Time

Week 9

AEM 2850: R for Business Analytics

Cornell Dyson

Spring 2022

Acknowledgements: Andrew Heiss

Announcements

Reminders:

- Mini Project 1 due April 1 (link)

Questions before we get started?

Plan for today

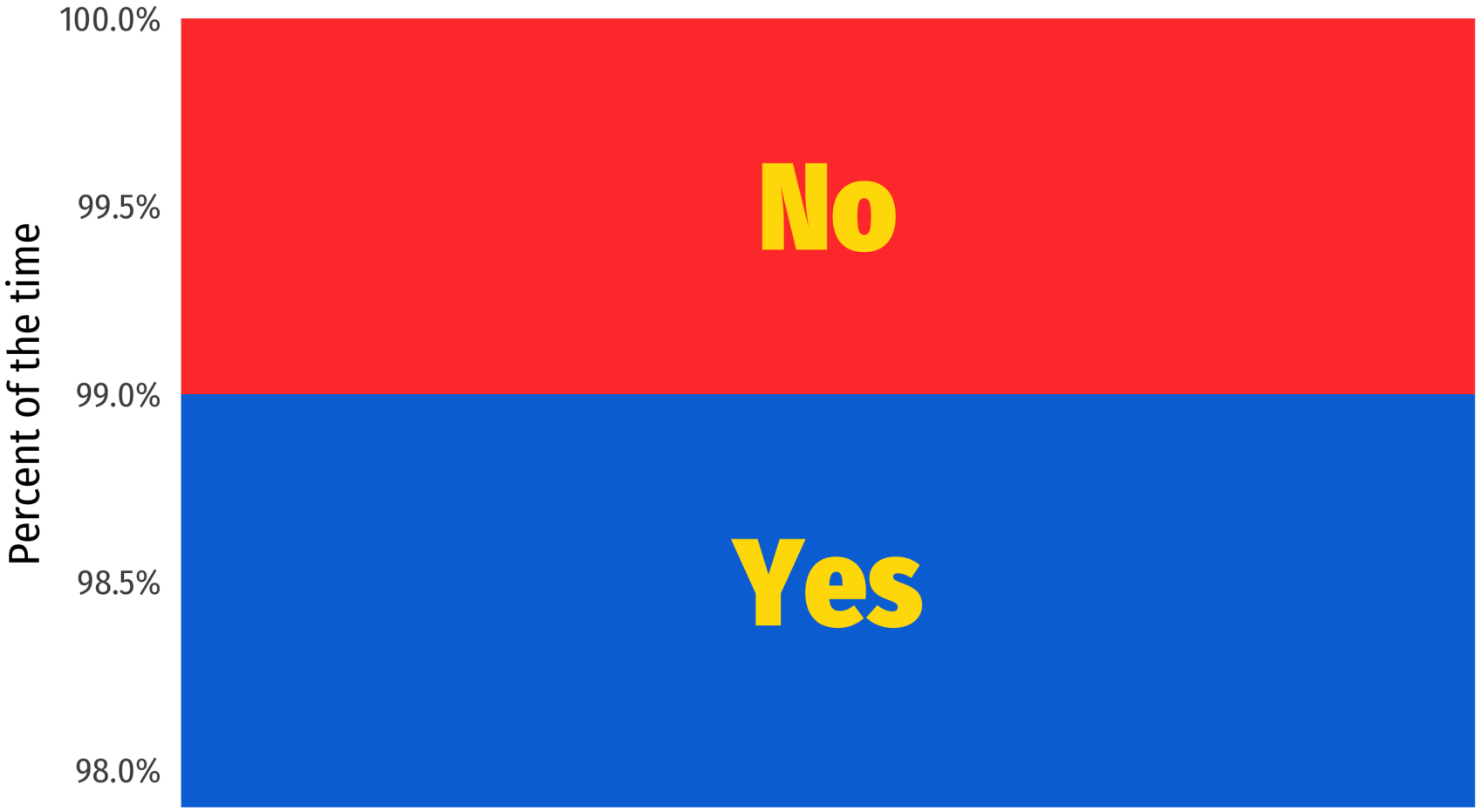
Prologue: Axis issues

Visualizing time

Starting, ending, and decomposing time

Prologue: Axis issues

Is truncating the y-axis misleading?



Don't be too extreme!

It is actually more legal to truncate the y-axis than you might think

When do you think it is okay to truncate?

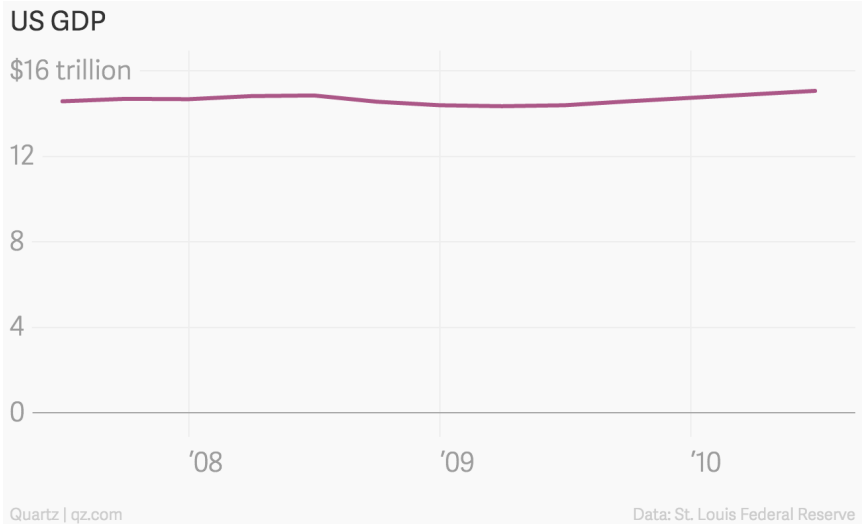
When small movements matter

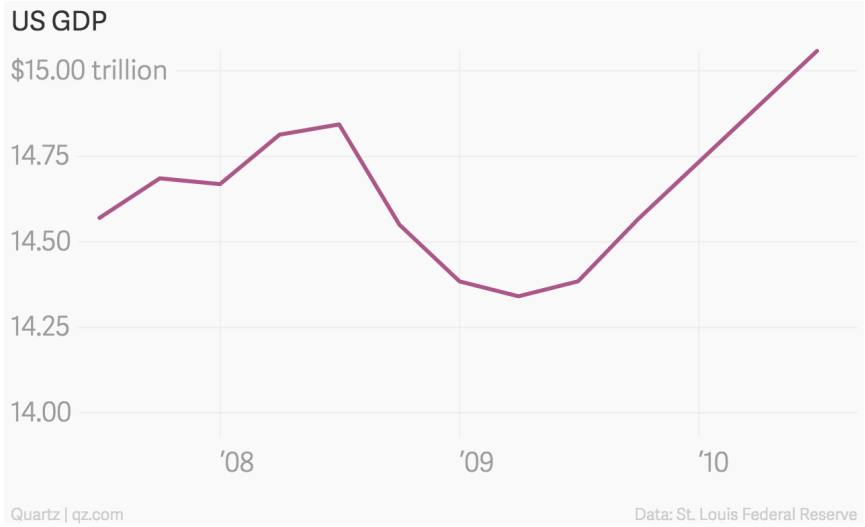
When the scale itself is distorted

When zero values are impossible

When is it okay to truncate?

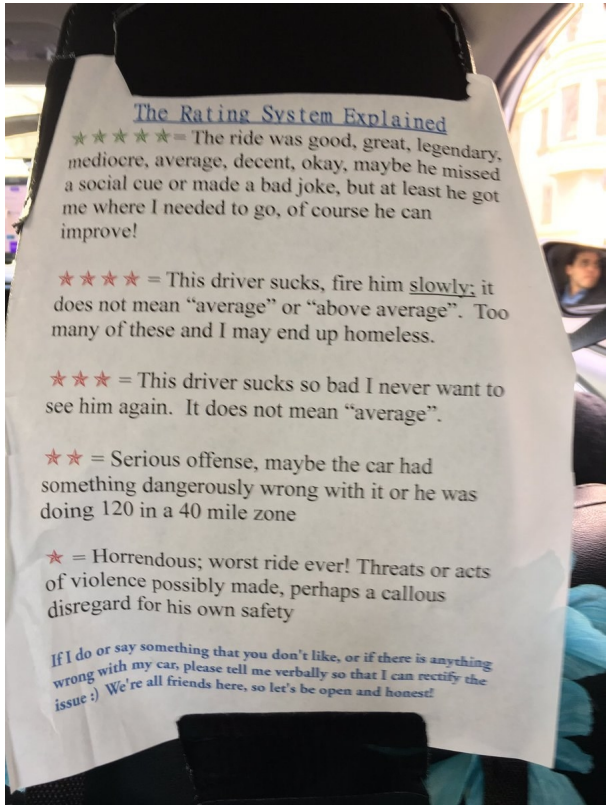
When small movements matter

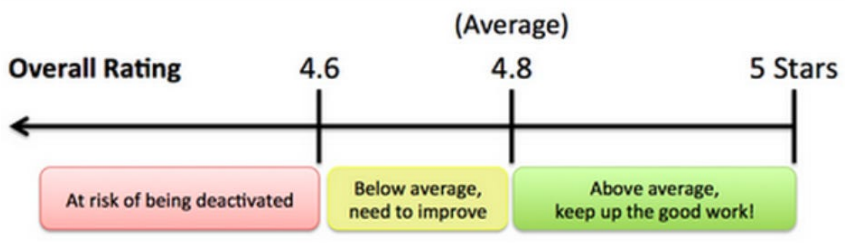




When is it okay to truncate?

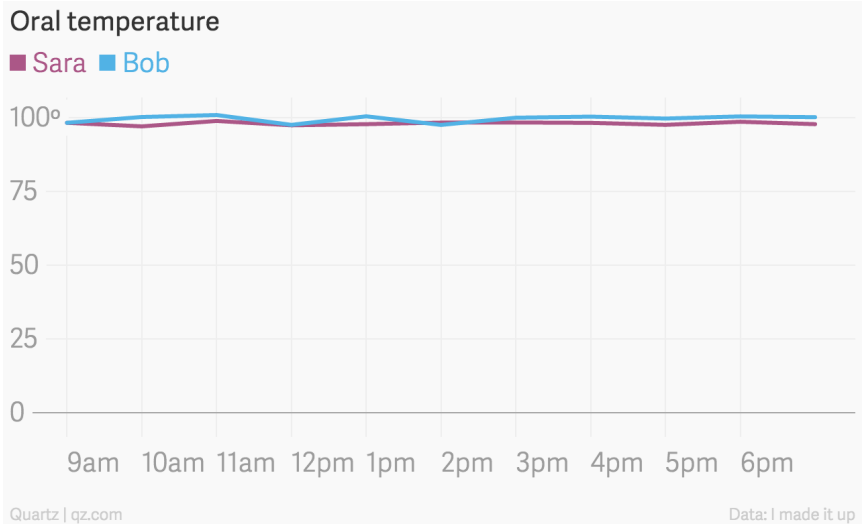
When the scale itself is distorted

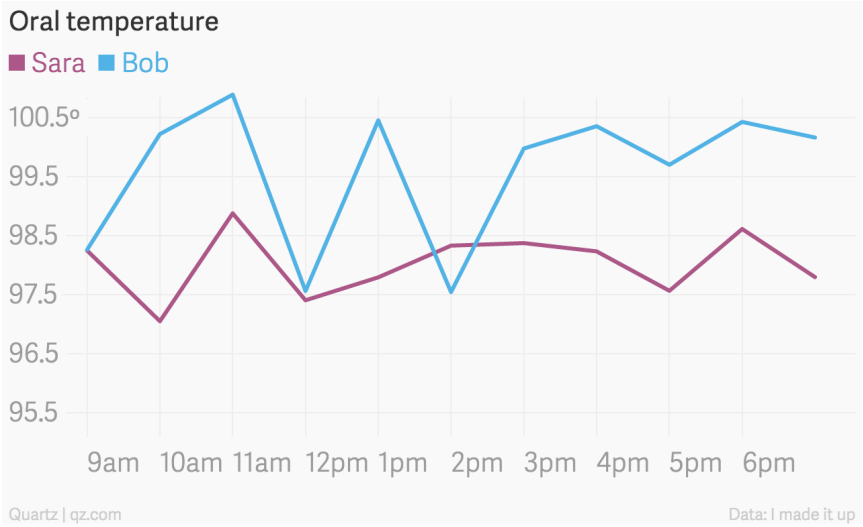




When is it okay to truncate?

