

# Introduction and Overview

EC 421, Set 1

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# Prologue

# Why?

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**One simple answer:** Learn about the world using data.

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2. Why do economists (or other people) study or use econometrics?

**One simple answer:** Learn about the world using data.

- *Learn about the world* = Raise, answer, and challenge questions, theories, assumptions.
- *data* = Plural of datum.

# Why?

## Example

GPA is an output from endowments (ability) and hours studied (inputs). So, one might hypothesize a model

$$\text{GPA} = f(H, \text{SAT}, \text{PCT})$$

where  $H$  is hours studied,  $\text{SAT}$  is SAT score and  $\text{PCT}$  is the percentage of classes an individual attended. We expect that GPA will rise with each of these variables (  $H$ ,  $\text{SAT}$ , and  $\text{PCT}$ ).

But who needs to *expect*?

We can test these hypotheses **using a regression model**.

# Why?

Example, cont.

**Regression model:**

$$\text{GPA}_i = \beta_0 + \beta_1 H_i + \beta_2 \text{SAT}_i + \beta_3 \text{PCT}_i + \varepsilon_i$$

We want to test estimate/test the relationship  $\text{GPA} = f(H, \text{SAT}, \text{PCT})$ .



# Why?

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(Review) Questions

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(Review) Questions

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- **Q:** Are the  $\beta_k$  terms population parameters or sample statistics?
- **A:** Greek letters denote **population parameters**. Their estimates get hats, e.g.,  $\hat{\beta}_k$ .

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- **A:** Not without making more assumptions and/or knowing more about the data-generating process.

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## (Review) Questions

- **Q:** Can we interpret the estimates for  $\beta_2$  as causal?
- **A:** Not without making more assumptions and/or knowing more about the data-generating process.
  
- **Q:** What is  $\varepsilon_i$ ?
- **A:** An individual's random deviation/disturbance from the population parameters.

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(Review) Questions

- **Q:** Which assumptions do we impose when estimating with OLS?

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## (Review) Questions

- **Q:** Which assumptions do we impose when estimating with OLS?
- **A:**
  - The relationship between the GPA and the explanatory variables is linear in parameters, and  $\varepsilon$  enters additively.
  - The explanatory variables are **exogenous**, *i.e.*,  $E[\varepsilon|X] = 0$ .
  - You've also typically assumed something along the lines of:  
 $E[\varepsilon_i] = 0$ ,  $E[\varepsilon_i^2] = \sigma^2$ ,  $E[\varepsilon_i \varepsilon_j] = 0$  for  $i \neq j$ .
  - And (maybe)  $\varepsilon_i$  is distributed normally.

# Assumptions

## How important can they be?

You've learned how **powerful and flexible** ordinary least squares (**OLS**) regression can be.

However, the results you learned required assumptions.

**Real life often violates these assumptions.**

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However, the results you learned required assumptions.

**Real life often violates these assumptions.**

EC421 asks "**what happens when we violate these assumptions?**"

- Can we find a fix? (Especially: How/when is  $\beta$  causal?)
- What happens if we don't (or can't) apply a fix?

OLS still does some amazing things—but you need to know when to be **cautious, confident, or dubious**.

# Not everything is causal



# Econometrics

An applied econometrician<sup>†</sup> needs a solid grasp on (at least) three areas:

1. The **theory** underlying econometrics (assumptions, results, strengths, weaknesses).
2. How to **apply theoretical methods** to actual data.
3. Efficient methods for **working with data**—cleaning, aggregating, joining, visualizing.

[†]: *Applied econometrician* = Practitioner of econometrics, e.g., analyst, consultant, data scientist.

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- 1: As before.
- 2–3: **R**

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R

## What is R?

To quote the [R project website](#):

R is a free software environment for statistical computing and graphics. It compiles and runs on a wide variety of UNIX platforms, Windows and MacOS.

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R is a free software environment for statistical computing and graphics. It compiles and runs on a wide variety of UNIX platforms, Windows and MacOS.

What does that mean?

- R was created for the statistical and graphical work required by econometrics.
- R has a vibrant, thriving online community. ([stack overflow](#))
- Plus it's **free** and **open source**.

