EC981: Dissertation

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Session 2022-2023

In this session, we will learn some R basics that will be help you to do analysis for your dissertation.

Key Terms

RStudio - RStudio is a Graphical User Interface (GUI) for easier use of R.

Objects - Everything you store in R.

Functions - A function is a code operation that accept inputs and returns a transformed output.

Packages - An R package is a shareable bundle of functions.

Scripts - A script is the document file that hold your commands.

Resources for learning

Resources within RStudio

- Help documentation
- Interactive tutorials
  - learnr R package
  - swirl

Cheatsheets

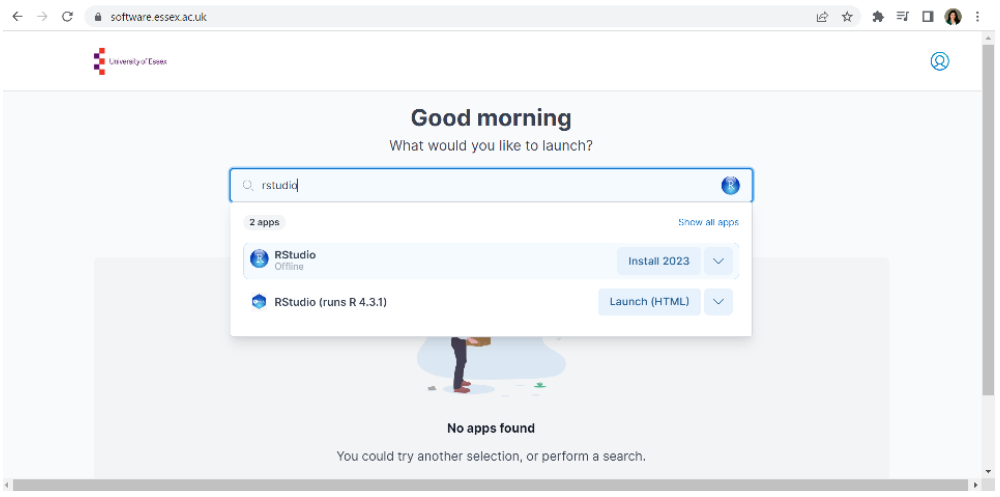
There are many PDF "cheatsheets" available on the RStudio website, for example:

- Factors with *forcats* package
- Dates and times with *lubridate* package
- Strings with *stringr* package
- iterative operataions with *purr* package
- Data import
- Data transformation cheatsheet with *dplyr* package
- R Markdown (to create documents like PDF, Word, Powerpoint…)
- Shiny (to build interactive web apps)
- Data visualization with *ggplot*2 package
- Cartography (GIS)
- *leaflet* package (interactive maps)
- Python with R (*reticulate* package)

Installation

Opening Rstudio via Essex Hub

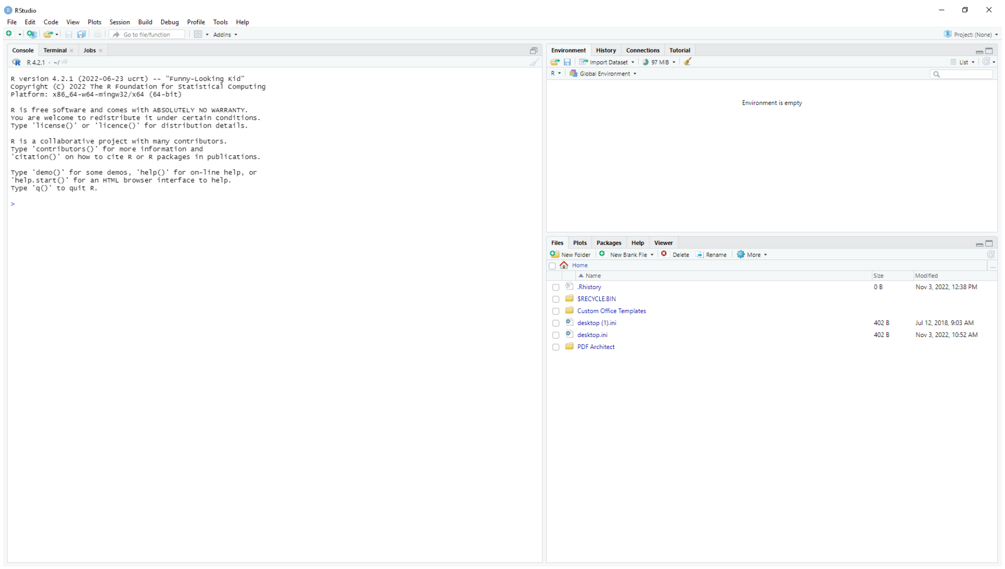
Open your web browser and google "Essex Software Hub". Open the first link in the list (https://software.essex.ac.uk/) (click "yes"/"open" to all the validation questions if there are any). Then locate RStudio and open 'RStudio (runs R.4.3.1)'.



