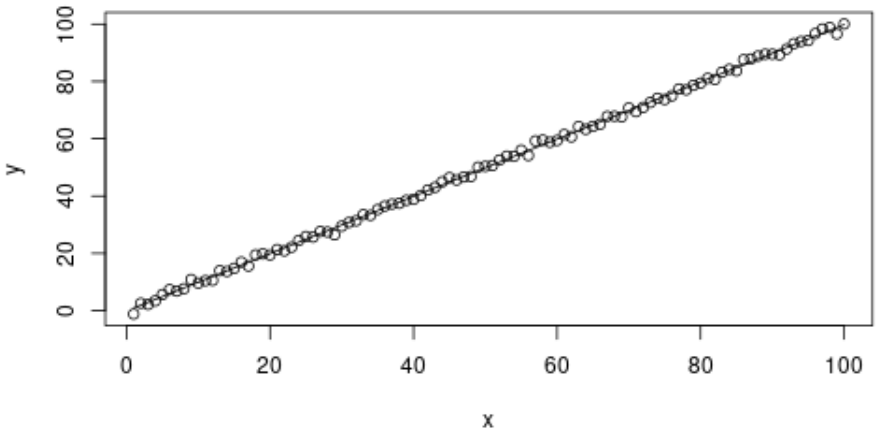
```
> anova(regr)
Analysis of Variance Table

Response: y
          Df Sum Sq Mean Sq F value    Pr(>F)
x          1  83574   83574   79827 < 2.2e-16 ***
Residuals 98    103       1
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
```

Do of course want to investigate fit further. An obvious in univariate regressions is to compare observations to fit. Use the fitted values for the regression in the same plot

Note that the plotting comand is in two parts, the scatterplot and the lines:

```
> plot(x,y)
> lines(x,fitted(regr))
```



Once one have results, also want to export them to text processing tools. For example, for the LaTeXusers, library `xtable`

```
library(xtable)
xtable(regr)
```

Giving the output table

	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	-0.0656	0.1721	-0.38	0.7039
x	1.0009	0.0030	338.35	0.0000

3 Libraries

The `xtable` command:

An example of the use of a *library*, an extension of basic `R`.

The number of such libraries is very large, and one needs to spend some time on *CRAN* (comprehensive R archive network) searching for it.

Once one have identified the R libraries to get, they need to be installed.

One-time occurance, and many of the more common R libraries are typically installed by default. (Check your installation)

Otherwise it is a matter of using the command:

```
> install.packages(c("xtable"))
```

Depending on the platform you are at, you will be asked where to download from and where to place the resulting library.

4 Libraries for time series

To illustrate the issues regarding R libraries, let us look at the case of organizing time series data.

This is one of the most common tasks confronting financial (and other) econometricians.

A time series is an ordered series of observations indexed by a date. If there are multiple observations on a date, also use the time of observation as well as the date. There are a number of operations typically involved when dealing with time series:

- Aligning on date - Two or more time series, pick only those dates where have observations of all, and place the observations on the same place in each time series
- Changing frequency - E.g. from daily to monthly. Issue: Monthly average or last observation?
- Lead - Lag operations
- ...

Since these are common observations, they belong in a library.
So, good part of R: Of course there is a library.
But, bad part of R: There are lots of different libraries, not always compatible.
Illustrate some of the more common libraries (There are many others).

- Most basic: `ts`, part of standard *R*. can only hold data at given frequencies (monthly, quarterly, annual)
- Most common library: `zoo`: Indexing by date. Special case when having regular (fixed frequency) observations: `zooreg`
- Integrate various time series libraries, try to make interoperable: `xts`. Very good for picking subperiods.

