Introduction and Overview

EC 421, Set 1

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October 1, 2019

Prologue

Why?

Motivation

Let's start with a few **basic, general questions:**

1. What is the goal of econometrics?
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

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

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

But who needs to *expect*?

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

Why?

Example, cont.

Regression model:

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

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

Why?

Example, cont.

Regression model:

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

(Review) Questions

- **Q:** How do we interpret β_1?
- **A:** An additional hour in class correlates with a β_1 unit increase in an individual's GPA.

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

Why?

Example, cont.

Regression model:

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

(Review) Questions

- **Q:** Can we interpret the estimates for β_2 as causal?
- **A:** Not without making more assumptions and/or knowing more about the data-generating process.

- **Q:** What is ε_i?
- **A:** An individual's random deviation/disturbance from the population parameters.

Why?

Example, cont.

Regression model:

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

(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 ε 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) ε_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.

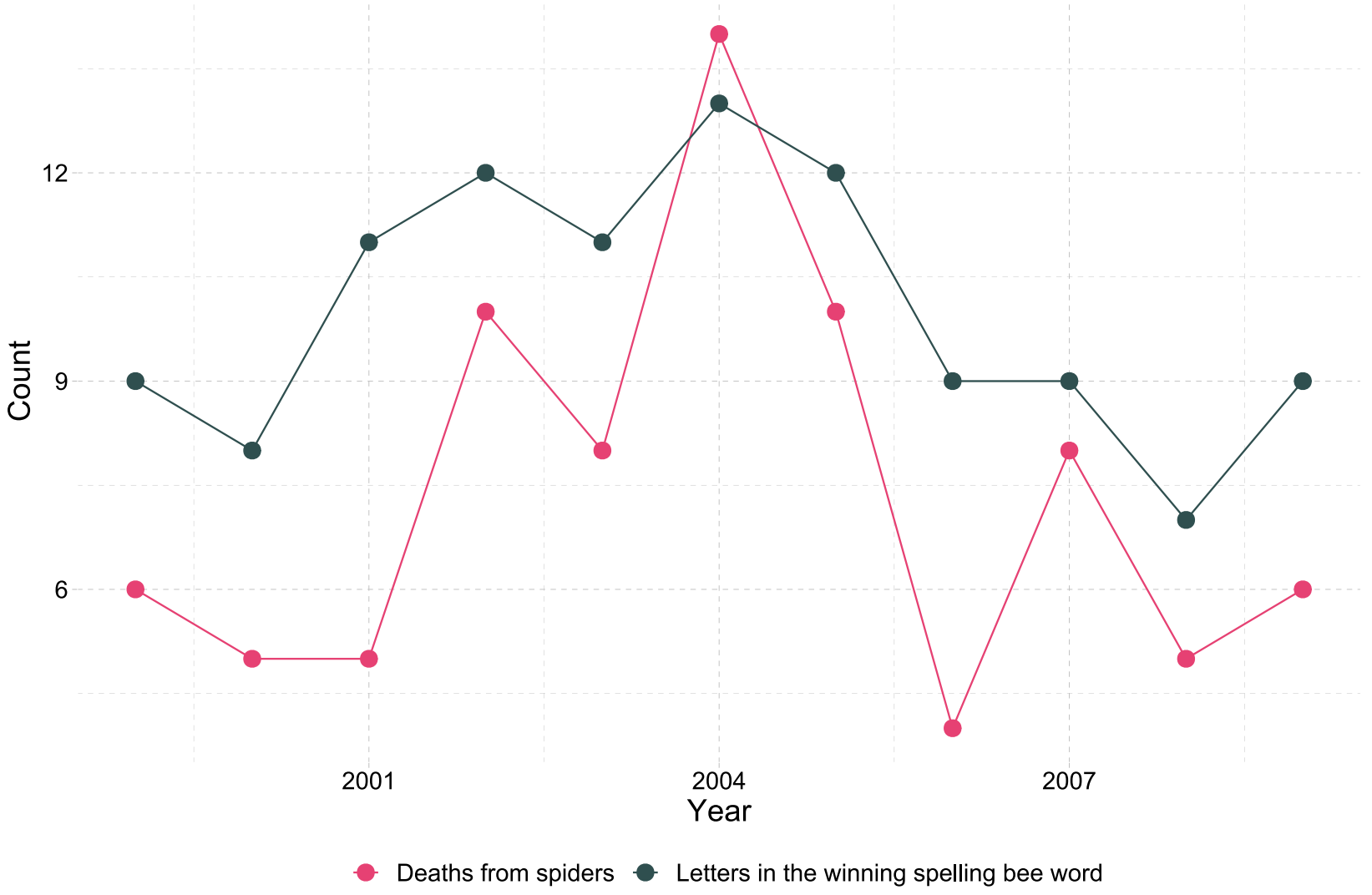
Real life often violates these assumptions.

