

# How to Use the R Programming Language for Statistical Analyses An Introduction to R

(diperkaya dari beberapa sumber tutorial R)

# What Is R?

- a programming “environment”
- object-oriented
- similar to S-Plus
- freeware
- provides calculations on matrices
- excellent graphics capabilities
- supported by a large user network

# What is R Not?

- a statistics software package
- menu-driven
- quick to learn
- a program with a complex graphical interface

# Installing R

- [www.r-project.org/](http://www.r-project.org/)
- download from CRAN
- select a download site
- download the base package at a minimum
- download contributed packages as needed



# The R Project for Statistical Computing

## Important News:

The R Development Core Team would like to formally announce the creation of the

### [R Foundation for Statistical Computing](#)

There are many reasons for this decision on our part, largely it is based on the belief that R has become a mature and valuable tool and we would like to ensure its continued development and the development of future innovations in software for statistical and computational research.

The R Foundation is a not for profit foundation whose general goals are to provide support for the R project and other innovations in statistical computing. The R Foundation will provide a reference point for individuals, institutions or commercial enterprises that want to support or interact with the R development community.

We would like to solicit memberships from interested parties (individual and institutional) in the R Foundation. Details regarding fees and membership categories can be obtained from the web site and email enquiries can be sent to [R-foundation@R-project.org](mailto:R-foundation@R-project.org).

Among the goals of the Foundation are the support of continued development of R, the exploration of new methodology, teaching and training of statistical computing and the organization of meetings and conferences with a statistical computing orientation. We hope to attract sufficient funding to make these goals realities.

For the R Development Core Team:

Robert Gentleman & Ross Ihaka  
Presidents, R Foundation

Friedrich Leisch  
Secretary General, R Foundation

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- [FAQs](#)
- [Contributed](#)
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Switzerland	
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<a href="http://lib.stat.cmu.edu/R/CRAN/">http://lib.stat.cmu.edu/R/CRAN/</a>	Statlib, Carnegie Mellon University, Pittsburgh, PA
<a href="http://cran.mirrors.pair.com/">http://cran.mirrors.pair.com/</a>	Pair Networks, Pittsburgh, PA
<a href="http://www.binarycode.org/cran">http://www.binarycode.org/cran</a>	BinaryCode.org, Austin, TX
<a href="http://mirrors.theonlinerecordstore.com/CRAN/">http://mirrors.theonlinerecordstore.com/CRAN/</a>	The Online Record Store, Houston, TX

Many of these sites can also be accessed using FTP. In addition, several [StatLib](#) mirrors around the world provide a complete CRAN mirror. Please let us know if you want your server being added to the list of mirrors.

The CRAN master site at TU Wien, Austria, can be found at the URLs

<http://cran.r-project.org>  
<ftp://cran.r-project.org/pub/R/>  
rsync: cran.r-project.org::CRAN

To "submit" to CRAN, simply upload to <ftp://cran.r-project.org/incoming> and send email to [cran@r-project.org](mailto:cran@r-project.org). Please indicate the copyright situation (GPL, ...) in your submission.

Last modified: July 4, 2003 by Friedrich Leisch



# The Comprehensive R Archive Network

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[R Homepage](#)

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[R Sources](#)  
[R Binaries](#)  
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[Manual](#)  
[FAQs](#)  
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### Precompiled Binary Distributions

Base system and contributed packages. **Windows and Mac** users most likely want these versions of R.

- [Linux](#)
- [MacOS \(System 8.6 to 9.1 and MacOS X\)](#)
- [MacOS X \(Darwin/X11\)](#)
- [Windows \(95 and later\)](#)

### Source Code for all Platforms

Windows and Mac users most likely want the precompiled binaries listed in the upper box, not the source code. The sources have to be compiled before you can use them. If you do not know what this means, you probably do not want to do it!