Setting up RStudio

The RStudio interface at the beginning

When opening R Studio, you will be presented with the following screen.


RStudio
File Edit Code View Plots Session Build Debug Profile Tools Help
Go to file/function
Addins
Project: (None)
Console Terminal Jobs
R 4.2.1 · ~/
Environment History Connections Tutorial
Import Dataset
97 MiB
List
Global Environment
Environment is empty
Files Plots Packages Help Viewer
New Folder New Blank File Delete Rename More
Home

```
R version 4.2.1 (2022-06-23 ucrt) -- "Funny-Looking Kid"
Copyright (C) 2022 The R Foundation for Statistical Computing
Platform: x86_64-w64-mingw32/x64 (64-bit)

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.

R is a collaborative project with many contributors.
Type 'contributors()' for more information and
'citation()' on how to cite R or R packages in publications.

Type 'demo()' for some demos, 'help()' for on-line help, or
'help.start()' for an HTML browser interface to help.
Type 'q()' to quit R.

>
```

Name	Size	Modified
.Rhistory	0 B	Nov 3, 2022, 12:38 PM
$RECYCLE.BIN		
Custom Office Templates		
desktop (1).ini	402 B	Jul 12, 2018, 9:03 AM
desktop.ini	402 B	Nov 3, 2022, 10:52 AM
PDF Architect		

How to update R

Version- $sessionInfo()$

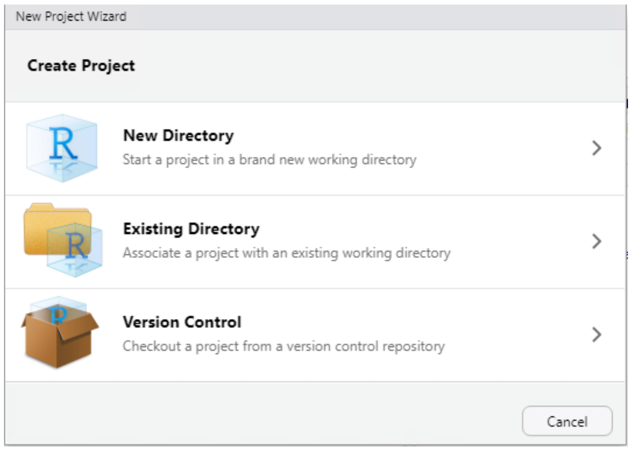
update- $installr :: updateR()$ or “Help” -> “Check for Updates”

Other software you may need to install

- TinyTeX (for compiling an RMarkdown document to PDF)
- Pandoc (for compiling RMarkdown documents)
- RTools (for building packages for R)
- phantomjs (for saving still images of animated networks, such as transmission chains)

Start a new project in R.

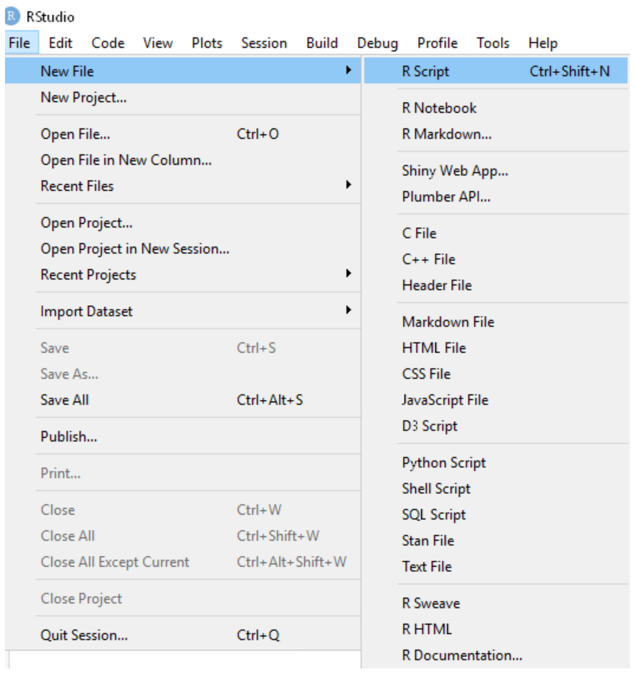
Creating a New Directory makes a default working directory and a logical place to store all associated files such as raw data spreadsheets.


