SciencesPo
DEPARTMENT OF ECONOMICS

ScPoEconometrics

Introduction

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What is *econometrics*?

- A set of techniques and methods to answer questions with data.
- Econometrics shares many things with *applied statistics* and *machine learning*.
- Some examples!

Answering Important Questions with Econometrics

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

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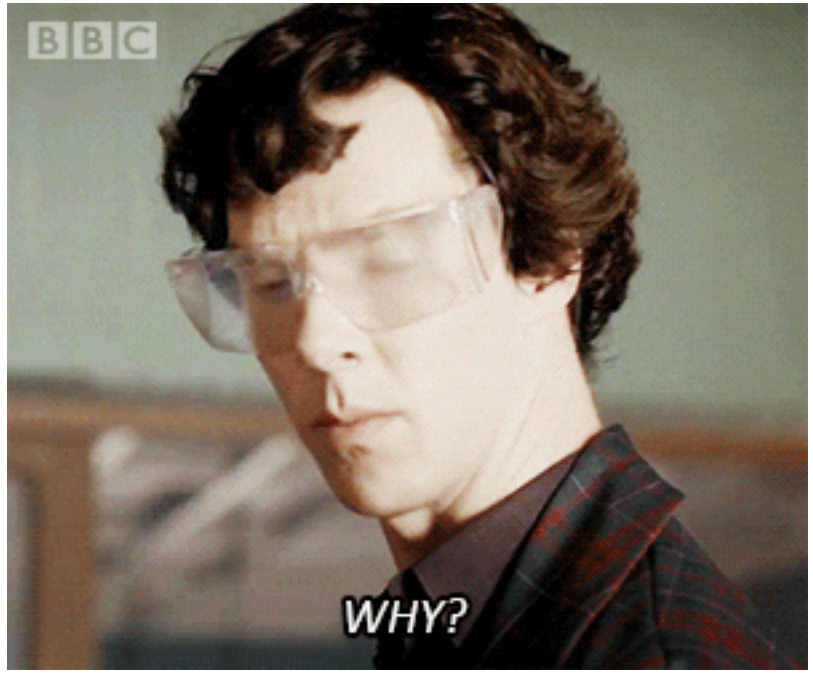
- Does immigration *cause* lower wages and higher unemployment for locals?
- Does increasing the minimum wage *cause* greater unemployment?
- Does more education *cause* higher wages?
- Does higher public debt levels *cause* lower economic growth?
- Does birth order *cause* differing education trajectories?

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.

As in the acclaimed Book of Why we often ask *why* did something happen?



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

Course Materials

1. The Book
2. The Slides
3. The code repository for book and R package
4. Quizzes on Moodle

Syllabus 🤞

Lecture 1: **Introduction**

Quiz 1 (after lecture 2)

Lecture 2/3: **Summarising Data**

Quiz 2

Lecture 4: **Simple Linear Regression**

Lecture 5: **Introduction to Causality**

Midterm Project

Lecture 6: **Multiple Linear Regression**

Lecture 7: **Sampling**

Quiz 3

Lecture 8/9: **Statistical Inference**

Quiz 4

Lecture 10: **Differences-in-Differences**

Lecture 11: **Regression Discontinuity**

Quiz 5

Lecture 12: ***Recap***

Final Project

Useful Resources (Other Than our *Book*)

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

R

What is R?

