A Brief Introduction to Programming with R

MEcon/MIQEF Introductory Week

Erik Senn & Jeremia Stalder

2025-09-05

Part I: Background / Tools

Schedule

Morning Sessions

09:15 - 10:00

Introduction, Background, Tools

10:00 - 10:15

Break, support with installations

10:15 - 11:00

Exercises, First steps with R

11:00 - 11:15

Break, Q&A

11:15 - 12:00

First steps with R, Concepts

Afternoon Sessions

12:00 - 13:15

Lunch (individually)

13:15 - 14:00

Exercises

14:00 - 14:15

Break, Q&A

14:15 - 15:00

Working with Data

Welcome

1. **Fire up** your notebooks!
2. **Download** (or clone) the course materials
    - GitHub Repository
    - Course slides available online

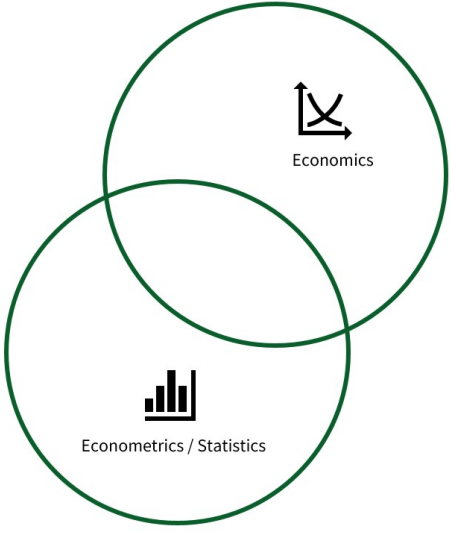
Why learn to program (now)?

Background: Technological change

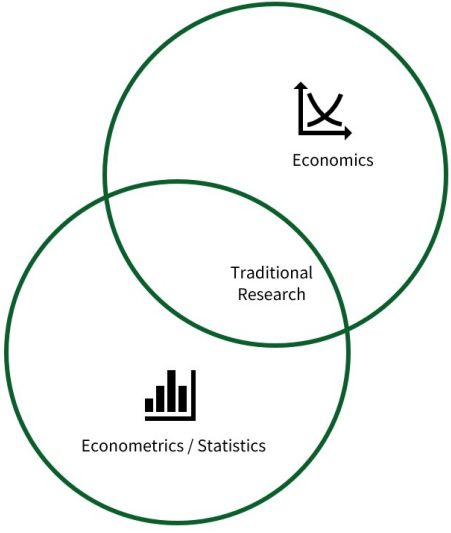
- Computers have become **omnipresent**
- Data is one of the world's most **valuable resources**
- **AI and machine learning** are reshaping every business and industry