When zero values are impossible



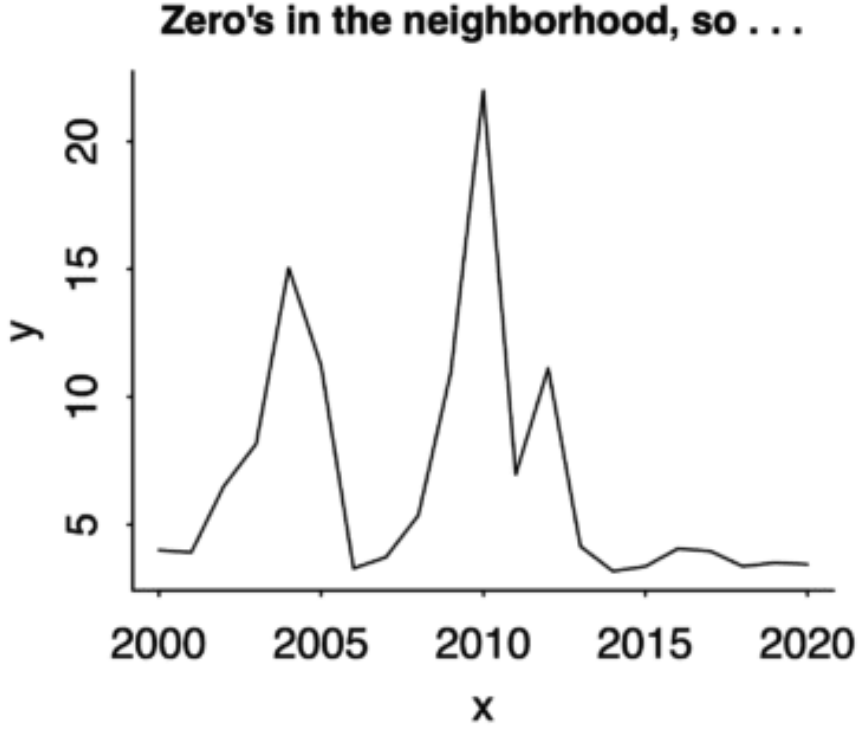


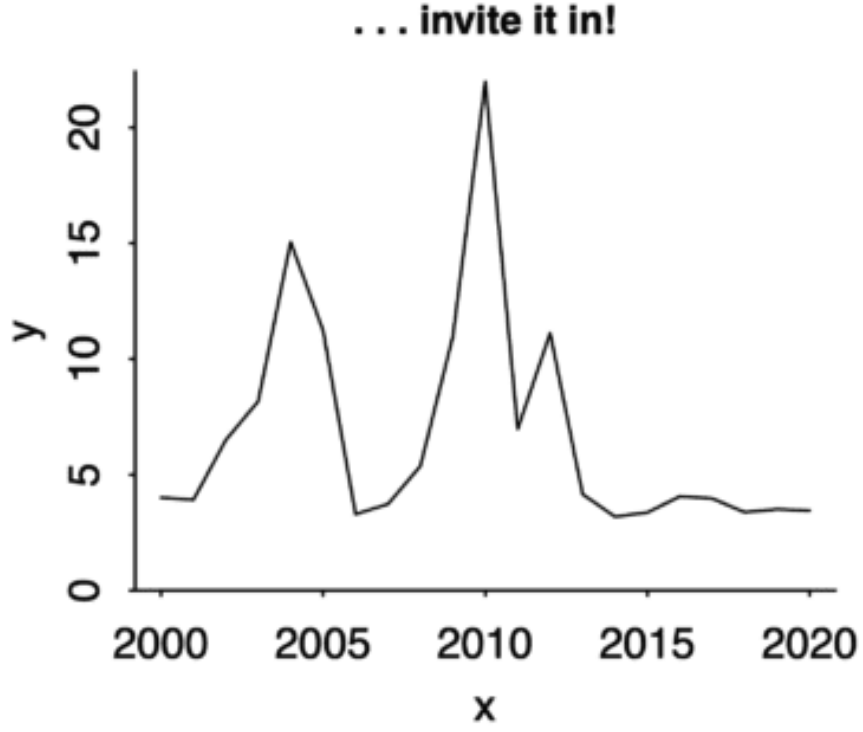
Never on bar charts

Zero is okay too!

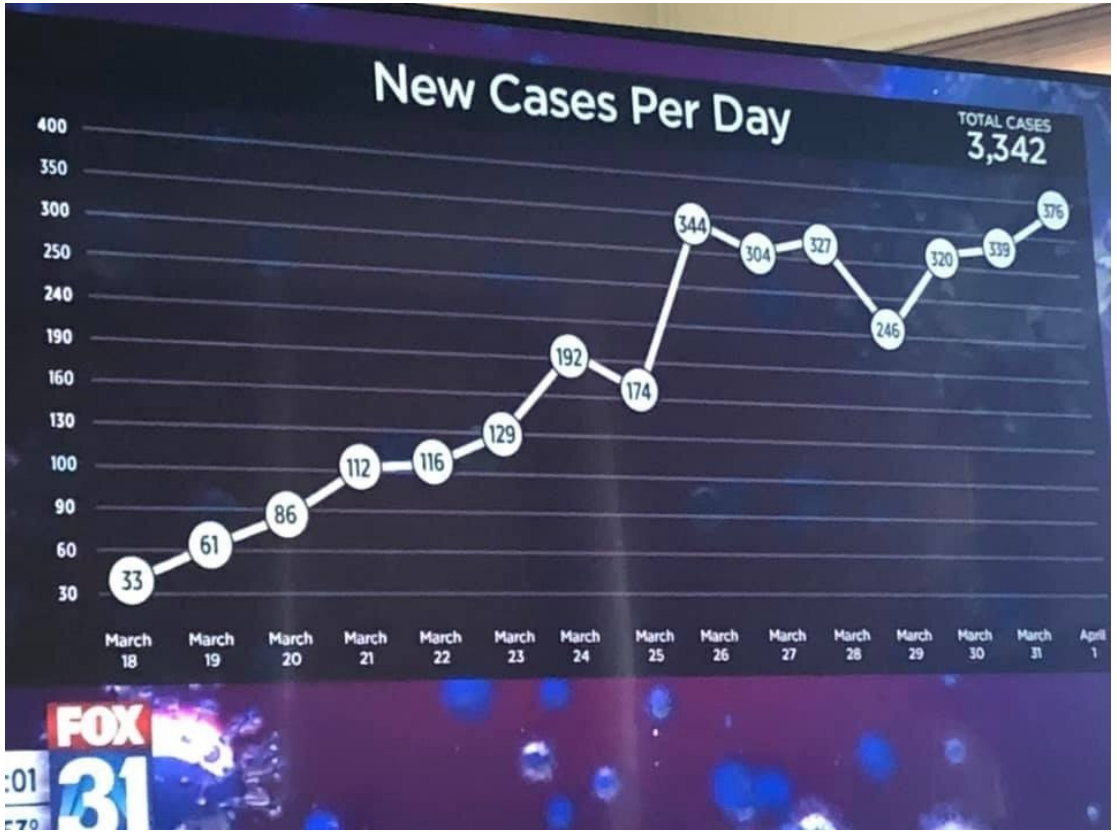
Just because you don't *have to* start at 0 doesn't mean you should *never* start at 0