- **Source code** of the latest release (2003-06-16): [R-1.7.1.tgz](#) (read what's [new](#) in the latest version).
- **Source code** of [contributed packages](#)
- Current patch set (daily snapshot): [R-release.diff.gz](#).

## what are R and CRAN?

R is 'GNU S', a freely available language and environment for statistical computing and graphics which provides a wide variety of statistical and graphical techniques: linear and nonlinear modelling, statistical tests, time series analysis, classification, clustering, etc.



# R for windows

This directory contains binaries for a base distribution and packages to run on Windows (NT, 95 and later) on Intel and clones (but not NT on Alpha and other platforms).

Note: CRAN does not have Windows systems and cannot check these binaries for viruses. Use the normal precautions with downloaded executables.

Subdirectories:

- [base](#) Binaries for base distribution (managed by Duncan Murdoch)
- [contrib](#) Binaries of contributed packages (managed by Uwe Ligges)
- [unsupported](#) Unsupported or obsolete packages

Please send contributions to Duncan Murdoch or Uwe Ligges, not to CRAN.

You may also want to read the [R FAQ](#) and [R for Windows FAQ](#).

Last modified: June 3, 2003, by Friedrich Leisch

CRAN  
[Mirrors](#)  
[What's new?](#)  
[Search](#)

About R  
[R Homepage](#)

Software  
[R Sources](#)  
[R Binaries](#)  
[Package Sources](#)  
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Documentation  
[Manual](#)  
[FAQs](#)  
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Related Projects  
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# Tutorials

- From R website under “Documentation”
  - “Manual” is the listing of official R documentation
    - An Introduction to R
    - R Language Definition
    - Writing R Extensions
    - R Data Import/Export
    - R Installation and Administration
    - The R Reference Index

# Tutorials cont.

- “Contributed” documentation are tutorials and manuals created by R users
  - Simple R
  - R for Beginners
  - Practical Regression and ANOVA Using R
- R FAQ
- Mailing Lists (listserv)
  - r-help

# Tutorials cont.

- Textbooks

- Venables & Ripley (2002) *Modern Applied Statistics with S*. New York: Springer-Verlag.
- Chambers (1998). *Programming With Data: A guide to the S language*. New York: Springer-Verlag.

# R Basics

- objects
- naming convention
- assignment
- functions
- workspace
- history

# Objects

- names
- types of objects: vector, factor, array, matrix, data.frame, ts, list
- attributes
  - mode: numeric, character, complex, logical
  - length: number of elements in object
- creation
  - assign a value
  - create a blank object

# Naming Convention

- must start with a letter (A-Z or a-z)
- can contain letters, digits (0-9), and/or periods “.”
- case-sensitive
  - `mydata` different from `MyData`
- do not use underscore “\_”

# Assignment

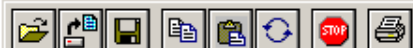
- “<-” used to indicate assignment
  - `x<-c(1,2,3,4,5,6,7)`
  - `x<-c(1:7)`
  - `x<-1:4`

# Functions

- actions can be performed on objects using functions (note: a function is itself an object)
- have arguments and options, often there are defaults
- provide a result
- parentheses () are used to specify that a function is being called



Let's look at R



R : Copyright 2003, The R Development Core Team

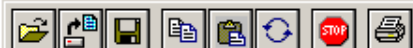
Version 1.7.0 (2003-04-16)

R is free software and comes with ABSOLUTELY NO WARRANTY.  
You are welcome to redistribute it under certain conditions.  
Type `'license()'` or `'licence()'` for distribution details.

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Type `'contributors()'` for more information.

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> █



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```
> library("MASS")
```

```
> █
```



```
R Console
R : Copyright 2003, The R Devel
Version 1.7.0 (2003-04-16)

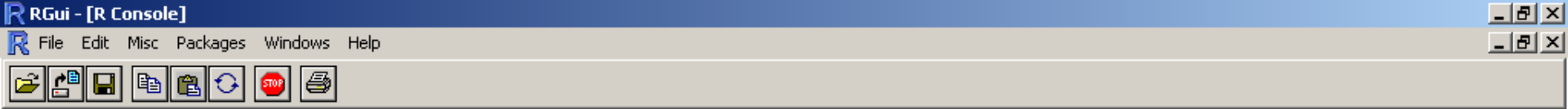
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Type `q()' to quit R.