Perspective: Data Science and Economics

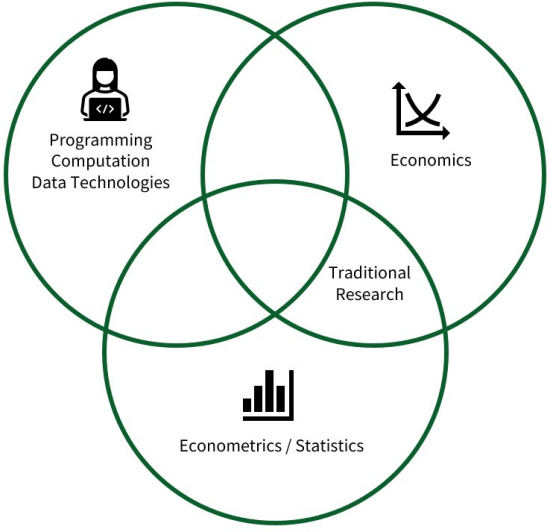
Perspective: Data Science and Economics



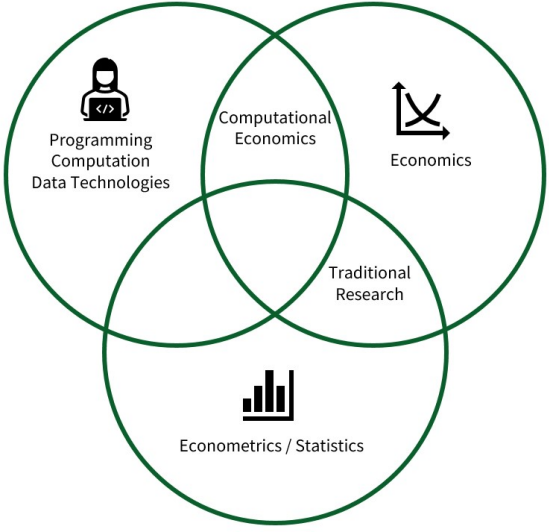
Perspective: Data Science and Economics



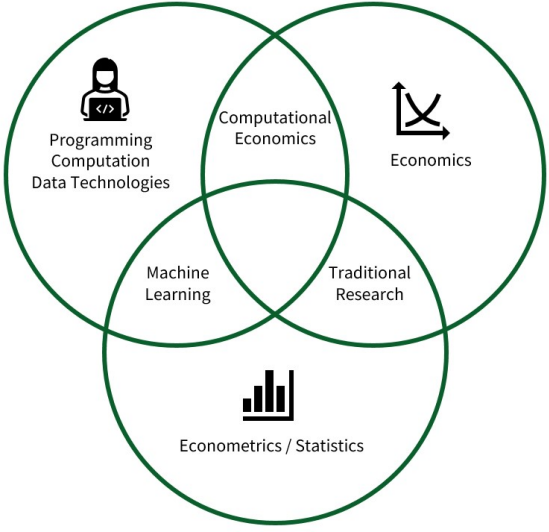
Perspective: Data Science and Economics



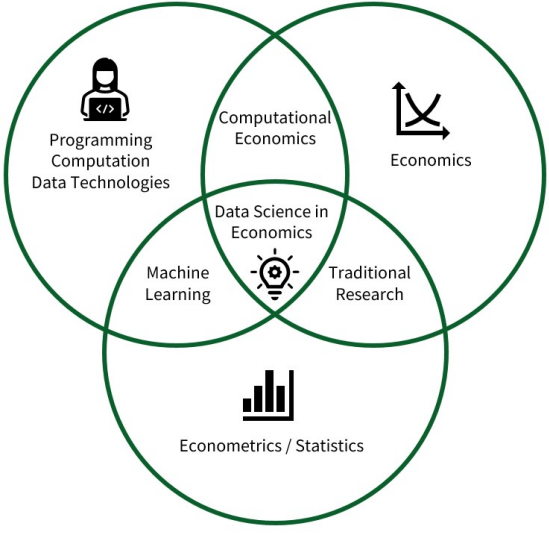
Perspective: Data Science and Economics



Perspective: Data Science and Economics



Perspective: Data Science and Economics



Why learn to program if AI assis

Why R?

A data language

- Widely used in **data science** jobs
- Particularly adapted to program with **data**
- Originally designed for **statistical analysis**
- Competing with Python as the **top data science language**

A high-level language

- **Relatively easy** to learn

A high-level language

- **Relatively easy** to learn
- Extensive **free resources**:

A high-level language

- **Relatively easy** to learn
- Extensive **free resources**:
  - DataCamp: Introduction to R

A high-level language

- **Relatively easy** to learn
- Extensive **free resources**:
  - DataCamp: Introduction to R
  - RStudio Cheatsheets

A high-level language

- **Relatively easy** to learn
- Extensive **free resources**:
  - DataCamp: Introduction to R
  - RStudio Cheatsheets
  - Stack Overflow

The Tools

R

R is the **programming language.**

You can download R from: https://cran.r-project.org/

RStudio Desktop

RStudio is the **integrated development environment (IDE).**

You can download RStudio Desktop from: https://posit.co/download/rstudio-desktop/

RStudio Cloud

RStudio Cloud lets you use RStudio **without a local installation**

You can use RStudio (Posit) Cloud by registering here: https://posit.cloud/

An RStudio Tour

An RStudio Tour

Exercises

Exercise A: Setting up a Working Environment

1. Open **RStudio** and navigate to your desired working folder
2. Create a new folder called **r_course**
3. Set it as your **working directory**
4. Create subfolders: **data** and **code**
5. Create a new **R Project** in the `r_course` folder

Exercise B: R Scripts

1. In the R console, type:

```
print("Hello world")
```

2. Create a new **R script**: `File > New File > R Script`
3. Type the same code in the script and **run it**

Part II: First Steps and Basic Concepts

First Steps in R

Variables and Vectors

```
a <- 2
a
```

```
[1] 2
```

Working with Vectors

R easily allows to work with **vectors** of data!

```
# Instantiate an integer vector 'a'
a <- c(10, 22, 33, 22, 40)
# Give names to the vector's elements
names(a) <- c("Andy", "Betty", "Claire",
              "Daniel", "Eva")
a  # Display the vector
```

```
  Andy  Betty Claire Daniel    Eva
    10     22     33     22     40
```

Indexing

We can access **single** (or **multiple**) elements of a vector:

```
a[3]     # Access the 3rd element
```

```
Claire
    33
```

```
a[3:5]   # Access the 3rd to 5th elements
```

```
Claire Daniel    Eva
    33     22     40
```

```
a["Claire"]  # Access by name
```

```
Claire
    33
```

Inspecting variables

```
class(a)  # Display the class
```

```
[1] "numeric"
```

```
str(a)    # Display the structure
```

```
 Named num [1:5] 10 22 33 22 40
 - attr(*, "names")= chr [1:5] "Andy" "Betty" "Claire" "Daniel" ...
```

Math Operators

Basic operators:

- $+$: `+`
- $-$: `-`
- $\times$: `*`
- $\div$: `/`

More operators:

- a^n : `a^n`
- $\sqrt{a}$: `sqrt(a)`
- $\ln a$: `log(a)`
- e^n : `exp(n)`

Basic Programming Concepts

Loops

- **Repeatedly execute** a sequence of commands
- For a **known** or **unknown** number of iterations
  - **for-loop**: number of iterations typically known
  - **while-loop**: iterate until a condition is met

for-loops in R

```r
n_iter <- 5  # Define number of iterations
# Specify the loop
for (i in 1:n_iter) {
    print(i)  # Print the number 'i'
}
```

```
[1] 1
[1] 2
[1] 3
[1] 4
[1] 5
```

for-loops: Summing numbers

```
numbers <- c(72, 42, 150, 13, 36, 19)
total_sum <- 0  # Initialize sum

# Specify the loop
for (n in numbers) {
    total_sum <- total_sum + n
}
total_sum
```

```
[1] 332
```

Nested for-loops

```
n_iter_inner <- 100
n_iter_outer <- 500

# Start outer loop
for (i in 1:n_iter_outer) {
    # Code for outer loop

    # Start inner loop
    for (j in 1:n_iter_inner) {
        # Code for inner loop
    }
}
```

How many iterations does this combination amount to?