Andrew Gelman's heuristic: **"If zero is in the neighborhood, invite it in."**



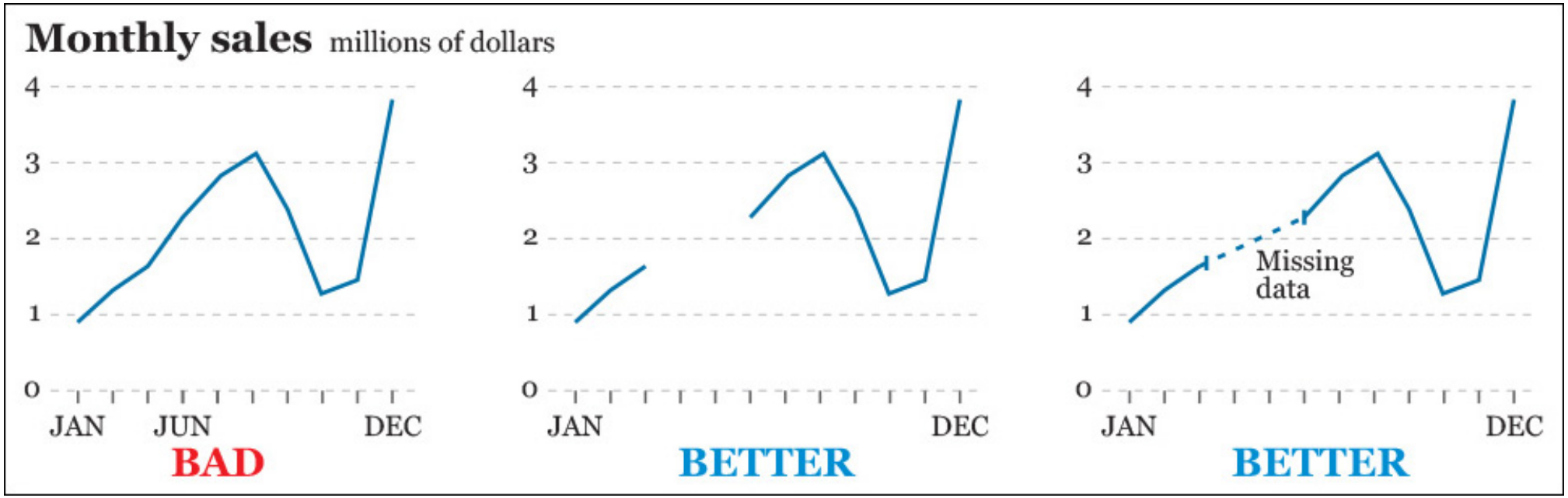


Keep axis scales consistent

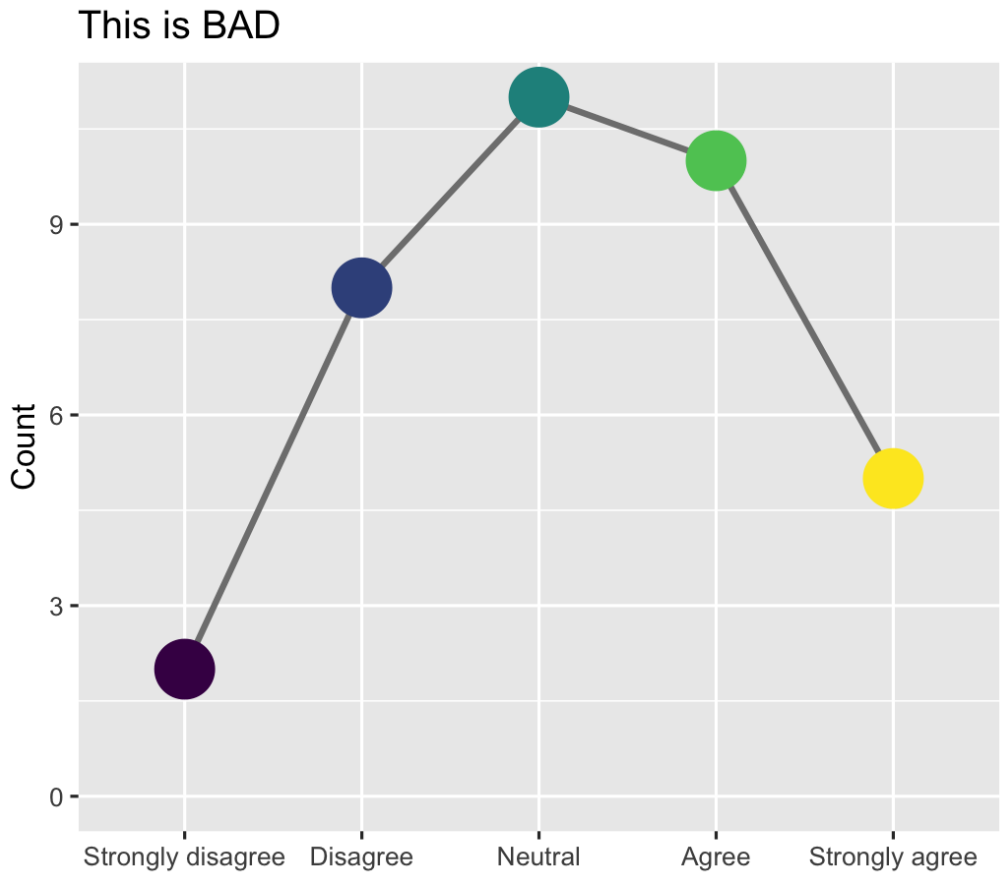


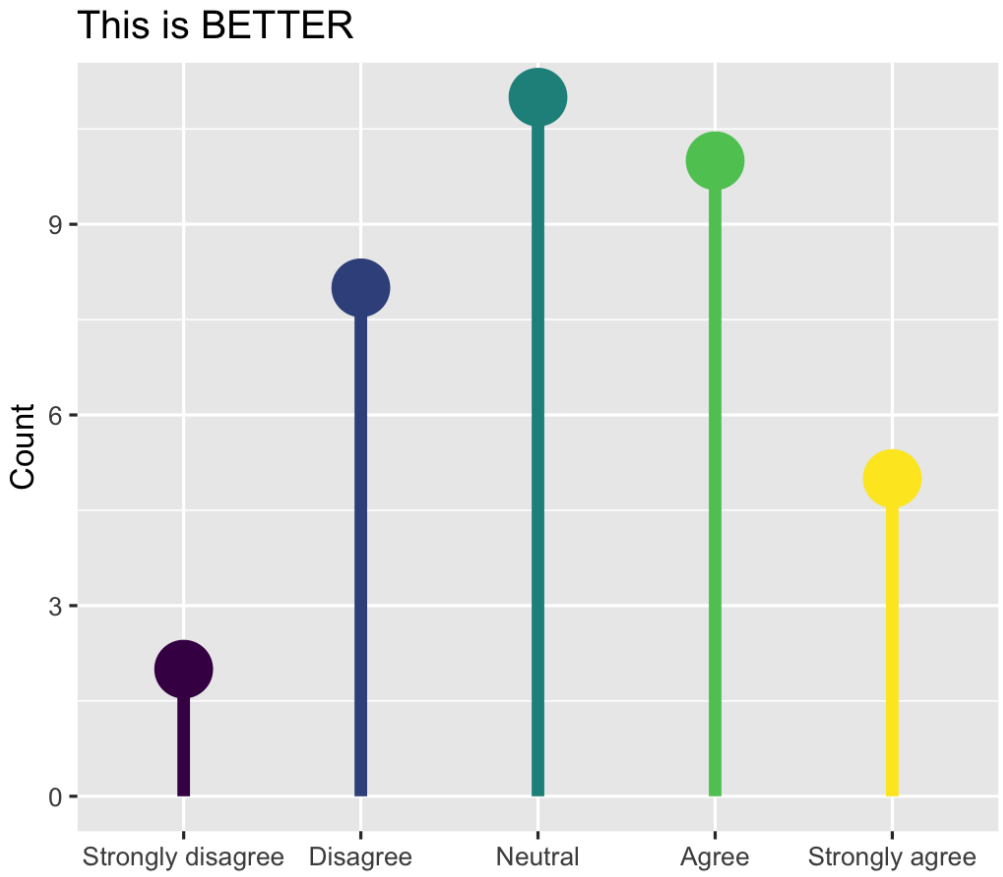
FOX affiliate in Colorado reporting on COVID-19 cases

Keep scales consistent and flag missing data



Don’t impute across categories





Visualizing time

Showing changes over time

Time is just a variable that can be mapped to an aesthetic

Can be used as `x`, `y`, `color`, `fill`, `facet`, and even animation

Can use all sorts of `geom`s: lines, columns, points, heatmaps, densities, maps, etc.

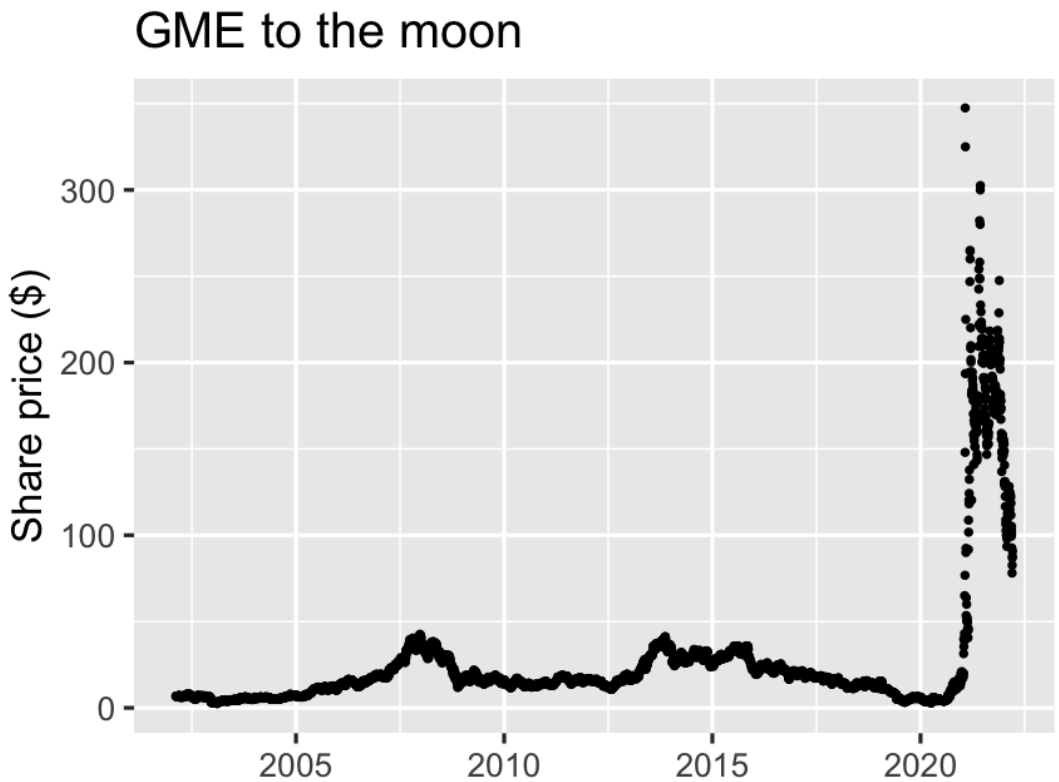
In general, follow reading conventions to show time progression:

→ & ↓

Time on x-axis + `geom_point()`

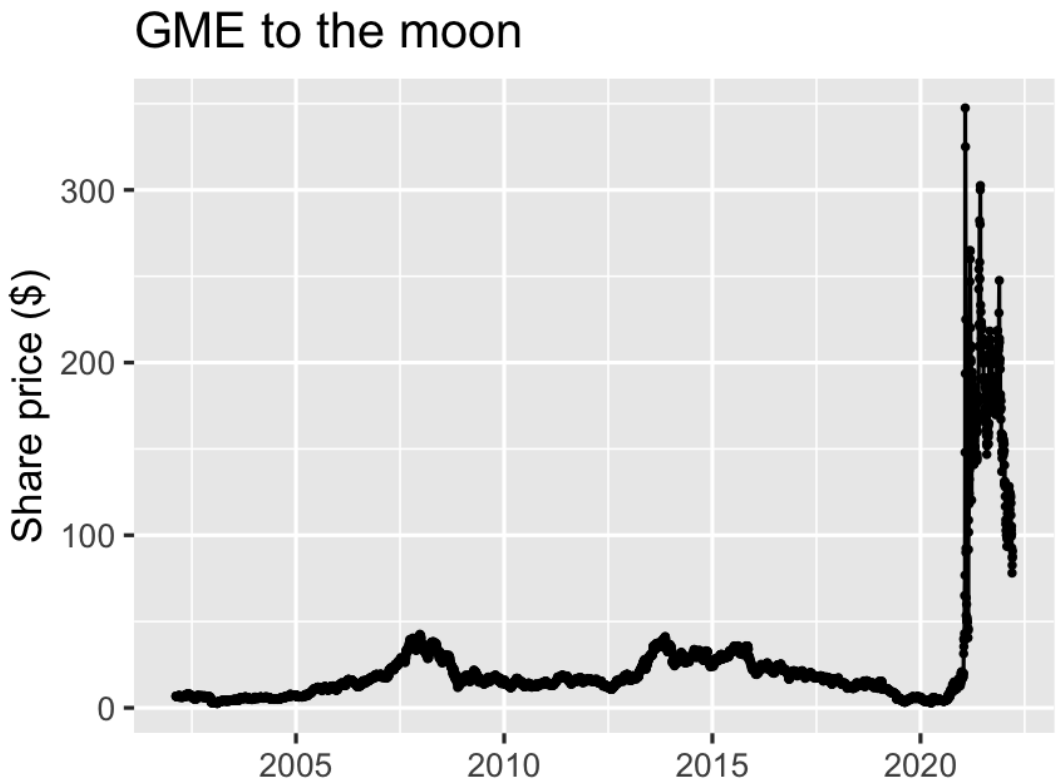
```
gme_prices %>%
  ggplot(aes(x = date, y = adjusted)) +
  geom_point(size = 0.5) +
  labs(x = NULL, y = "Share price ($)",
       title = "GME to the moon")
```

How would you add a line to this?



Time on x-axis + `geom_point()`

```
gme_prices %>%
  ggplot(aes(x = date, y = adjusted)) +
  geom_point(size = 0.5) +
  geom_line() +
  labs(x = NULL, y = "Share price ($)",
       title = "GME to the moon")
```



Time on x-axis: points vs lines

Points emphasize observations

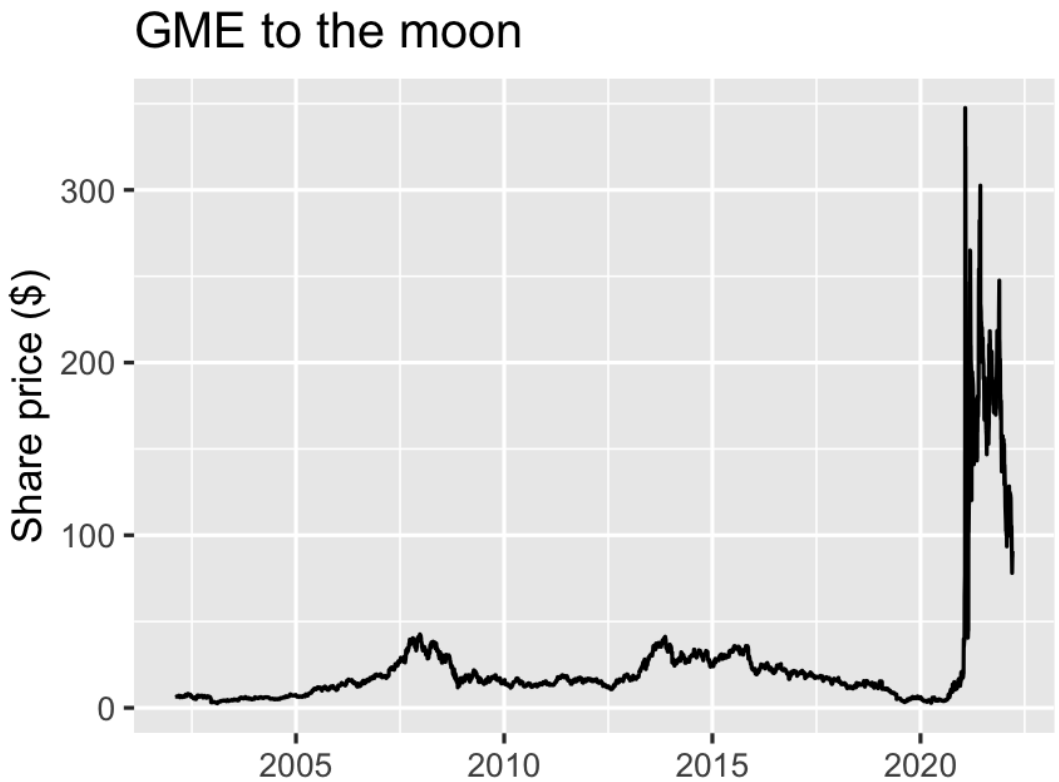
Lines emphasize trends

Using lines for time series is often fine since data are evenly spaced and usually complete

But lines are effectively made-up data, so be careful how you use them!