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

- Can we find a fix?
- 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[†] 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.

This course aims to deepen your knowledge in each of these three areas.

- 1: As before.
- 2–3: **R**

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

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.

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 and these notes all came out of R.

Why are we using R?

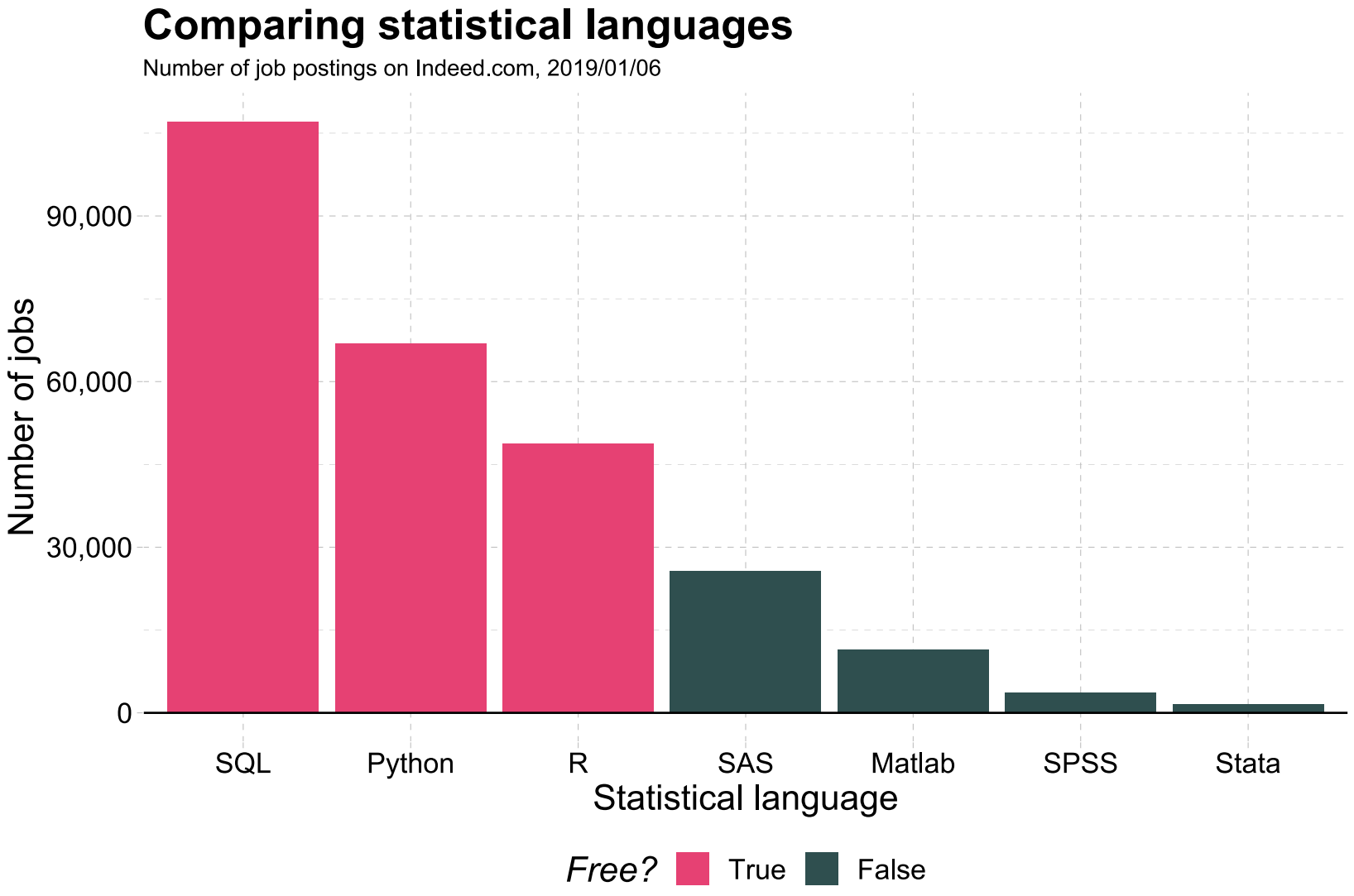
4. *Related:* R imposes **no limitations** on your amount of observations, variables, memory, or processing power. (I'm looking at **you**, `Stata`.)