Booleans and Logical Statements

```
2 + 2 == 4  # Is 2+2 equal to 4?
```

```
[1] TRUE
```

```
3 + 3 == 7  # Is 3+3 equal to 7?
```

```
[1] FALSE
```

```
4 != 7      # Is 4 not equal to 7?
```

```
[1] TRUE
```

Control Flow with Booleans

```r
condition <- TRUE

if (condition) {
    print("The condition is true!")
} else {
    print("The condition is false!")
}
```

```
[1] "The condition is true!"
```

R Functions

- Functions take **parameter values** as input, process these values, and **return** results
- Many functions are **provided with R**
- Additional functions via **packages**

```
numbers <- c(13, 25, 39, 881)
mean(numbers)    # Compute the mean
```

```
[1] 240
```

```
sd(numbers)      # Standard deviation
```

```
[1] 428
```

```
median(numbers)  # Median
```

```
[1] 32
```

Creating Custom Functions

```
# Define custom mean function
my_mean <- function(x) {
    x_bar <- sum(x) / length(x)
    return(x_bar)
}

# Test the function
my_mean(numbers)
```

```
[1] 240
```

```
mean(numbers)  # Compare with built-in
```

```
[1] 240
```

Data Structures and Indices

Vectors and Lists

```
# Integer vector
integer_vector <- 9:20
integer_vector[2]    # Second element
```

```
[1] 10
```

```
integer_vector[2:5]  # Second to fifth
```

```
[1] 10 11 12 13
```

```
# String vector
string_vector <- c("a", "b", "c")
string_vector[-3]    # All except third
```

```
[1] "a" "b"
```

Lists

Lists can contain **different types** of elements:

```
# Create a list
my_list <- list(
    numbers = integer_vector,
    letters = string_vector,
    condition = TRUE
)
str(my_list)
```

```
List of 3
 $ numbers  : int [1:12] 9 10 11 12 13 14 15 16 17 18 ...
 $ letters  : chr [1:3] "a" "b" "c"
 $ condition: logi TRUE
```

Accessing List Elements

```
# Access by name
my_list$numbers[1:3]
```

```
[1]  9 10 11
```

```
my_list[["letters"]]
```

```
[1] "a" "b" "c"
```

```
# Access by index
my_list[[1]][1:3]
```

```
[1]  9 10 11
```

Matrices

```
# Create a matrix
my_matrix <- matrix(integer_vector, nrow = 4)
my_matrix
```

```
     [,1] [,2] [,3]
[1,]    9   13   17
[2,]   10   14   18
[3,]   11   15   19
[4,]   12   16   20
```

```
my_matrix[2,]      # Second row
```

```
[1] 10 14 18
```

```
my_matrix[, 1:2]   # First two columns
```

```
     [,1] [,2]
```

Data Frames

```r
# Create a dataframe
my_df <- data.frame(
    Name = c("Alice", "Betty", "Claire"),
    Age = c(20, 30, 45)
)

my_df
```

Name	Age
Alice	20
Betty	30
Claire	45

```r
my_df$Age          # Access column
```

```
[1] 20 30 45
```

Exercises

Exercise A: Write a Sum Function

Write a function that takes a **numeric vector** as input and returns the **sum** of the vector's elements.

```
my_sum <- function(x) {
    # Your code here
}
```

Test by comparing with built-in `sum()` function.

Exercise B: Robustness and Warnings

Test your `my_sum()` function with:

```
numbers2 <- c("1", "2", "3")
```

Add **error checking** to make the function robust.

Exercise C: Standard Deviation Function

Implement a function to compute the **standard deviation**:

$$\text{SD} = \sqrt{\frac{1}{N-1}\sum_{i=1}^{N}(x_i - \bar{x})^2}$$

Exercise D: Standard Error Function

Building on Exercise C, implement:

$$\text{SE}_{\bar{x}} = \frac{\text{SD}}{\sqrt{N}}$$

Exercise E: T-test

Implement a **one-sample t-test** function:

$$t = \frac{\bar{x} - \mu_0}{\text{SE}_{\bar{x}}}$$

Exercise F: Fibonacci Sequence

Generate the first 30 **Fibonacci numbers** where:

- $F_0 = 0, F_1 = 1$
- $F_n = F_{n-1} + F_{n-2}$ for $n > 1$

Exercise G: Multiples of 3 and 5 (*)

Write a function that computes the sum of all **multiples of 3 or 5** up to a number N.

Hint: Multiples of both 3 and 5 should only be added once!

Exercise H: Prime numbers (*)

Write a function that computes the sum of all **prime numbers** up to a number N.

Part III: Working with Data

Loading/Importing Data

Loading built-in R data sets

```
# Load built-in dataset
data(swiss)

# Check if loaded
class(swiss)
```

```
[1] "data.frame"
```

The `data()` function loads **built-in R datasets** into your environment.

