Engaging and Effective ggplot (3)

VCS, Rice 2025

Kieran Healy
Duke University

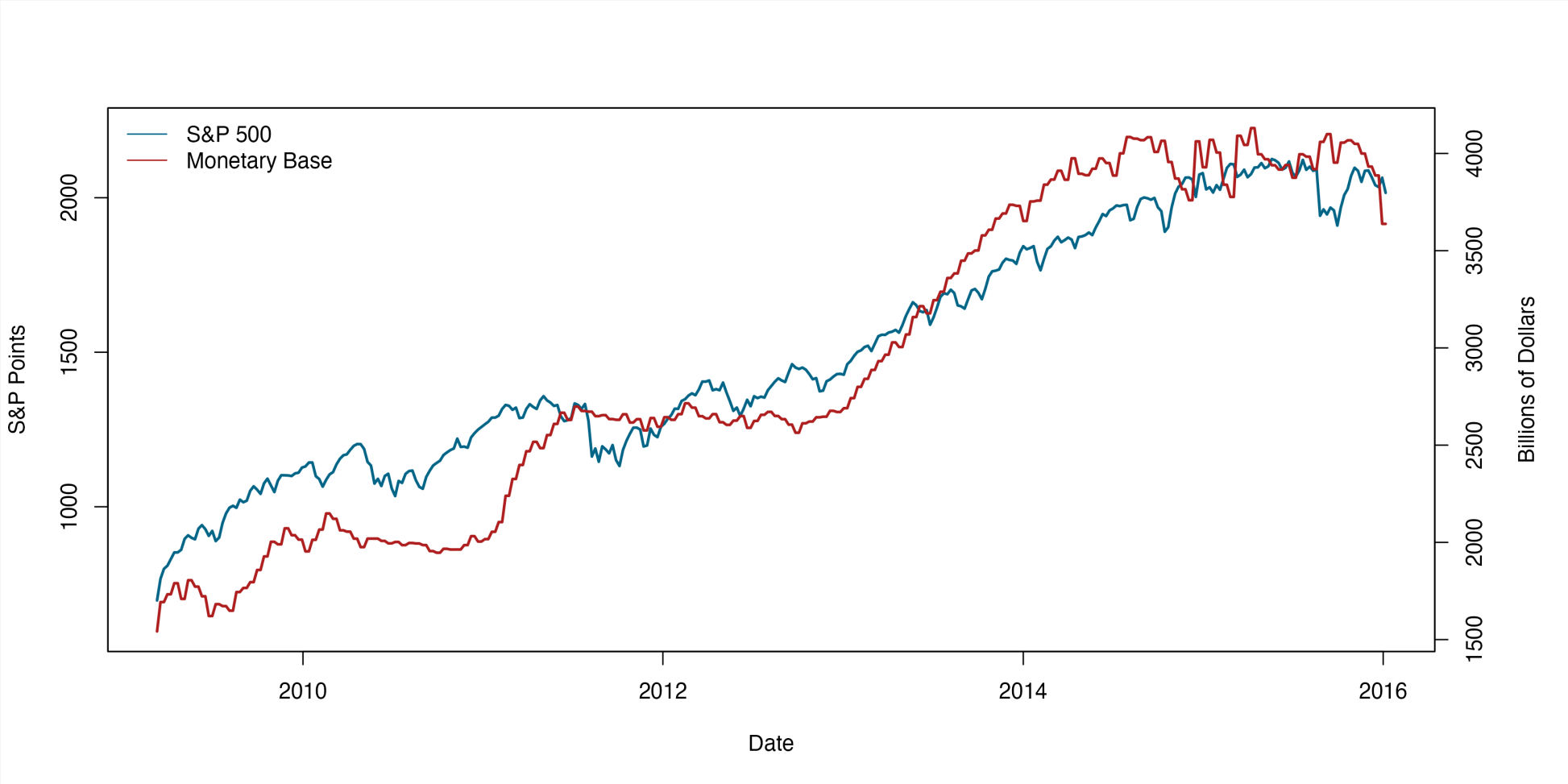
March 2025

Some Case Studies

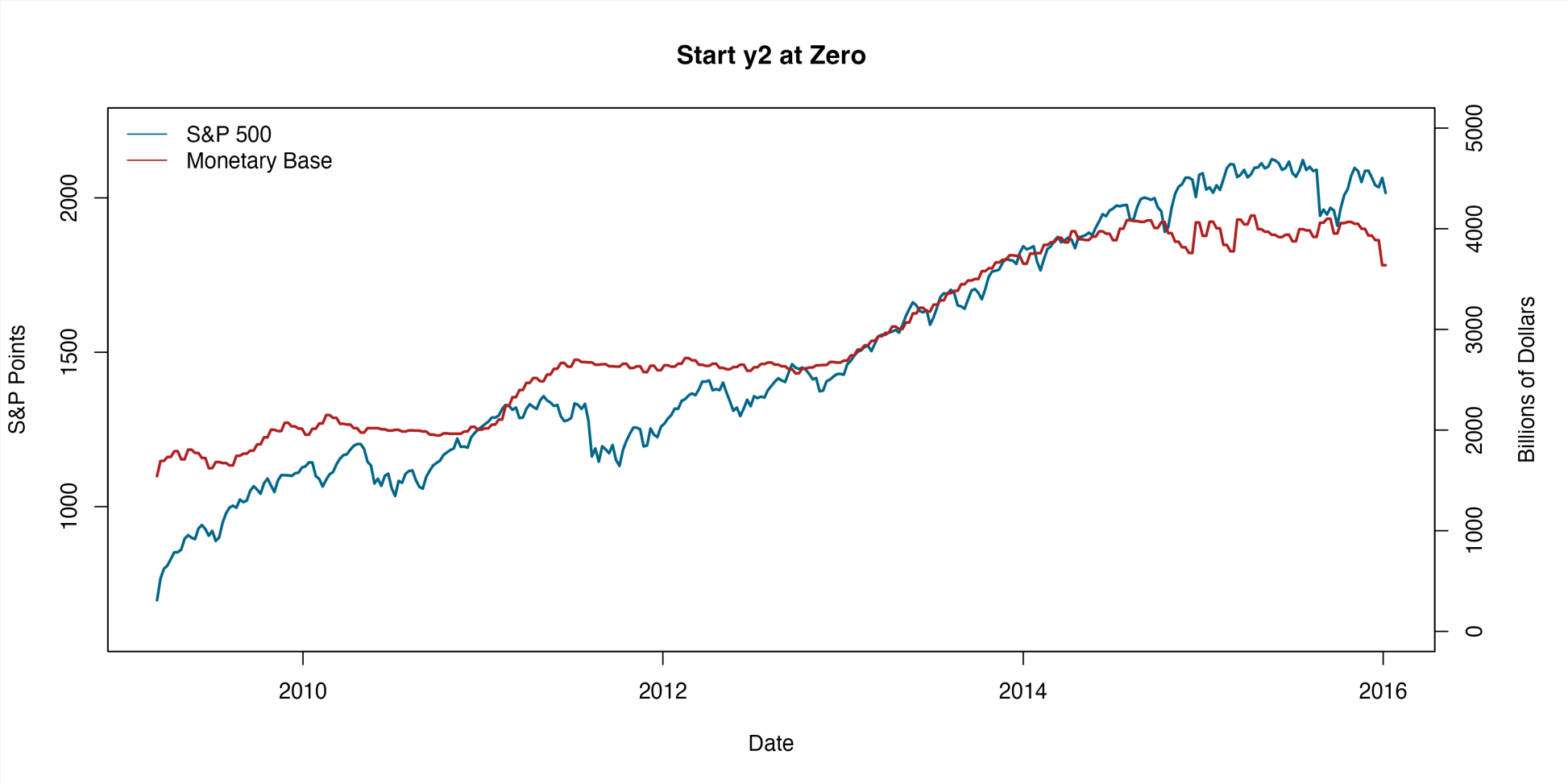
Load our packages

```
library(here)       # manage file paths
library(tidyverse)  # your friend and mine
library(cavax)      # california vaccination exemption data
library(colorspace) # luminance-balanced palettes
library(demog)      # demographic data for a graph
library(ggforce)    # useful enhancements to ggplot
library(ggrepel)    # Text and labels
library(gssr)       # the gss packaged for r
library(patchwork)  # compose multiple plots
library(scales)     # scale adjustments and enhancements
library(socviz)     # data and some useful functions
```