New Project Wizard
Create Project
New Directory
Start a project in a brand new working directory
Existing Directory
Associate a project with an existing working directory
Version Control
Checkout a project from a version control repository
Cancel

Any associated excel documents or text files can be saved into this new folder and easily accessed from within R. You can then perform data analysis or produce visualizations with your imported data.

Creating a new script in R

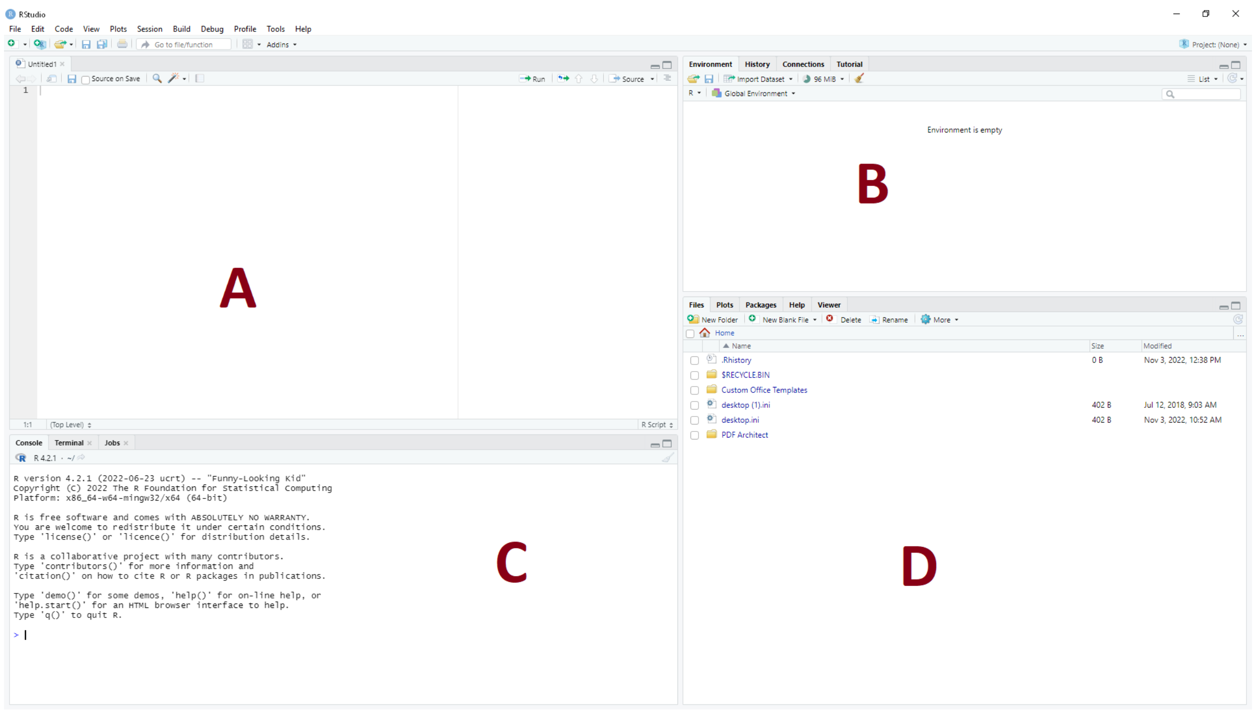
To create a new script in R, go to File > New File > R Script. On creating a new R script, the script panel will open. A script allows you to write your code/script and save your commands to be reopened later.



RStudio orientation

- The Source Pane
- The R Console Pane
- The Environment Pane
- Plots, Viewer, Packages, and Help Pane

Take a moment to look at the way RStudio organises the screen.



```
R version 4.2.1 (2022-06-23 ucrt) -- "Funny-Looking Kid"
Copyright (C) 2022 The R Foundation for Statistical Computing
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'help.start()' for an HTML browser interface to help.
Type 'q()' to quit R.

>
```

A The top-left Script window keeps the history of the commands you type. This window is known as Source Pane.

B The top-right Environment window shows an organised list of your created variables, History tab provides a list of commands that have been previously run.