> library("MASS")
> data()
> █
```

R data sets	
volcano	Topographic Information on Auckland's Maunga W\$
warpbreaks	The Number of Breaks in Yarn during Weaving
women	Average Heights and Weights for American Women
Data sets in package 'MASS':	
abbey	Determinations of Nickel Content
accdeaths	Accidental Deaths in the US 1973-1978
Aids2	Australian AIDS Survival Data
Animals	Brain and Body Weights for 28 Species
anorexia	Anorexia Data on Weight Change
austres	Quarterly Time Series of the Number of Austral\$
bacteria	Presence of Bacteria after Drug Treatments
beav1	Body Temperature Series of Beaver 1
beav2	Body Temperature Series of Beaver 2
biopsy	Biopsy Data on Breast Cancer Patients
birthwt	Risk Factors Associated with Low Infant Birth \$
Boston	Housing Values in Suburbs of Boston
cabbages	Data from a cabbage field trial
caith	Colours of Eyes and Hair of People in Caithness
Cars93	Data from 93 Cars on Sale in the USA in 1993
cats	Anatomical Data from Domestic Cats
cement	Heat Evolved by Setting Cements
chem	Copper in Wholemeal Flour
coop	Co-operative Trial in Analytical Chemistry
cpus	Performance of Computer CPUs
crabs	Morphological Measurements on Leptograpsus Cra\$
Cushings	Diagnostic Tests on Patients with Cushing's Sy\$
DDT	DDT in Kale
deaths	Monthly Deaths from Lung Diseases in the UK



