

Introduction and Overview

EC 421, Set 1

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Prologue

Why?

Motivation

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

One simple answer: Learn about the world using data.

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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

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

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**. After the midterm, we'll revisit this example.

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?

Example, cont.

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(Review) Questions

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Example, cont.

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(Review) Questions

- **Q:** How do we interpret β_1 ?

Why?

Example, cont.

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- **A:** An additional hour in class correlates with a β_1 unit increase in an individual's GPA (controlling for SAT and PCT).

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- **Q:** Are the β_k terms population parameters or sample statistics?

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- **A:** Greek letters denote **population parameters**. Their estimates get hats, e.g., $\hat{\beta}_k$.

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(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.

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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 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.

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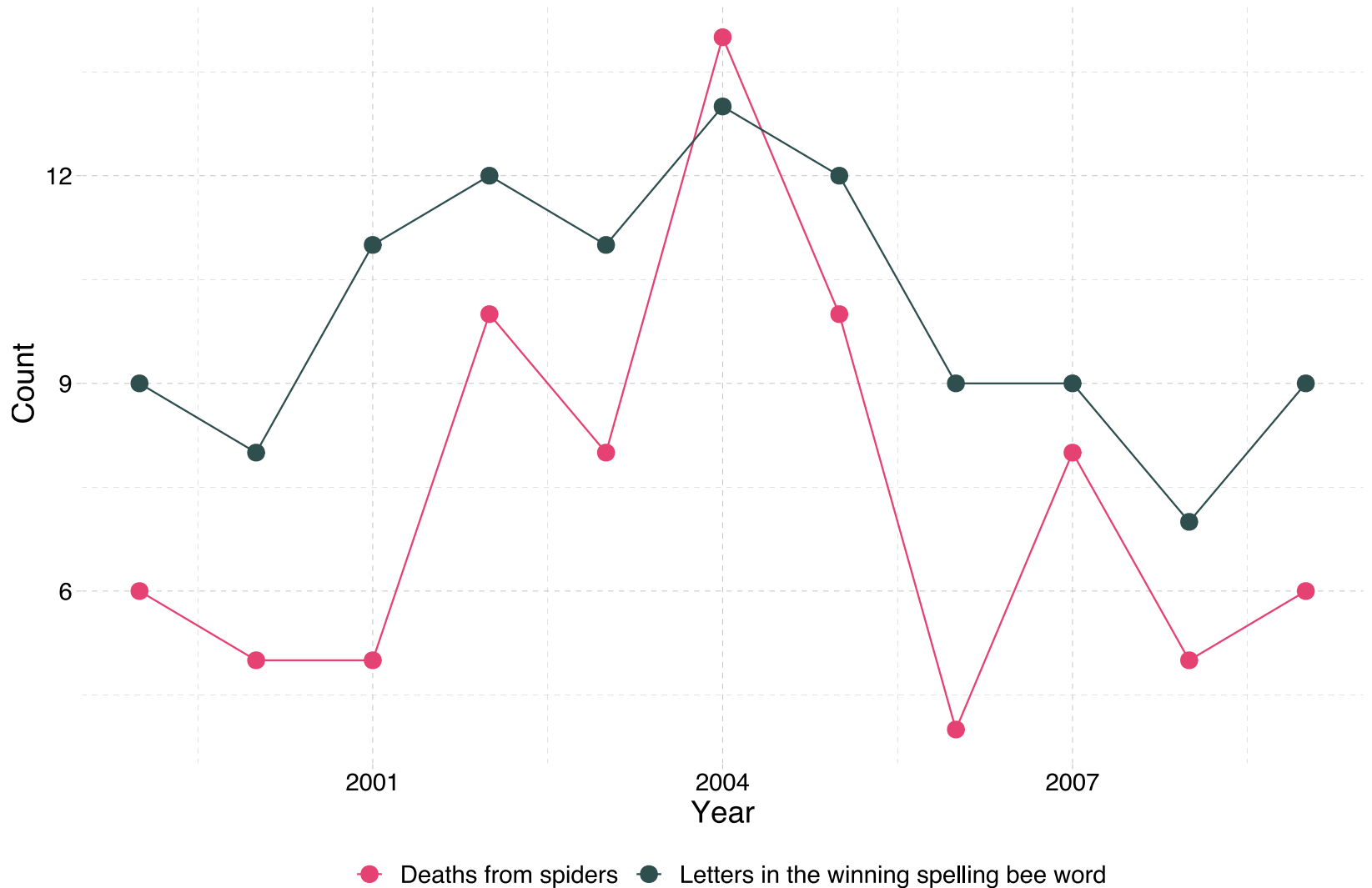
Real life often violates these assumptions.

