

# ScPoEconometrics

## Introduction

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- In this course you will learn the core tools of *econometrics*.



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## What is *econometrics*?

*The method of econometric research aims, essentially, at a conjunction of economic theory and actual measurements, using the theory and technique of statistical inference as a bridge pier.*

*Haavelmo (1944). The Probability Approach to Econometrics.*



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*The method of econometric research aims, essentially, at a conjunction of economic theory and actual measurements, using the theory and technique of statistical inference as a bridge pier.*

*Haavelmo (1944). The Probability Approach to Econometrics.*

- A set of **techniques and methods** to answer (generally) economic questions with **data**.
- Some examples!



# Answering Important Questions with Econometrics

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Does more education *cause* higher wages and better jobs?

Does higher public debt levels *cause* lower economic growth?



# Answering Important Questions with Econometrics

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Does raising the minimum wage *cause* reduced employment for the low-skilled?

Does more education *cause* higher wages and better jobs?

Does higher public debt levels *cause* lower economic growth?

Does birth order *cause* differing education and employment outcomes?



# Causality

- Notice the keyword **cause** in all of the above.
- Notice also that ***many other factors could have caused*** each of those outcomes.



# Causality

- Notice the keyword **cause** in all of the above.
- Notice also that ***many other factors could have caused*** each of those outcomes.
- Econometrics is often about spelling out ***conditions*** under which we can ***claim to measure causal relationships***.
- We will encounter the most basic of those conditions, and talk about some potential pitfalls.



R

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R is a **programming language** with powerful statistical and graphic capabilities.



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3. R has a vibrant, **thriving online community** that will (almost) always have a solution to your problem.
4. If you put in the work<sup>2</sup>, you will come away with a **very valuable and marketable** tool.

[1]: This list has been inspired by Ed Rubin's.

[2]: Learning R definitely requires time and effort but it's worth it, trust me! 💪



# Why can't we just use Excel?

Many reasons but here are just a few:



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- Very fastidious to *clean* data.
- Limited to *small datasets*.
- Not designed for proper *econometric analyses*, maps, complex visualisations, etc.



# R SHOWCASE

# Showcase #1: Spatial Data

- R is very strong with spatial data. In particular via the sf package.
- We can represent *any* shape or geometry.
- Maps are the most obvious example:

```
library(sf)
library(tmap)
iris_shfl <- read_sf("chapter_intro_files/figure-html/
  mutate(dep = substr(INSEE_COM, 1, 2)) %>%
  select(CODE_IRIS, dep, geometry) %>%
  filter(dep == "75")
iris_income <- readRDS("../rds/iris_inc.rds") %>%
  mutate(CODE_IRIS = IRIS) %>%
  select(CODE_IRIS, DISP_MED15)
iris_map <- left_join(iris_shfl, iris_income, by = "C
tmap_mode("plot")
tm_shape(iris_map) +
  tm_borders() +
  tm_fill(col = "DISP_MED15", title = "Median househo
```



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iris_map <- left_join(iris_shfl, iris_income, by = "CODE_IRIS")
tmap_mode("plot")
tm_shape(iris_map) +
  tm_borders() +
  tm_fill(col = "DISP_MED15", title = "Median household income (euros)",
```

- Can be improved but you get this with only **13 lines of code!**



# Showcase #2: Interactive Web Applications



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France Stratégie has created a **simple web application** to visualize the evolution of residential segregation in France between 1968 and 2015.



The screenshot shows the homepage of the France Stratégie residential segregation web application. At the top, there is a banner featuring a photograph of a crowded street scene. Below the banner, the France Stratégie logo is visible. The main navigation menu includes links for "La ségrégation résidentielle en France" (selected), "Accueil", "Composition sociale et démographique des quartiers", "Niveau de vie des quartiers", "Ségrégation et Concentration ▾", and "Comment ça marche ?".

## L'évolution de la ségrégation résidentielle en France de 1968 à 2015

Ce projet a été réalisé par France Stratégie dans le cadre de ses travaux

### La ségrégation, qu'est ce que c'est ?

La ségrégation résidentielle désigne l'inégale répartition dans l'espace urbain des différentes catégories de population. Elle peut résulter de choix individuels, motivés par la recherche d'un entresoi, ou de phénomènes de relégation, liés notamment au prix des logements. Pour mesurer la réalité des phénomènes de ségrégation, deux principaux indicateurs ont été utilisés :

#### L'indice de ségrégation :

Il permet de juger dans quelle mesure un groupe est réparti de façon homogène entre les quartiers



# In Practice: Data Wrangling



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- The `gapminder` dataset contains data on life expectancy, GDP per capita and population by country between 1952 and 2007.
- Suppose we want to know the average life expectancy and average GDP per capita for each continent in each year.



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- We need to group the data by continent *and* year, then compute the average life expectancy and average GDP per capita



# In Practice: Data Wrangling

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- We need to group the data by continent *and* year, then compute the average life expectancy and average GDP per capita