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Type `'q()'` to quit R.

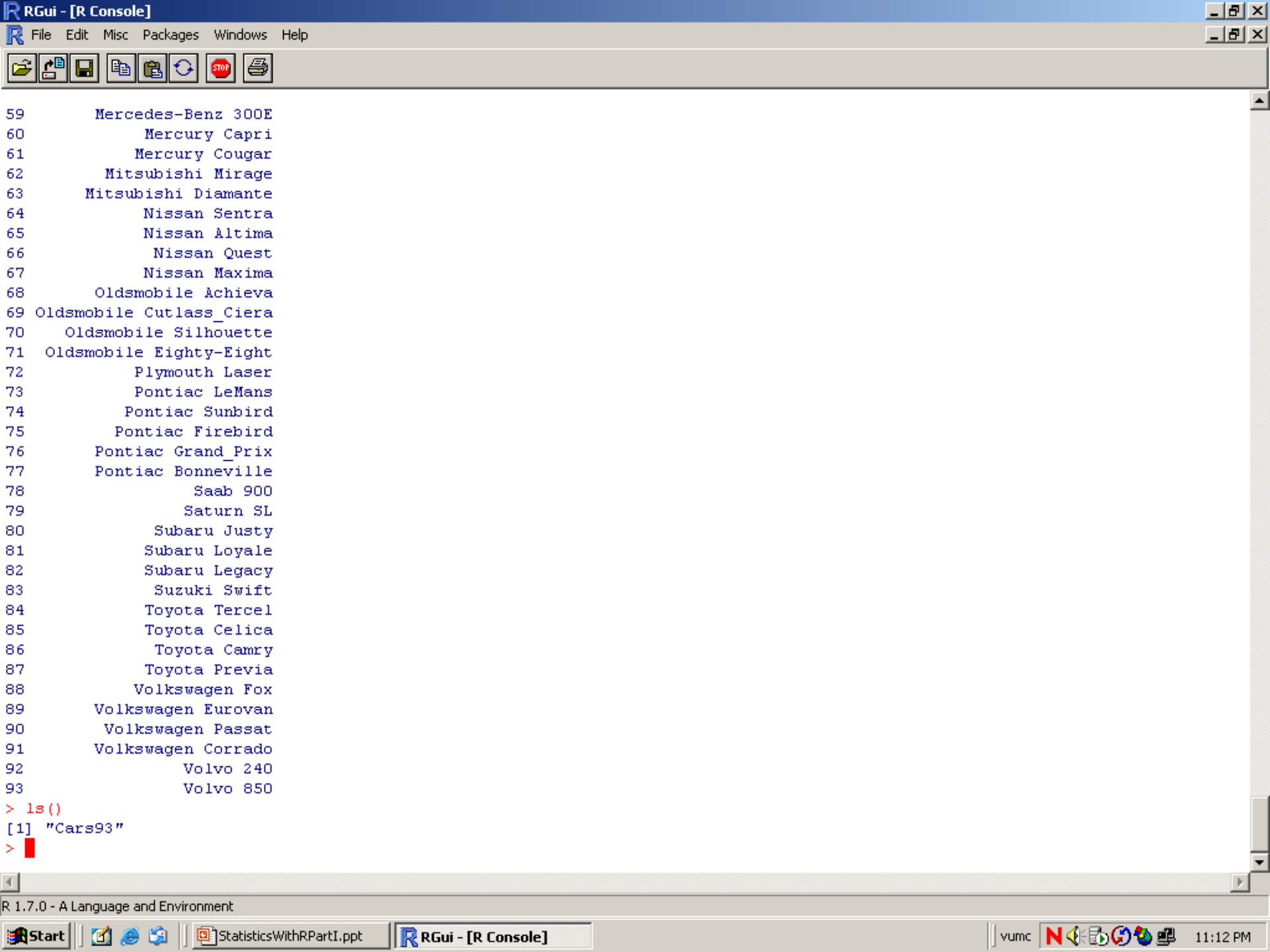
```
> library("MASS")  
> data()  
> data(Cars93)  
> Cars93
```

	Manufacturer	Model	Type	Min.Price	Price	Max.Price	MPG.city
1	Acura	Integra	Small	12.9	15.9	18.8	25
2	Acura	Legend	Midsize	29.2	33.9	38.7	18
3	Audi	90	Compact	25.9	29.1	32.3	20
4	Audi	100	Midsize	30.8	37.7	44.6	19
5	BMW	535i	Midsize	23.7	30.0	36.2	22
6	Buick	Century	Midsize	14.2	15.7	17.3	22
7	Buick	LeSabre	Large	19.9	20.8	21.7	19
8	Buick	Roadmaster	Large	22.6	23.7	24.9	16
9	Buick	Riviera	Midsize	26.3	26.3	26.3	19
10	Cadillac	DeVille	Large	33.0	34.7	36.3	16
11	Cadillac	Seville	Midsize	37.5	40.1	42.7	16
12	Chevrolet	Cavalier	Compact	8.5	13.4	18.3	25
13	Chevrolet	Corsica	Compact	11.4	11.4	11.4	25
14	Chevrolet	Camaro	Sporty	13.4	15.1	16.8	19
15	Chevrolet	Lumina	Midsize	13.4	15.9	18.4	21
16	Chevrolet	Lumina_APV	Van	14.7	16.3	18.0	18
17	Chevrolet	Astro	Van	14.7	16.6	18.6	15
18	Chevrolet	Caprice	Large	18.0	18.8	19.6	17

# R Workspace & History

# Workspace

- during an R session, all objects are stored in a temporary, working memory
- list objects
  - `ls()`
- remove objects
  - `rm()`
- objects that you want to access later must be saved in a “workspace”
  - from the menu bar: File->save workspace
  - from the command line: `save(x, file="MyData.Rdata")`