Time on x-axis + `geom_line/col()`

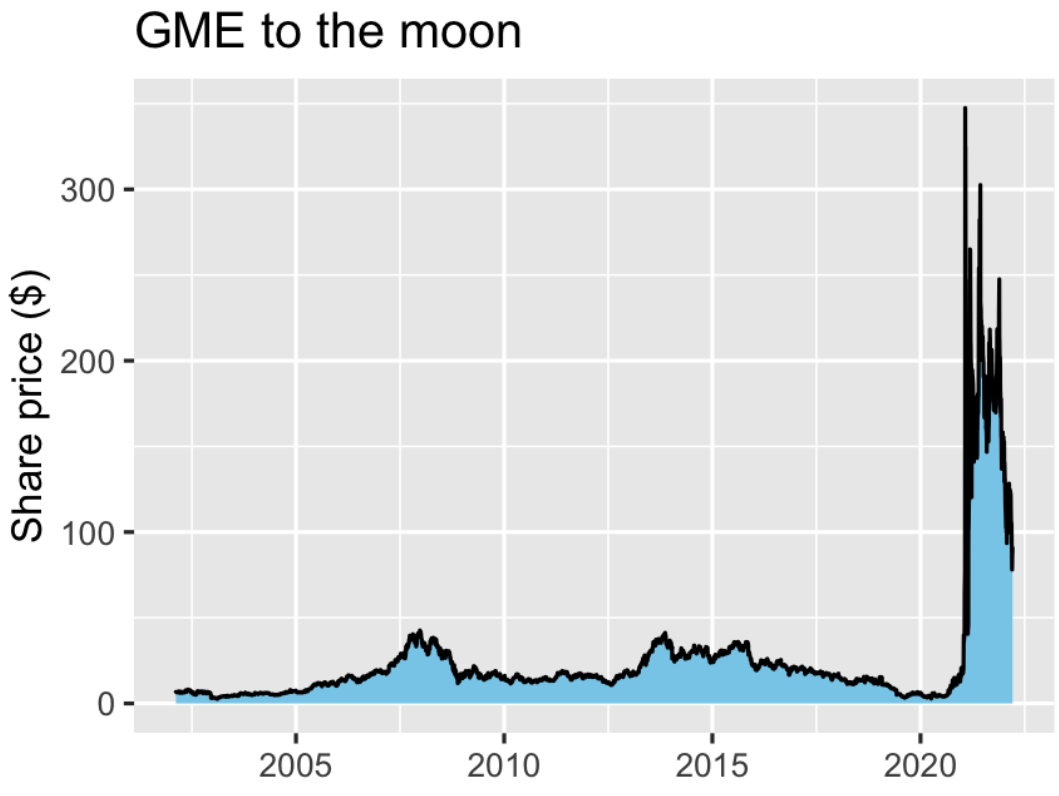
```
gme_prices %>%
  ggplot(aes(x = date, y = adjusted)) +
  geom_line() +
  labs(x = NULL, y = "Share price ($)",
       title = "GME to the moon")
```



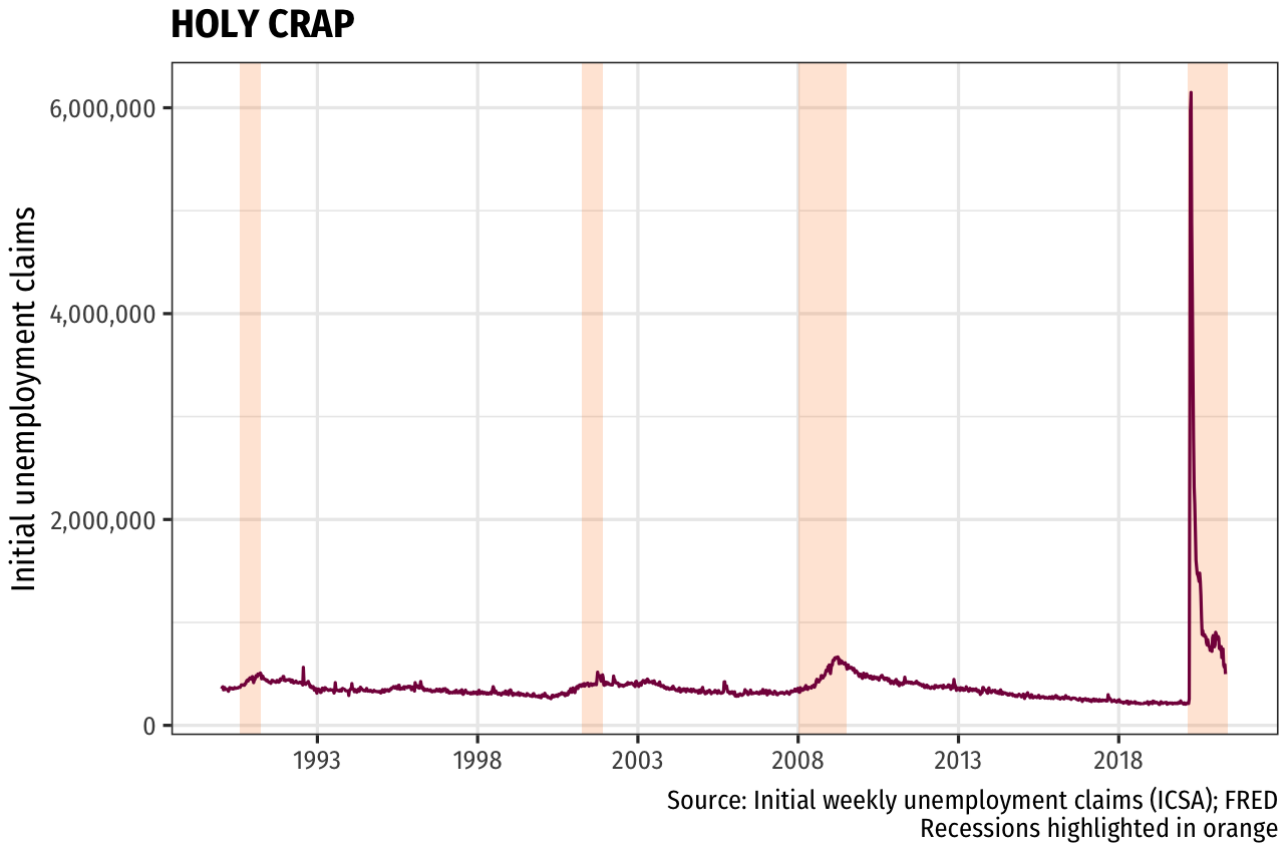
Time on x-axis + `geom_line/col()`

Can also use a fill for the area under a line, **as long as the y-axis starts at zero**

```
gme_prices %>%
  ggplot(aes(x = date, y = adjusted)) +
  geom_area(fill = "skyblue", color = "black") +
  labs(x = NULL, y = "Share price ($)",
       title = "GME to the moon")
```

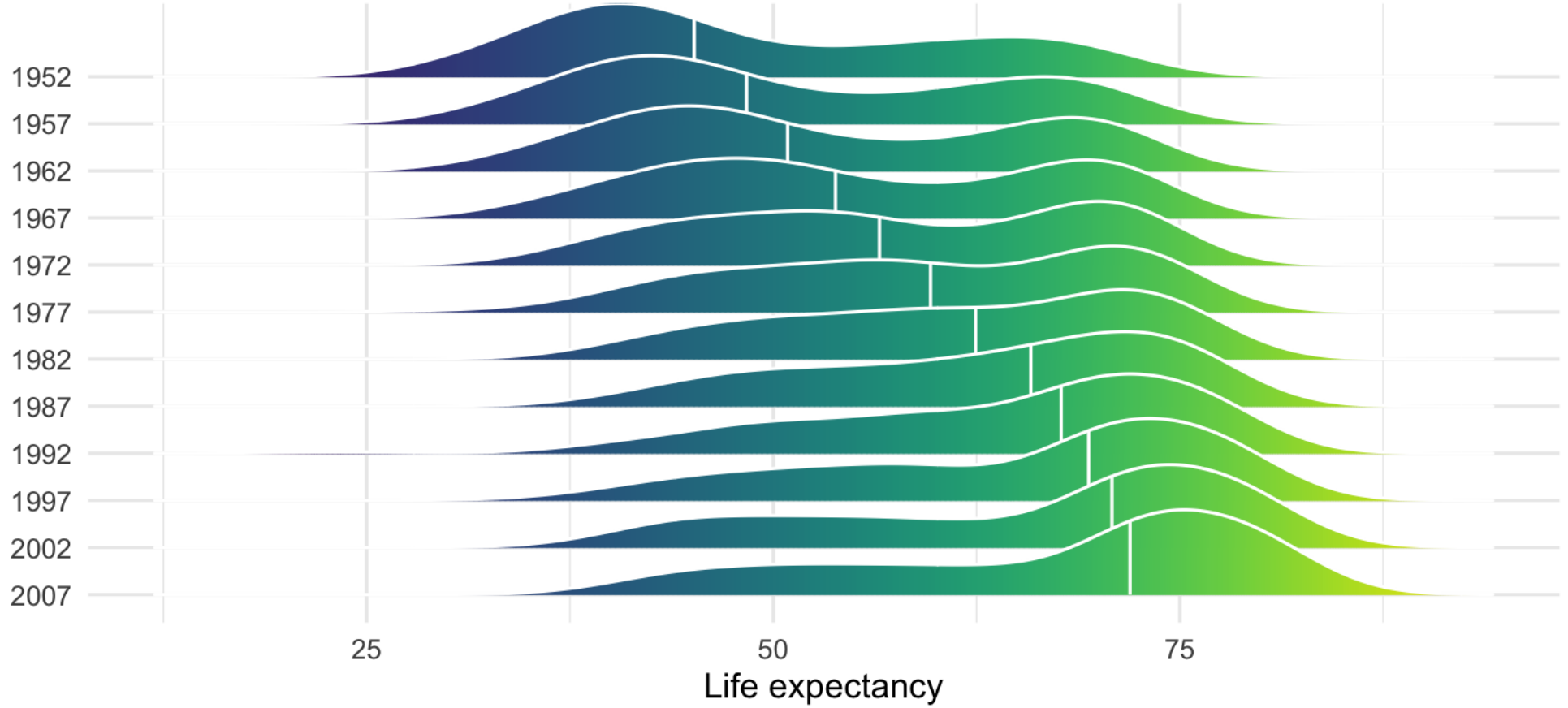


Line plots don't have to be boring



Time on x-axis + `geom_tile()`

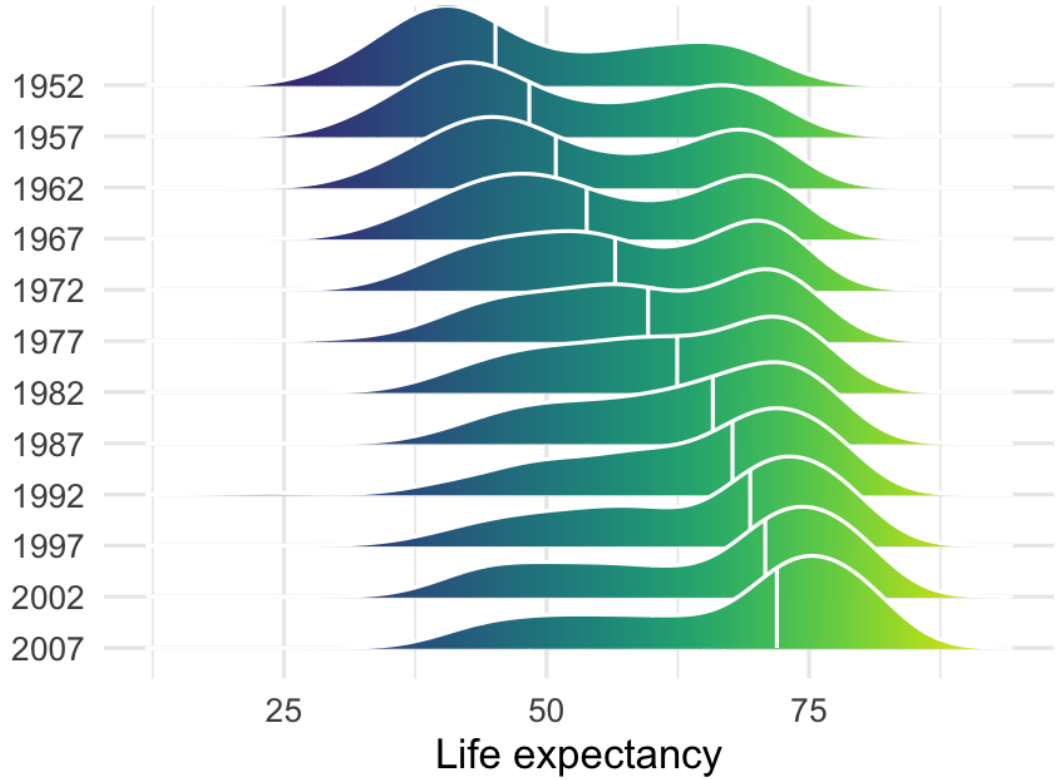
Time on y-axis + `geom_density()`



How would you make this plot?