```
# load gapminder package
library(gapminder)
# load the dataset in object
gapminder = gapminder::gapminder
# display variables in the object
names(gapminder)
# show first 4 lines of this dataset
head(gapminder, n = 4)
```

	country	continent	year	lifeExp	pop	gdpPercap
	<fct>	<fct>	<int>	<dbl>	<int>	<dbl>
## 1	Afghanistan	Asia	1952	28.8	8425333	779.
## 2	Afghanistan	Asia	1957	30.3	9240934	821.
## 3	Afghanistan	Asia	1962	32.0	10267083	853.
## 4	Afghanistan	Asia	1967	34.0	11537966	836.



# In Practice: Data Wrangling

- There are always several ways to achieve a goal. (As in life 😊)
- Here we will only focus on the `dplyr` way:

```
# compute the required statistics
gapminder_dplyr <- gapminder %>%
  group_by(continent, year) %>%
  summarise(count = n(),
            mean_lifeexp = mean(lifeExp, na.rm = TRUE),
            mean_gdppercap = mean(gdpPercap, na.rm = TRUE))
```

```
# show first 5 lines of this dataframe
head(gapminder_dplyr, n = 5)
```

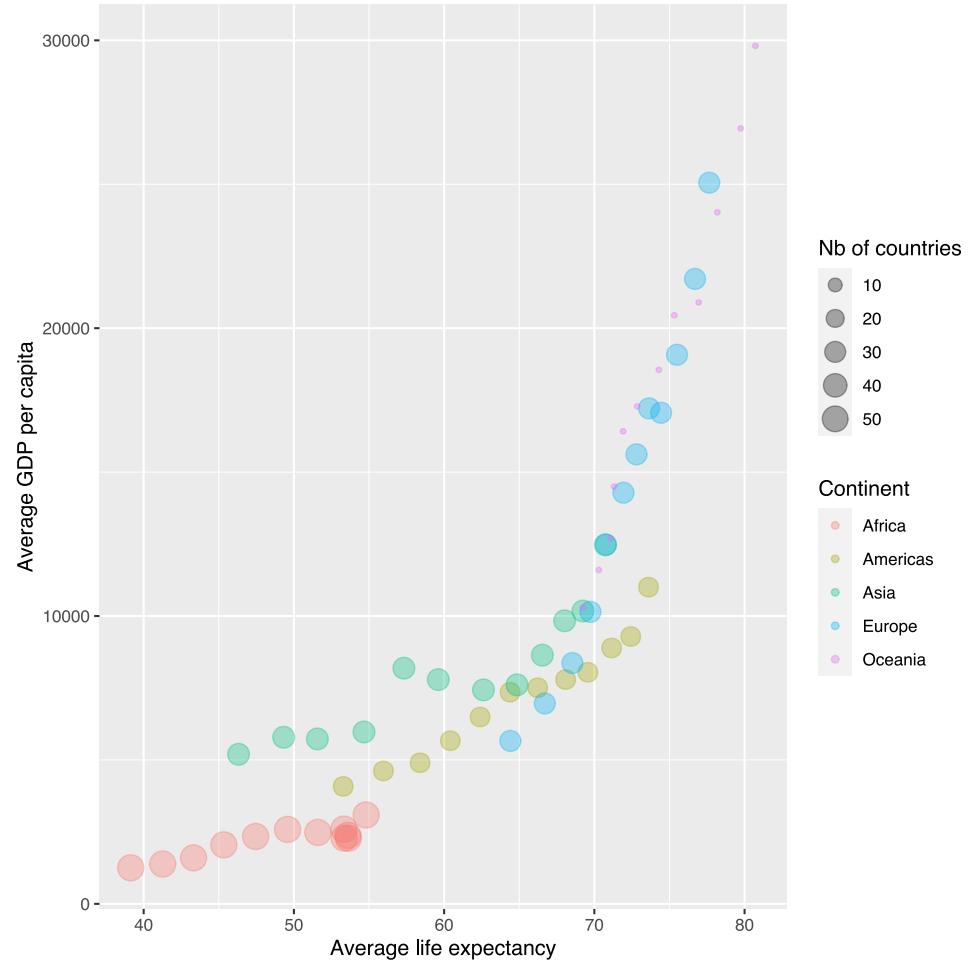
```
## # A tibble: 5 x 5
## # Groups: continent [1]
##   continent year count mean_lifeexp mean_gdppercap
##   <fct>     <int> <int>      <dbl>        <dbl>
## 1 Africa     1952    52       39.1       1253.
## 2 Africa     1957    52       41.3       1385.
## 3 Africa     1962    52       43.3       1598.
## 4 Africa     1967    52       45.3       2050.
## 5 Africa     1972    52       47.5       2340.
```



# Visualisation

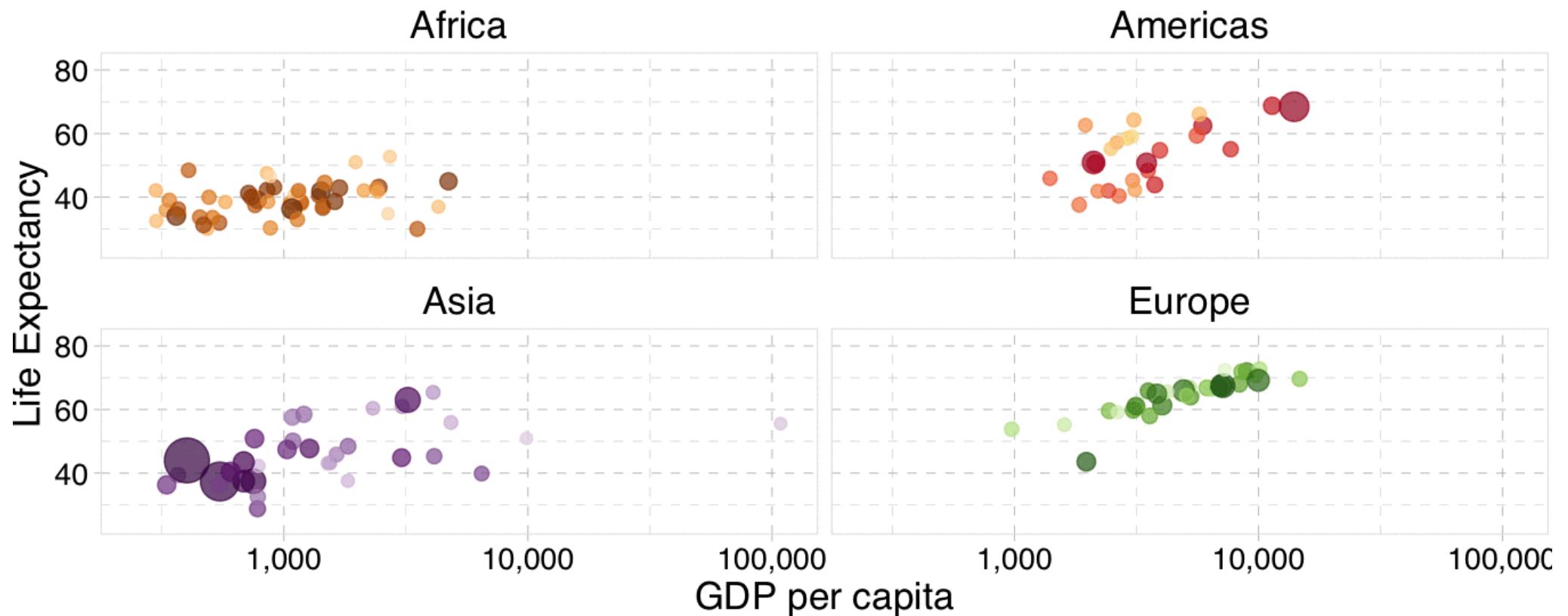
- Now we could *look* at the result in `gapminder_dplyr`, or compute some statistics from it.
- Nothing beats a picture, though:

```
ggplot(data = gapminder_dplyr,  
       mapping = aes(x = mean_lifeexp,  
                      y = mean_gdppercap,  
                      color = continent,  
                      size = count)) +  
  geom_point(alpha = 1/3) +  
  labs(x = "Average life expectancy",  
       y = "Average GDP per capita",  
       color = "Continent",  
       size = "Nb of countries")
```



# Animated Plotting 🤝 1

Year: 1952



[1]: This animation is taken from [Ed Rubin](#).



R 101: Here Is Where You Start

# Start your RStudio!

## First Glossary of Terms

- R: a programming language.
- RStudio: an integrated development environment (IDE) to work with R.



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- RStudio: an integrated development environment (IDE) to work with R.
- *command*: user input (text or numbers) that R understands.
- *script*: a list of commands collected in a text file, each separated by a new line, to be run one after the other.



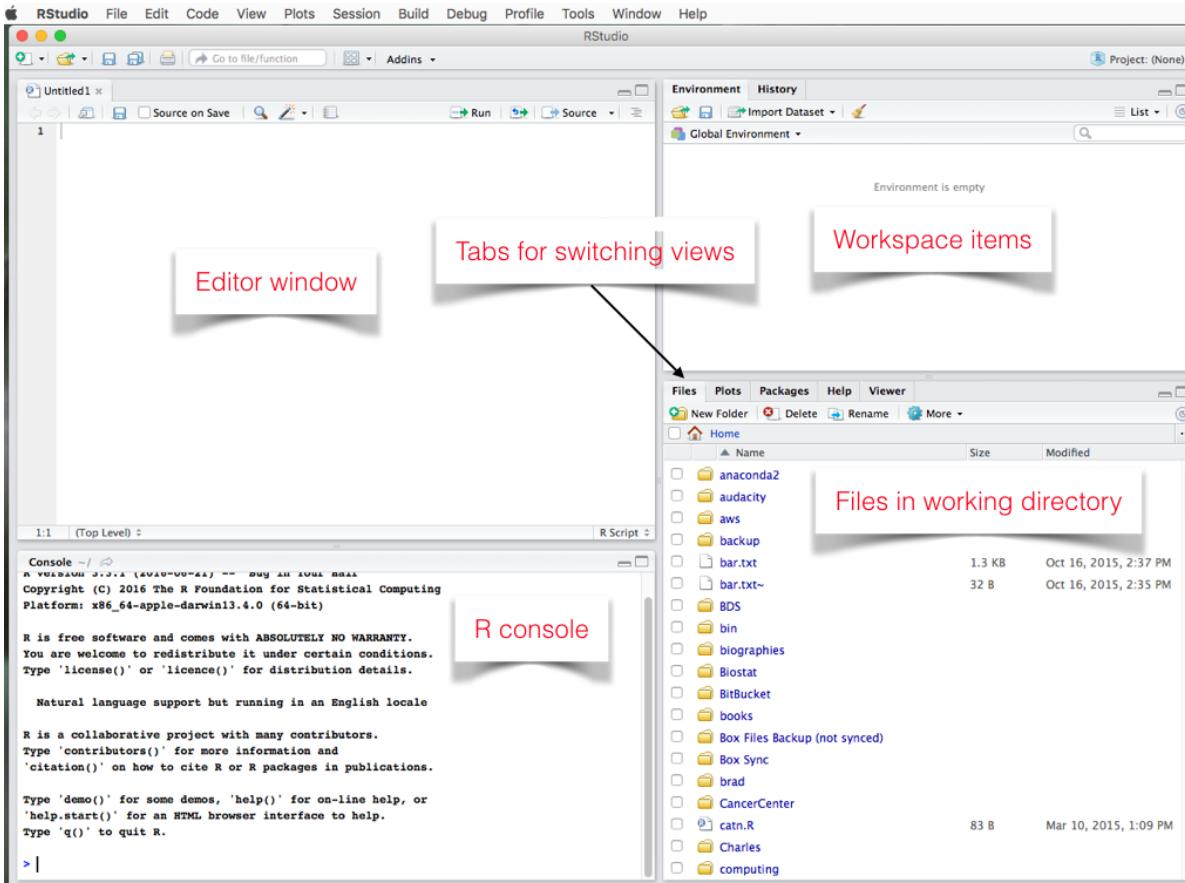
# Start your RStudio!

## First Glossary of Terms

- **R**: a programming language.
- **RStudio**: an integrated development environment (IDE) to work with **R**.
- *command*: user input (text or numbers) that **R** *understands*.
- *script*: a list of commands collected in a text file, each separated by a new line, to be run one after the other.
- To run a script, you need to highlight the relevant code lines and hit **Ctrl+Enter** (Windows) or **Cmd+Enter** (Mac).



# RStudio Layout



# R as a Calculator

- You can use the R console like a calculator
- Just type an arithmetic operation after > and hit Enter!



# R as a Calculator

- You can use the R console like a calculator
- Just type an arithmetic operation after > and hit Enter!

- Some basic arithmetic first:

```
4 + 1  
## [1] 5  
8 / 2  
## [1] 4
```

- Great! What about this?

```
log(exp(1))  
## [1] 1  
# by the way: this is a comment! (R disregards it)
```



# Task 1

05 : 00

1. Create a new R script (File → New File → R Script). Save it somewhere as `lecture_intro.R`.
2. Write in your script and run the following code: (`Ctrl` or `Cmd` + `Enter`)

```
4 * 8
```

3. Write in your script and run the following code. What happens if you only run the first line of the code?

```
x = 5 # equivalently x <- 5
x
```

Congratulations, you have created your first R "object"! Everything is an object in R!  
Objects are assigned using `=` or `<-`.

4. Lastly, find the cube of `x` and assign that value to `x_3`.



# Where to get Help?

R built-in help:

```
?log #? in front of function  
help(lm) # help() is equivalent  
??plot # get all help on keyword "plot"
```



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In practice:



Jesse Maegan  
@kierisi

Following

My #rstats learning path:

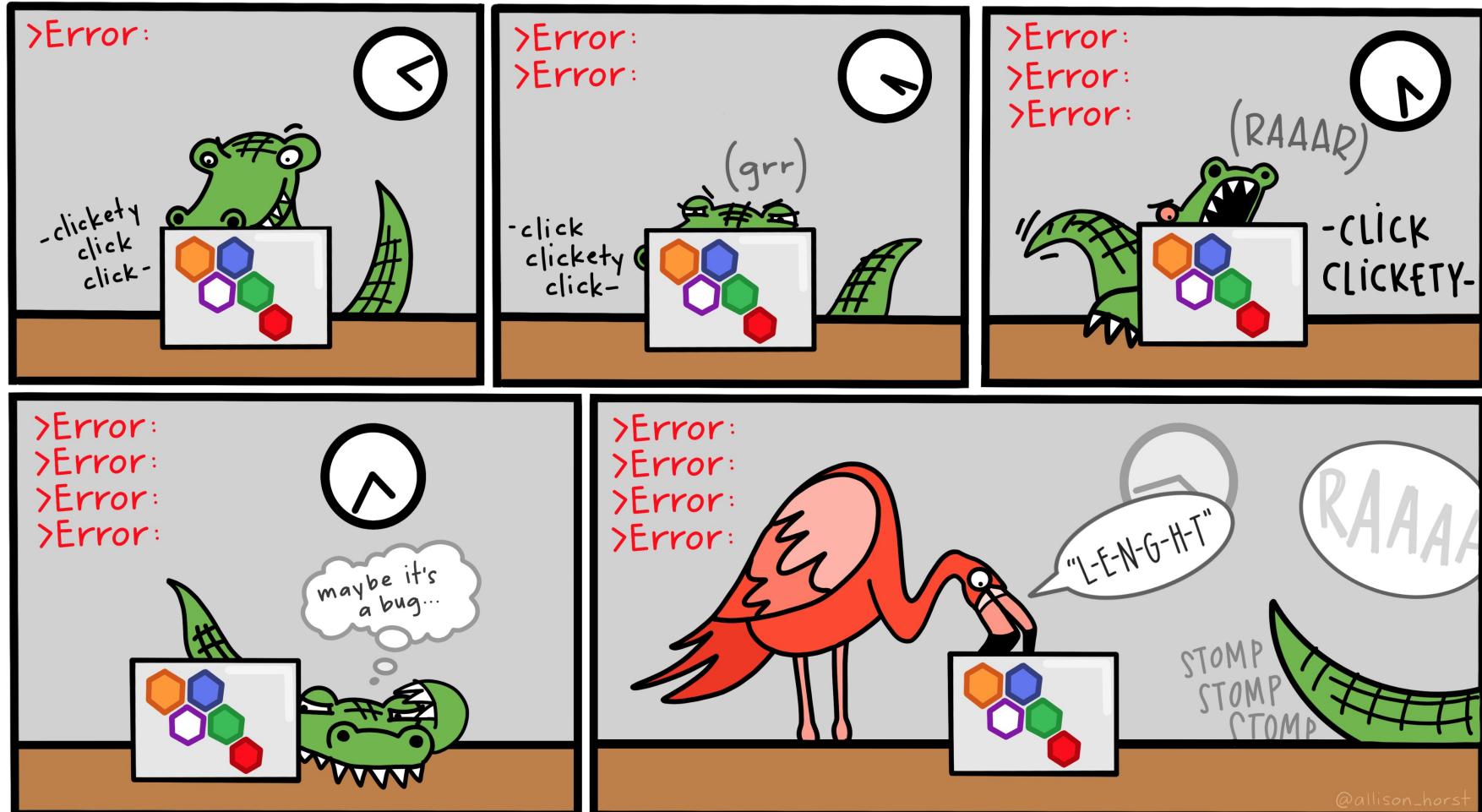
1. Install R
2. Install RStudio
3. Google "How do I [THING I WANT TO DO] in R?"

Repeat step 3 ad infinitum.

7:19 AM - 18 Aug 2017



# Collaborate!



# R Packages

- R users contribute add-on data and functions as *packages*
- Installing packages is easy! Just use the `install.packages` function:

```
install.packages("ggplot2") # do NOT run this code on your end
```

- To *use* the contents of a packge, we must load it from our library using `library`:

```
library(ggplot2)
```



# Vectors

- What is a **vector**?
- The `c` function creates vectors.

```
c(1, 3, 5, 7, 8, 9)
```

```
## [1] 1 3 5 7 8 9
```

- Coercion to unique types:

```
c(42, "Statistics", TRUE)
```

```
## [1] "42"           "Statistics"    "TRUE"
```

- Creating a *range*

```
1:10
```

```
## [1] 1 2 3 4 5 6 7 8 9 10
```



# data.frames

data.frames are like spreadsheets.

```
example_data = data.frame(x = c(1, 3, 5, 7),
                           y = c(rep("Hello", 3), "Goodbye"),
                           z = sample(c(TRUE, FALSE), size=4, replace=TRUE))
example_data
##   x     y   z
## 1 1 Hello TRUE
## 2 3 Hello TRUE
## 3 5 Hello FALSE
## 4 7 Goodbye TRUE
```

In practice, you will be importing files that contain the data into R rather than creating data.frames by hand.



# Task 2

07 : 00

1. Find out (using `help()` or google) how to import a .csv file.
2. Import `gun_murders.csv`<sup>1</sup> in a new object `murders`. This file contains data on gun murders by US state in 2010. (Hint: objects are created using `=`).
3. Ensure that `murders` is a `data.frame` by running:

```
class(murder) # check class
```

4. Find out what variables are contained in `murders` by running:

```
names(murders) # obtain variable names
```

5. View the contents of `murders` by clicking on `murders` in your workspace. What does the `total` variable correspond to?



[1]: This dataset is taken from the `dslabs` package.

# data.frames

Useful functions to describe a dataframe:

```
str(murders) # describes the data.frame

## 'data.frame':   51 obs. of  5 variables:
## $ state      : chr  "Alabama" "Alaska" "Arizona" "Arkansas" ...
## $ abb        : chr  "AL" "AK" "AZ" "AR" ...
## $ region     : Factor w/ 4 levels "Northeast","South",...: 2 4 4 2 4 4 1 2 2 2 ...
## $ population: num  4779736 710231 6392017 2915918 37253956 ...
## $ total      : num  135 19 232 93 1257 ...
```



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names(murders) # column names

## [1] "state"      "abb"        "region"      "population" "total"
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## [1] "state"      "abb"        "region"      "population" "total"

nrow(murders) # number of rows

## [1] 51
```