```
59 Mercedes-Benz 300E
60 Mercury Capri
61 Mercury Cougar
62 Mitsubishi Mirage
63 Mitsubishi Diamante
64 Nissan Sentra
65 Nissan Altima
66 Nissan Quest
67 Nissan Maxima
68 Oldsmobile Achieva
69 Oldsmobile Cutlass_Ciera
70 Oldsmobile Silhouette
71 Oldsmobile Eighty-Eight
72 Plymouth Laser
73 Pontiac LeMans
74 Pontiac Sunbird
75 Pontiac Firebird
76 Pontiac Grand_Prix
77 Pontiac Bonneville
78 Saab 900
79 Saturn SL
80 Subaru Justy
81 Subaru Loyale
82 Subaru Legacy
83 Suzuki Swift
84 Toyota Tercel
85 Toyota Celica
86 Toyota Camry
87 Toyota Previa
88 Volkswagen Fox
89 Volkswagen Eurovan
90 Volkswagen Passat
91 Volkswagen Corrado
92 Volvo 240
93 Volvo 850
```

```
> ls()
[1] "Cars93"
>
```



# History

- command line history
- can be saved, loaded, or displayed
  - `savehistory(file="MyData.Rhistory")`
  - `loadhistory(file="MyData.Rhistory")`
  - `history(max.show=Inf)`
- during a session you can use the arrow keys to review the command history



```
R Console  
73 Pontiac LeMans  
74 Pontiac Sunbird  
75 Pontiac Firebird  
76 Pontiac Grand_Prix  
77 Pontiac Bonneville  
78 Saab 900  
79 Saturn SL  
80 Subaru Justy  
81 Subaru Loyale  
82 Subaru Legacy  
83 Suzuki Swift  
84 Toyota Tercel  
85 Toyota Celica  
86 Toyota Camry  
87 Toyota Previa  
88 Volkswagen Fox  
89 Volkswagen Eurovan  
90 Volkswagen Passat  
91 Volkswagen Corrado  
92 Volvo 240  
93 Volvo 850  
  
> ls()  
[1] "Cars93"  
> history(max.show=Inf)  
> █
```

```
R History  
  
library("MASS")  
data()  
data(Cars93)  
Cars93  
ls()  
history(max.show=Inf)
```

Two most common object types for statistics:

matrix

data frame

# Matrix

- a matrix is a vector with an additional attribute (`dim`) that defines the number of columns and rows
- only one mode (numeric, character, complex, or logical) allowed
- can be created using `matrix()`