## Why are we using R?

1. R is **free** and **open source**—saving both you and the university 💰💰💰.
2. *Related:* Outside of a small group of economists, private- and public-sector **employers favor R** over Stata and most competing softwares.
3. R is very **flexible and powerful**—adaptable to nearly any task, *e.g.*, 'metrics, spatial data analysis, machine learning, web scraping, data cleaning, website building, teaching. My website, the TWEEDS website, and these notes all came out of R.

## Why are we using R?

4. *Related*: R imposes **no limitations** on your amount of observations, variables, memory, or processing power. (I'm looking at **you**, Stata.)

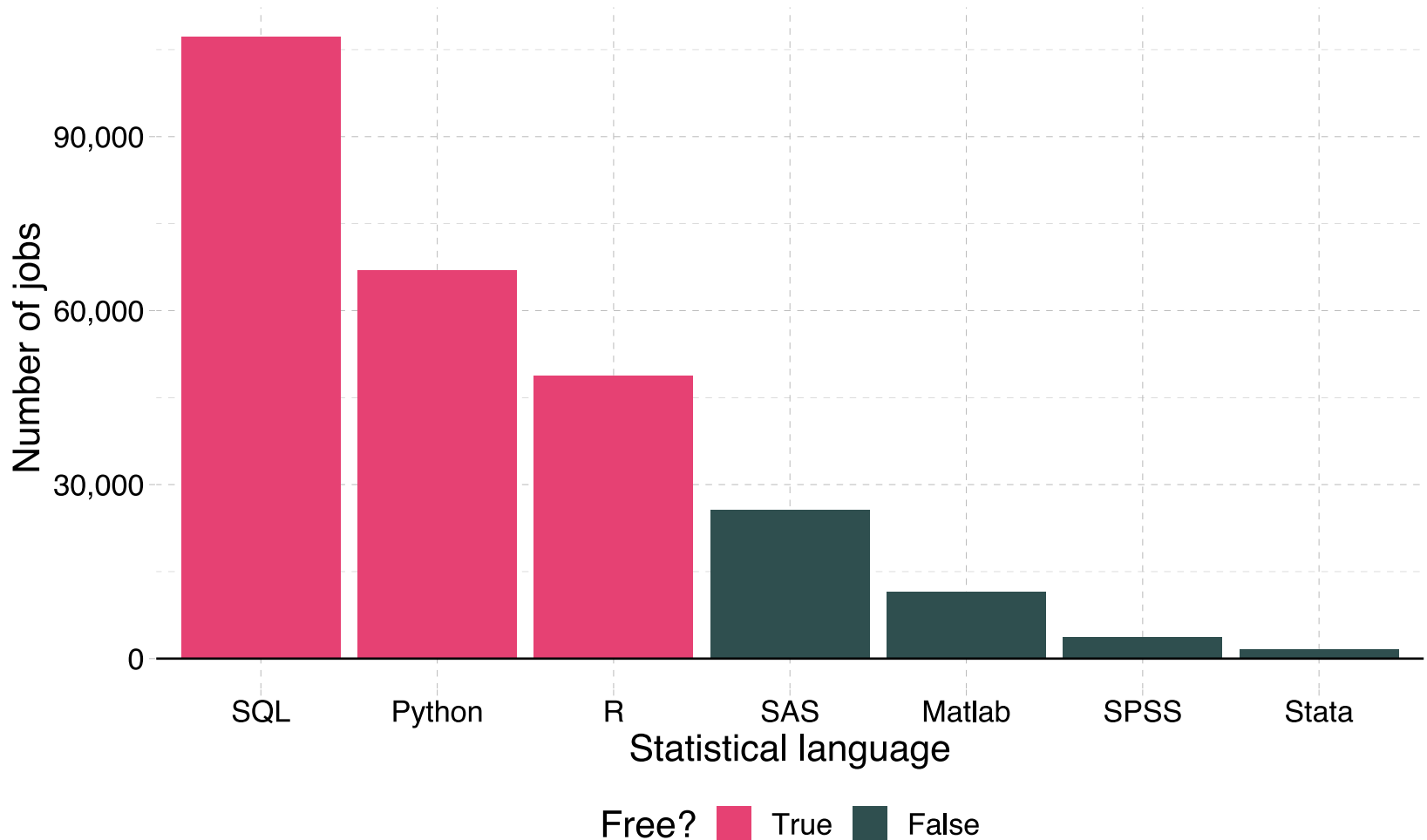
5. If you put in the work,<sup>†</sup> you will come away with a **valuable and marketable** tool.