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

- Can we find a fix? (Especially: How/when is β *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[†] 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.

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- 1: As before.
- 2–3: **R**

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R

What is R?

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

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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. As an example - all of 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.)

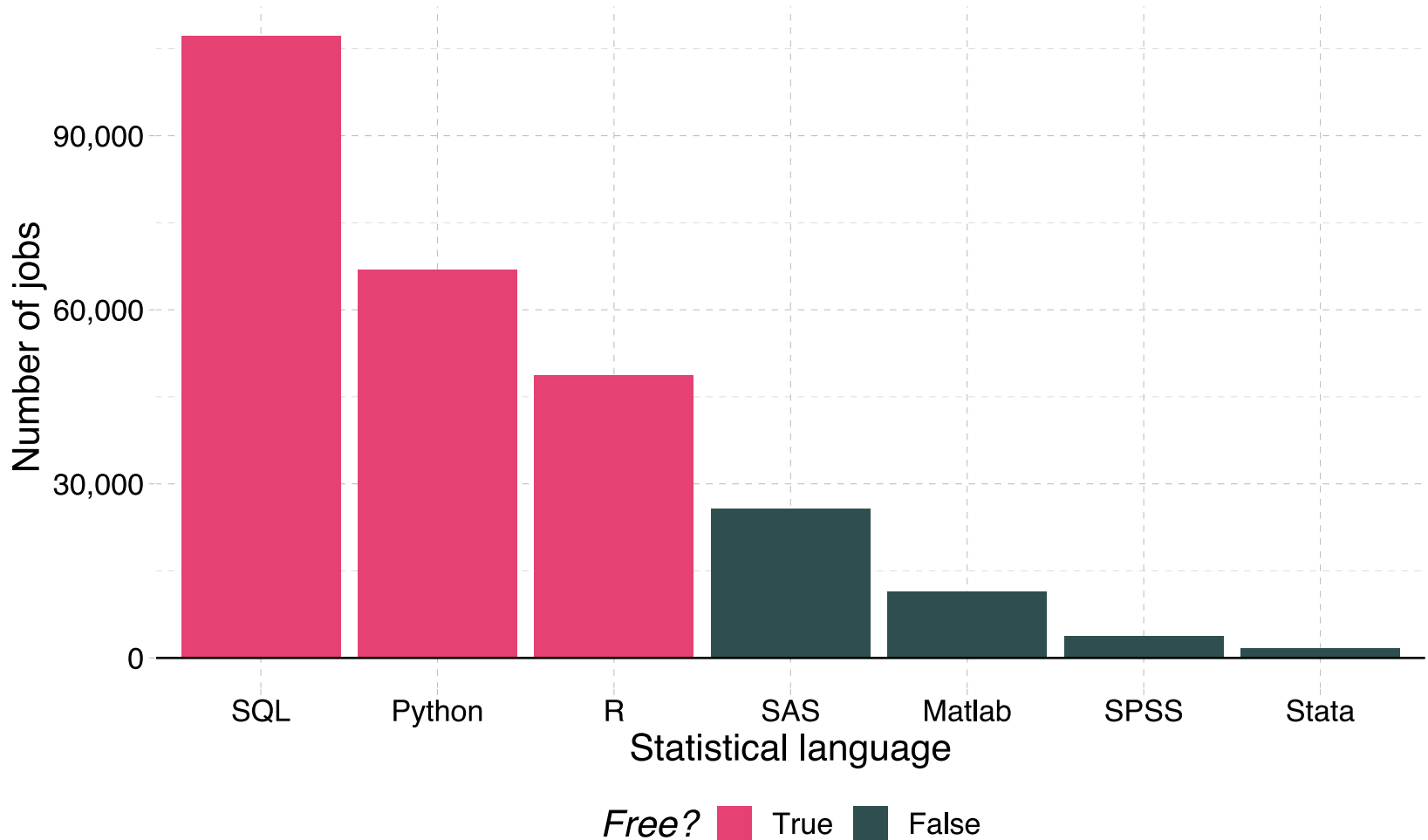
5. If you put in the work,[†] you will come away with a **valuable and marketable** tool.