Inspect the data structure

```
# Structure of the swiss dataset
str(swiss)
```

```
'data.frame':   47 obs. of  6 variables:
 $ Fertility       : num  80.2 83.1 92.5 85.8 76.9 76.1 83.8 92.4 82.4 82.9 ...
 $ Agriculture     : num  17 45.1 39.7 36.5 43.5 35.3 70.2 67.8 53.3 45.2 ...
 $ Examination     : int  15 6 5 12 17 9 16 14 12 16 ...
 $ Education       : int  12 9 5 7 15 7 7 8 7 13 ...
 $ Catholic        : num  9.96 84.84 93.4 33.77 5.16 ...
 $ Infant.Mortality: num  22.2 22.2 20.2 20.3 20.6 26.6 23.6 24.9 21 24.4 ...
```

First few rows of the data

```
head(swiss, 4)
```

	Fertility	Agriculture	Examination	Education	Catholic	Infant.Mortality
Courtelary	80.2	17.0	15	12	9.96	22.2
Delemont	83.1	45.1	6	9	84.84	22.2
Franches-Mnt	92.5	39.7	5	5	93.40	20.2
Moutier	85.8	36.5	12	7	33.77	20.3

Comma Separated Values (CSV)

Example of **CSV format**:

```
"","Fertility","Agriculture","Examination",...
"Courtelary",80.2,17,15,...
"Delemont",83.1,45.1,6,...
```

Importing data from different sources

```
# CSV files
swiss_csv <- read.csv("./data/swiss.csv")

# Excel files (requires readxl)
library(readxl)
swiss_excel <- read_excel("./data/swiss.xlsx")

# SPSS files (requires haven)
library(haven)
swiss_spss <- read_spss("./data/swiss.sav")
```

Introduction to the Tidyverse

What is the Tidyverse?

To install and load:

```
install.packages("tidyverse")
library(tidyverse)
```

The Pipe Operator |>

Transform nested functions into **readable pipelines**:

```
# Traditional approach
head(select(swiss, Fertility, Education), 3)
```

	Fertility	Education
Courtelary	80.2	12
Delemont	83.1	9
Franches-Mnt	92.5	5

```
# With pipe operator
swiss |>
  select(Fertility, Education) |>
  head(3)
```

	Fertility	Education

Select columns with `select()`

```
# Select specific columns
swiss |>
  select(Fertility, Education, Catholic) |>
  head(3)
```

	Fertility	Education	Catholic
Courtelary	80.2	12	9.96
Delemont	83.1	9	84.84
Franches-Mnt	92.5	5	93.40

Select columns - Advanced patterns

```
# Select by pattern
swiss |>
  select(starts_with("E"), contains("Mort")) |>
  head(3)
```

	Examination	Education	Infant.Mortality
Courtelary	15	12	22.2
Delemont	6	9	22.2
Franches-Mnt	5	5	20.2

Filter rows with `filter()`

```
# Keep rows meeting conditions
swiss |>
  filter(Education > 20) |>
  select(Fertility, Education, Catholic) |>
  head()
```

	Fertility	Education	Catholic
Lausanne	55.7	28	12.1
Neuchatel	64.4	32	16.9
V. De Geneve	35.0	53	42.3
Rive Droite	44.7	29	50.4
Rive Gauche	42.8	29	58.3

Create new variables with `mutate()`

```
swiss |>
  mutate(
    High_Education = Education > 15,
    Fert_per_100 = Fertility / 100
  ) |>
  select(Education, High_Education,
         Fertility, Fert_per_100) |>
  head(3)
```

	Education	High_Education	Fertility	Fert_per_100
Courtelary	12	FALSE	80.2	0.802
Delemont	9	FALSE	83.1	0.831
Franches-Mnt	5	FALSE	92.5	0.925

Arrange rows with `arrange()`

```
swiss |>
  arrange(desc(Education)) |>
  select(Education, Examination) |>
  head(4)
```

	Education	Examination
V. De Geneve	53	37
Neuchatel	32	35
Rive Droite	29	16
Rive Gauche	29	22

Summarize data with `summarize()`

```
swiss |>
  summarize(
    mean_edu = mean(Education),
    sd_edu = sd(Education),
    median_fert = median(Fertility),
    n = n()
  )
```

mean_edu	sd_edu	median_fert	n
11	9.62	70.4	47

Group operations with `group_by()`

```
# Add Religion variable
swiss <- swiss |>
  mutate(Religion = ifelse(Catholic > 50,
                           'Catholic',
                           'Protestant'))

# Group and summarize
swiss |>
  group_by(Religion) |>
  summarize(
    mean_education = mean(Education),
    mean_fertility = mean(Fertility),
    count = n()
  )
```

Religion	mean_education	mean_fertility	count
Catholic	9.11	76.5	18

Combining multiple operations

```
swiss |>
  filter(Agriculture < 50) |>
  group_by(Religion) |>
  summarize(
    avg_exam = mean(Examination),
    n = n(),
    .groups = "drop"
  ) |>
  arrange(desc(avg_exam))
```

Religion	avg_exam	n
Protestant	23.1	15
Catholic	12.3	6

Reshape data: Wide to Long

```
# Original wide format
swiss_subset <- swiss |>
  slice(1:2) |>
  select(Fertility, Agriculture)

swiss_subset
```