5. If you put in the work,[†] you will come away with a **valuable and marketable** tool.

6. I  **R**

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

R


Comparing statistical languages
Number of job postings on Indeed.com, 2019/01/06
Number of jobs
90,000
60,000
30,000
0
SQL
Python
R
SAS
Matlab
SPSS
Stata
Statistical language
Free?
True
False

R + [Examples]

R + Regression

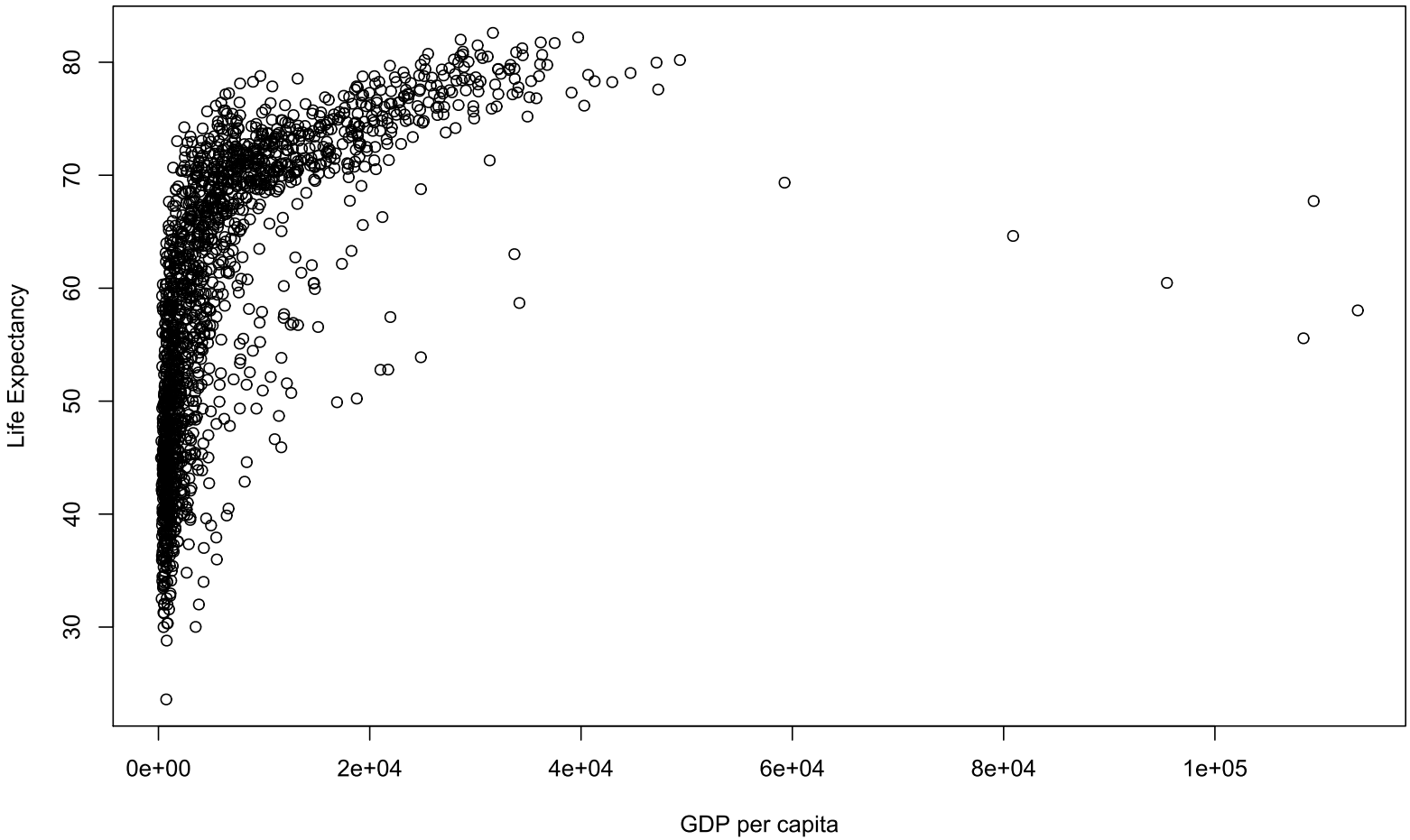
```r
# A simple regression
fit ← lm(dist ~ 1 + speed, data = cars)
# Show the coefficients
coef(summary(fit))
```

```
#>               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
```

```r
# 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`)

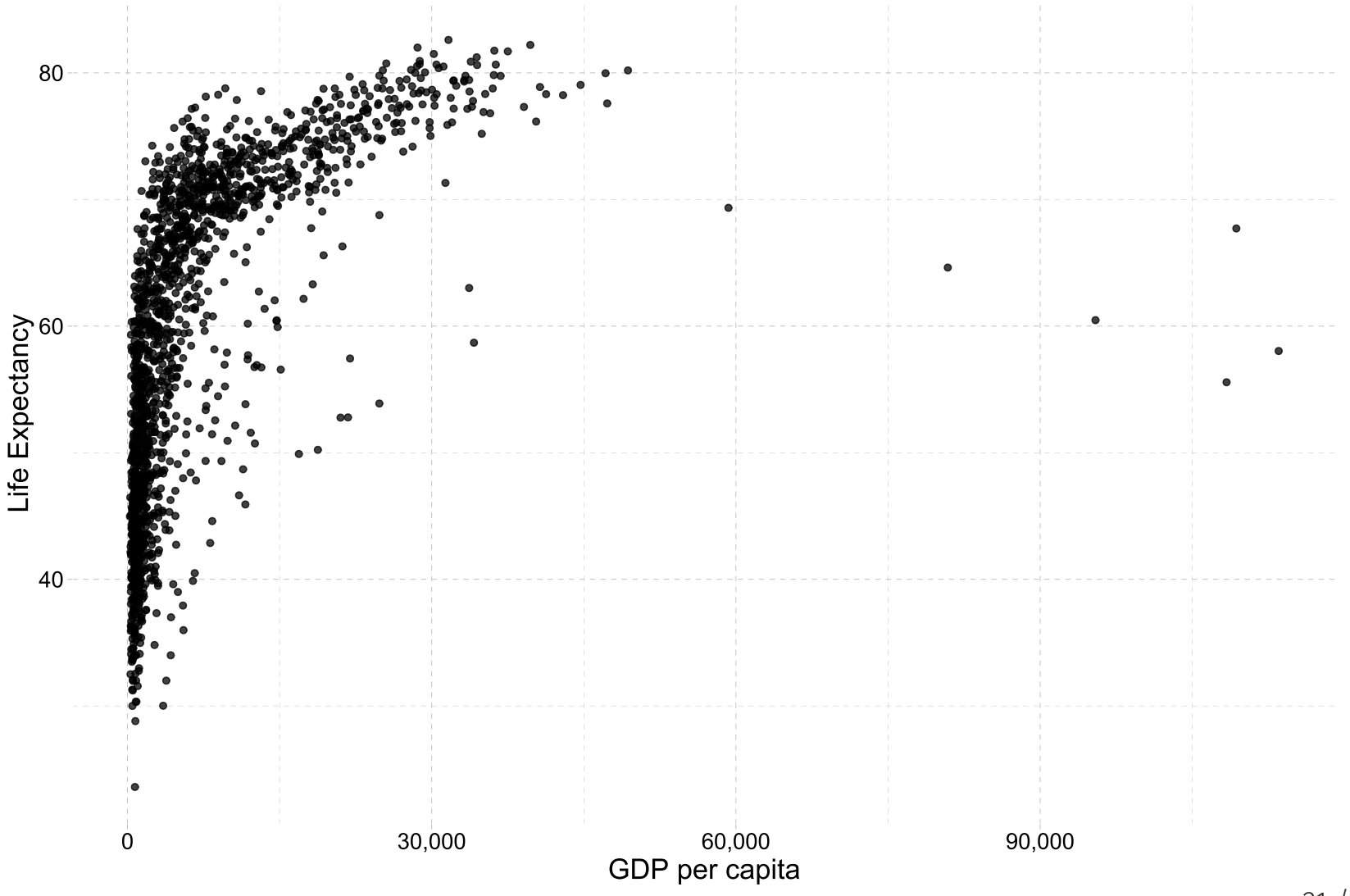


R + Plotting (w/ plot)