Will illustrate some usage using a time series of stock prices for the Norwegian company *Akers Mekaniske Verksted*

30	12	1910	500
22	12	1911	690
20	12	1912	750
31	12	1913	805
31	12	1914	640
31	12	1915	760

In R, will be reading the file `aker.txt`:

```
 Date    Price
30.12.1910 500
22.12.1911 690
20.12.1912 750
31.12.1913 805
31.12.1914 640
31.12.1915 760
```

Using the standard time series package `ts`:

```
> data <- read.table("../data/aker.txt",header=TRUE)
> aker <- ts(data$Price,frequency=1,start=1910)
> print(aker)
Time Series:
Start = 1910
End = 1915
Frequency = 1
[1] 500 690 750 805 640 760
```

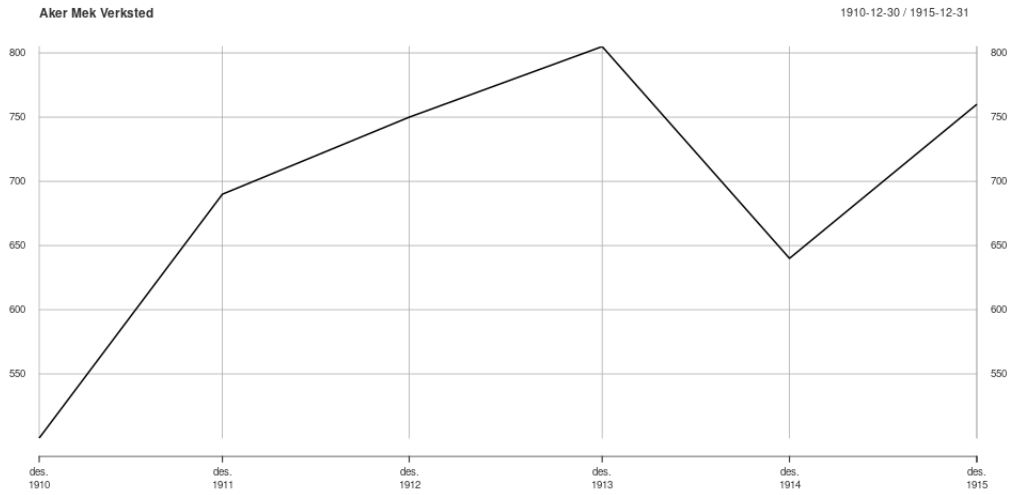
Let us do the same in zoo:

```
> library(zoo)
> akerZ <- read.zoo("../data/aker.txt",format="%d.%m.%Y",header=TRUE)
> akerZ
1910-12-30 1911-12-22 1912-12-20 1913-12-31 1914-12-31 1915-12-31
       500        690        750        805        640        760
```

Getting an `xts` object is typically done by converting another

```
> library(xts)
> akerX <- as.xts(akerZ)
> print(akerX)
           [,1]
1910-12-30  500
1911-12-22  690
1912-12-20  750
1913-12-31  805
1914-12-31  640
1915-12-31  760
```

Here is an example of a time series plot, using the `xts` plotting routine



5 Using R to access data directly

For some internet sources of data, there are routines that lets R directly access and import this data, almost magically.

One such routine is in the library `quantmod`, which can import various time series of interest for finance and economics, such as

- Yahoo finance – individual stocks, etc
- FRED – St Louis Fed database of macroeconomic variables

If one knows the names of the series it is a simple matter of the following sequence of R commands to get the time series of Ford (`F`) from Yahoo Finance and JPY/USD exchange rates (DEXJPUS) from the St Louis Fed Fred database

```
library(quantmod)
getSymbols("F")
getSymbols("DEXJPUS",src="FRED")
```

Note that yahoo finance is the default data source.