	Fertility	Agriculture
Courtelary	80.2	17.0
Delemont	83.1	45.1

Reshape data: pivot_longer()

```
# Convert to long format
swiss_subset |>
  pivot_longer(
    cols = everything(),
    names_to = "Metric",
    values_to = "Value"
  )
```

Metric	Value
Fertility	80.2
Agriculture	17.0
Fertility	83.1
Agriculture	45.1

Join data frames

```r
# Sample data
df1 <- data.frame(
  Province = c("A", "B"),
  Population = c(5000, 6000)
)

df2 <- data.frame(
  Province = c("A", "B", "C"),
  Language = c("FR", "FR", "DE")
)

# Left join keeps all rows from df1
left_join(df1, df2, by = "Province")
```

Province	Population	Language
A	5000	FR
B	6000	FR

Working with dates using lubridate

```r
library(lubridate)

# Create and parse dates
dates <- c("2023-09-08", "2023-09-15")
parsed_dates <- ymd(dates)

# Extract components
data.frame(
  date = parsed_dates,
  year = year(parsed_dates),
  month = month(parsed_dates),
  weekday = wday(parsed_dates, label = TRUE)
)
```

date	year	month	weekday
2023-09-08	2023	9	Fr
2023-09-15	2023	9	Fr

Advanced tidyverse: map functions

```
# Apply a function to multiple columns
swiss |>
  select(Fertility, Agriculture, Education) |>
  map_dbl(~ mean(.x)) |>
  round(2)
```

```
  Fertility Agriculture   Education
       70.1        50.7        11.0
```

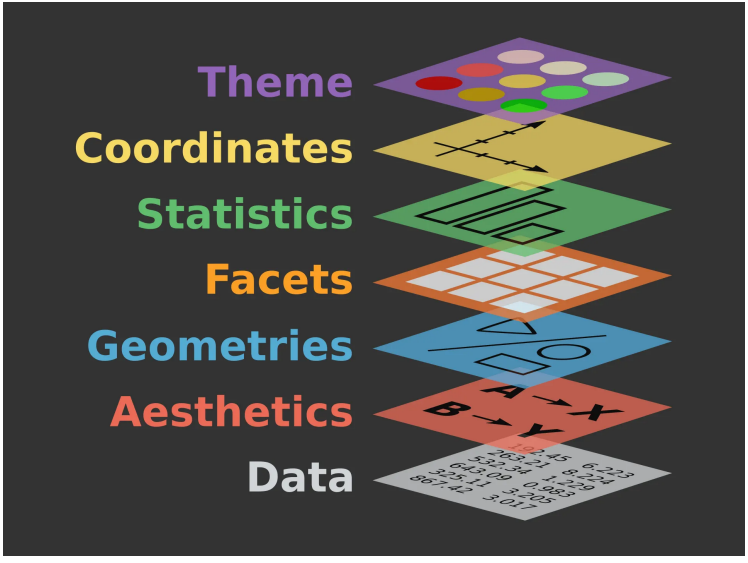
String manipulation with stringr

```
library(stringr)

# Example text
provinces <- c("Courtelary", "Delemont", "Franches-Mnt")

# String operations
data.frame(
  original = provinces,
  lower = str_to_lower(provinces),
  length = str_length(provinces),
  contains_e = str_detect(provinces, "e")
)
```

original	lower	length	contains_e
Courtelary	courtelary	10	TRUE
Delemont	delemont	8	TRUE
Franches-Mnt	franches-mnt	12	TRUE

Visualization with R (ggplot2)

Grammar of Graphics - Layers



ggplot2 basics

```
# Basic structure
ggplot(data = <DATA>,
       mapping = aes(x = <X>, y = <Y>)) +
  <GEOM_FUNCTION>() +
  <OPTIONAL_LAYERS>
```

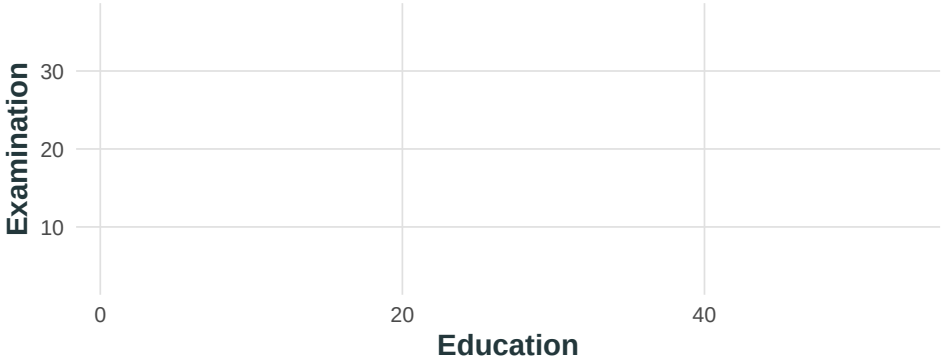
Prepare the data

```
# Add Religion indicator
swiss$Religion <- factor(
  ifelse(swiss$Catholic > 50,
         'Catholic', 'Protestant')
)

# Check the data
table(swiss$Religion)
```

```
  Catholic Protestant
        18         29
```