Time on y-axis + `geom_density()`

```
gapminder %>%
    mutate(year_factor = factor(year)) %>%
    ggplot(
      aes(x = lifeExp,
          y = fct_rev(year_factor),# map time to y
          fill = after_stat(x)) # fill by x value
      ) +
    geom_density_ridges_gradient( # add geom
      color = "white",
      quantile_lines = TRUE,
      quantiles = 2 # denote median
      ) +
    guides(fill = "none") +
    scale_fill_viridis() +
    labs(x = "Life expectancy",
         y = NULL, fill = NULL) +
    theme_minimal()
```

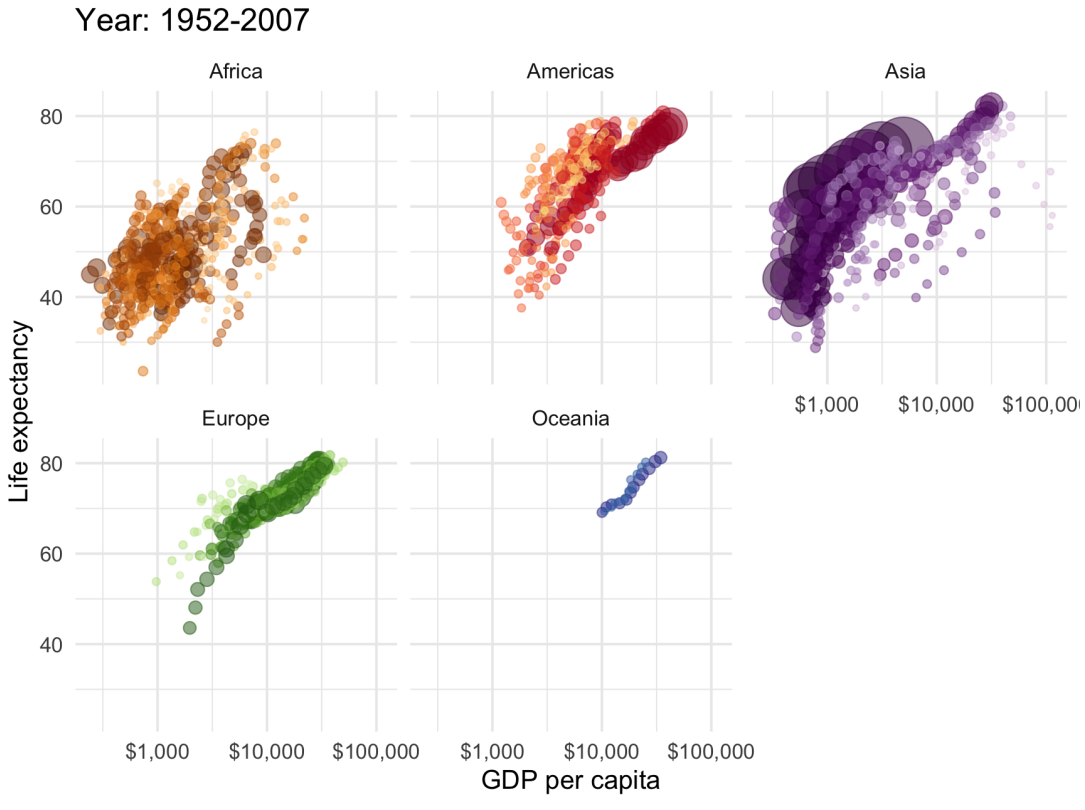


Time in animation + `geom_point()`

How can we make this animation in R?

First, how would we make a static plot of the data?

```
gapminder %>%
  ggplot(aes(gdpPercap, lifeExp,
             size = pop, color = country)) +
  geom_point(alpha = 0.5, show.legend = FALSE) +
  facet_wrap(~continent) +
  scale_color_manual(
    values = gapminder::country_colors
    ) +
  scale_size_continuous(range = c(1, 15)) +
  scale_x_log10(labels = scales::dollar) +
  theme_minimal(base_size = 14) +
  labs(x = "GDP per capita",
       y = "Life expectancy",
       title = "Year: 1952-2007")
```

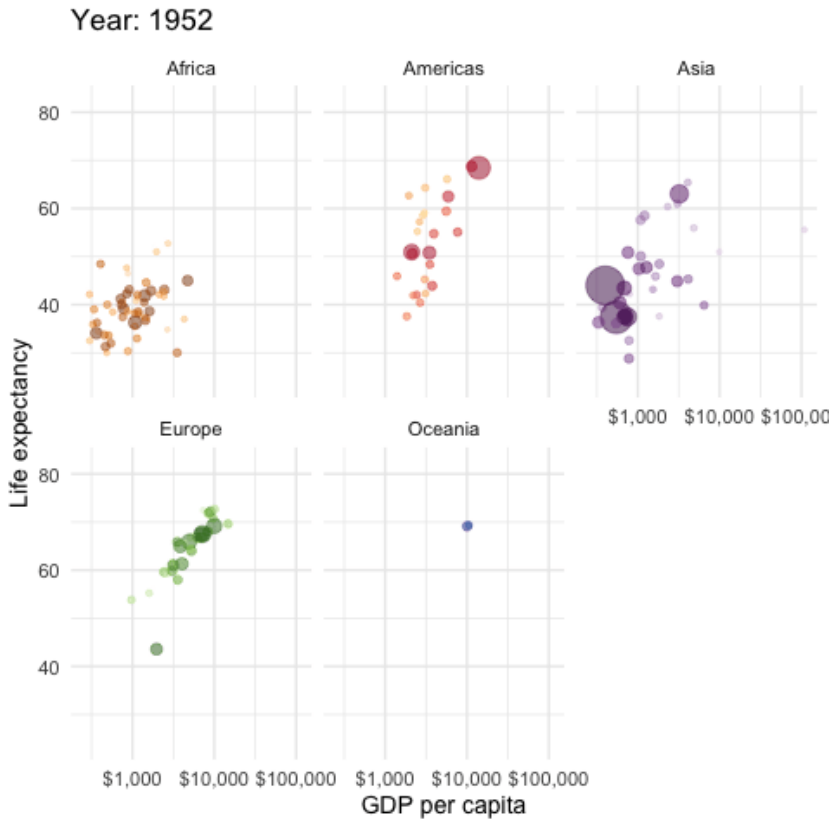


Time in animation + `geom_point()`

Second, let's use `gganimate` to visualize changes over time

```
library(gganimate) # plot animation package

gapminder %>%
  ggplot(aes(gdpPercap, lifeExp,
             size = pop, color = country)) +
  geom_point(alpha = 0.5, show.legend = FALSE) +
  facet_wrap(~continent) +
  scale_color_manual(
    values = gapminder::country_colors
    ) +
  scale_size_continuous(range = c(1, 15)) +
  scale_x_log10(labels = scales::dollar) +
  theme_minimal(base_size = 14) +
  labs(x = "GDP per capita",
       y = "Life expectancy",
       title = "Year: {frame_time}") +
  transition_time(year) +
  ease_aes('linear') # default progression
```



Time in animation + `geom_point()`

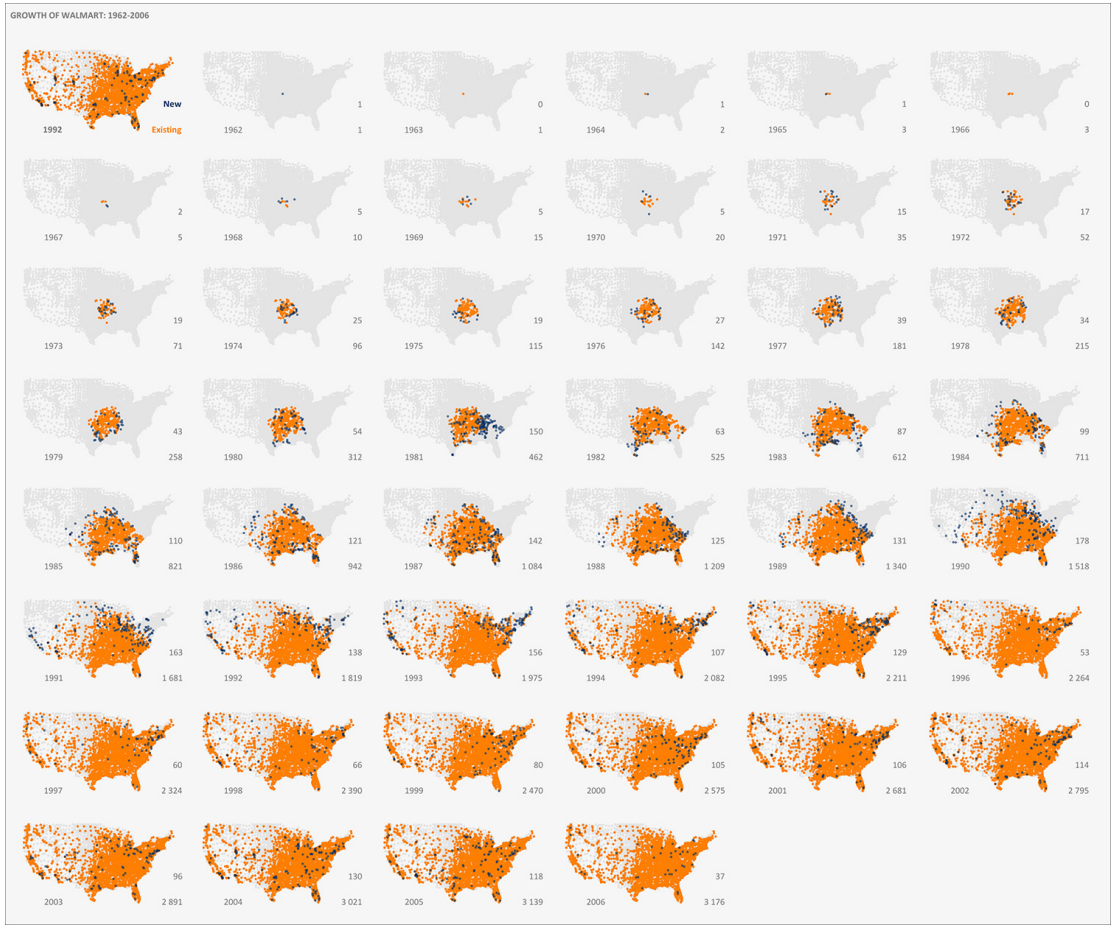
Third, use `anim_save()` to write a `.gif` that you can text to your mom

```
library(gganimate) # plot animation package

my_gapminder_animation <- gapminder %>%
  ggplot(aes(gdpPercap, lifeExp, size = pop, color = country)) +
  geom_point(alpha = 0.5, show.legend = FALSE) +
  scale_color_manual(values = gapminder::country_colors) +
  scale_size_continuous(range = c(1, 15)) +
  scale_x_log10(labels = scales::dollar) +
  facet_wrap(~continent) +
  theme_minimal(base_size = 14) +
  labs(x = "GDP per capita",
       y = "Life expectancy",
       title = "Year: {frame_time}") +
  transition_time(year) +
  ease_aes('linear')

anim_save("content/slides/img/09/my-gapminder-animation.gif",
          my_gapminder_animation)
```