6. I  R

[†]: Learning R definitely requires time and effort.

## Comparing statistical languages

Number of job postings on Indeed.com, 2019/01/06



# $\mathbb{R}$ + Examples



# R + Regression

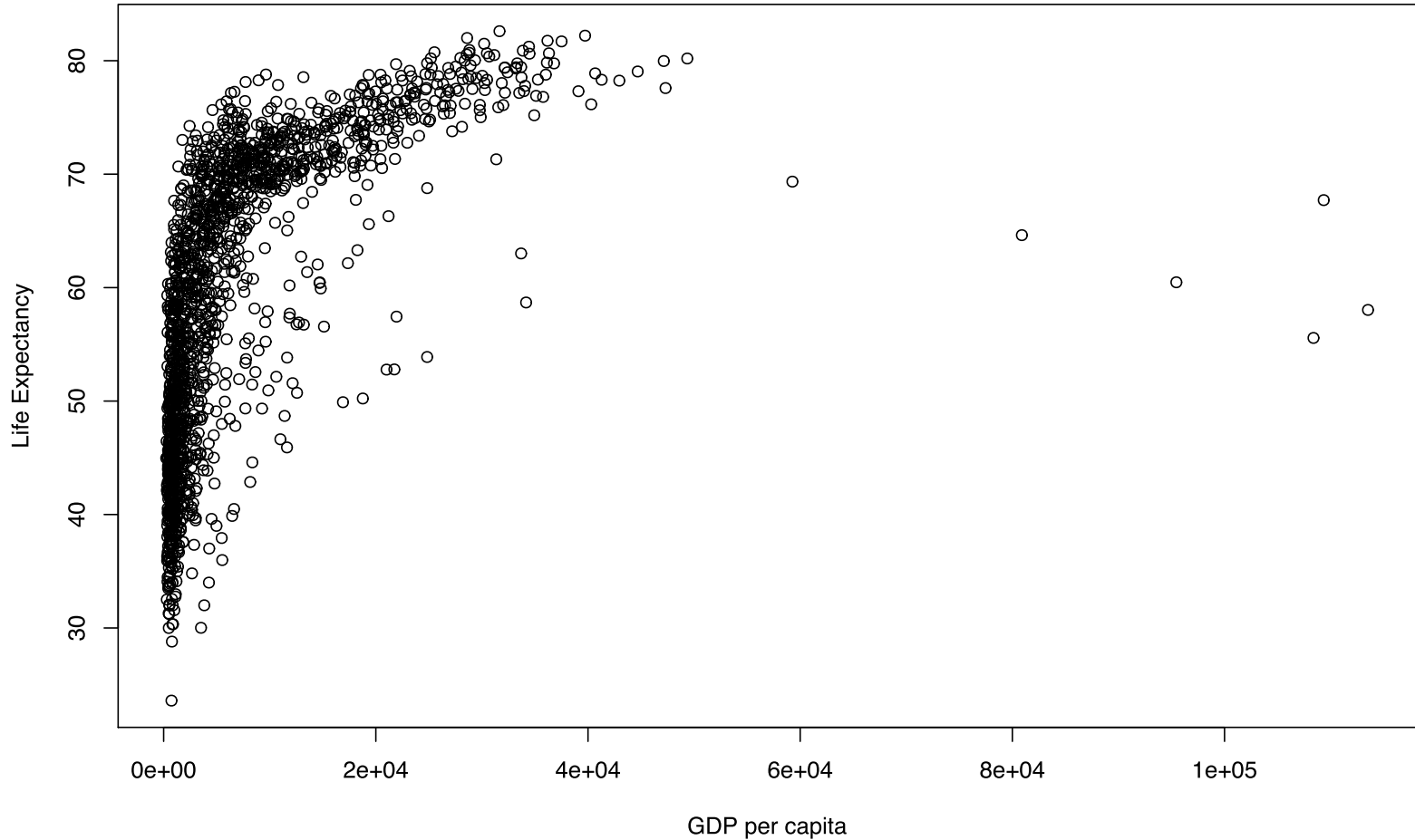
```
# A simple regression  
fit ← lm(dist ~ 1 + speed, data = cars)  
# Show the coefficients  
coef(summary(fit))
```

```
#>           Estimate Std. Error  t value    Pr(>|t|)  
#> (Intercept) -17.579095  6.7584402 -2.601058 1.231882e-02  
#> speed        3.932409  0.4155128  9.463990 1.489836e-12
```

```
# A nice, clear table  
library(broom)  
tidy(fit)
```

```
#> # A tibble: 2 x 5  
#>   term      estimate std.error statistic  p.value  
#>   <chr>      <dbl>    <dbl>    <dbl>    <dbl>  
#> 1 (Intercept) -17.6      6.76     -2.60 1.23e- 2  
#> 2 speed        3.93      0.416     9.46 1.49e-12
```