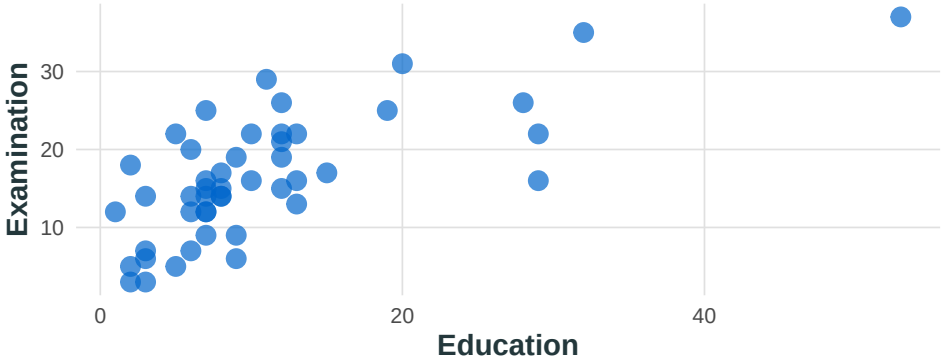
Building a plot: Data + Aesthetics

```
ggplot(data = swiss,
       aes(x = Education, y = Examination))
```



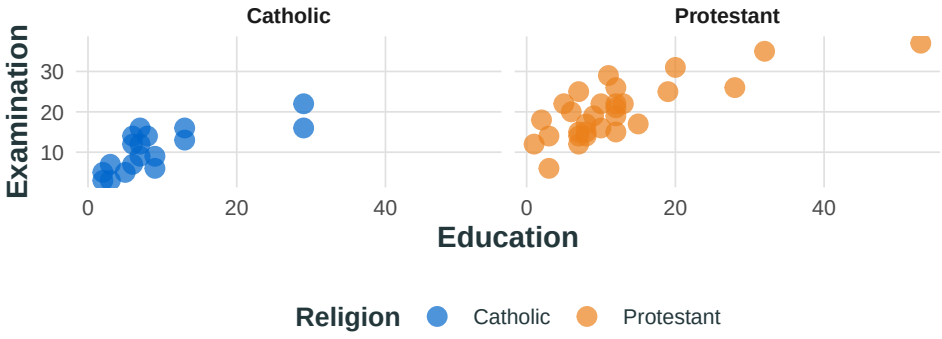
Adding Geometries

```
ggplot(data = swiss,
       aes(x = Education, y = Examination)) +
  geom_point(size = 3, alpha = 0.7, color = "#0066CC")
```



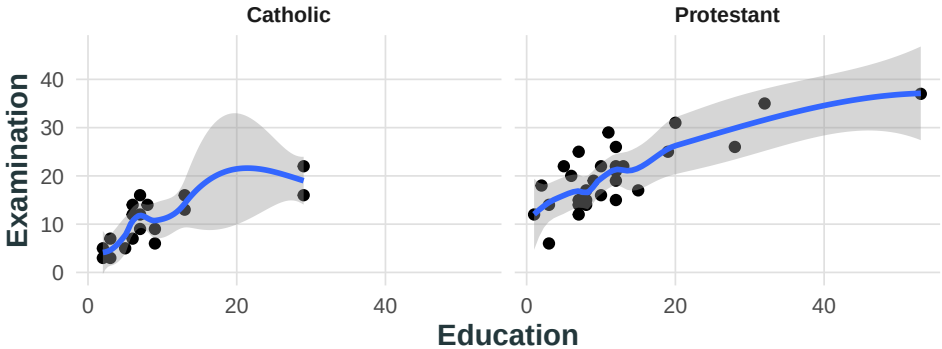
Using Facets

```
ggplot(data = swiss,
       aes(x = Education, y = Examination)) +
  geom_point(size = 3, alpha = 0.7, aes(color = Religion)) +
  scale_color_modern() +
  facet_wrap(~Religion)
```



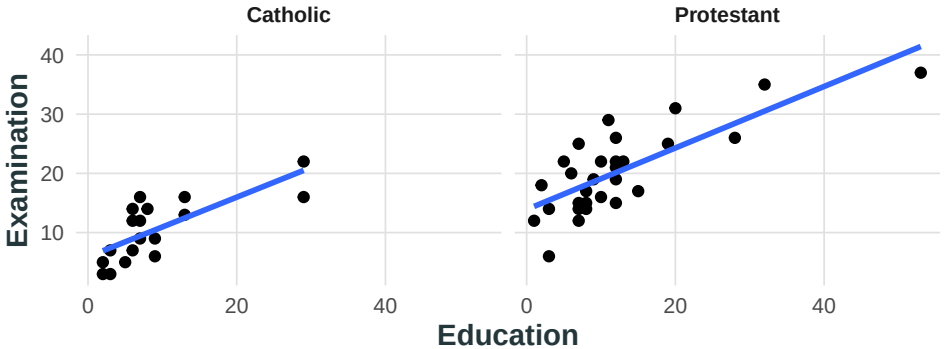
Adding Statistics with loess

```
ggplot(data = swiss,
       aes(x = Education, y = Examination)) +
  geom_point() +
  geom_smooth(method = 'loess') +
  facet_wrap(~Religion)
```