Time in maps



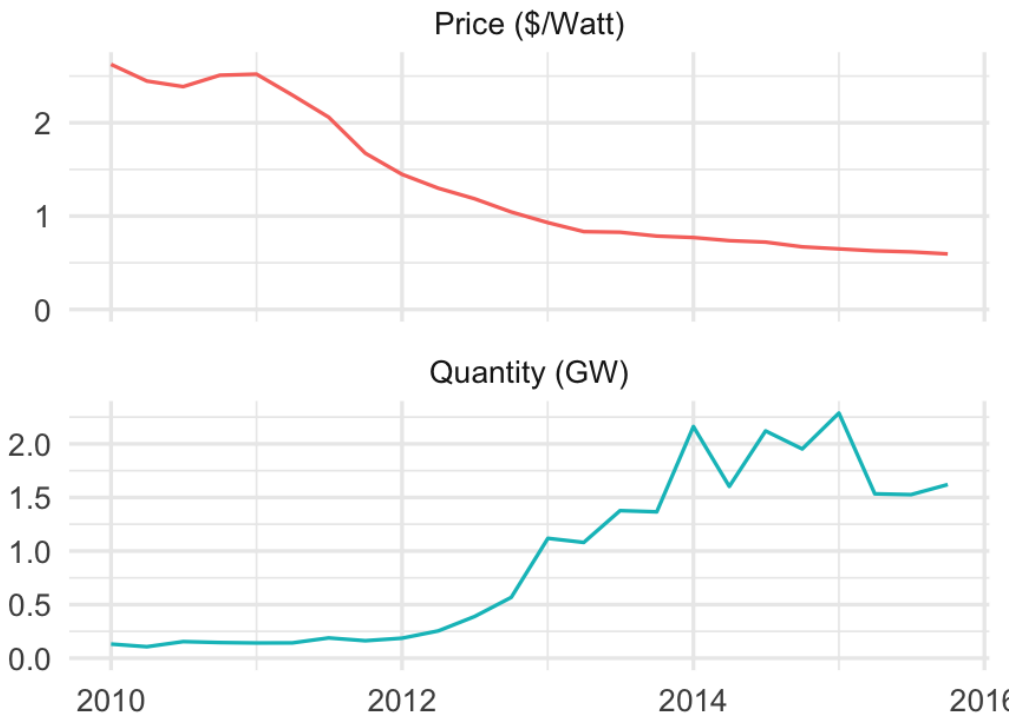
Map of the spread of Walmart by Jorge Camões

Connected scatter plots

Sometimes connected scatter plots of time series data make sense

What is a connected scatter plot?

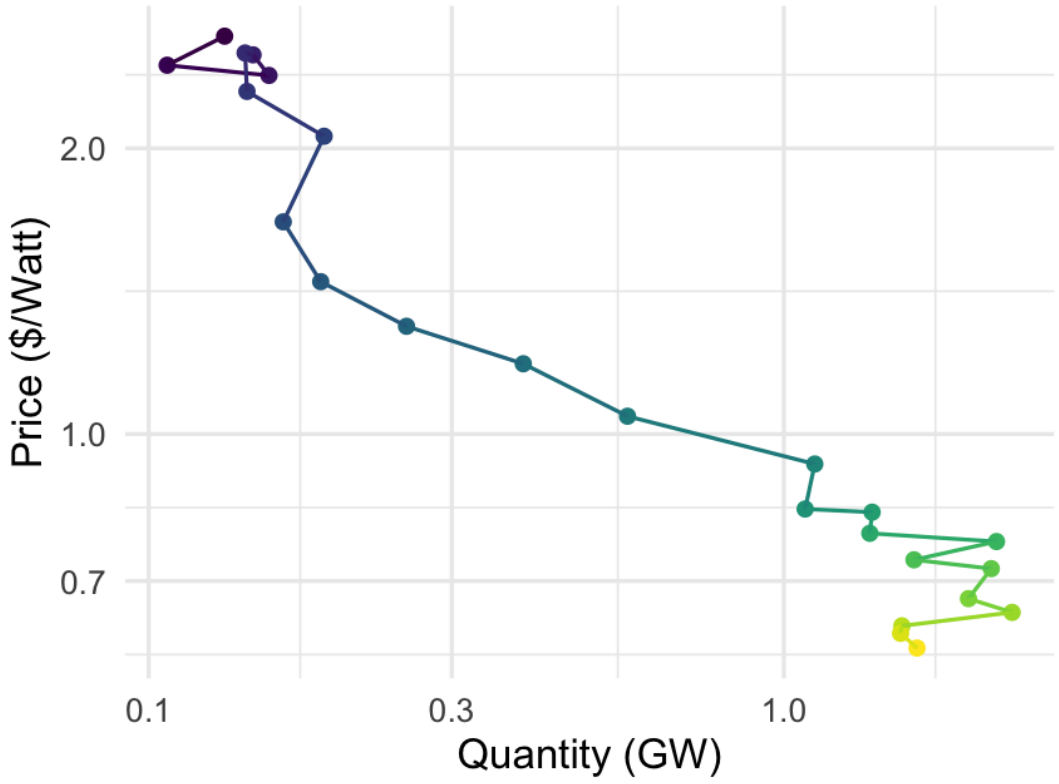
Are solar panels in Japan a good use case?



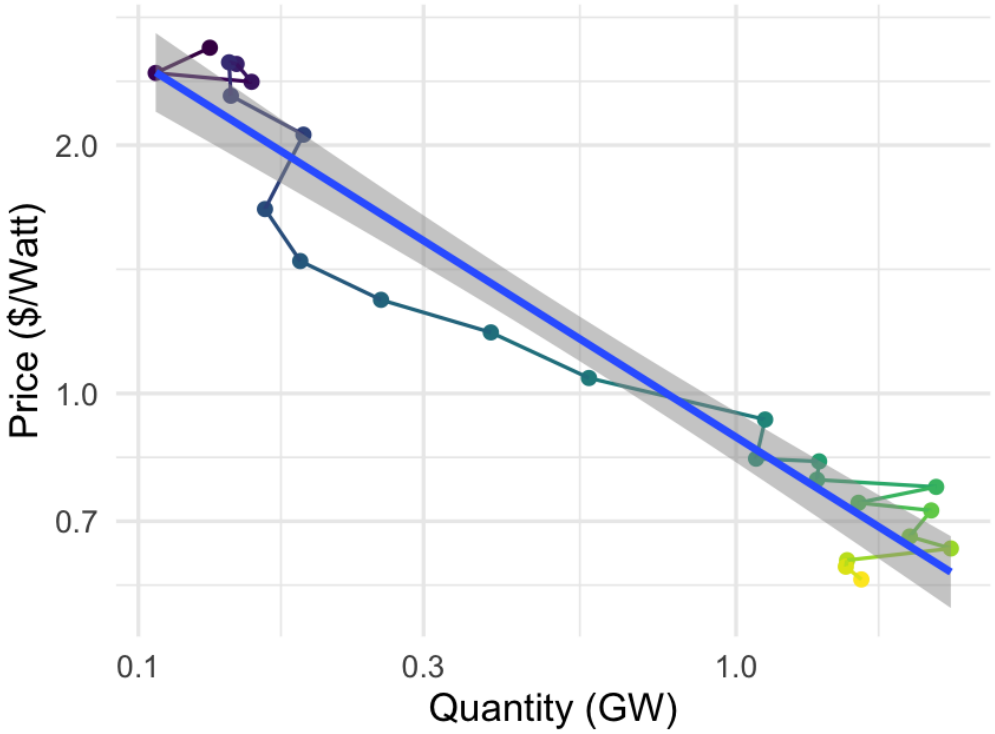
Connected scatter plots

```
solar_data %>%
  ggplot(aes(x = `Quantity (GW)`,  # not time
             y = `Price ($/Watt)`, # not time
             color = date)) +      # time!
  geom_point() +
  geom_path() + # connect by time, not x
  scale_x_log10() +
  scale_y_log10() +
  scale_color_viridis() +
  guides(color = "none") +
  theme_minimal()
```

Note the log axes



Why might this make sense?



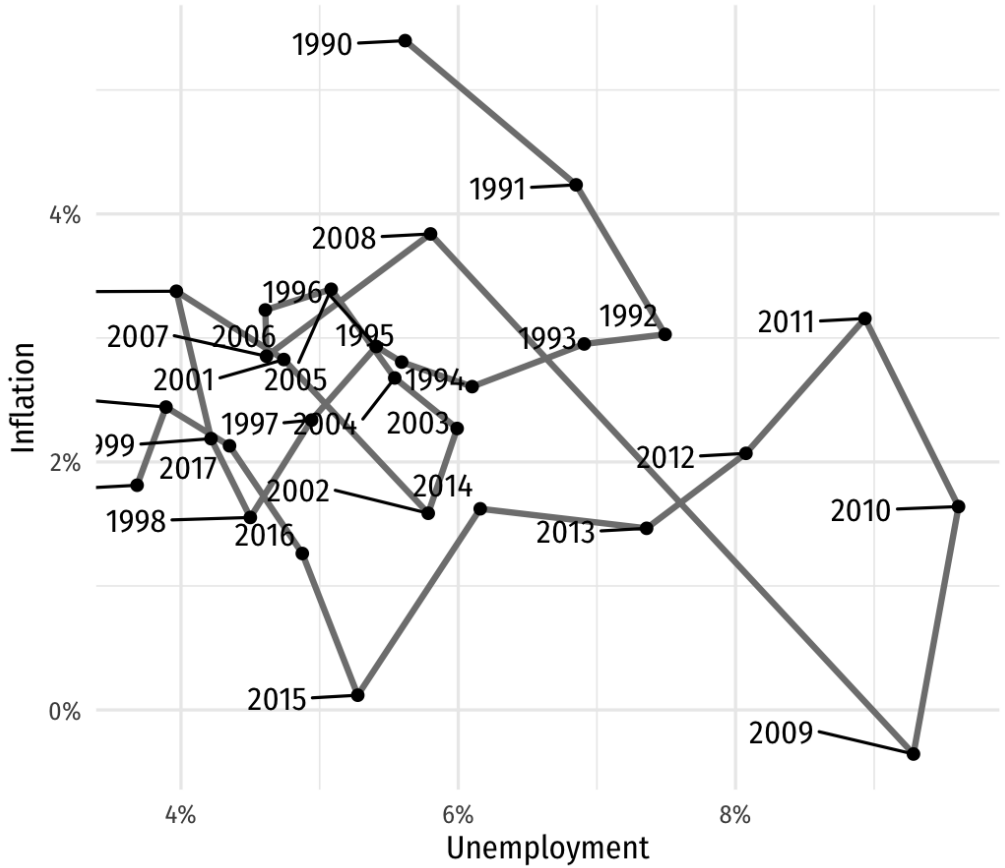
Looks a lot like a demand curve!