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names(murders) # column names

## [1] "state"      "abb"        "region"      "population" "total"

nrow(murders) # number of rows

## [1] 51

ncol(murders) # number of columns

## [1] 5
```



# Data on Gun Murders in the US

- To access one of the variables **as a vector**, we use the `$` operator as in `murders$state`. We can check the type of `murders$state` with

```
class(murders$state) # type of the state variable in the murders data.frame  
## [1] "character"
```



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```
class(murders$state) # type of the state variable in the murders data.frame  
## [1] "character"
```

- Or we use the column name or index: `murders[, "state"]` or `murders[, 1]`

```
class(murders[, "state"]) # type of the state variable in the murders data.frame  
## [1] "character"
```



# Subsetting data.frames

- Subsetting a data.frame: `murders[row condition, column number]` or `murders[row condition, "column name"]`

```
# Only keep states with over 500 gun murders and keep only the "state" and "total" variables
murders[murders$total > 500, c("state", "total")]
```

```
##           state total
## 5    California  1257
## 10   Florida     669
## 33   New York    517
## 44   Texas       805
```

```
# Only keep California and Texas and keep only the "state" and "total" variables
murders[murders$state %in% c("California", "Texas"), c("state", "total")]
```

```
##           state total
## 5    California  1257
## 44   Texas       805
```



# Task 3

10:00

1. How many observations are there in `murders`?
2. How many variables? What are the data types of each variable?
3. Remember that the colon operator `a:b` is just short for *construct a sequence from a to b*. Create a new object `murders_2` containing the rows 10 to 25 of `murders`.
4. Create a new object `murders_3` which only contains the columns `state` and `total`. (Recall that `c` creates vectors.)
5. What is the average value of `total` for state's in the "South", i.e. with `region == "South"`?
6. Create a `total_percap` variable equal to the number of murders per 10,000 inhabitants:

```
murders$total_percap = (murders$total / murders$population) * 10000
```

Congratulations, you've created your first variable!



# Class Details

# This Course

- Teach you the basics of *linear regression*, *statistical inference* and *impact evaluation*.



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- Equip you with a framework to think more deeply about *causality*.



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## Grading

1. There will be *five quizzes* on Moodle roughly every two weeks → 40%



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2. There will be *two take home exams / case studies* → 60%
3. There will be *no final exam* 😅



# Syllabus



Lecture 1 (today): **Introduction**

Quiz 1 (*after lecture 2*)

Lectures 2 and 3: **Tidying, Visualising and Summarising Data**

Quiz 2

Lecture 4: **Simple Linear Regression**

Lecture 5: **Introduction to Causality**

*Midterm Project*

Lecture 6: **Multiple Linear Regression**

Lecture 7: **Linear Regression Extensions**

Quiz 3

Lecture 8: **Sampling**

Lecture 9: **Confidence Intervals and Hypothesis Testing**

Quiz 4

Lecture 10: **Statistical Inference**

Lecture 11: **Regression Discontinuity**

Quiz 5

Lecture 12: **Recap**

*Final Project*



# Course Materials and Useful Resources

[Book](#)

[Slides](#)

[Reading Suggestions](#)

[Interactive R Apps](#)



# Course Materials and Useful Resources

Book	Slides	Reading Suggestions	Interactive R Apps
------	--------	---------------------	--------------------

## Econometrics

- *Mastering Metrics* by Angrist and Pischke
- *Modern Introduction to Econometrics* by Wooldridge
- *Introduction to Econometrics* by Stock and Watson
- *Causal Inference: The Mixtape* by Cunningham
- Ben Lambert's youtube channel

## Metrics and R

- ModernDive
- Introduction to Econometrics with R
- R for Data Science
- Awesome R Learning Resources



# Course Policies

*Be nice. Be honest. Don't cheat.<sup>1</sup>*

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## **Class conduct and expectations**

*Late work:* Won't be accepted unless you have a very good reason.

*Cheating:* I will have a chat with you. Just don't cheat, it's honestly not worth it.

*Work in groups:* You can/should work in groups of 2 (3 max) on the quizzes.

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# Mental Health

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To combat everyone's social isolation (mine included!), I propose we meet weekly on ***gather.town*** 😊 (details on Slack)



**SEE YOU NEXT WEEK!**

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 Slides

 Book

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