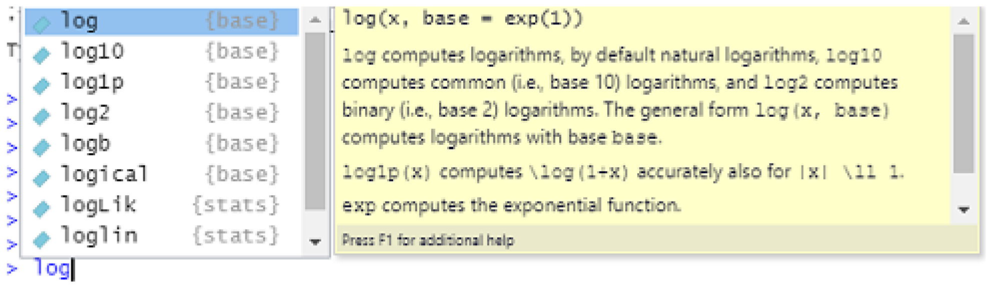
C The bottom-left Console window shows commands to run and the results output.

D In the bottom-right window, File tab shows the computer's file system, Plot tab shows your graphs and plots, Packages tab shows R packages installed or available to install, Help tab provides help and documentation for all commands.

Basic commands in RStudio

Run a command

Commands in R can be entered directly into the console (C). Entering 3 or more characters of a command into the console or a script will open the suggested command menu. The command menu suggests commands or the names of variables you have intended to type, alongside a description and suggested use of the command.



```
log(x, base = exp(1))
```

log computes logarithms, by default natural logarithms, log10 computes common (i.e., base 10) logarithms, and log2 computes binary (i.e., base 2) logarithms. The general form log(x, base) computes logarithms with base base.

log1p(x) computes \log(1+x) accurately also for |x| \ll 1.

exp computes the exponential function.

After completing a command and pressing *Enter*, R will immediately run the code, print the output and move to a new line. Using the ↑ key will repeat the last command entered into the console.

Using R Script

Multiple commands can be entered into a script, one after the other across multiple lines. R Script allows you to edit and reuse previous commands and to create more complicated lists of commands.

To run the script one line at a time, navigate the cursor to the appropriate line and press *CTRL* + *Enter*. To run all commands from the start, press *CTRL* + *Shift* + *Enter*.

Saving script in R

To save the script click File > Save and then enter the file name 'rbasics' in the project folder. This will save your script as 'rbasics.R'.

Objects

Everything in R is an object, and R is an "object-oriented" language. These sections will explain:

- How to create objects (<-)
- Types of objects (e.g. data frames, vectors..)

- How to access subparts of objects (e.g. variables in a dataset)
- Classes of objects (e.g. numeric, logical, integer, double, character, factor)

Defining Objects

Defining objects (<-) "is defined as"

$object\_name < -value$

Equals signs =

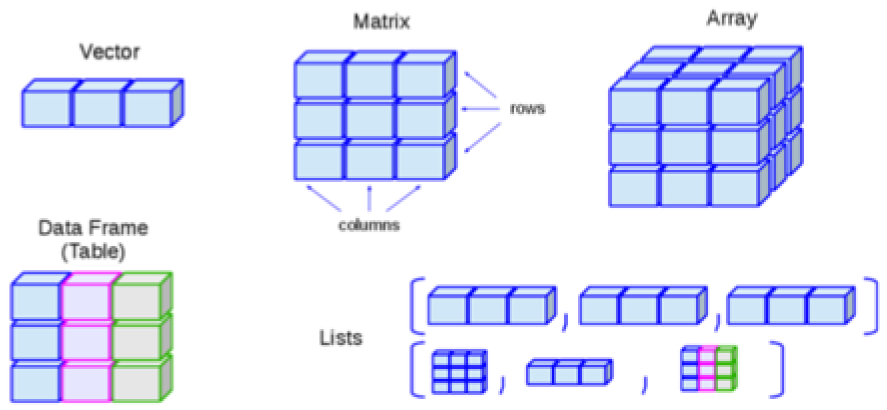
You will also see equals signs in R code:

- A double equals sign == between two objects or values asks a logical question: "is this equal to that?".
- You can use a single equals sign = in place of <- to create and define objects, but this is discouraged.