Let us see how to access the data afterwords:

```
> library(quantmod)
> getSymbols("F")
> head(F)
           F.Open F.High F.Low F.Close F.Volume F.Adjusted
2007-01-03   7.56   7.67  7.44    7.51 78652200       7.12
2007-01-04   7.56   7.72  7.43    7.70 63454900       7.30
2007-01-05   7.72   7.75  7.57    7.62 40562100       7.23
2007-01-08   7.63   7.75  7.62    7.73 48938500       7.33
2007-01-09   7.75   7.86  7.73    7.79 56732200       7.39
2007-01-10   7.79   7.79  7.67    7.73 42397100       7.33
> summary(F)
     Index                F.Open          F.High          F.Low
 Min.   :2007-01-03   Min.   : 1.31   Min.   : 1.55   Min.   : 1.010
 1st Qu.:2008-10-26   1st Qu.: 7.60   1st Qu.: 7.74   1st Qu.: 7.478
 Median :2010-08-21   Median :10.51   Median :10.68   Median :10.350
 Mean   :2010-08-21   Mean   :10.42   Mean   :10.56   Mean   :10.252
 3rd Qu.:2012-06-14   3rd Qu.:13.42   3rd Qu.:13.59   3rd Qu.:13.260
 Max.   :2014-04-11   Max.   :18.81   Max.   :18.97   Max.   :18.610
    F.Close         F.Volume           F.Adjusted
 Min.   : 1.26   Min.   : 12102200   Min.   : 1.200
 1st Qu.: 7.59   1st Qu.: 36805875   1st Qu.: 7.200
 Median :10.56   Median : 50419900   Median :10.050
 Mean   :10.40   Mean   : 62105359   Mean   : 9.983
 3rd Qu.:13.42   3rd Qu.: 71055475   3rd Qu.:12.940
 Max.   :18.79   Max.   :541175600   Max.   :17.830
> getSymbols("DEXJPUS",src="FRED")
> head(DEXJPUS)
           DEXJPUS
1971-01-04  357.73
1971-01-05  357.81
1971-01-06  357.86
1971-01-07  357.87
1971-01-08  357.82
1971-01-11  357.95
> summary(DEXJPUS)
     Index               DEXJPUS
 Min.   :1971-01-04   Min.   : 75.72
 1st Qu.:1981-10-27   1st Qu.:108.24
 Median :1992-08-19   Median :127.80
 Mean   :1992-08-19   Mean   :165.52
 3rd Qu.:2003-06-12   3rd Qu.:233.50
 Max.   :2014-04-04   Max.   :358.44
                      NA's   :433
```

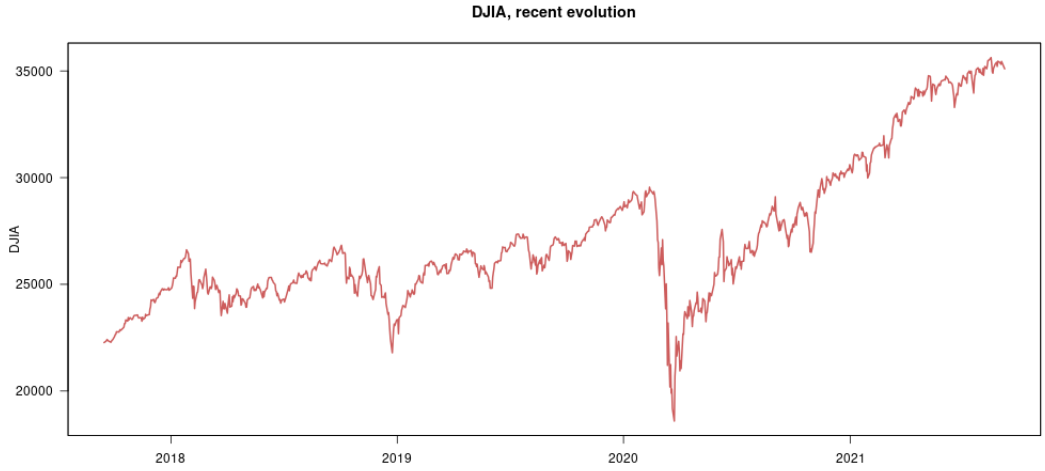
As these two examples show, the type of the resulting output depend on where the data is gotten from. If it is yahoo finance, get several columns, with the obvious time series data for asset price records (open, close, high, low, volume, adjusted close), if it is FRED it is just one time series.