```
x<-matrix(data=0,nr=2,nc=2)
```

or

```
x<-matrix(0,2,2)
```

```
x=matrix(c(1,2,3,4,5,6,7,8,9),nr=3,nc=3)
```

# Data Elements

- select only one element
  - `x[2]`
- select range of elements
  - `x[1:3]`
- select all but one element
  - `x[-3]`
- slicing: including only part of the object
  - `x[c(1, 2, 5)]`
- select elements based on logical operator
  - `x(x>3)`

# Basic Statistics

1. Qualitative Data
2. Quantitative Data
  - a. Descriptive
  - b. Classification
  - c. Plotting
  - d. Variance
  - e. Analysis of Variance

# Exercise

- **Open library** : `data (airquality)`
- **Select column Ozone** : `airquality$Ozone`
- **Several descriptive calculation:**
  - `mean ()`
  - `median ()`
  - **Range** : `max ()` and `min ()` **or** `range ()`
  - `quantile ()`
  - **Percentile** : `quantile (data, c (P1, P2, P3, ...))`
  - **Standard Deviation** : `sd ()`
  - **Correlation** : `cor (x, y)`
  - `summary ()`

# Exercise

- **Open library** : `data(airquality)`
- **Select coloumn Ozone** : `airquality$Ozone`
  - **Range** : `max()` and `min()` or `range()`
  - `class<-seq(a,b,by=..)`
  - `A.cut<-cut(A,class,right=FALSE)`



# Exercise

- Plotting several information:
  - Histogram : `hist ()`
  - Barplot : `barplot ()`
    - `color=c ("red", "yellow", "green", "blue", "cyan")`
    - `barplot (... , col=color)`
  - Pie Chart : `pie ()`
  - Scatter plot : `plot (x, y)`
  - Boxplot: `boxplot (x, y)`
  - Cumulative Plot : `plot (x, y); x = class, y=c (0, cumsum ())`

# STATISTIK INFERENSIAL

---

# Estimasi -1

We take a sample from a population to learn about (i.e., estimate) population parameters such as:

Population Parameter:	Mean $\mu$	Prop. $\pi$	Std. Dev. $\sigma$	Corr. $\rho$	Slope $\beta$
Estimate or Statistic:	$\hat{\mu} = \bar{x}$	$\hat{\pi} = p$	$\hat{\sigma} = s$	$\hat{\rho} = r$	$\hat{\beta} = b$

$\bar{x} = \frac{1}{n} \sum_{i=1}^n x_i$  is the sample mean (average)

$p$  is the sample proportion

$s = \sqrt{\frac{1}{n-1} \sum_{i=1}^n (x_i - \bar{x})^2}$  is the sample standard deviation

$r$  is the sample correlation coefficient

$b$  is the estimated slope in a linear regression model

# Estimasi -2

$$\text{var}(\bar{X}) = \text{var}\left(\frac{1}{n} \sum_{i=1}^n X_i\right) = \frac{1}{n^2} \sum_{i=1}^n \text{var}(X_i) = \frac{1}{n^2} \sum_{i=1}^n \sigma^2 = \frac{\sigma^2}{n}$$

- Hence, the standard deviation of the sample mean is

$$\sqrt{\text{var}(\bar{X})} = \sqrt{\frac{\sigma^2}{n}} = \frac{\sigma}{\sqrt{n}}$$

- The larger the sample size  $n$ , the smaller the spread of the sample mean  $\bar{X}$ .
- But not proportionally: taking 4 times as large a sample only reduces the spread (=precision) of  $\bar{X}$  by a factor of 2!

## Inference: Hypothesis Test for $\pi$

- **Step 1:** Specify null and alternative hypotheses (always about a population parameter):

$$\text{two-sided:} \quad H_0 : \pi = \pi_0 \quad H_A : \pi \neq \pi_0$$

$$\text{one-sided:} \quad H_0 : \pi \leq \pi_0 \quad H_A : \pi > \pi_0$$

$$\text{one-sided:} \quad H_0 : \pi \geq \pi_0 \quad H_A : \pi < \pi_0,$$

where  $\pi$  is the true (unknown) proportion and  $\pi_0$  is some specific value. Also, choose  $\alpha$ -level (controls type I error, see later).

- **Step 2:** Specify the (asymptotic) distribution for the estimator of the unknown parameter. In almost all cases: apply the CLT assuming  $H_0$  is true:

$$P \sim N(\pi_0, \pi_0(1 - \pi_0)/n)$$

## Inference: Hypothesis Test for $\pi$

- **Step 3 (P-value):** Assuming that  $H_0$  is true, find the probability of observing an even more extreme (as specified by the alternative hypothesis) sample proportion as the one observed:

I.e., in the one sided case with  $H_A: \pi > \pi_0$ , find  $\Pr(P > p)$ , where  $p$  is the observed proportion.

In the two-sided case, find  $2 \times \Pr(P > |p|)$ .

To find this, calculate the **Test Statistic:** under  $H_0$

$$Z = \frac{P - \pi_0}{\sqrt{\pi_0(1 - \pi_0)/n}}.$$

## Inference: Hypothesis Test for $\pi$

- Calculate the **Test Statistic**: under  $H_0$

$$Z = \frac{P - \pi_0}{\sqrt{\pi_0(1 - \pi_0)/n}}.$$

The probability  $\Pr(P > p)$  is the same as  $\Pr(Z > z)$ , and  $2 \times \Pr(P > |p|)$  is the same as  $2 \times \Pr(Z > |z|)$ , where  $Z$  is a standard normal random variable (i.e.,  $Z \sim N(0, 1)$ ).

The probability under the  $N(0, 1)$  model is easy to calculate (Tables, R). The resulting probability is known as the P-value.

## Inference: Hypothesis Test for $\pi$

- **Step 4 (Conclusion):**

If P-value  $< \alpha$ : **Sufficient evidence** for  $H_A$ .

- $H_0$  is no more tenable, reject it. The likelihood of observing such a sample proportion when the null hypothesis is true is so small, so that the null hypothesis must be wrong.

If P-value  $\geq \alpha$ : **Insufficient evidence**. Cannot reject the claim  $H_0$ , therefore retain it.

- The sample did not provide overwhelming evidence to reject the null hypothesis. The likelihood of observing such a sample proportion is not so small when the null hypothesis is correct. Therefore, no reason to reject it.
- How to choose  $\alpha$ ?



## Exercise – One tailed Test (Known variance)