A quick note on naming of objects

- Object names must not contain spaces, but you should use underscore (_) or a period (.) instead of a space.
- Object names are case-sensitive (meaning that Dataset_A is different from dataset_A).
- Object names must begin with a letter (cannot begin with a number like 1, 2 or 3)

Object structure



Source: Internet

Object Classes

Class	Examples
Character	"Character objects are in quotation marks"
Integer	-6, 12, or 2023
Numeric	23.5 or 16
Factor	An variable of economic status with ordered values
Date	2018-06-12 or 15/3/1956 or Wed 6 Jan 1988
Logical	TRUE or FALSE
data.frame	The example AJS dataset
tibble	Any data frame, list, or matrix can be converted to a tibble with as_tibble()
list	A list could hold a single number, and a dataframe, and a vector, and even another list within it!

Operators

Mathematical Operators

Purpose	Example in R
addition	2 + 3
subtraction	2 - 3
multiplication	2 * 3
division	30 / 5
exponent	2^3
order of operations	( )

Mathematical functions

Purpose	Function
rounding	round(x, digits = n)
rounding	janitor::round_half_up(x, digits = n)
ceiling (round up)	ceiling(x)
floor (round down)	floor(x)
absolute value	abs(x)
square root	sqrt(x)
exponent	exponent(x)
natural logarithm	log(x)
log base 10	log10(x)
log base 2	log2(x)

Using %in%

```r
vector <- c("a", "b", "c", "d","e")


"a" %in% vector


"g" %in% vector
```

```r
# to negate, put an exclamation in front

!"a" %in% vector
```

Working directory

To know the current working directory use the following command:

```r
getwd()
```

Setting working directory *setwd*()

Installing packages

To run commands other than basic functions, you will need to install some plugins or packages to bring extra functionality. To install packages use the command *install.packages*(). You can install the following packages in R.

```r
install.packages(c("readxl","psych","FSA","car","ggplot2","stargazer"))
```

Loading packages

```r
library(readxl)
library(psych)
library(FSA)
library(car)
library(ggplot2)
library(stargazer)
```

Importing an excel file into R

To import the data from an excel file, use the command *read_excel*().

```
# you can use package wooldridge to get data as well.
datadf <- read_excel("M:/EC969/R/EC969/wages.xlsx",sheet = "WAGE2")

#install.packages('AER')
## install devtools and then
devtools::install_git("https://github.com/ccolonescu/PoEdata")

## install.packages(POEdata)
library(AER)
data(Fatalities)
library(PoEdata)
data(food, package='PoEdata')
```

The data is now imported into R.

Viewing imported data

To view all the data, you can use $View()$ command to view data/variables.

```
View(datadf)

View(Fatalities)
```

To view a particular part of the data set, for example, you can use command

```
# to view wage column
View(datadf$wage)

# to view wage to IQ
View(datadf[,1:3])
# before comma represents row number
# after comma presents column number
# to view first 10 rows of datadf
View(datadf[1:10,])
```

To see the variables in console, you can use *print*()

```
# to view first 10 rows of wage to IQ in console


print(datadf[1:10,1:3])
```

```
## # A tibble: 10 x 3
##     wage hours    IQ
##    <dbl> <dbl> <dbl>
##  1   769    40    93
##  2   808    50   119
##  3   825    40   108
##  4   650    40    96
##  5   562    40    74
##  6  1400    40   116
##  7   600    40    91
##  8  1081    40   114
##  9  1154    45   111
## 10  1000    40    95
```

R variables and data type

The common variable types and data types that you will be working with in R is as follows:

```
str(datadf)
str(Fatalities)
str(food)
```