# R + Plotting (w/ `plot`)



# R + Plotting (w/ plot)

```
# Load packages with dataset
```

```
library(gapminder)
```

```
# Create dataset
```

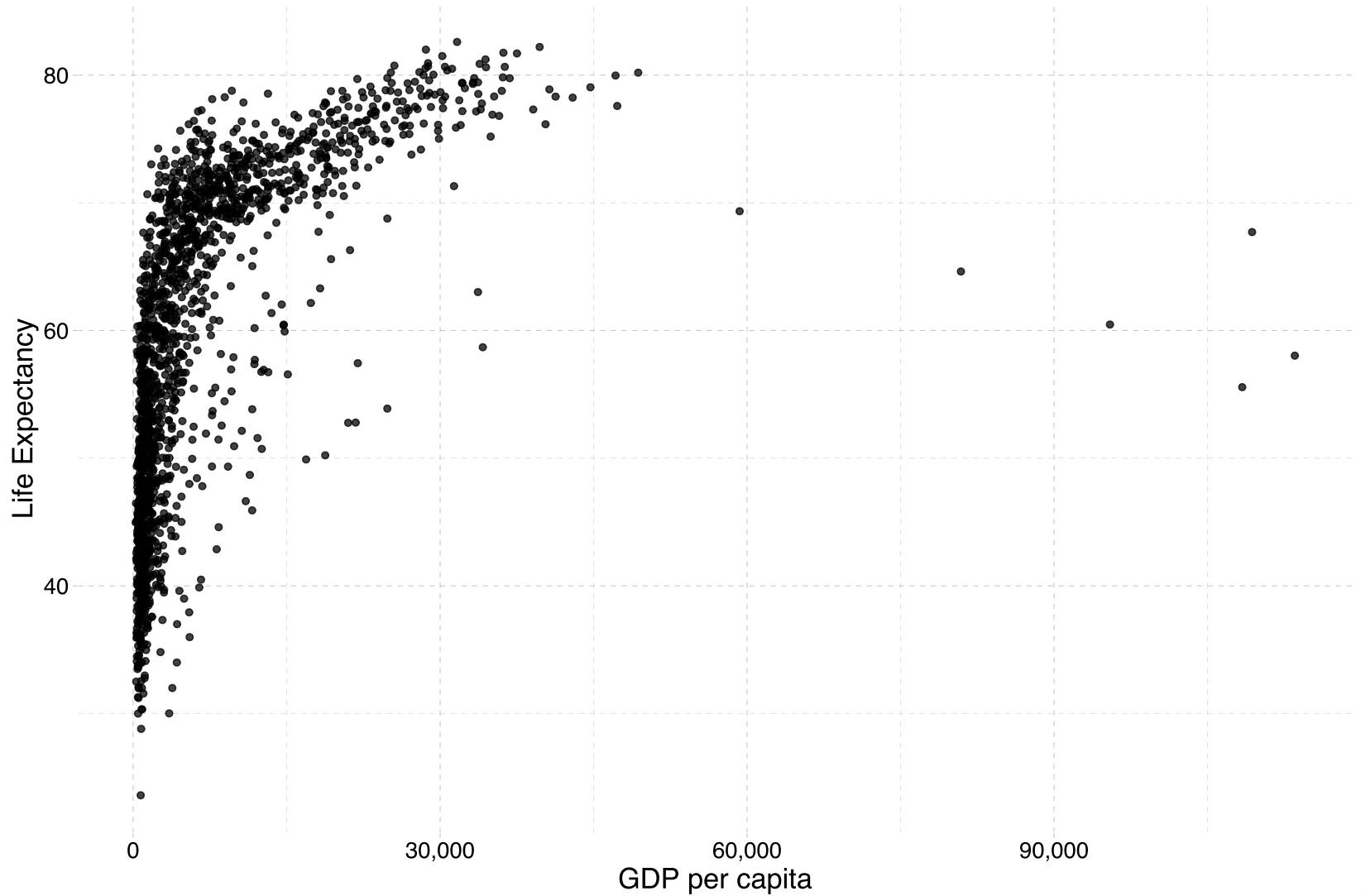
```
plot(
```

```
  x = gapminder$gdpPercap, y = gapminder$lifeExp,
```

```
  xlab = "GDP per capita", ylab = "Life Expectancy"
```

```
)
```