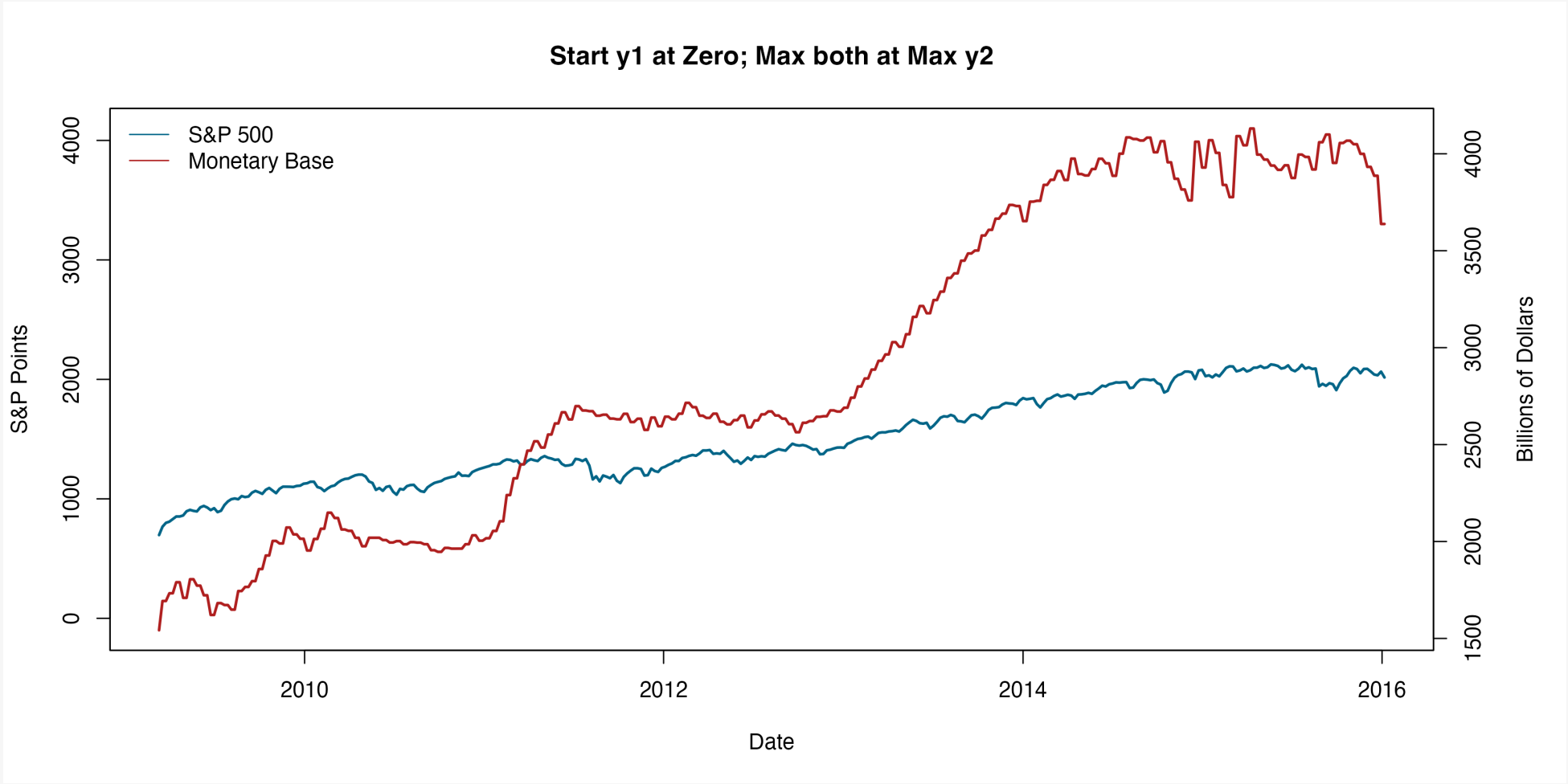
Two y-axes



Have we found the secret key to the stock market?



No. No we have not.