6. I  **R**

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

Comparing statistical languages

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



R + Examples

R + Regression

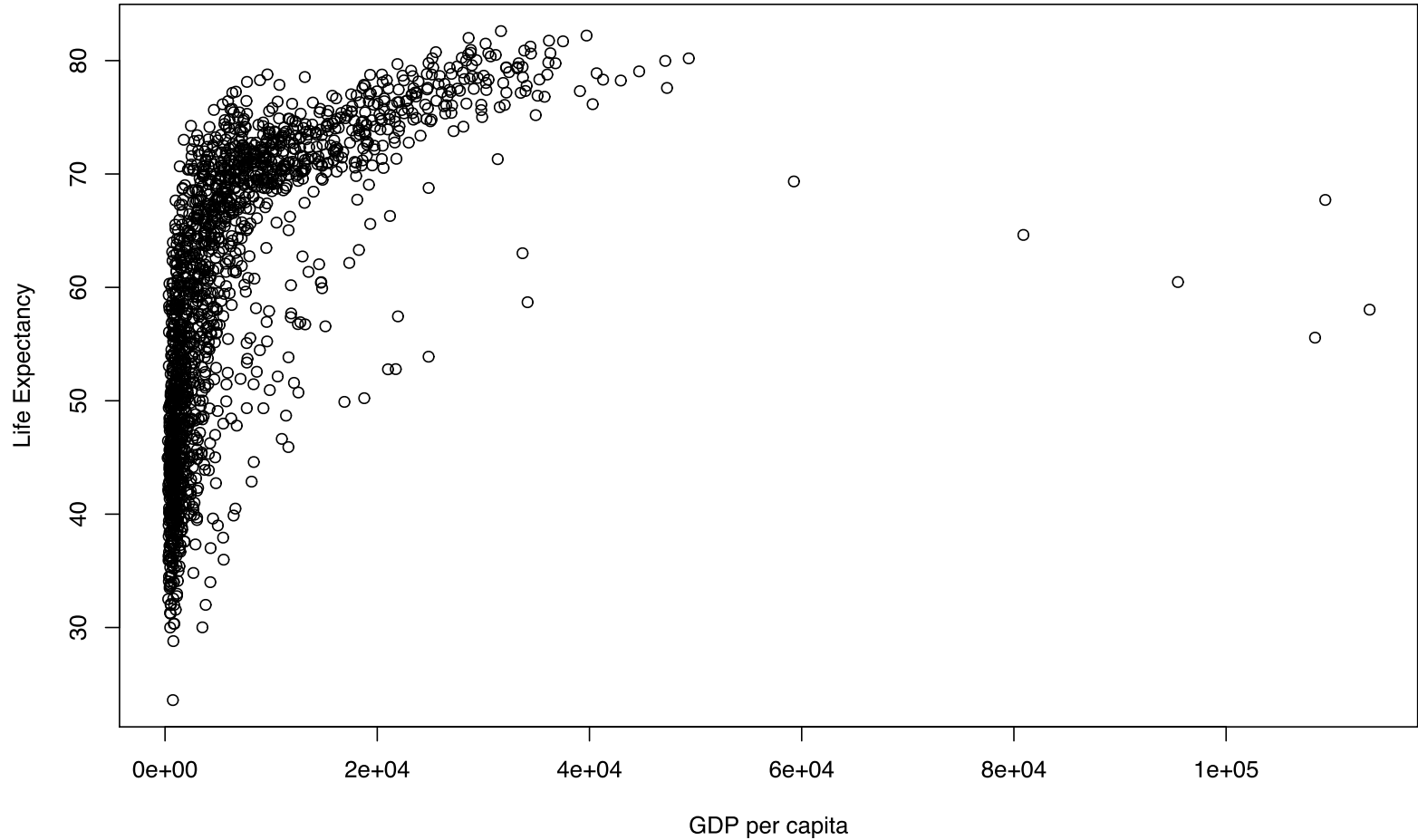
```
# A simple regression  
fit ← lm(dist ~ 1 + speed, data = cars)  
# Show the coefficients  
coef(summary(fit))
```

```
#>               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
```