# R + Plotting (w/ ggplot2)



# R + Plotting (w/ ggplot2)

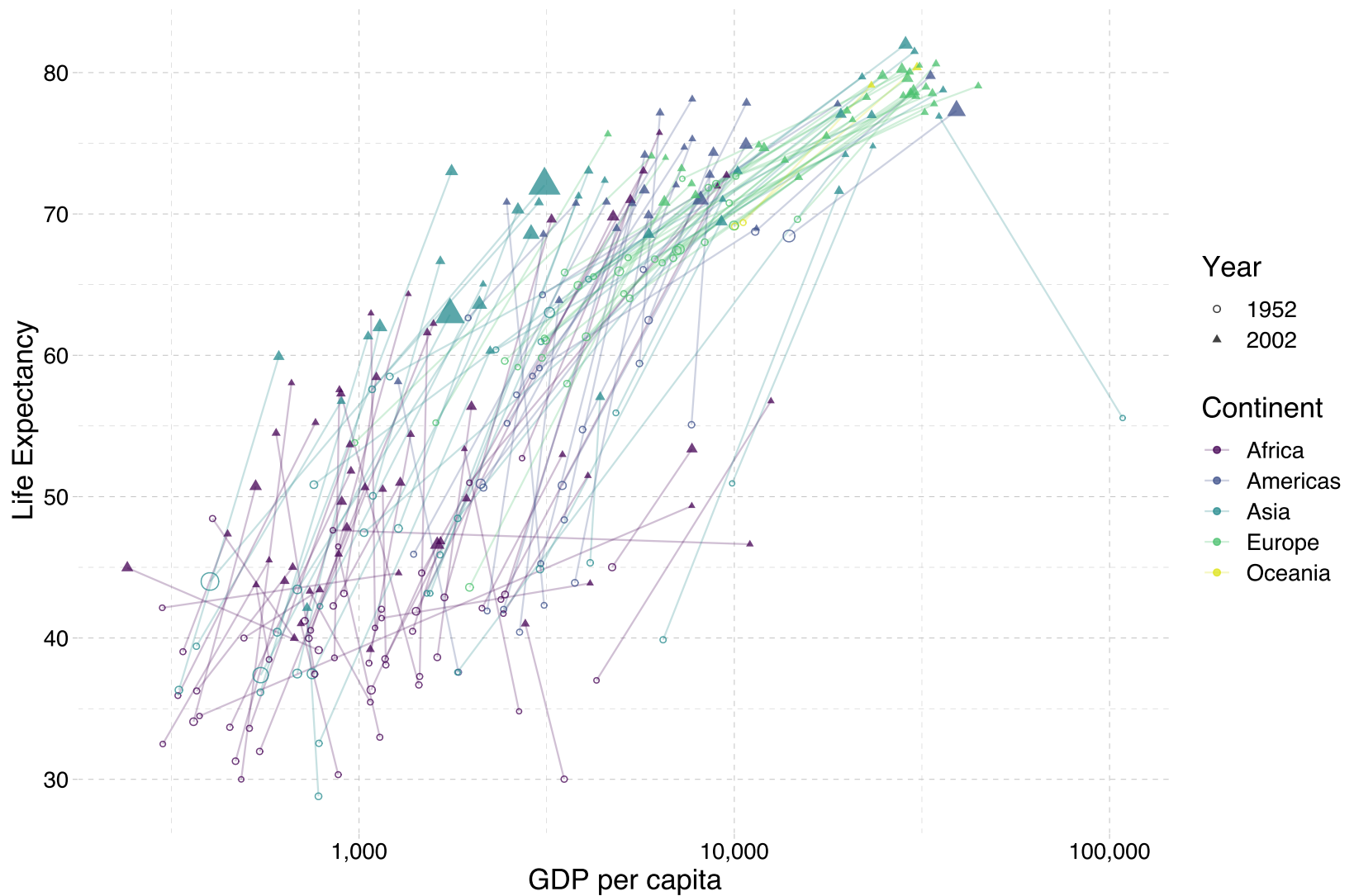
```
# Load packages
```

```
library(gapminder); library(dplyr)
```

```
# Create dataset
```

```
ggplot(data = gapminder, aes(x = gdpPercap, y = lifeExp)) +  
geom_point(alpha = 0.75) +  
scale_x_continuous("GDP per capita", label = scales::comma) +  
ylab("Life Expectancy") +  
theme_pander(base_size = 16)
```