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. (stack overflow)
4. If you put in the work[2], 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("chapter1_files/figure-html/conto
  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 = "CO
tmap_mode("plot")
tm_shape(iris_map) +
  tm_borders() +
  tm_fill(col = "DISP_MED15", title = "Median household
```

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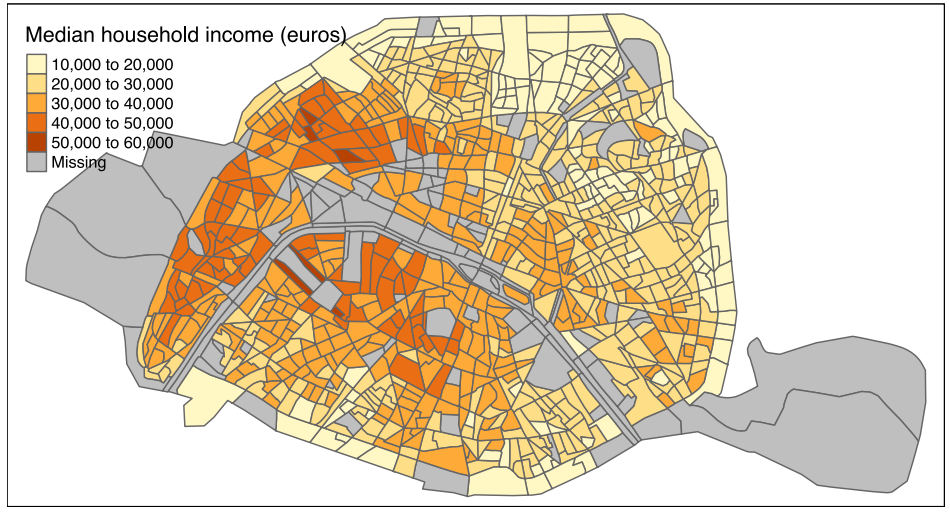
- Can be improved but you get this with only **13 lines of code!**



Showcase #2: Interactive web applications

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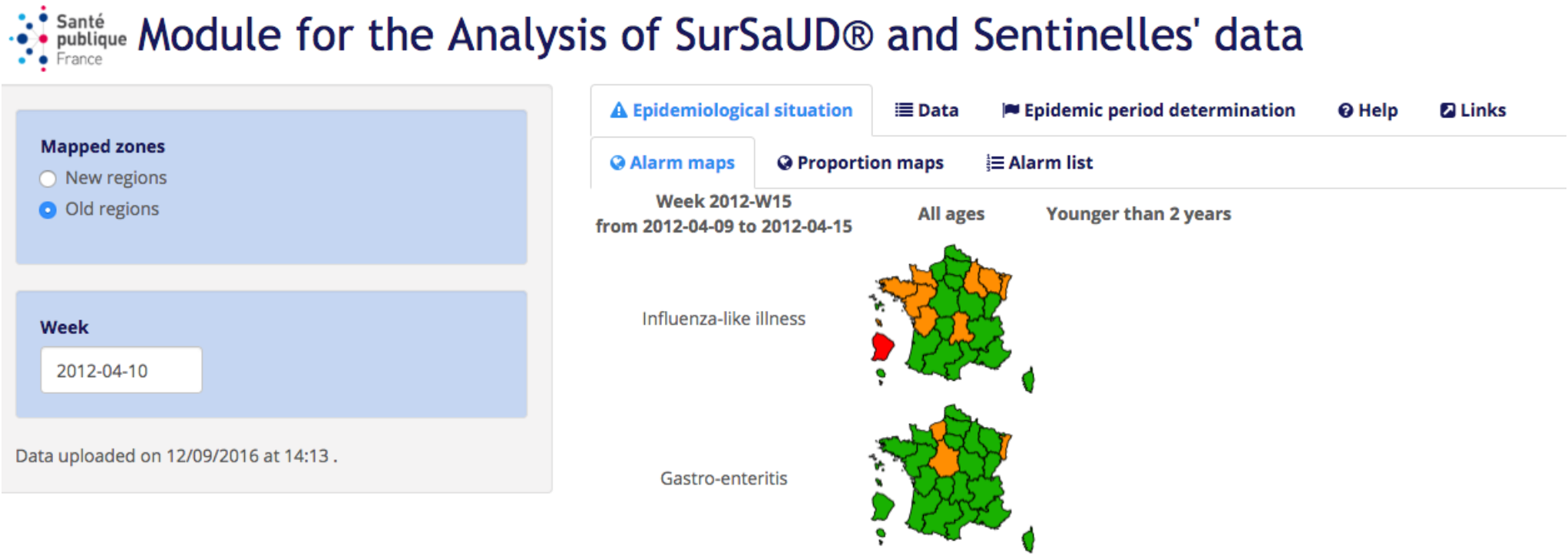
- Santé publique France has created a simple web application to track the epidemiological situation in French regions per week



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.
- 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 obj
gapminder = gapminder::gapm
  # display variables in th
names(gapminder)
  # show first 4 lines of t
head(gapminder,n = 4)
```

```
## [1] "country"   "continent" "year"      "lifeExp"   "pop"       "gdpPercap"
## # A tibble: 4 x 6
##   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)
  )
```