Start y1 at Zero; Max both at Max y2
S&P 500
Monetary Base
S&P Points
Billions of Dollars
0
1000
2000
3000
4000
1500
2000
2500
3000
3500
4000
2010
2012
2014
2016
Date

What to do instead?

```
fredts ← as_tibble(fredts)
fredts
```

```
# A tibble: 357 × 5
   date       sp500 monbase sp500_i monbase_i
   <date>     <dbl>   <int>   <dbl>     <dbl>
 1 2009-03-11  697. 1542228    100       100
 2 2009-03-18  767. 1693133    110.      110.
 3 2009-03-25  799. 1693133    115.      110.
 4 2009-04-01  809. 1733017    116.      112.
 5 2009-04-08  831. 1733017    119.      112.
 6 2009-04-15  852. 1789878    122.      116.
 7 2009-04-22  852. 1789878    122.      116.
 8 2009-04-29  861. 1709369    124.      111.
 9 2009-05-06  896. 1709369    129.      111.
10 2009-05-13  908. 1805373    130.      117.
# ℹ 347 more rows
```

Pivot the data

```
fredts
```

```
# A tibble: 357 × 5
   date       sp500 monbase sp500_i monbase_i
   <date>     <dbl>   <int>   <dbl>     <dbl>
 1 2009-03-11  697. 1542228    100       100
 2 2009-03-18  767. 1693133    110.      110.
 3 2009-03-25  799. 1693133    115.      110.
 4 2009-04-01  809. 1733017    116.      112.
 5 2009-04-08  831. 1733017    119.      112.
 6 2009-04-15  852. 1789878    122.      116.
 7 2009-04-22  852. 1789878    122.      116.
 8 2009-04-29  861. 1709369    124.      111.
 9 2009-05-06  896. 1709369    129.      111.
10 2009-05-13  908. 1805373    130.      117.
# ℹ 347 more rows
```

Pivot the data

```
fredts ▷
  select(date, sp500_i, monbase_i)
```

```
# A tibble: 357 × 3
   date       sp500_i monbase_i
   <date>       <dbl>     <dbl>
 1 2009-03-11    100        100
 2 2009-03-18    110.       110.
 3 2009-03-25    115.       110.
 4 2009-04-01    116.       112.
 5 2009-04-08    119.       112.
 6 2009-04-15    122.       116.
 7 2009-04-22    122.       116.
 8 2009-04-29    124.       111.
 9 2009-05-06    129.       111.
10 2009-05-13    130.       117.
# ℹ 347 more rows
```

Pivot the data

```
fredts ▷
  select(date, sp500_i, monbase_i)  ▷
  pivot_longer(sp500_i:monbase_i,
               names_to = "series",
               values_to = "score")
```

```
# A tibble: 714 × 3
   date       series    score
   <date>     <chr>     <dbl>
 1 2009-03-11 sp500_i    100
 2 2009-03-11 monbase_i  100
 3 2009-03-18 sp500_i    110.
 4 2009-03-18 monbase_i  110.
 5 2009-03-25 sp500_i    115.
 6 2009-03-25 monbase_i  110.
 7 2009-04-01 sp500_i    116.
 8 2009-04-01 monbase_i  112.
 9 2009-04-08 sp500_i    119.
10 2009-04-08 monbase_i  112.
# ℹ 704 more rows
```

Pivot the data

```
fredts ▷
  select(date, sp500_i, monbase_i)  ▷
  pivot_longer(sp500_i:monbase_i,
               names_to = "series",
               values_to = "score") →
  fredts_m
```

Pivot the data

```
fredts ▷
  select(date, sp500_i, monbase_i)  ▷
  pivot_longer(sp500_i:monbase_i,
               names_to = "series",
               values_to = "score") →
  fredts_m
```

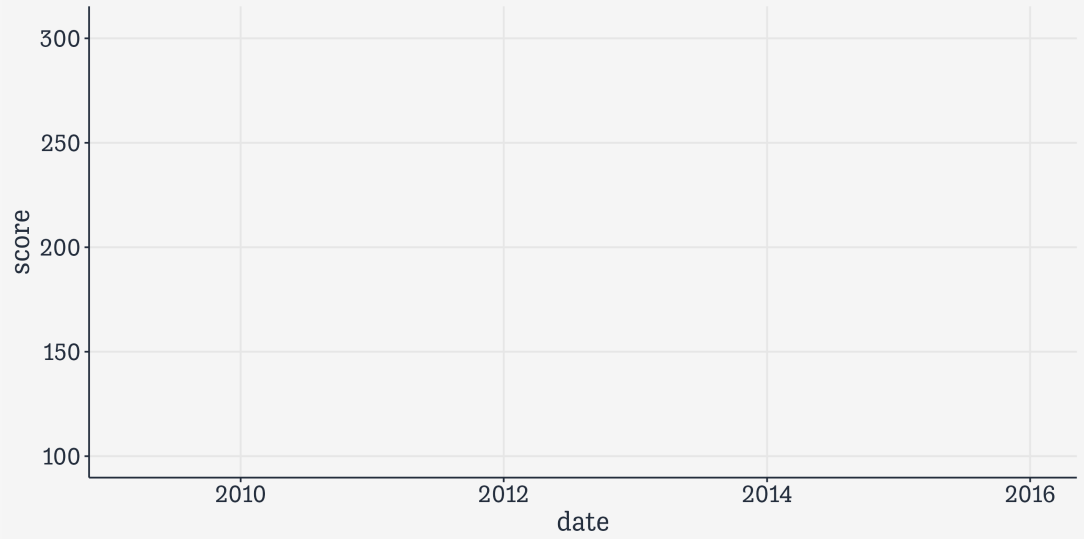
Make two plots

```
fredts_m
```

```
# A tibble: 714 × 3
   date       series    score
   <date>     <chr>     <dbl>
 1 2009-03-11 sp500_i    100
 2 2009-03-11 monbase_i  100
 3 2009-03-18 sp500_i    110.
 4 2009-03-18 monbase_i  110.
 5 2009-03-25 sp500_i    115.
 6 2009-03-25 monbase_i  110.
 7 2009-04-01 sp500_i    116.
 8 2009-04-01 monbase_i  112.
 9 2009-04-08 sp500_i    119.
10 2009-04-08 monbase_i  112.
# ℹ 704 more rows
```