# R + More plotting (w/ `ggplot2`)



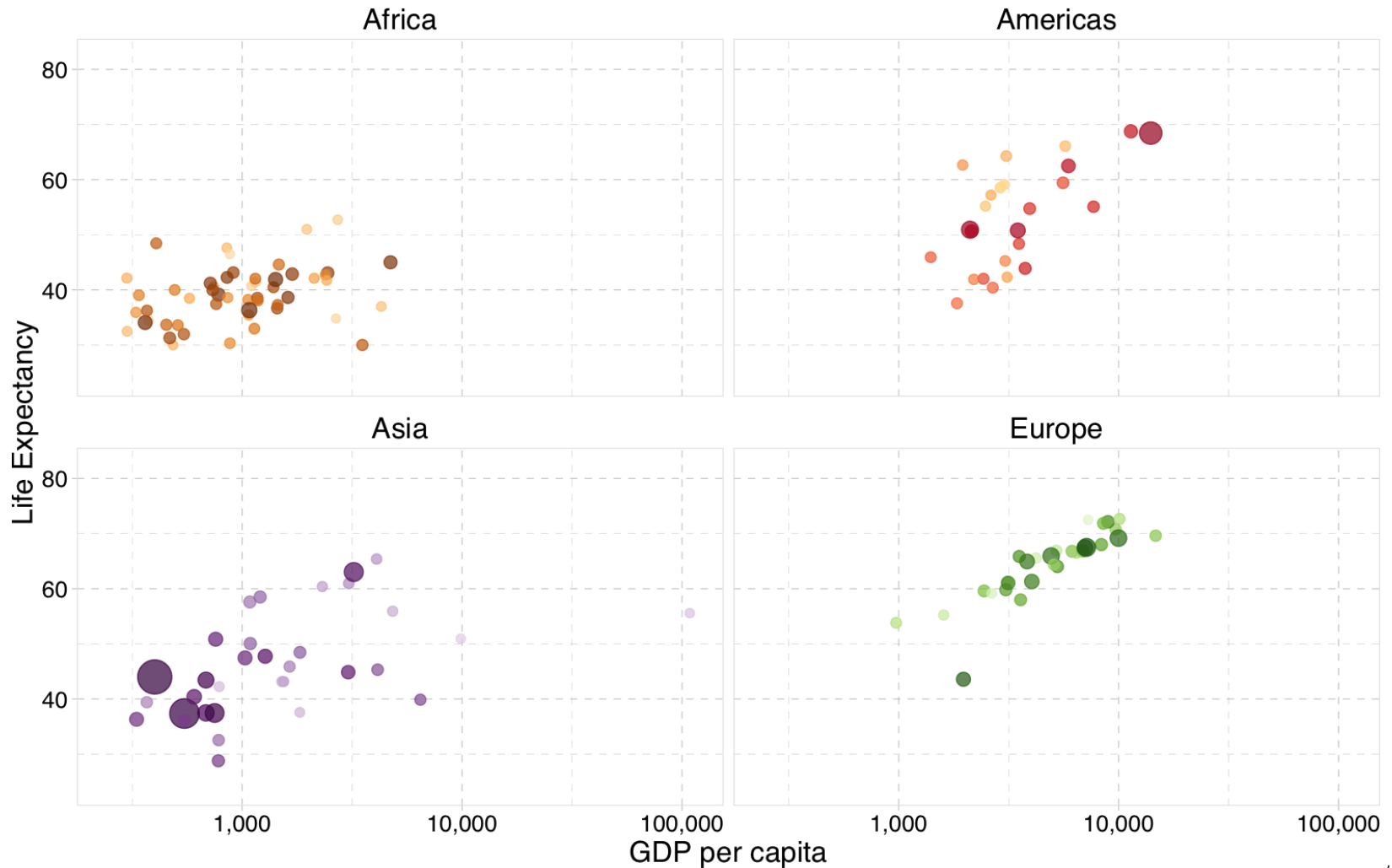
# R + More plotting (w/ ggplot2)

```
# Load packages
library(gapminder); library(dplyr)

# Create dataset
ggplot(
  data = filter(gapminder, year %in% c(1952, 2002)),
  aes(x = gdpPercap, y = lifeExp, color = continent, group = country)
) +
geom_path(alpha = 0.25) +
geom_point(aes(shape = as.character(year), size = pop), alpha = 0.75) +
scale_x_log10("GDP per capita", label = scales::comma) +
ylab("Life Expectancy") +
scale_shape_manual("Year", values = c(1, 17)) +
scale_color_viridis("Continent", discrete = T, end = 0.95) +
guides(size = F) +
theme_pander(base_size = 16)
```