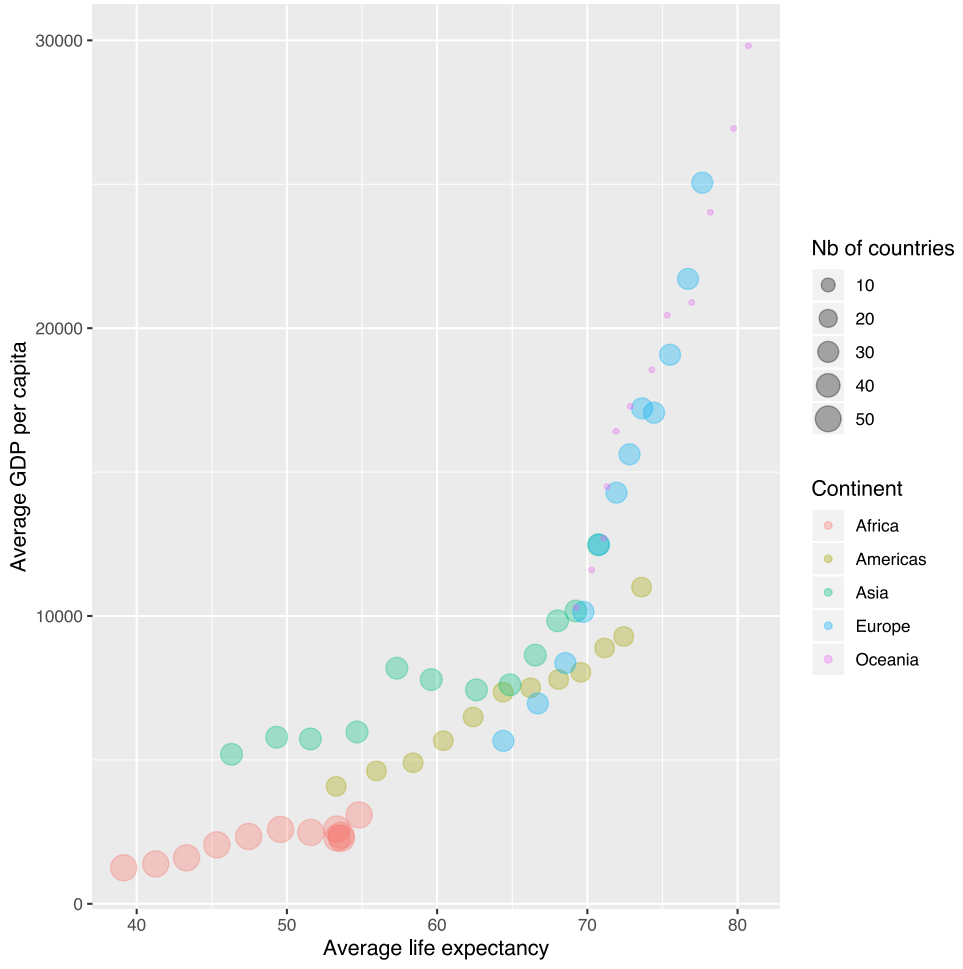
```
  # show first 5 lines of this dataframe
head(gapminder_dplyr, n = 5)
```

```
## # 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.
```