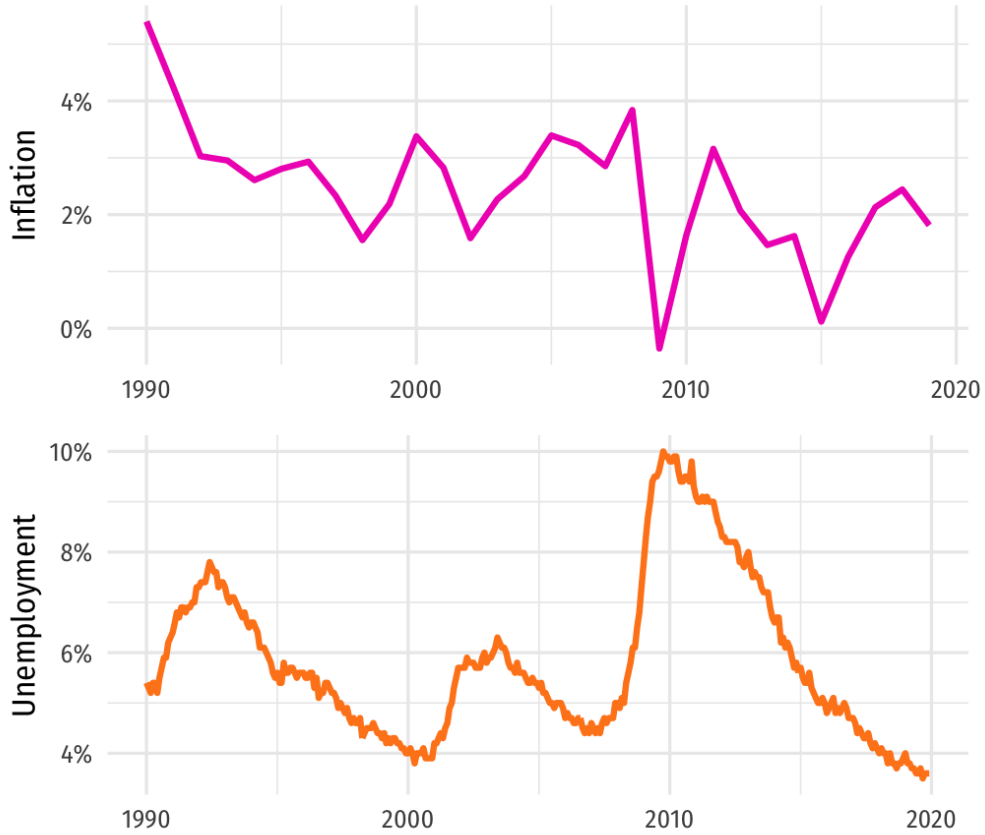
$$log(Q) = \alpha + \beta log(P) + \varepsilon$$

We could use OLS to estimate β

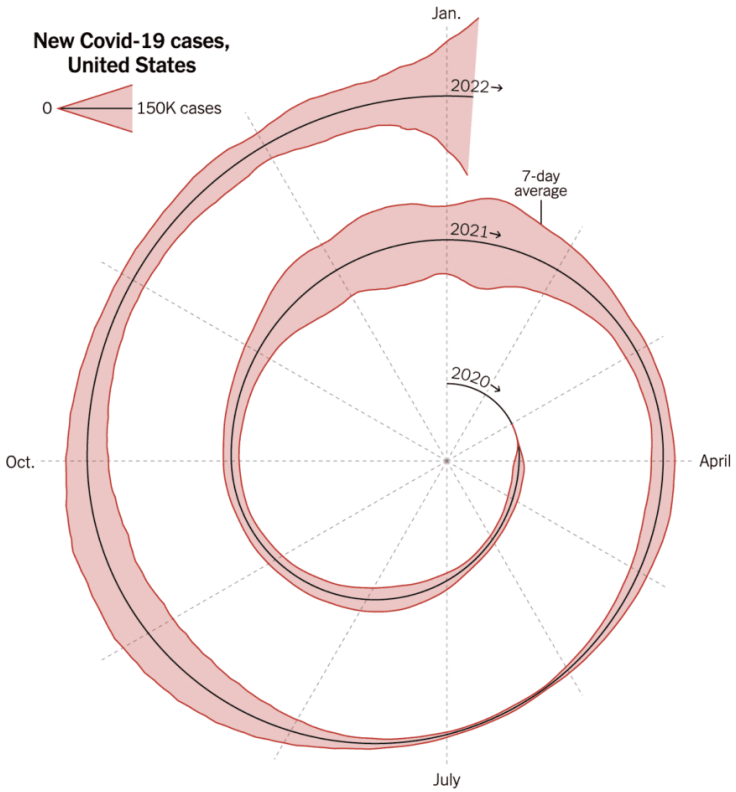
How might we interpret β?

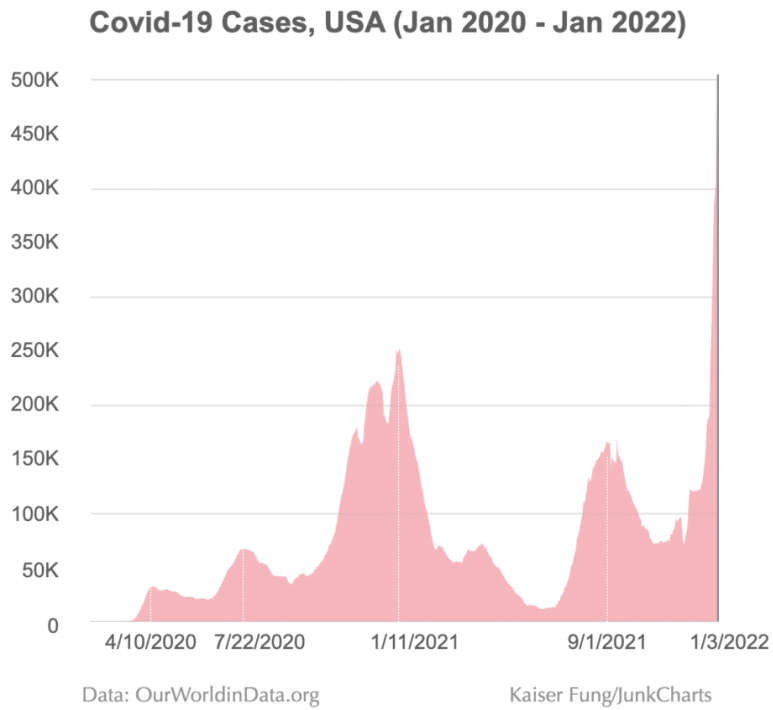
Often it's better to use multiple plots





Don't go wild with time mapping!





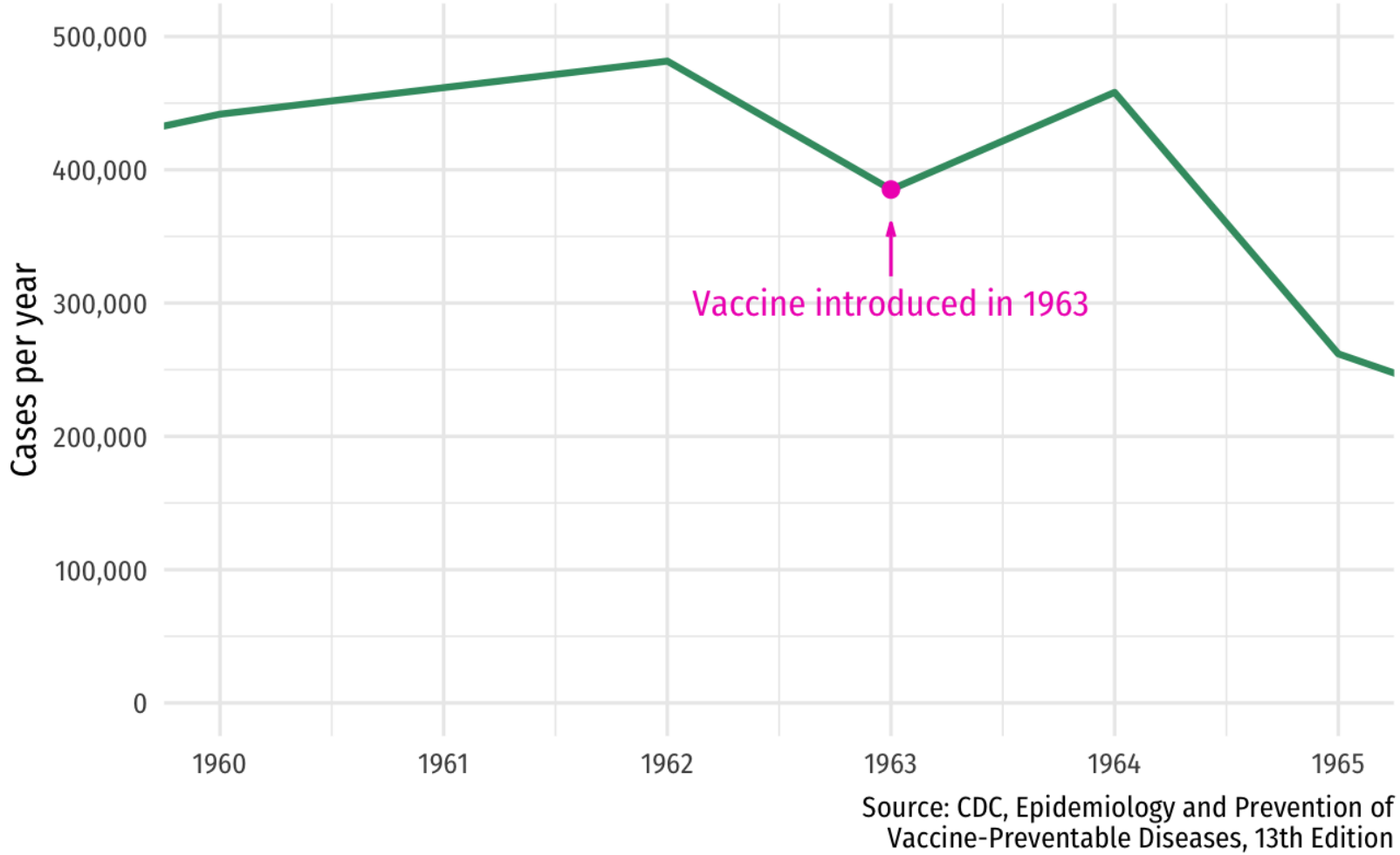
Starting, ending, and decomposing time

You have to start (and end) somewhere

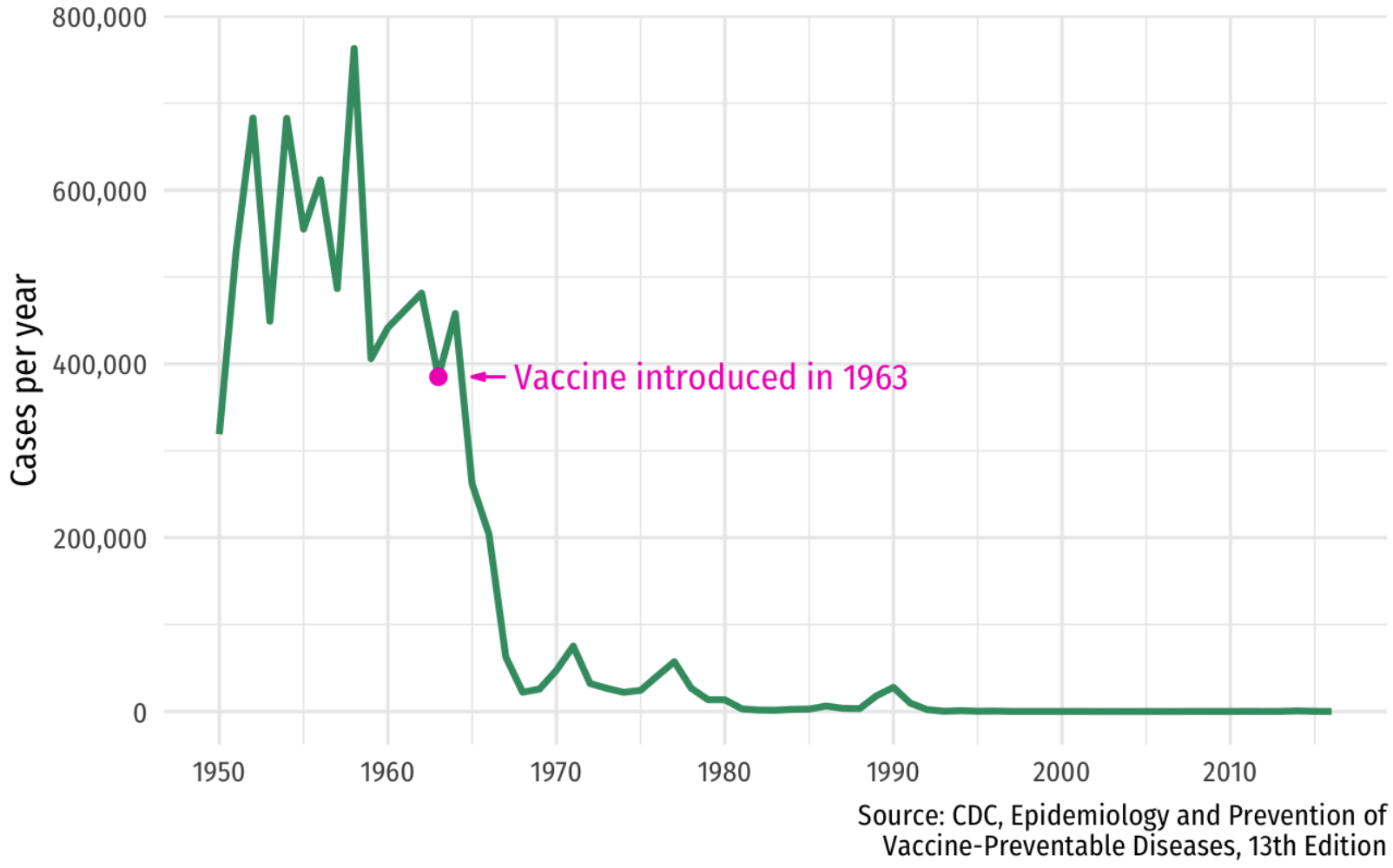
You always have to choose a start and end point