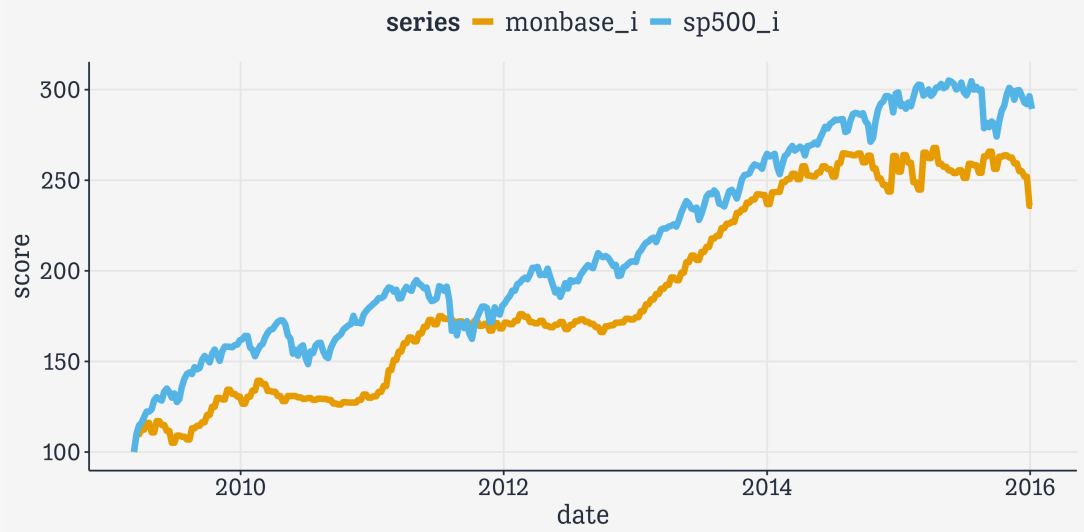
Make two plots

```
fredts_m ▷
  ggplot(mapping =
           aes(x = date,
               y = score,
               color = series))
```



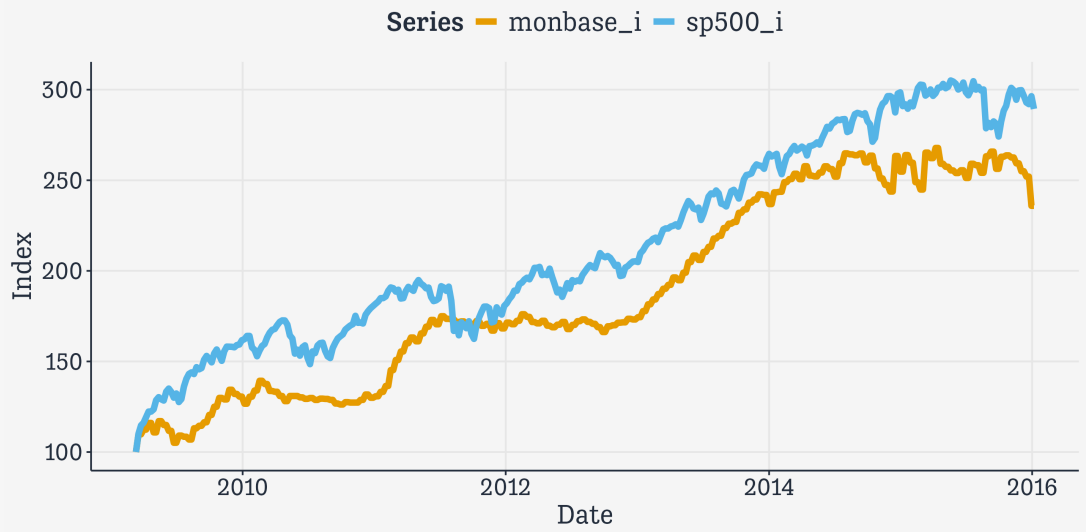
Make two plots

```
fredts_m ▷
  ggplot(mapping =
           aes(x = date,
               y = score,
               color = series)) +
  geom_line(linewidth = 2)
```



Make two plots

```
fredts_m ▷
  ggplot(mapping =
           aes(x = date,
               y = score,
               color = series)) +
  geom_line(linewidth = 2) +
  labs(x = "Date", y = "Index",
       color = "Series")
```



Make two plots

```
fredts_m ▷
  ggplot(mapping =
           aes(x = date,
               y = score,
               color = series)) +
  geom_line(linewidth = 2) +
  labs(x = "Date", y = "Index",
       color = "Series") →
  p1
```

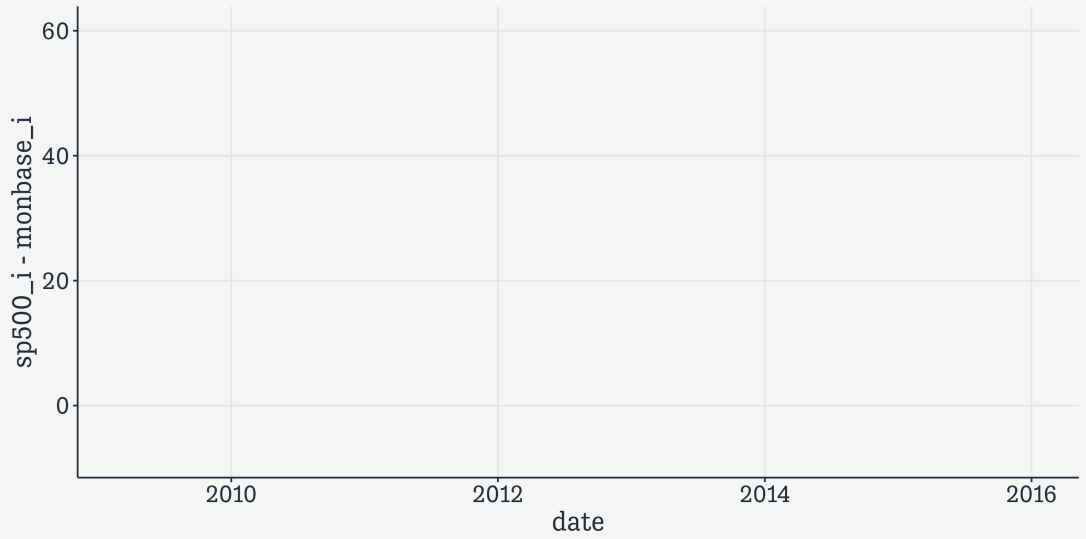
Make two plots

```
fredts_m ▷
  ggplot(mapping =
           aes(x = date,
               y = score,
               color = series)) +
  geom_line(linewidth = 2) +
  labs(x = "Date", y = "Index",
       color = "Series") →
  p1

# The original df
fredts
```

```
# A tibble: 357 × 5
   date       sp500 monbase sp500_i monbase_i
   <date>     <dbl>   <int>   <dbl>     <dbl>
 1 2009-03-11  697. 1542228    100        100
 2 2009-03-18  767. 1693133    110.       110.
 3 2009-03-25  799. 1693133    115.       110.
 4 2009-04-01  809. 1733017    116.       112.
 5 2009-04-08  831. 1733017    119.       112.
 6 2009-04-15  852. 1789878    122.       116.
 7 2009-04-22  852. 1789878    122.       116.
 8 2009-04-29  861. 1709369    124.       111.
 9 2009-05-06  896. 1709369    129.       111.
10 2009-05-13  908. 1805373    130.       117.
# ℹ 347 more rows
```