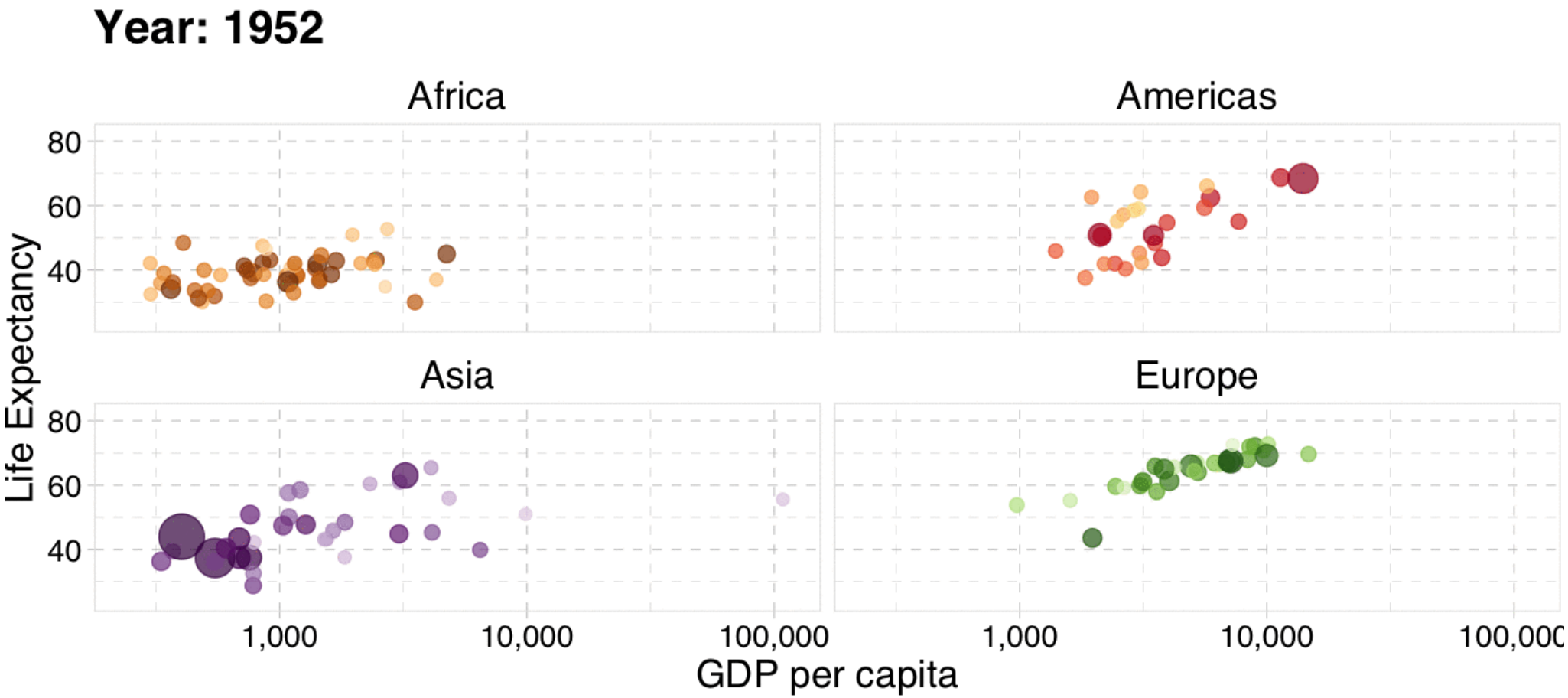
Visualisation

- 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]



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

R 101: Here Is Where You Start

Tool Time!

Getting R and Rstudio

- Download `R` from CRAN for your OS.
- Download `RStudio` from here for your OS.

Start your `RStudio`!

First Glossary of Terms

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- *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`!

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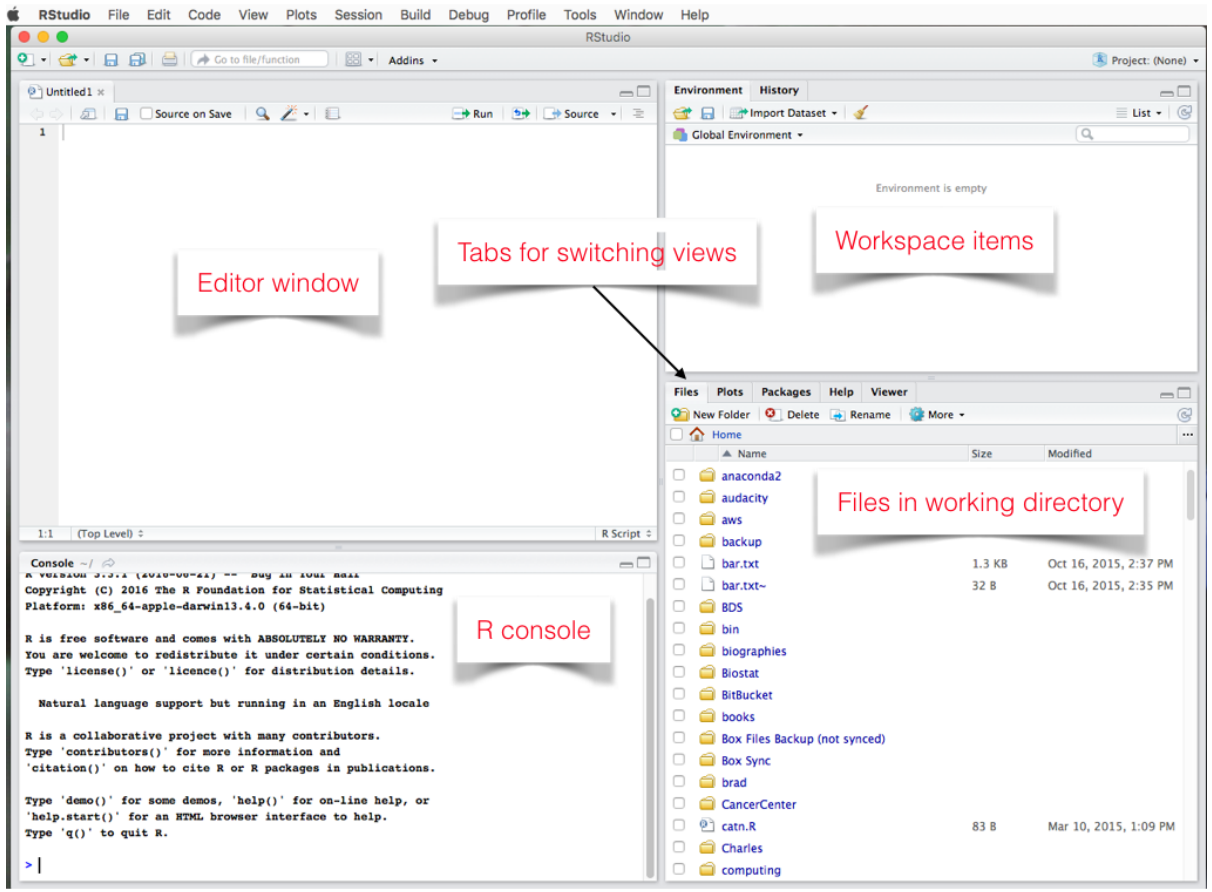
- *command*: user input (text or numbers) that `R` *understands*.
- *script*: a list of commands collected in a text file, each separated by a new line, to be run one after the other.
- To run a script, you need to highlight the relevant code lines and hit `Ctrl`+`Enter` (Windows) or `Cmd`+`Enter` (Mac).