Start and end at reasonable times that help maintain the context of the story

Measles vaccine was pretty effective

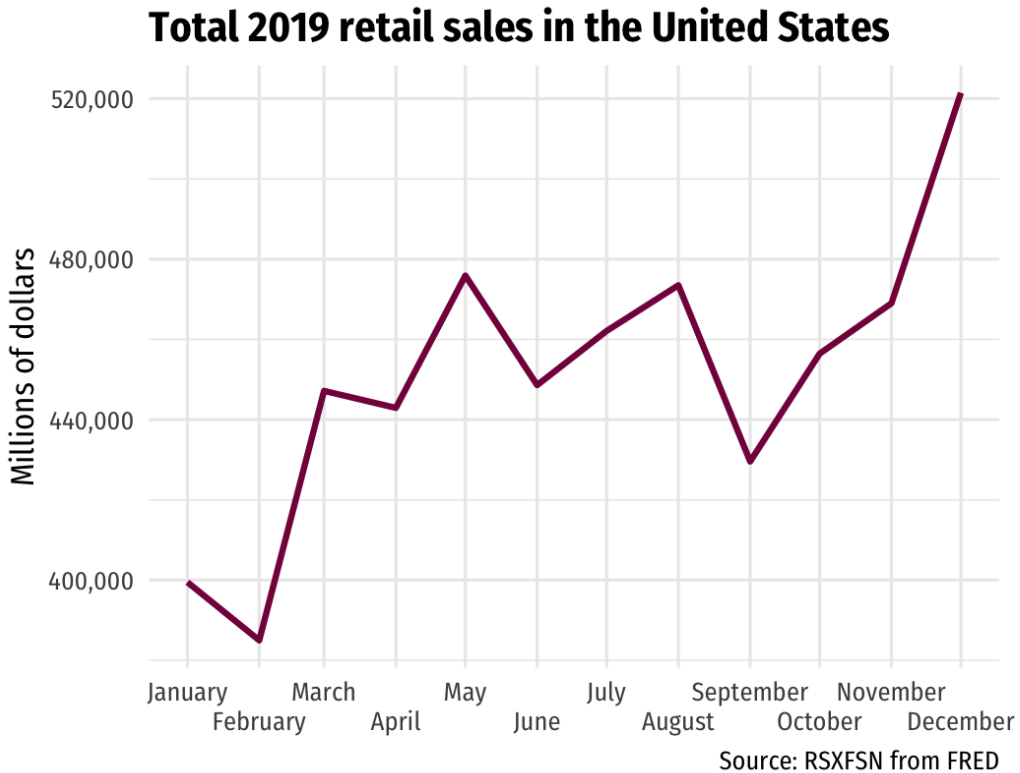


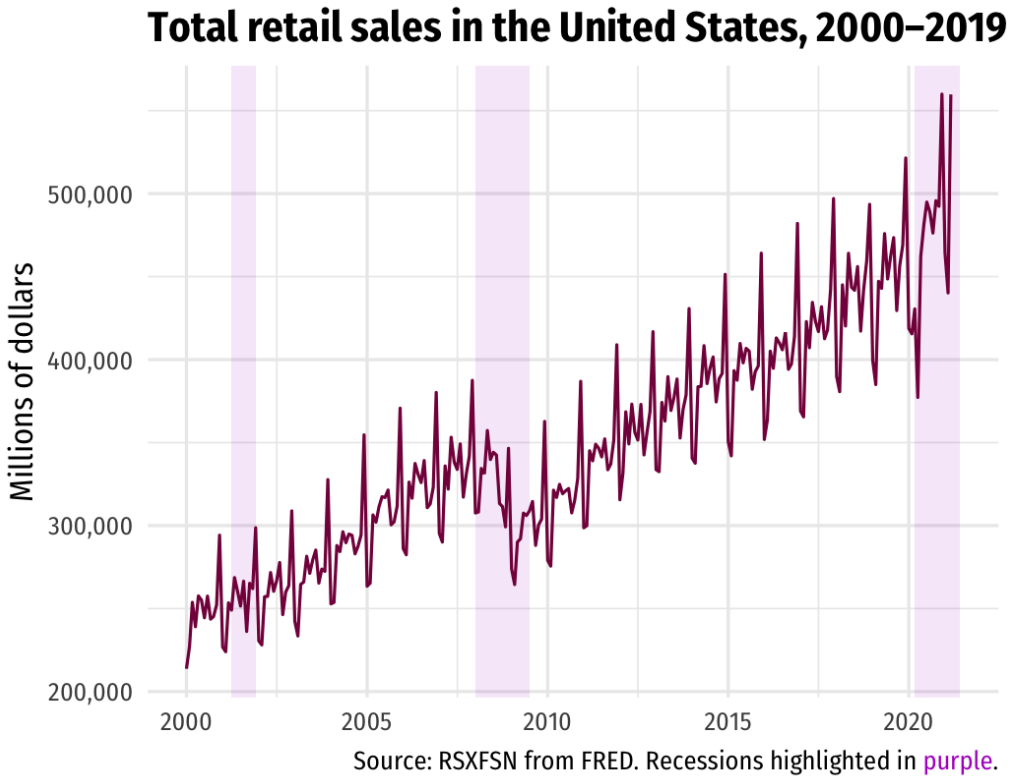
Measles vaccine was *incredible*!



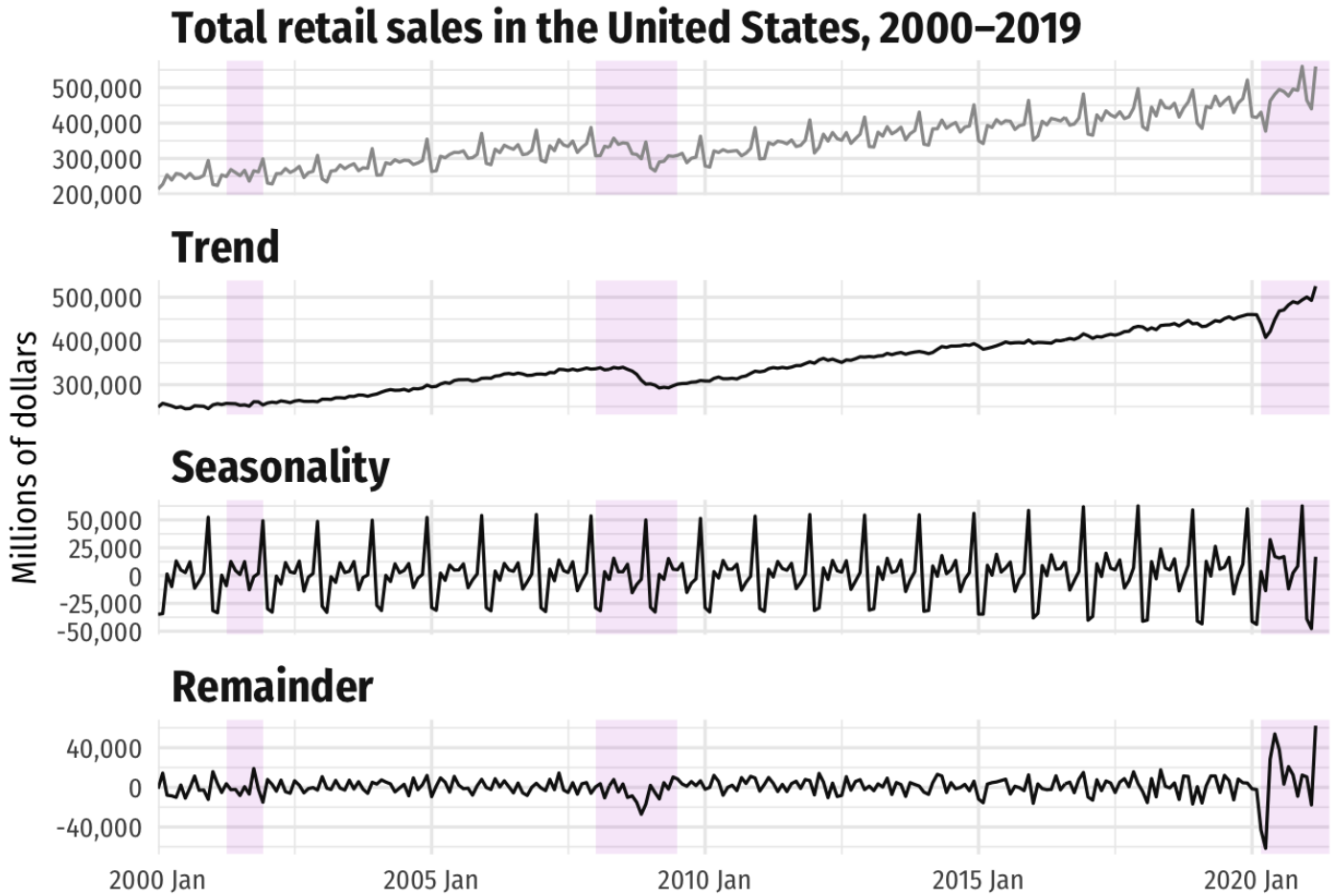
Seasonality

Don't mistake seasonality for actual trends



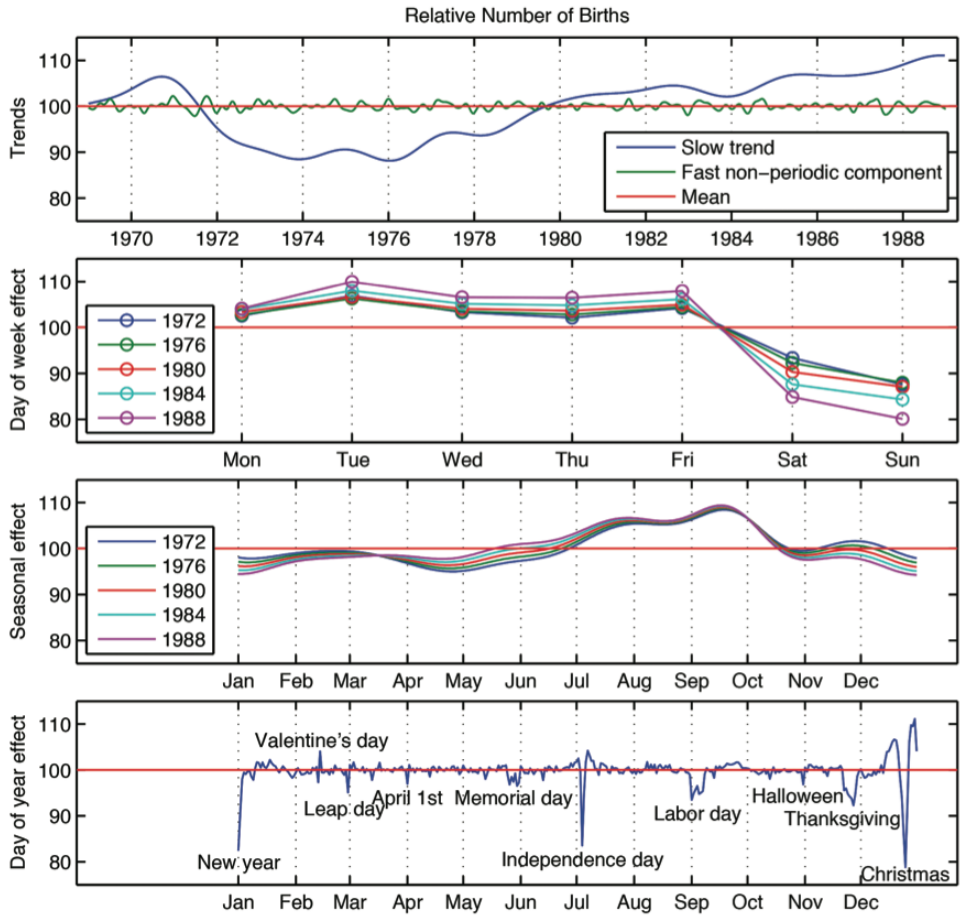


Decomposition



Source: RSXFSN from FRED. Recessions highlighted in purple.

Birthday decomposition



Cover of Andrew Gelman, et al., *Bayesian Data Analysis*