# R + Animated plots (w/ gganimate)

Year: 1952



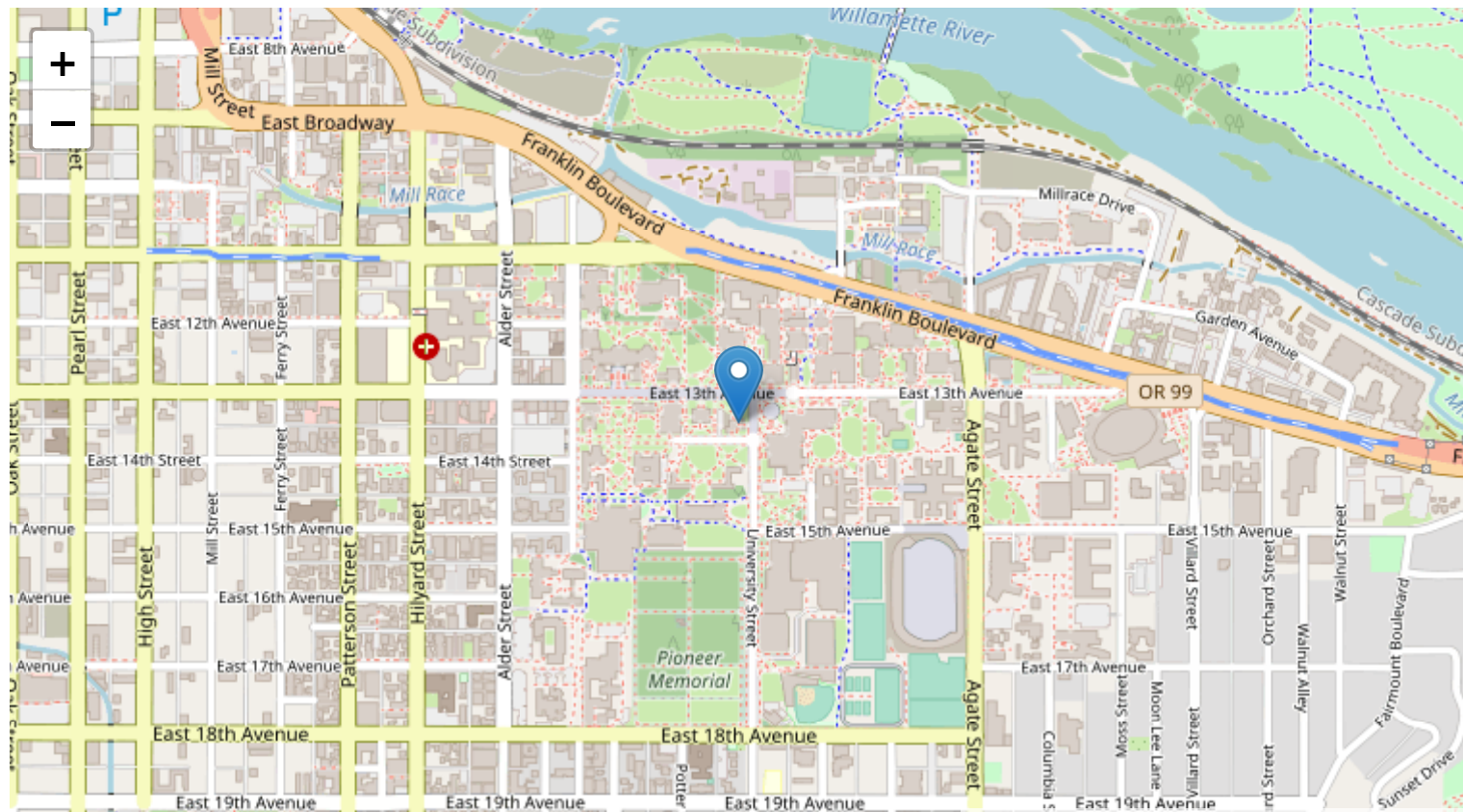


# R + Animated plots (w/ gganimate)

```
# The package for animating ggplot2
library(gganimate)
# As before
ggplot(
  data = gapminder %>% filter(continent ≠ "Oceania"),
  aes(gdpPercap, lifeExp, size = pop, color = country)
) +
geom_point(alpha = 0.7, show.legend = FALSE) +
scale_colour_manual(values = country_colors) +
scale_size(range = c(2, 12)) +
scale_x_log10("GDP per capita", label = scales::comma) +
facet_wrap(~continent) +
theme_pander(base_size = 16) +
theme(panel.border = element_rect(color = "grey90", fill = NA)) +
# Here comes the gganimate-specific bits
labs(title = "Year: {frame_time}") +
ylab("Life Expectancy") +
transition_time(year) +
ease_aes("linear")
```

# R + Maps

```
library(leaflet)
leaflet() %>%
  addTiles() %>%
  addMarkers(lng = -123.075, lat = 44.045, popup = "The University of Oregon")
```



# Getting started with $\mathbb{R}$

# Starting R

## Installation

- Install [R](#).
- Install [RStudio](#).
- **Optional/Overkill:** [Git](#)
  - Create an account on [GitHub](#)
  - Register for a student/educator [discount](#).
  - For installation guidance and troubleshooting, check out Jenny Bryan's [website](#).
- **Note:** The lab in 442 McKenzie has R installed and ready. That said, having a copy of R on your own computer will likely be very convenient for homework, projects, *etc*.

# Starting R

## Resources

### Free(-ish)

- Google (which inevitably leads to StackOverflow)
- Time
- Your classmates
- Your GEs
- Me
- R resources [here](#) and [here](#)

### Money

- Book: *R for Stata Users*
- Short online course: [DataCamp](#)

# Starting R

## Some R basics

You will dive deeper into R in lab, but here six big points about R:

1. Everything is an **object**.

```
foo
```

2. Every object has a **name** and **value**.

```
foo ← 2
```

3. You use **functions** on these objects.

```
mean(foo)
```

4. Functions come in **libraries (packages)**

```
library(dplyr)
```

5. R will try to **help** you.

```
?dplyr
```

6. R has its **quirks**.

```
NA; error; warning
```

# Starting R

## R **VS.** Stata

Coming from Stata, here are a few important changes (benefits):

- Multiple objects and arrays (e.g., data frames) can exist in the same workspace (in memory). No more `keep`, `preserve`, `restore`, `snapshot` nonsense!
- (Base) R comes with lots of useful built-in functions—and provides all the tools necessary for you to build your own functions. However, many of the *best* functions come from external libraries.
- You don't need to `tset` or `xtset` data (you can if you really want... `ts`).

Next: Metrics review(s)