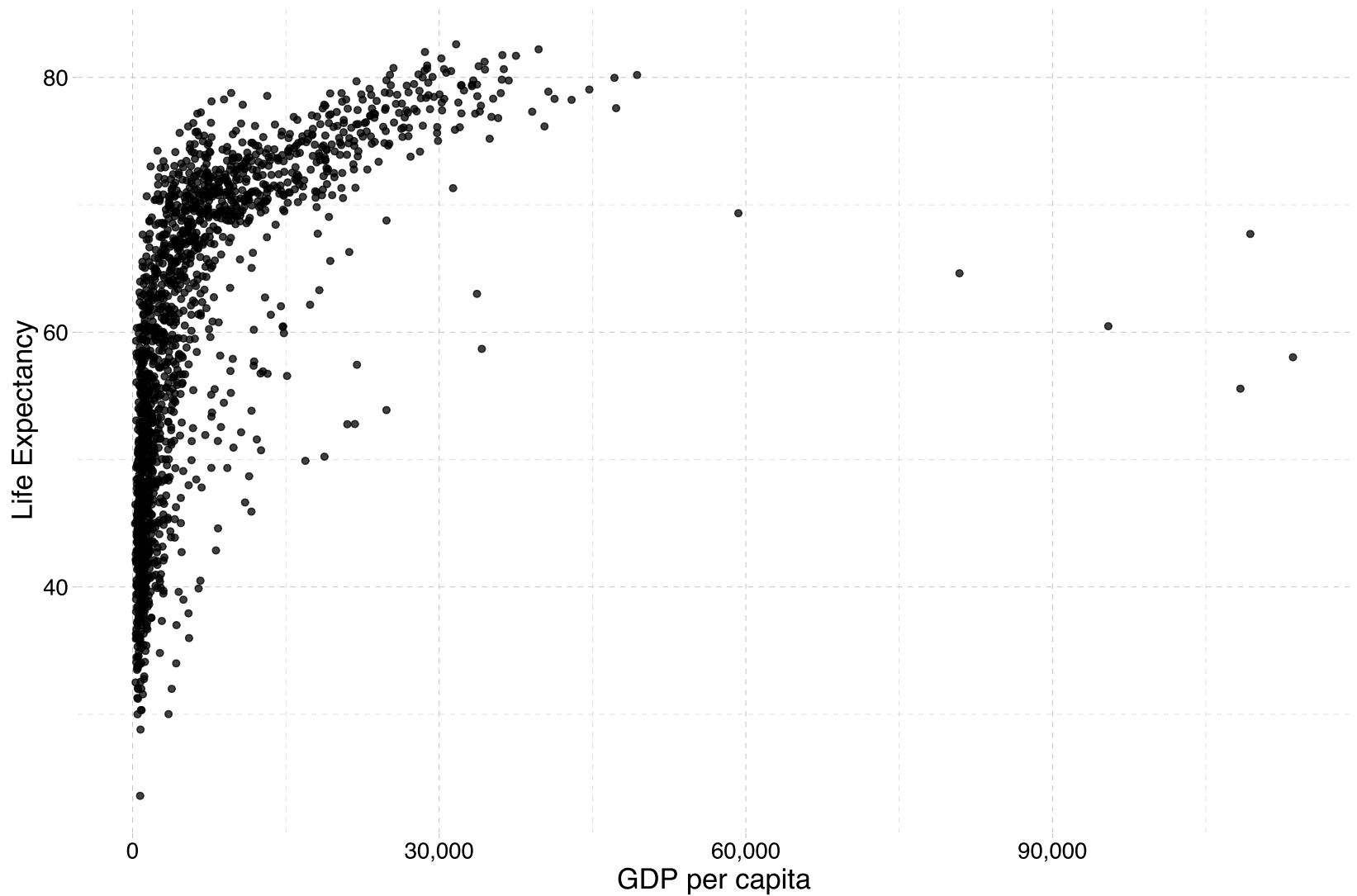
R + Plotting (w/ `plot`)