Make two plots

```
fredts_m ▷
  ggplot(mapping =
           aes(x = date,
               y = score,
               color = series)) +
  geom_line(linewidth = 2) +
  labs(x = "Date", y = "Index",
       color = "Series") →
  p1

# The original df
fredts ▷
  ggplot(mapping =
          aes(x = date,
              y = sp500_i - monbase_i))
```



Make two plots

```
fredts_m ▷
  ggplot(mapping =
           aes(x = date,
               y = score,
               color = series)) +
  geom_line(linewidth = 2) +
  labs(x = "Date", y = "Index",
       color = "Series") →
  p1

# The original df
fredts ▷
  ggplot(mapping =
           aes(x = date,
               y = sp500_i - monbase_i)) +
  geom_line(linewidth = 1.5)
```

Make two plots

```
fredts_m ▷
  ggplot(mapping =
           aes(x = date,
               y = score,
               color = series)) +
  geom_line(linewidth = 2) +
  labs(x = "Date", y = "Index",
       color = "Series") →
  p1

# The original df
fredts ▷
  ggplot(mapping =
           aes(x = date,
               y = sp500_i - monbase_i)) +
  geom_line(linewidth = 1.5) +
  labs(x = "Date", y = "Difference")
```

Make two plots

```
fredts_m ▷
  ggplot(mapping =
           aes(x = date,
               y = score,
               color = series)) +
  geom_line(linewidth = 2) +
  labs(x = "Date", y = "Index",
       color = "Series") →
  p1

# The original df
fredts ▷
  ggplot(mapping =
          aes(x = date,
              y = sp500_i - monbase_i)) +
  geom_line(linewidth = 1.5) +
  labs(x = "Date", y = "Difference") →
  p2
```

Make two plots

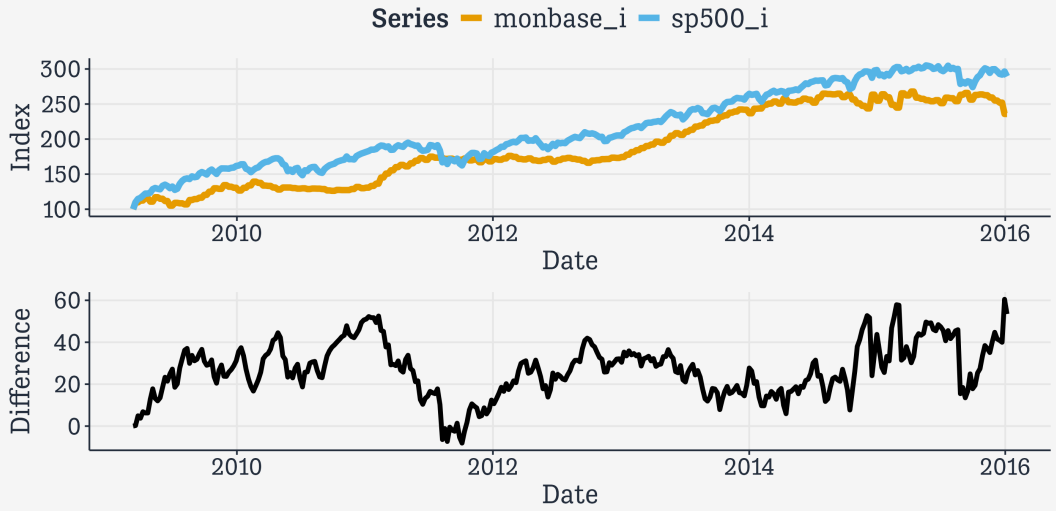
```
fredts_m ▷
  ggplot(mapping =
           aes(x = date,
               y = score,
               color = series)) +
  geom_line(linewidth = 2) +
  labs(x = "Date", y = "Index",
       color = "Series") →
  p1

# The original df
fredts ▷
  ggplot(mapping =
          aes(x = date,
              y = sp500_i - monbase_i)) +
  geom_line(linewidth = 1.5) +
  labs(x = "Date", y = "Difference") →
  p2
```

Combine with patchwork

```
library(patchwork)
```

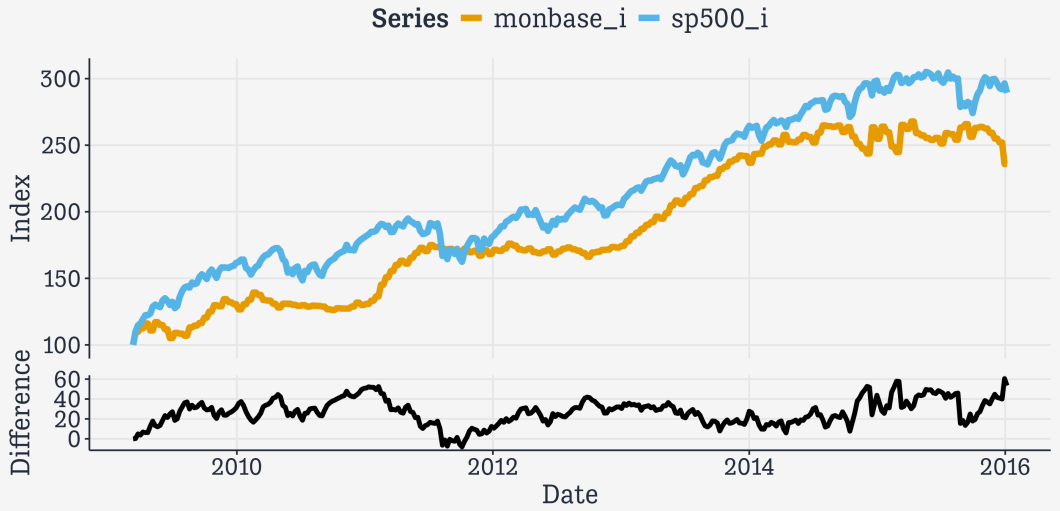
Combine with patchwork

```
library(patchwork)

(p1 / p2)
```