```r
# 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)

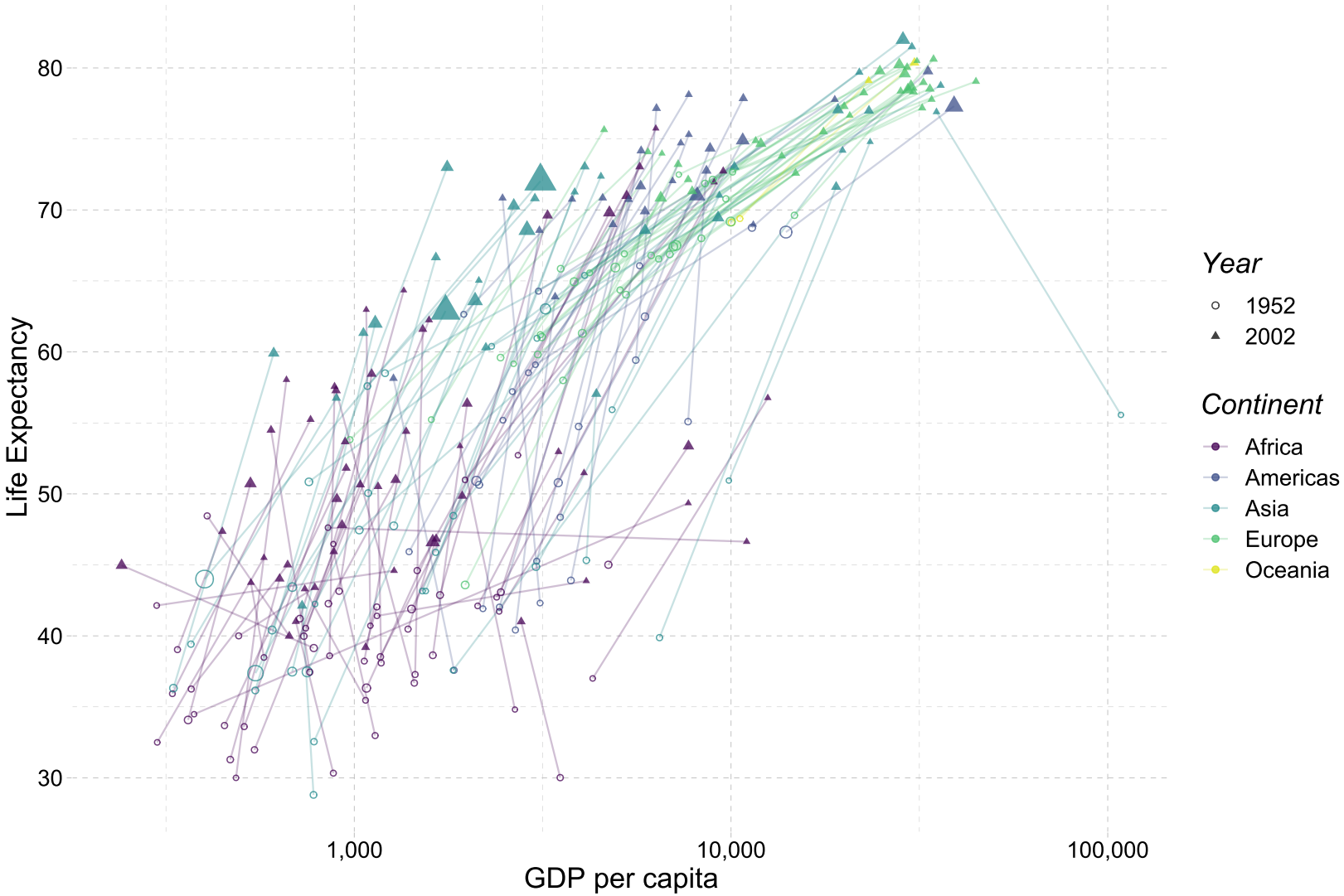


R + Plotting (w/ ggplot2)

```r
# 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)

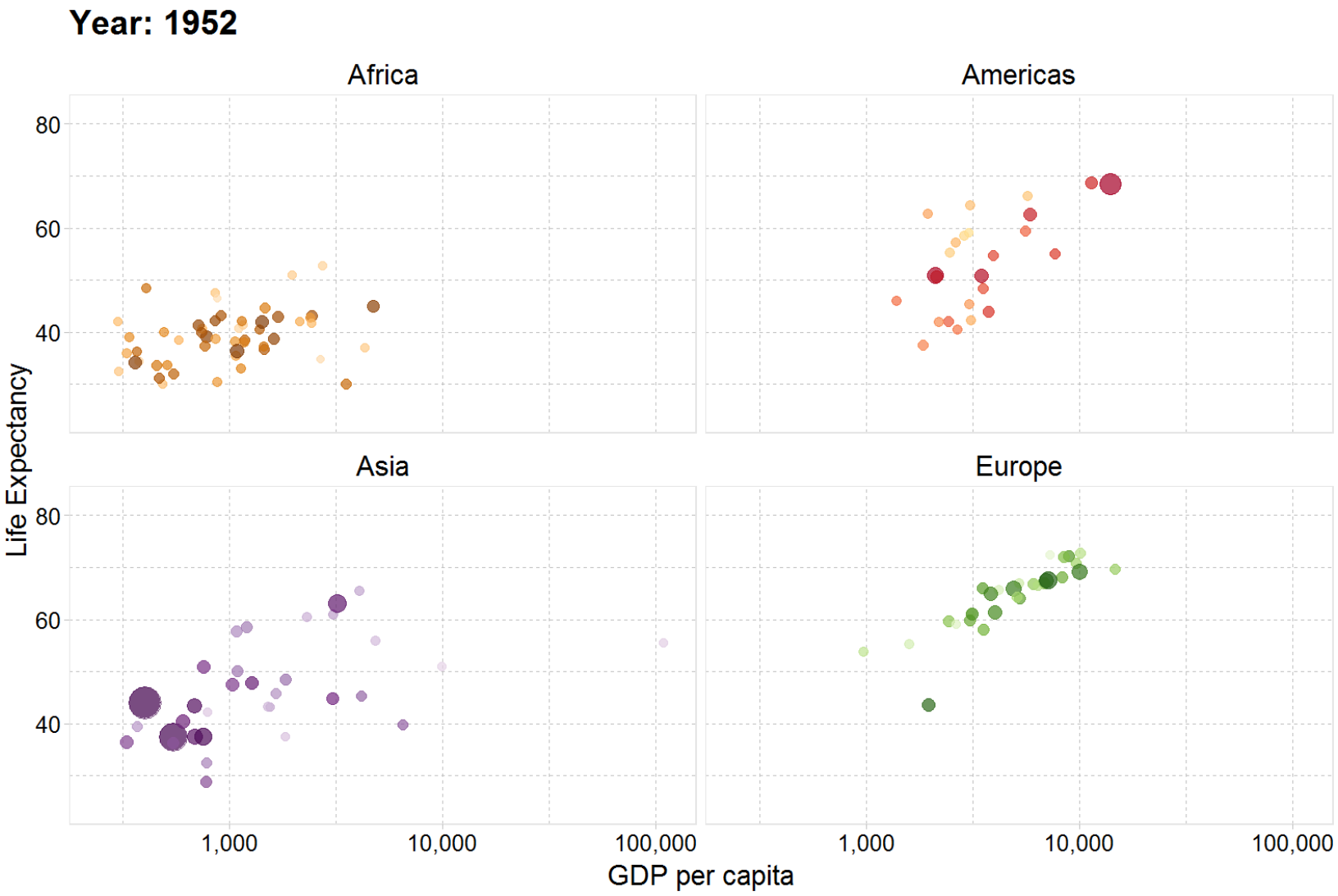


R + More plotting (w/ ggplot2)

```r
# 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)



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")
```

<!-- id="htmlwidget-6302e644aad645358103"
style="width:756px;height:360px;" class="leaflet html-widget">

<!----

class: inverse, middle

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