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"  
)
```

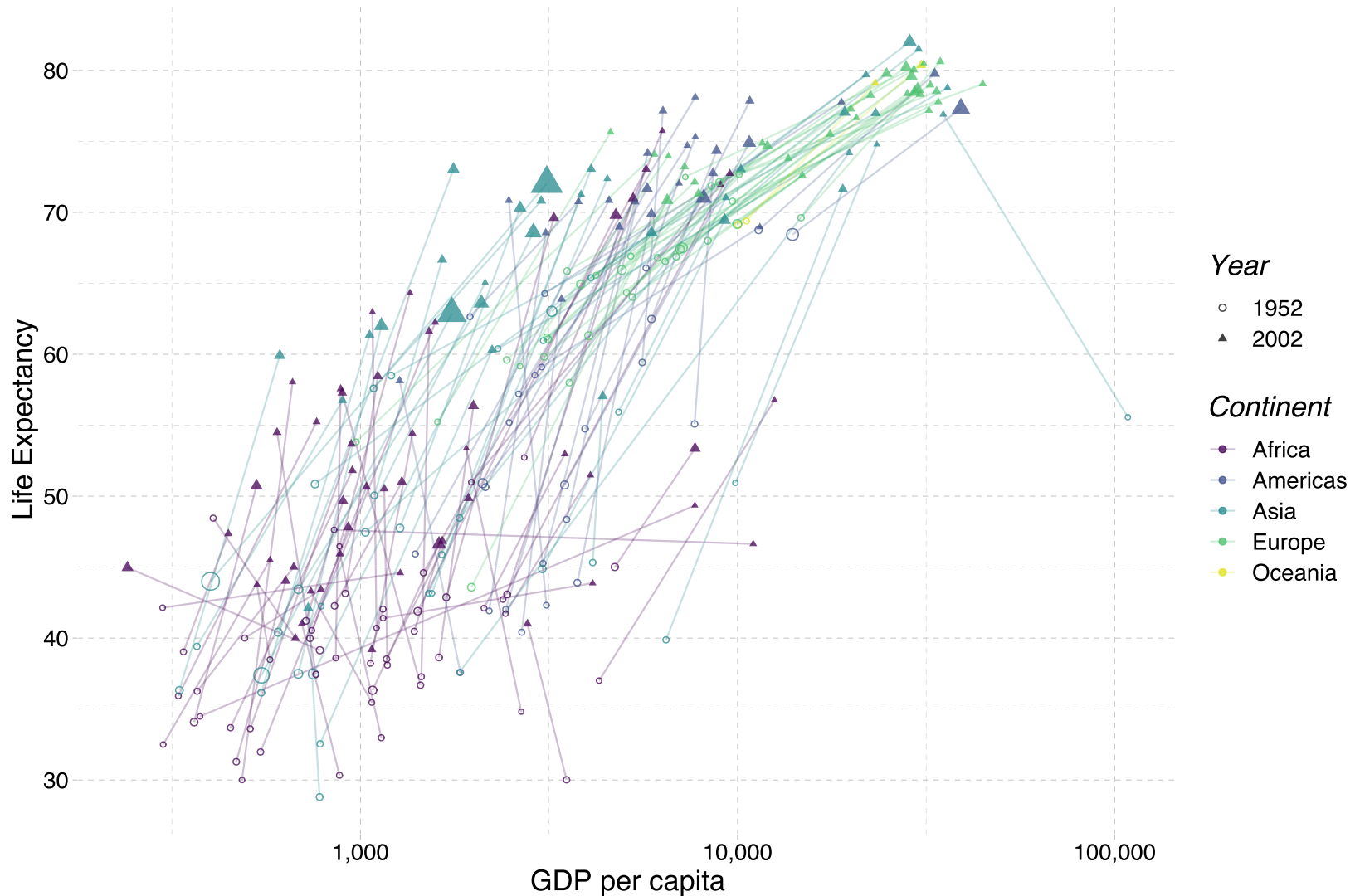
R + Plotting (w/ `ggplot2`)