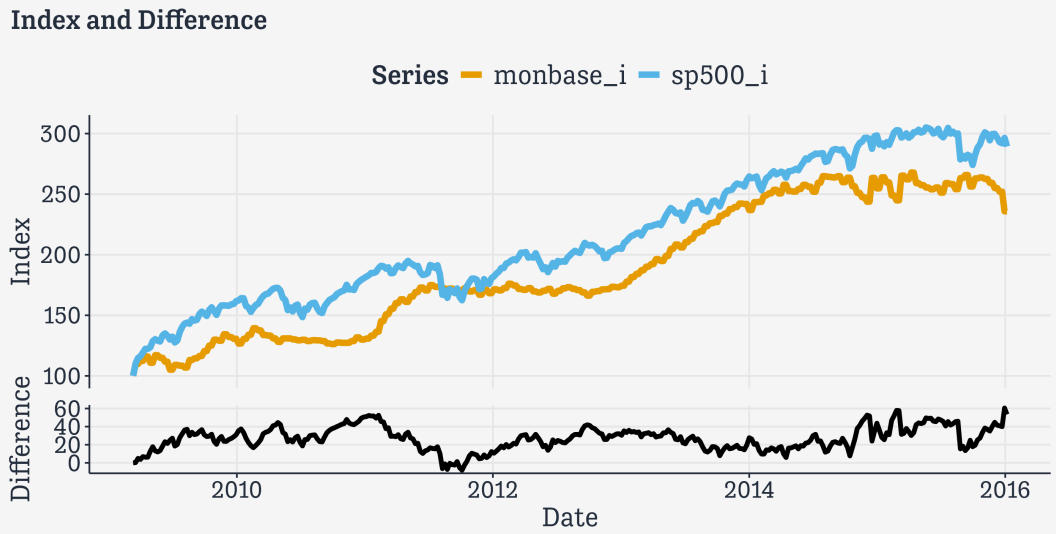
Combine with patchwork

```
library(patchwork)

(p1 / p2) +
  plot_layout(heights = c(4, 1), axes = "collect")
```



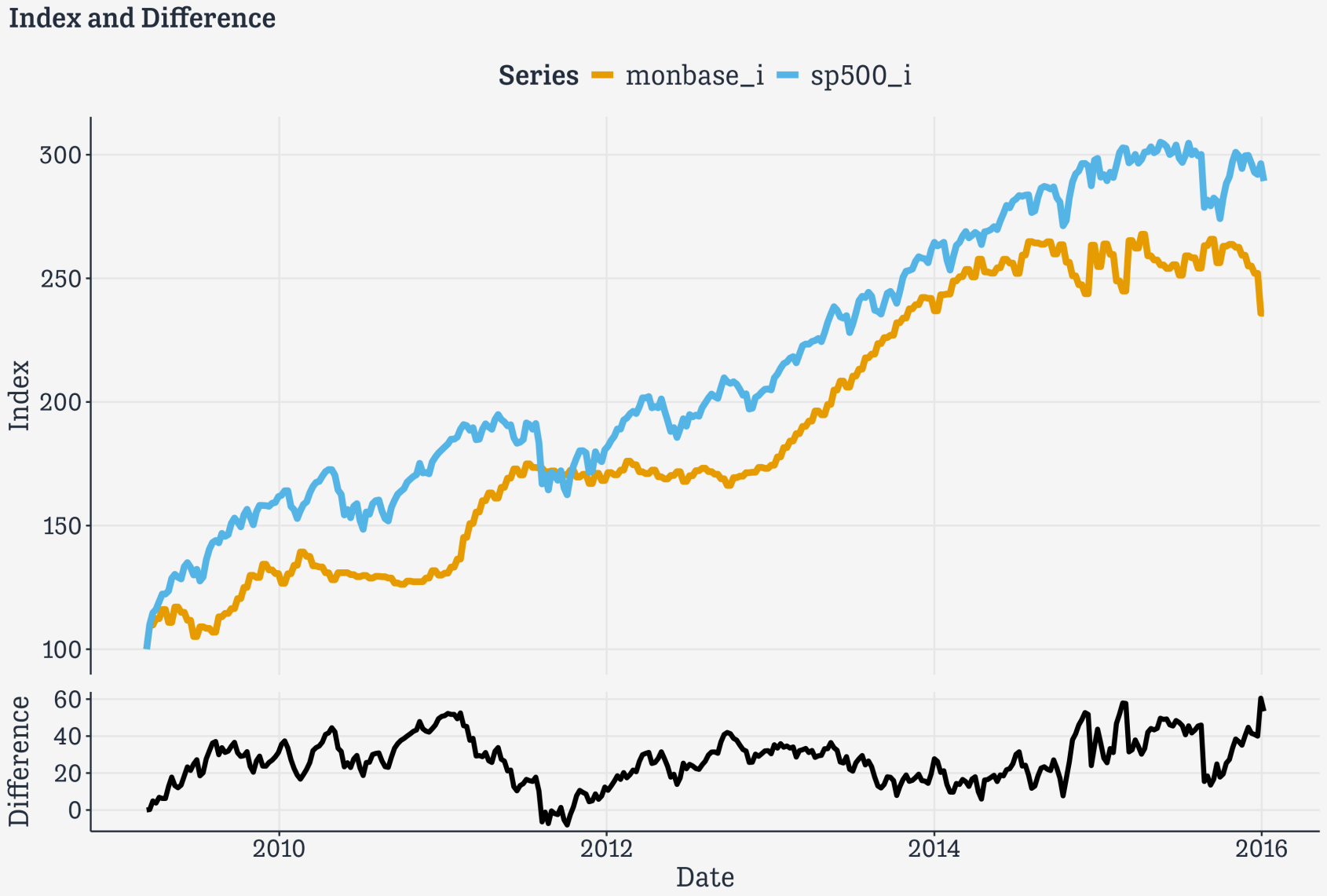
Combine with patchwork

```
library(patchwork)

(p1 / p2) +
  plot_layout(heights = c(4, 1), axes = "collect") +
  plot_annotation(title = "Index and Difference")
```