Summary/Descriptive statistics

It is important to know the summary and descriptive statistics of the data. You can do this using the following commands. *summary*() command provide details of minimum, 1st quantile, median, mean, 3rd quantile and maximum of variables. *psych* :: *describe*() provide

```
# to view summary of the data
summary(datadf)
```

```
##       wage            hours             IQ              educ
##  Min.   : 115.0   Min.   :20.00   Min.   : 50.0   Min.   : 9.00
##  1st Qu.: 669.0   1st Qu.:40.00   1st Qu.: 92.0   1st Qu.:12.00
##  Median : 905.0   Median :40.00   Median :102.0   Median :12.00
##  Mean   : 957.9   Mean   :43.93   Mean   :101.3   Mean   :13.47
##  3rd Qu.:1160.0   3rd Qu.:48.00   3rd Qu.:112.0   3rd Qu.:16.00
##  Max.   :3078.0   Max.   :80.00   Max.   :145.0   Max.   :18.00
##      exper           tenure            age           married
##  Min.   : 1.00   Min.   : 0.000   Min.   :28.00   Min.   :0.000
##  1st Qu.: 8.00   1st Qu.: 3.000   1st Qu.:30.00   1st Qu.:1.000
##  Median :11.00   Median : 7.000   Median :33.00   Median :1.000
##  Mean   :11.56   Mean   : 7.234   Mean   :33.08   Mean   :0.893
##  3rd Qu.:15.00   3rd Qu.:11.000   3rd Qu.:36.00   3rd Qu.:1.000
##  Max.   :23.00   Max.   :22.000   Max.   :38.00   Max.   :1.000
##      south            urban
##  Min.   :0.0000   Min.   :0.0000
##  1st Qu.:0.0000   1st Qu.:0.0000
##  Median :0.0000   Median :1.0000
##  Mean   :0.3412   Mean   :0.7176
##  3rd Qu.:1.0000   3rd Qu.:1.0000
##  Max.   :1.0000   Max.   :1.0000
```

```
# to view descriptive statistics of data
psych::describe(datadf)
```

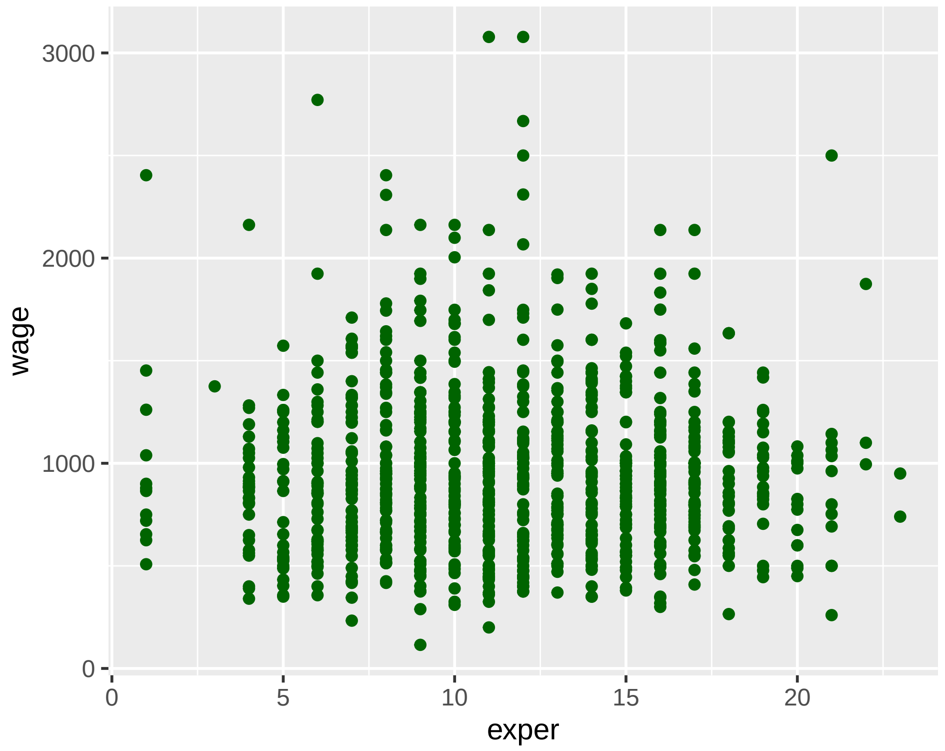
```
##         vars   n   mean     sd median trimmed    mad min  max range  skew
## wage       1 935 957.95 404.36    905  919.69 369.17 115 3078  2963  1.20
## hours      2 935  43.93   7.22     40   42.80   0.00  20   80    60  1.59
## IQ         3 935 101.28  15.05    102  101.87  14.83  50  145    95 -0.34
## educ       4 935  13.47   2.20     12   13.33   1.48   9   18     9  0.55
## exper      5 935  11.56   4.37     11   11.52   4.45   1   23    22  0.08
## tenure     6 935   7.23   5.08      7    6.89   5.93   0   22    22  0.43
## age        7 935  33.08   3.11     33   33.04   4.45  28   38    10  0.12
## married    8 935   0.89   0.31      1    0.99   0.00   0    1     1 -2.54
## south      9 935   0.34   0.47      0    0.30   0.00   0    1     1  0.67
## urban     10 935   0.72   0.45      1    0.77   0.00   0    1     1 -0.97
##         kurtosis    se
## wage        2.68 13.22
## hours       4.14  0.24
## IQ         -0.03  0.49
## educ       -0.74  0.07
## exper      -0.57  0.14
## tenure     -0.81  0.17
## age        -1.26  0.10
## married     4.45  0.01
## south      -1.55  0.02
## urban      -1.07  0.01
```