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`)

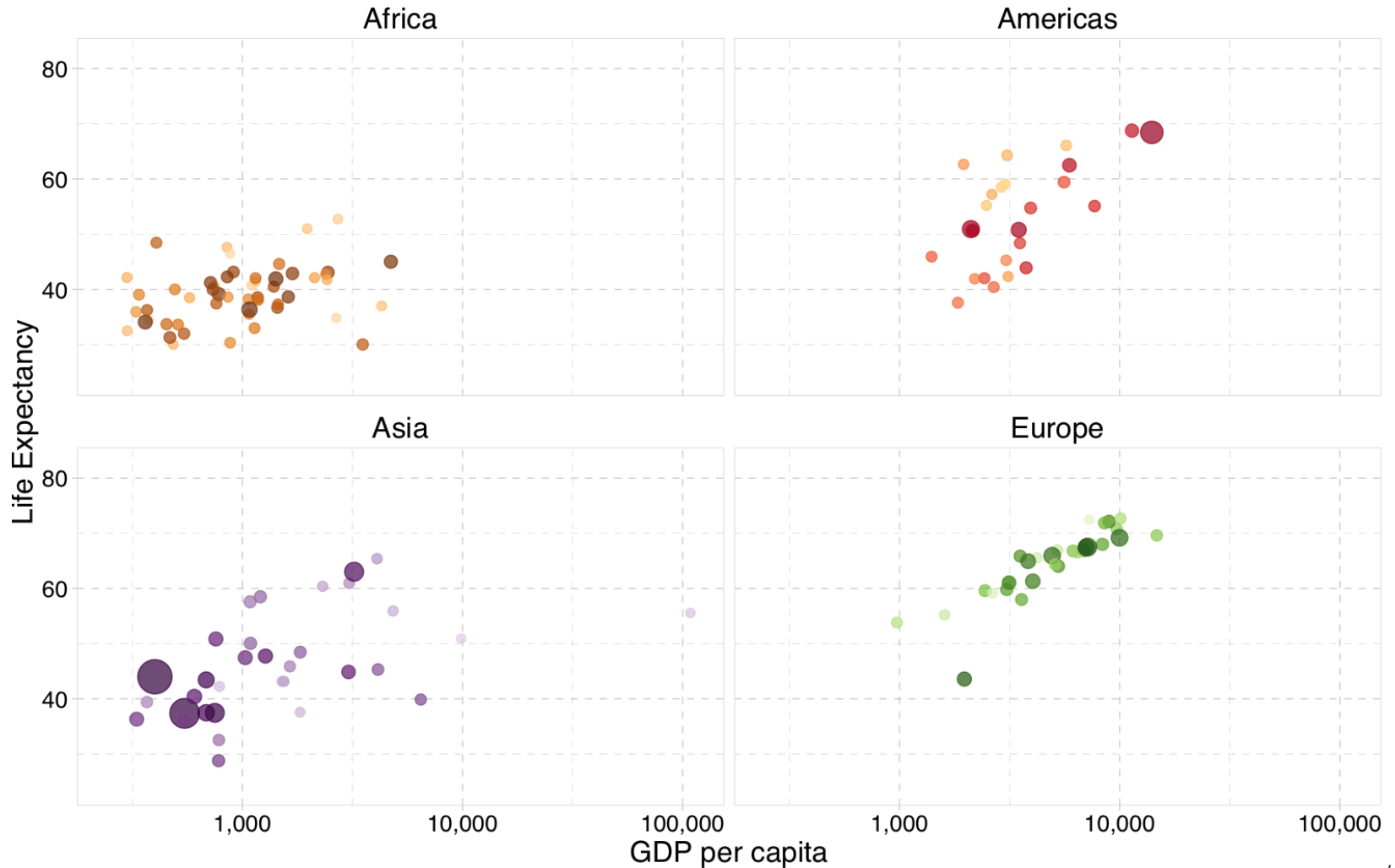


R + More plotting (w/ ggplot2)