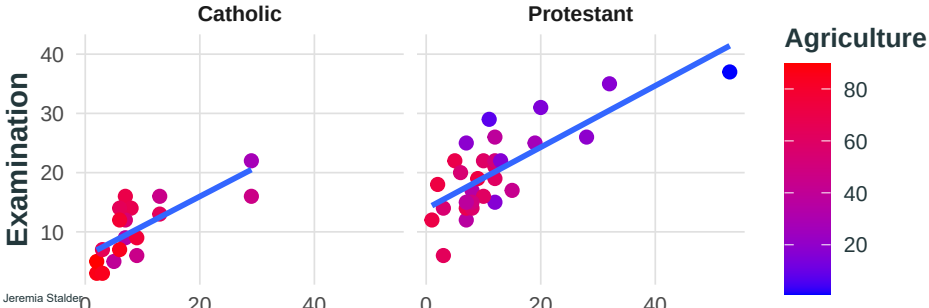
Adding Statistics with lm

```
ggplot(data = swiss,
       aes(x = Education, y = Examination)) +
  geom_point() +
  geom_smooth(method = 'lm', se = FALSE) +
  facet_wrap(~Religion)
```



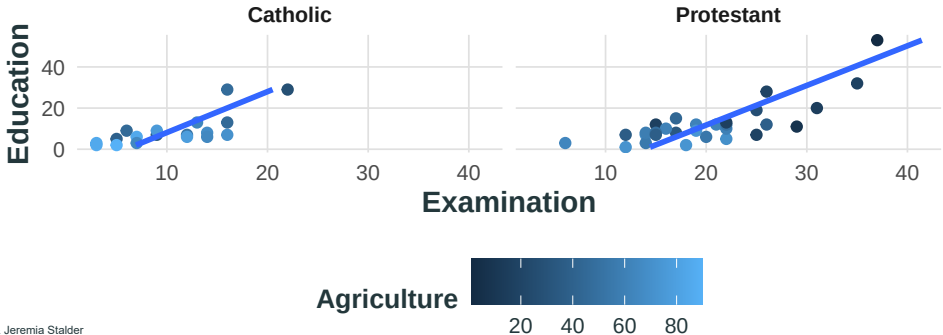
Multiple Aesthetics

```
ggplot(data = swiss,
       aes(x = Education, y = Examination)) +
  geom_point(aes(color = Agriculture), size = 2) +
  geom_smooth(method = 'lm', se = FALSE) +
  facet_wrap(~Religion) +
  scale_color_gradient(low = "blue", high = "red") +
  theme(legend.position = "right")
```



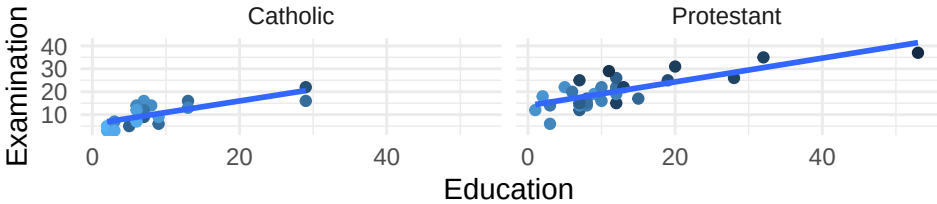
Change coordinates

```
ggplot(data = swiss,
       aes(x = Education, y = Examination)) +
  geom_point(aes(color = Agriculture)) +
  geom_smooth(method = 'lm', se = FALSE) +
  facet_wrap(~Religion) +
  coord_flip()
```



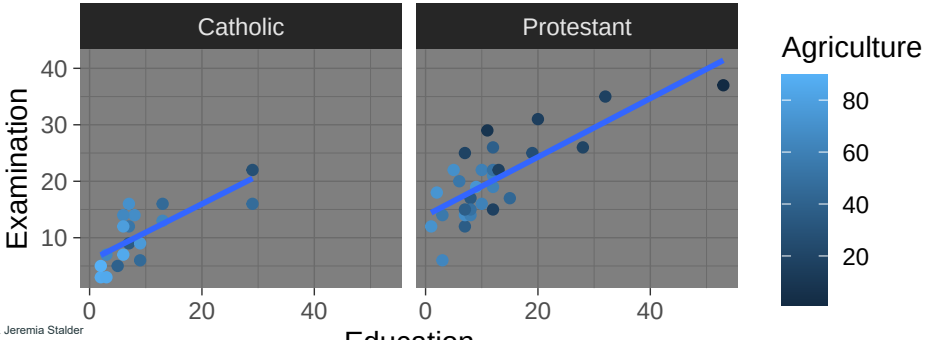
Customizing Themes

```
ggplot(data = swiss,
       aes(x = Education, y = Examination)) +
  geom_point(aes(color = Agriculture)) +
  geom_smooth(method = 'lm', se = FALSE) +
  facet_wrap(~Religion) +
  theme_minimal() +
  theme(legend.position = "bottom")
```



Pre-built Themes

```
ggplot(data = swiss,
       aes(x = Education, y = Examination)) +
  geom_point(aes(color = Agriculture)) +
  geom_smooth(method = 'lm', se = FALSE) +
  facet_wrap(~Religion) +
  theme_dark()
```



Save plots

```
# Save the last plot
ggsave("my_plot.png",
       width = 8, height = 5,
       dpi = 300)

# Save a specific plot
p <- ggplot(swiss, aes(Education, Examination)) +
  geom_point()

ggsave("scatter.pdf", plot = p,
       width = 6, height = 4)
```