Plotting data

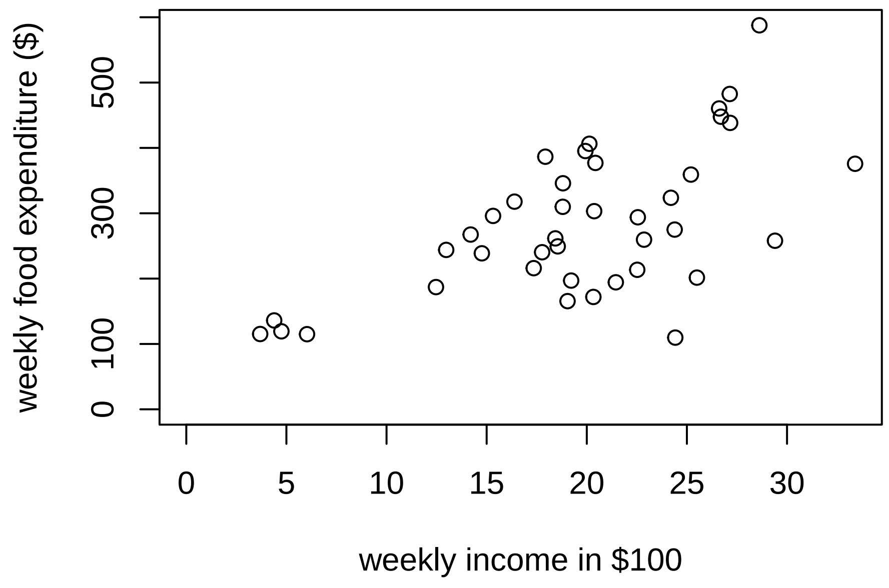
Scatter plot

Looking at the data is a good practice. To do a scatter plot, for instance *wage* versus *exper*, you can use the command

```
# you can change shape, color, size of geom point
ggplot(datadf,aes(x=exper,y=wage))+ geom_point(color="darkgreen")
```



```
#from PoEdata using plot function
plot(food$income, food$food_exp,
     ylim=c(0, max(food$food_exp)),
     xlim=c(0, max(food$income)),
     xlab="weekly income in $100",
     ylab="weekly food expenditure ($)",
     type = "p")
```



Removing variables from your data

Sometimes you might want to remove variables from your dataset. There various ways to do that. For example, to remove the variables *south* and *urban* we could use,

1. Delete column by name

The most easiest way to drop columns is by using *subset*() function. In the code below, we are telling R to drop variables *south* and *urban*. The − sign indicates dropping variables. Make sure the variable names would NOT be specified in quotes when using *subset*() function.

```
dfsthur <- subset(datadf, select = -c(south,urban))
```

2. Drop columns by column index numbers

It's easier to remove variables by their position number. In the following code, we want to drop variables that are positioned at ninth column and tenth columns. The − sign is to drop variables.

```
dfsthur <- datadf[,-c(9,10)]
```

Alternatively, to remove all variables other than *wage* we could use any of the following commands

```
dfwage <- datadf$wage # using $


dfwage <- subset(datadf,select = wage) # using function subset()


dfwage <- datadf[,1] # column index
```

Also, if a variable already exists and you want to redefine its content, you can change the right side of the function to change the content.

3. Deleting object

If you want to delete a object you have created, you can use the function $rm()$. For removing all the object use-$rm(list = ls())$.

Estimating a Linear Regression

$$food\_exp = \beta_1 + \beta_2 income + u$$

```
# Running linear regression
mod1 <- lm(food_exp ~ income, data = food)


# beta1
b1 <- coef(mod1)[[1]]


#beta2
b2 <- coef(mod1)[[2]]


# summary results from linear regression
```

```
smod1<- summary(mod1)


smod1
```

```
##
## Call:
## lm(formula = food_exp ~ income, data = food)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -223.025  -50.816   -6.324   67.879  212.044
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept)   83.416     43.410   1.922   0.0622 .
## income        10.210      2.093   4.877 1.95e-05 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 89.52 on 38 degrees of freedom
## Multiple R-squared:  0.385,  Adjusted R-squared:  0.3688
## F-statistic: 23.79 on 1 and 38 DF,  p-value: 1.946e-05
```