```
# 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

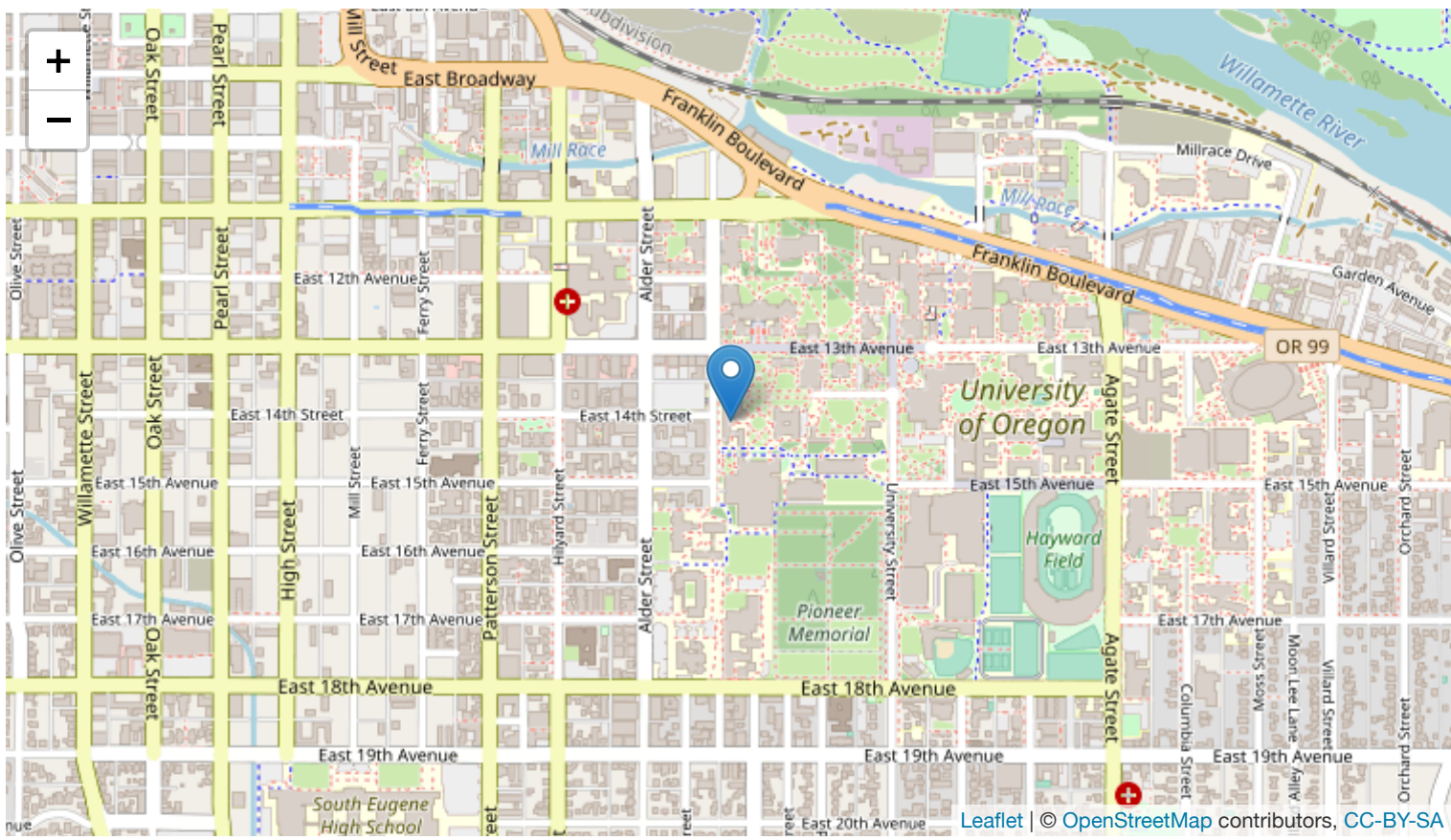


R + Animated plots (w/ gganimate)

```
# 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 = -123.0783, lat = 44.0443, popup = "The University of Oregon:
```



Getting started with 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:** Having a copy of R on your own computer will likely be imperative for homework, projects, *etc.* - at least until we return to in-person coursework (fingers crossed.)

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)