Combine with patchwork

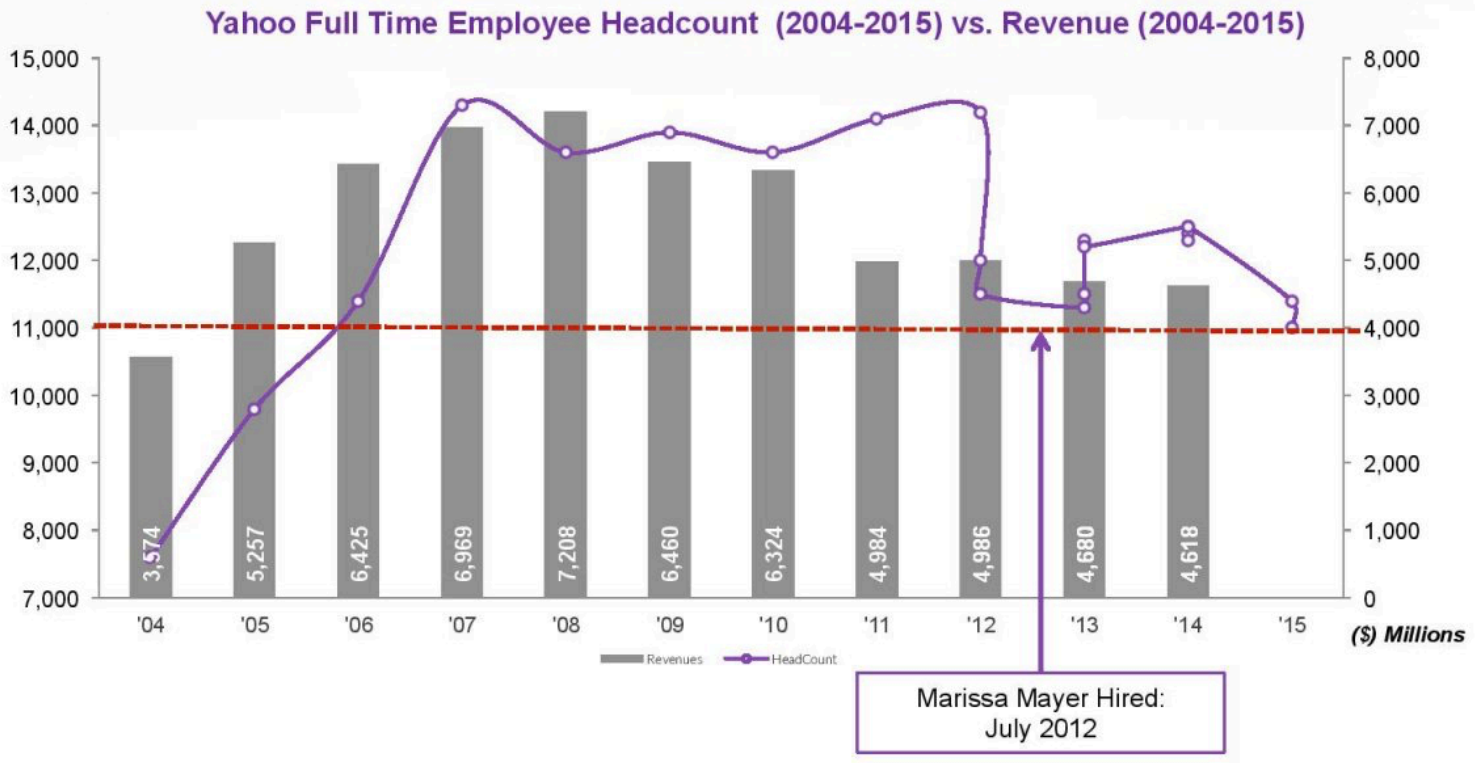
```
library(patchwork)

(p1 / p2) +
  plot_layout(heights = c(4, 1), axes = "collect") +
  plot_annotation(title = "Index and Difference") →
  p_patch
```



Patchwork plot.

Redrawing a bad slide

Yahoo's Headcount Still Excessively High Given Revenues:



Source: Company Filings (10K), Analyst calls

What can one say, really

The data

yahoo

```
# A tibble: 12 × 4
    Year Revenue Employees Mayer
   <dbl>   <dbl>     <dbl> <chr>
 1  2004    3574      7600 No
 2  2005    5257      9800 No
 3  2006    6425     11400 No
 4  2007    6969     14300 No
 5  2008    7208     13600 No
 6  2009    6460     13900 No
 7  2010    6324     13600 No
 8  2011    4984     14100 No
 9  2012    4986     12000 No
10  2012    4986     11500 Yes
11  2013    4680     12200 Yes
12  2014    4618     12500 Yes
```

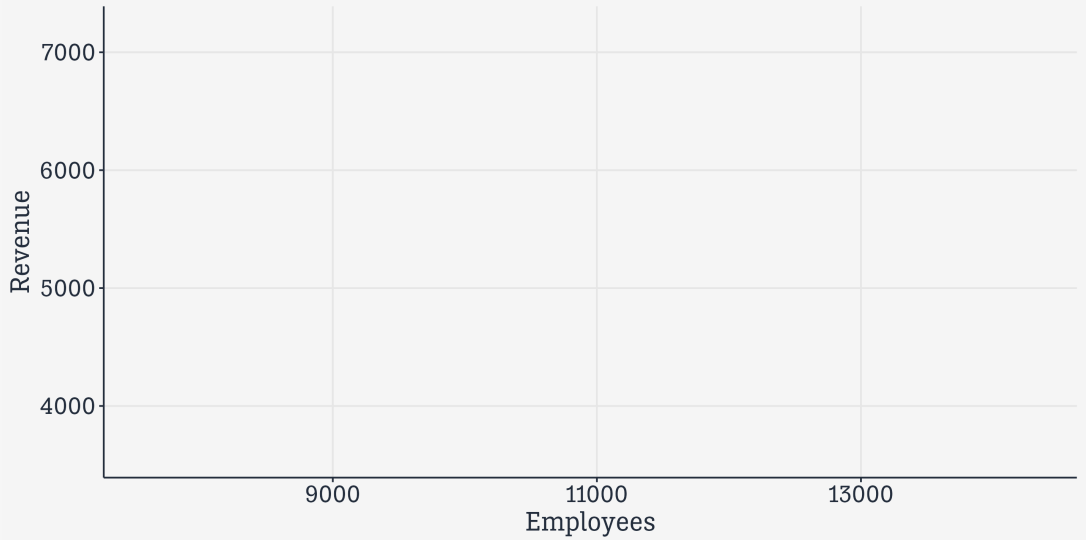
Option 1

```
yahoo
```

```
# A tibble: 12 × 4
    Year Revenue Employees Mayer
   <dbl>   <dbl>     <dbl> <chr>
 1  2004    3574      7600 No
 2  2005    5257      9800 No
 3  2006    6425     11400 No
 4  2007    6969     14300 No
 5  2008    7208     13600 No
 6  2009    6460     13900 No
 7  2010    6324     13600 No
 8  2011    4984     14100 No
 9  2012    4986     12000 No
10  2012    4986     11500 Yes
11  2013    4680     12200 Yes
12  2014    4618     12500 Yes
```