Using a fancy table

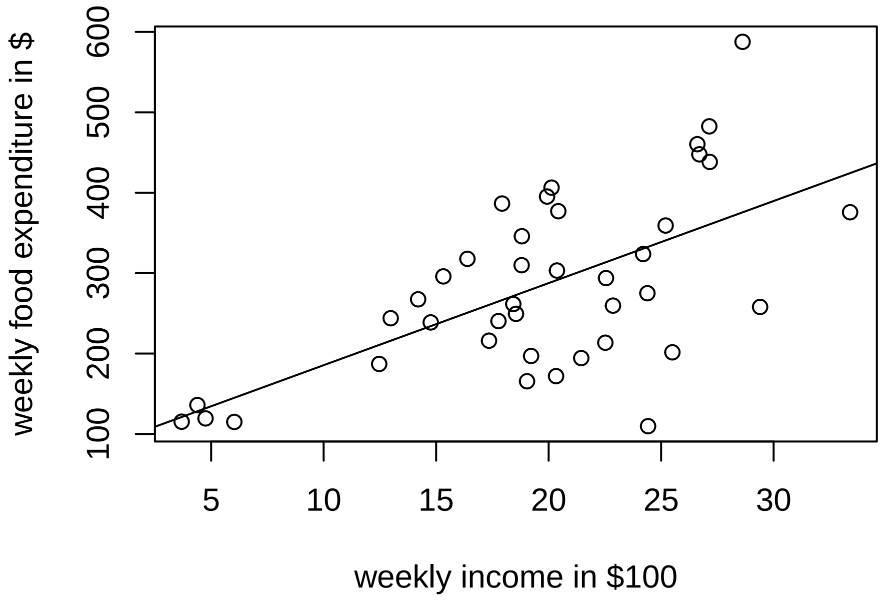
```
# Using fancy table style
stargazer::stargazer(mod1,type='latex')
```

Table 4:

	Dependent variable:
	food_exp
income	10.210***
	(2.093)
Constant	83.416*
	(43.410)
Observations	40
R^2	0.385
Adjusted R^2	0.369
Residual Std. Error	89.517 (df = 38)
F Statistic	23.789*** (df = 1; 38)
Note:	*p<0.1; **p<0.05; ***p<0.01

Plotting with coefficients

```
plot(food$income, food$food_exp,
     xlab="weekly income in $100",
     ylab="weekly food expenditure in $",
     type = "p")
abline(b1,b2)
```



Getting name/coefficients from estimated model

```
# list of names
names(mod1)
```

```
##  [1] "coefficients"  "residuals"     "effects"       "rank"
##  [5] "fitted.values" "assign"        "qr"            "df.residual"
##  [9] "xlevels"       "call"          "terms"         "model"
```

```
names(smod1)
```

```
##  [1] "call"          "terms"         "residuals"     "coefficients"
##  [5] "aliased"       "sigma"         "df"            "r.squared"
##  [9] "adj.r.squared" "fstatistic"    "cov.unscaled"
```

```
# coefficient
mod1$coefficients
```

```
## (Intercept)      income
##    83.41600    10.20964
```

```r
smod1$coefficients
```

```
##              Estimate Std. Error  t value     Pr(>|t|)
## (Intercept) 83.41600  43.410163 1.921578 6.218242e-02
## income      10.20964   2.093264 4.877381 1.945862e-05
```

Prediction with the Linear Regression Model

$$\widehat{food\_exp} = 83.416002 + 10.209643 * 20 = 287.608861$$

```r
mod1 <- lm(food_exp~income, data=food)
newx <- data.frame(income = c(20, 25, 27))
y_hat <- predict(mod1, newx)
names(y_hat) <- c("income=$2000", "$2500", "$2700")
y_hat
```

```
## income=$2000        $2500        $2700
##     287.6089     338.6571     359.0764
```

Estimated Variances and Covariance of Regression Coefficients

```r
varb1 <- vcov(mod1)[1, 1]; varb1
```

```
## [1] 1884.442
```

```r
varb2 <- vcov(mod1)[2, 2]; varb2
```

```
## [1] 4.381752
```

```r
covb1b2 <- vcov(mod1)[1,2]; covb1b2
```

```
## [1] -85.90316
```