Basic Statistics with R

Descriptive Statistics

```r
# Create sample data
x <- c(10, 22, 33, 22, 40)

# Basic statistics
c(mean = mean(x),
  median = median(x),
  sd = sd(x),
  min = min(x),
  max = max(x))
```

```
  mean median     sd    min    max
  25.4   22.0   11.5   10.0   40.0
```

T-test Example

```r
# Generate sample data
set.seed(123)
sample <- rnorm(30, mean = 10, sd = 2)

# One-sample t-test
t_result <- t.test(sample, mu = 10)
t_result$p.value
```

```
[1] 0.794
```

```r
t_result$conf.int
```

```
[1]  9.17 10.64
attr(,"conf.level")
[1] 0.95
```

Linear Regression - Setup

```r
# Define the model formula
model1 <- Examination ~ Education

# Fit the model
fit1 <- lm(model1, data = swiss)

# View coefficients
coef(fit1)
```

```
(Intercept)   Education
     10.127       0.579
```

Simple Linear Regression - Results

```
summary(fit1)
```

```
Call:
lm(formula = model1, data = swiss)

Residuals:
    Min      1Q  Median      3Q     Max
-10.932  -4.763  -0.184   3.891  12.498

Coefficients:
            Estimate Std. Error t value
(Intercept)  10.1275     1.2859    7.88
Education     0.5795     0.0885    6.55
                Pr(>|t|)
(Intercept) 0.00000000052 ***
Education   0.00000004811 ***
```

Multiple Linear Regression

```
# Fit model with multiple predictors
fit2 <- lm(Examination ~ Education + Catholic +
           Agriculture, data = swiss)

# Model fit statistics
c(R2 = summary(fit2)$r.squared,
  Adj_R2 = summary(fit2)$adj.r.squared,
  RMSE = sigma(fit2))
```

```
    R2 Adj_R2   RMSE
 0.728  0.709  4.304
```

Regression Coefficients Table

```r
# Extract coefficient information
coef_summary <- summary(fit2)$coefficients
round(coef_summary, 3)
```

```
             Estimate Std. Error t value Pr(>|t|)
(Intercept)    18.537      2.637    7.03    0.000
Education       0.424      0.087    4.89    0.000
Catholic       -0.080      0.017   -4.75    0.000
Agriculture    -0.068      0.040   -1.71    0.095
```

Other Econometric Models

```r
# Binary outcomes - Logit
glm(y ~ x1 + x2,
    family = binomial(link = "logit"))

# Binary outcomes - Probit
glm(y ~ x1 + x2,
    family = binomial(link = "probit"))

# Count data - Poisson
glm(y ~ x1 + x2,
    family = poisson())

# Panel data - Fixed effects (requires plm)
library(plm)
plm(y ~ x1 + x2,
    data = panel_data,
    model = "within")
```

Print Regression Results - Console

```
# Basic regression table
stargazer(fit1, fit2,
          type = "text",
          digits = 2,
          star.cutoffs = c(0.05, 0.01, 0.001),
          omit.stat = c("ser", "f"),
          column.sep.width = "1pt")
```

```
================================================ Dependent variable:
————————————————— Examination
(1) (2)
————————————————————————— Education 0.58*** 0.42***
(0.09) (0.09)

Catholic -0.08***
(0.02)

Agriculture -0.07
(0.04)

Constant 10.10*** 18.50***

(1.29) (2.64)
```

Observations 47 47
R2 0.49 0.73
Adjusted R2 0.48 0.71
========== Note: *p<0.05;* ***p<0.01;*** p<0.001

Export Results to LaTeX

```
# For LaTeX documents
stargazer(fit1, fit2,
          type = "latex",
          title = "Regression Results",
          label = "tab:reg",
          digits = 2,
          header = FALSE,
          font.size = "small",
          column.sep.width = "1pt",
          single.row = TRUE)
```

Save Regression Output

```
# Save as LaTeX file
stargazer(fit1, fit2,
          type = "latex",
          out = "./results/regression_table.tex",
          title = "Swiss Data Analysis",
          covariate.labels = c("Education (years)",
                               "Catholic (%)",
                               "Agriculture (%)"))

# Save as HTML
stargazer(fit1, fit2,
          type = "html",
          out = "./results/regression_table.html")
```

Final Remarks

Best Practices for R Programming

1. **Organization**
   - Start scripts with `library()` calls
   - Use meaningful variable names
   - Comment your code with #
2. **Efficiency**
   - Use functions to avoid repetition
   - Vectorize operations when possible
   - Use the tidyverse for data manipulation
3. **Reproducibility**
   - Set seeds for random operations
   - Use relative paths (`./data/`)
   - Document package versions

Resources for Learning R

Online Resources:

- **Stack Overflow**
- **R for Data Science** book
- **RStudio cheatsheets**
- **CRAN documentation**

AI Assistance:

- **ChatGPT**
- **GitHub Copilot**
- **Google Bard**

An example on AI Assistance for learning coding

Upcoming Courses

Next Week

R Programming Course

Instructor: Erik Senn
Dates: September 8-11, 2025
Time: 9:00-12:00 and 13:00-17:00
Location: Rosenbergstrasse 30, Room 61-152 Contents: Similar contents as today in slower pace. Automated reports using R-markdown on last day.

Thank You!

Thanks for joining our R workshop!

Happy Coding!

Survey

Please take a moment to provide feedback on today’s workshop.

Your input helps us improve future courses!