```
> xbar = 9900           # sample mean
> mu0 = 10000          # hypothesized value
> sigma = 120          # population standard deviation
> n = 30                # sample size
> z = (xbar-mu0)/(sigma/sqrt(n))
> z                    # test statistic
[1] -4.5644

> alpha = .05
> z.alpha = qnorm(1-alpha)
> -z.alpha             # critical value
[1] -1.6449
```

# Exercise

- Buka data airquality, pilih Temp
- Hitung rerata Temp dan standar deviasinya.
- Buat sample secara random dari data Temp sebanyak 100 data
  - `Y<- sample(X,100)`
- Hitung rerata dari sample Y
- Hitung Nilai Z sample dan ujilah null hypothesis

## Exercise – Two tailed Test (Known variance)

- ```
> xbar = 14.6      # sample mean
> mu0 = 15.4      # hypothesized value
> sigma = 2.5     # population standard deviation
> n = 35          # sample size
> z = (xbar-mu0)/(sigma/sqrt(n))
> z              # test statistic
[1] -1.8931
```
- ```
> alpha = .05
> z.half.alpha = qnorm(1-alpha/2)
> c(-z.half.alpha, z.half.alpha)
[1] -1.9600  1.9600
```

## Exercise – One tailed Test (Unknown variance)

- ```
> xbar = 9900           # sample mean
> mu0 = 10000          # hypothesized value
> s = 125              # sample standard deviation
> n = 30               # sample size
> t = (xbar-mu0)/(s/sqrt(n))
> t                    # test statistic
[1] -4.3818
```
- ```
> alpha = .05
> t.alpha = qt(1-alpha, df=n-1)
> -t.alpha             # critical value
[1] -1.6991
```

# Exercise

- Buka data airquality, pilih Temp
- Hitung rerata Temp dan standar deviasinya.
- Buat sample secara random dari data Temp sebanyak 100 data
  - `Y<- sample(X,100)`
- Hitung rerata dari sample Y
- Hitung Nilai Z sample dan ujilah null hypothesis

## Exercise – Two tailed Test (Unknown variance)

- ```
> xbar = 14.6           # sample mean
> mu0 = 15.4           # hypothesized value
> s = 2.5               # sample standard deviation
> n = 35                # sample size
> t = (xbar-mu0)/(s/sqrt(n))
> t                     # test statistic
[1] -1.8931
```
- ```
> alpha = .05
> t.half.alpha = qt(1-alpha/2, df=n-1)
> c(-t.half.alpha, t.half.alpha)
[1] -2.0322  2.0322
```

## Alternative – Two tailed Test (Unknown variance)

- ```
> pval = 2 * pt(t, df=n-1) # lower tail  
> pval # two-tailed p-value  
[1] 0.066876
```
- Uji  $pval > 0.05 \rightarrow$  Do not Reject
- Uji  $pval \leq 0.05 \rightarrow$  Reject
- ```
t.test(x,y) #uji t untuk variable x dan y
```