RStudio Layout



R as a Calculator

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

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- 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 (5 minutes)

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

```
4 * 8
```

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

Where to get Help?

- `R` built-in `help`:

```
?log
?sin
?paste
?lm
help(lm)   # help() is equivalent
??plot  # get all help on keyword "plot"
help(ggplot,package="ggplot2")  # show help from a certain package
```

- Help from Humans!
  - Google is your best friend!
  - stackoverflow.com [SO]
  - Your classroom channel on Slack
  - rstudio forum

HOW to get Help? Follow this for Slack questions!

1. Describe what you want to do.
2. Describe what you *expect* your code to do.
3. Describe what your code *does instead*.
    - Provide the entire error message.
4. Provide enough code to *reproduce* your error.
    - You can post post code snippets on Slack and Stack Overflow

R Packages

- `R` users contribute add-on data and functions as *packages*
- Installing packages is easy!

```
install.packages("ggplot2")
```

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

```
library(ggplot2)
```

`ScPoEconometrics` package

- We wrote an `R` package for you.
- It's hosted on GitHub
- You can install (and frequently update!) from here:

```
if (!require("devtools")) install.packages("devtools")
library(devtools)
install_github(repo = "ScPoEcon/ScPoEconometrics")
```

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library(devtools)
install_github(repo = "ScPoEcon/ScPoEconometrics")
```

- Did it work?

```
library(ScPoEconometrics)
packageVersion("ScPoEconometrics")
```

```
## [1] '0.2.6'
```

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*

```
c(y = 1:6)
```

```
## y1 y2 y3 y4 y5 y6
##  1  2  3  4  5  6
```

`data.frame`'s

`data.frame`s 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 FALSE
## 2 3   Hello FALSE
## 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.frame`s by hand.

Task 2 (10 minutes)

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

```
# Check class
class(murder)
```

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

```
# Obain variable names
names(murders)
```

- 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 methods for 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 ...
```

```
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

- Let's look at the first rows of `murders`.

```
head(murders, n = 3)  # show first 3 rows
```

```
##     state abb region population total
## 1 Alabama  AL  South    4779736   135
## 2  Alaska  AK   West     710231    19
## 3 Arizona  AZ   West    6392017   232
```

- 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"
```

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

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
```

- But there is a special function which looks nicer.

```
subset(murders, subset = total > 500, select = c("state", "total"))
```

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

Task 3 (10 minutes)

1. How many observations are there in `murders`?
2. How many variables? What are the data types of each variable?
3. Notice 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`?
6. What is the average value of `total` for state's in the "South", i.e. with `region == "South"`?
7. Create a total_percap variable:

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

Congratulations, you've created your first variable!

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SEE YOU NEXT WEEK!

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	Slides
	Book
	@ScPoEcon
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