Let us show one more example, of how one can set up R to produce updated pictures of e.g. the Dow Jones index for the last year, a picture which is updated each time the little file of code is executed.

```
outdir <- "../../results/2018_03_plot_current/"
library(quantmod)
```

```
library(xts)
getSymbols("^DJI")
dj <- xts(as.vector(DJI$DJI.Close),
          order.by=index(DJI))
names(dj) <- "dj"
n <- length(dj)
dj <- dj[(n-1000):n,]
filename <- paste0(outdir,"djia_recent_evolution.png")
png(filename, width=1000, height=500)
plot.zoo(dj,
         col=c("indianred"),
         main="DJIA, recent evolution",
         ylab="DJIA",
         lwd=2,
         lty=1,
         las=1,
         xlab="")
dev.off()
```

And you can put up a plot of the most recent Dow Jones evolution

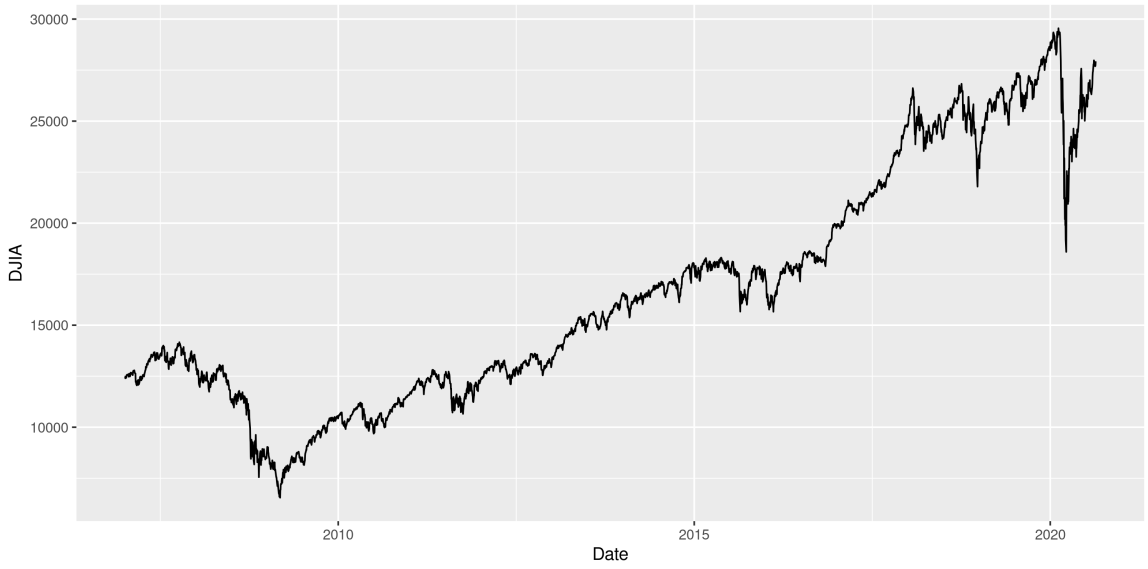


6 Plotting - ggplot2

Another useful library is the plotting library, ggplot2, which offers a unified view of graphics.

Here, for example, is a piece of code which plots the last year of the Dow Jones

```
outdir <- "../../results/2019_05_ggplot2/"
library(ggplot2)
library(quantmod)
getSymbols("^DJI") #using yahoo finance as the source for the DJIA
summary(DJI)
ggplot(data=DJI, mapping=aes(x=Index,y=DJI.Adjusted)) +
    geom_line() +
    theme_gray() +
    labs(x="Date",y="DJIA")
filename <- paste0(outdir,"djia_current.png")
ggsave(filename,width=10,height=5)
```



7 Documentation

Using R, need to look up documentation.
Options

- When learning R, keep a couple of books on your shelf.
  Examples: *The R book / R in a nutshell*
- Help in R: "?" command - but need to know command
- Internet: CRAN
  - Manuals
  - Task views
  - Package documentation: How to use the functions provided by the package.
- Internet: Googling

8 Readings

Summary of time series issues:
Working with time series