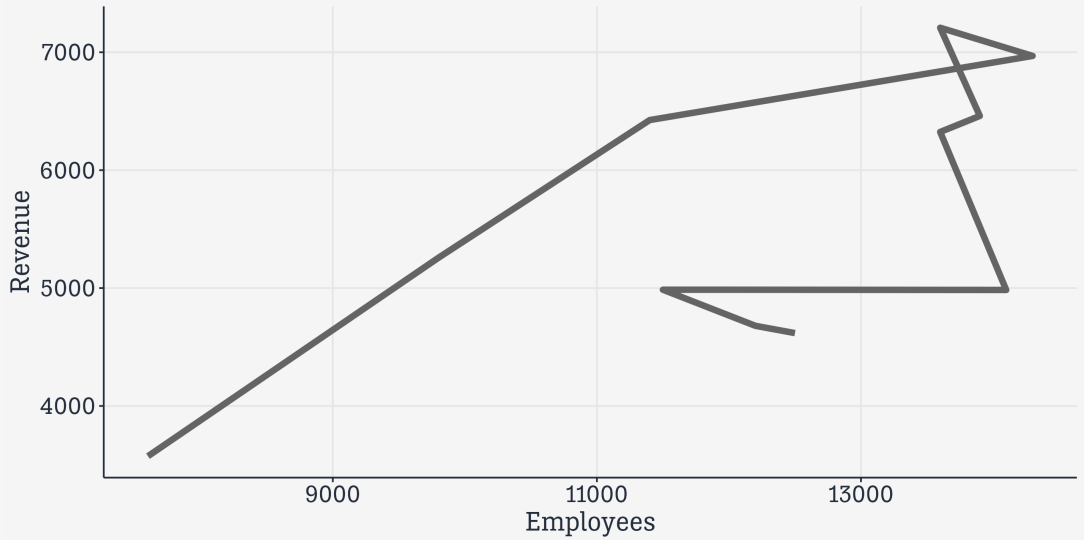
Option 1

```
yahoo ▷
  ggplot(mapping =
           aes(x = Employees,
               y = Revenue))
```



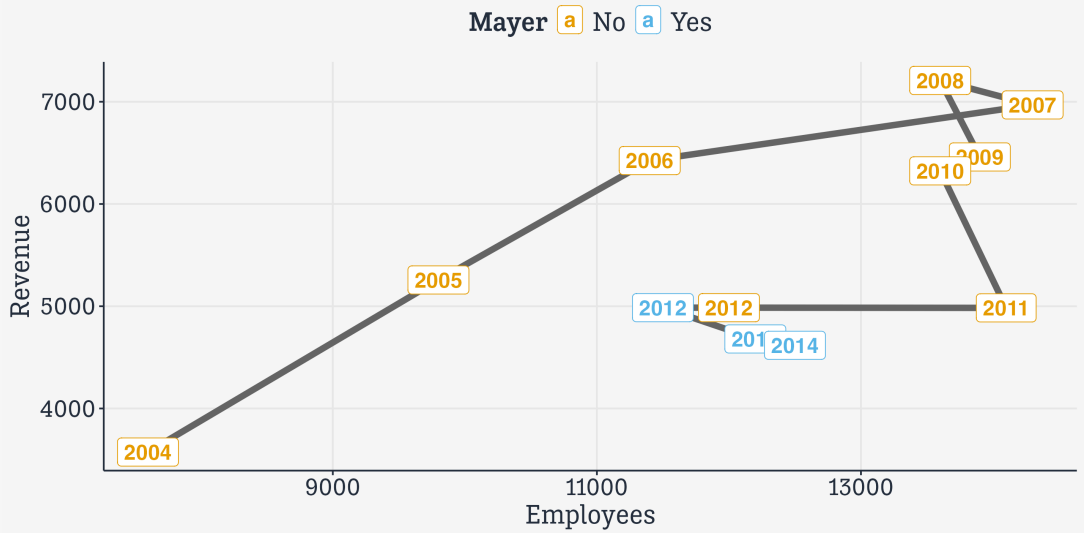
Option 1

```
yahoo ▷
  ggplot(mapping =
           aes(x = Employees,
               y = Revenue)) +
  geom_path(color = "gray40",
            linewidth = rel(2))
```



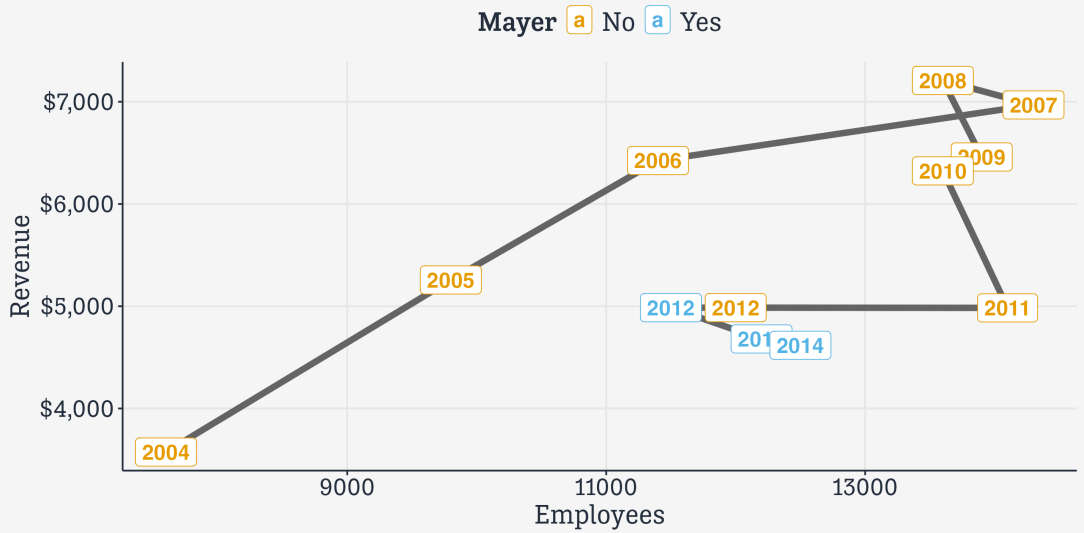
Option 1

```
yahoo ▷
  ggplot(mapping =
           aes(x = Employees,
               y = Revenue)) +
  geom_path(color = "gray40",
            linewidth = rel(2)) +
  geom_label(aes(color = Mayer,
                 label = Year),
             size = rel(5),
             fontface = "bold")
```



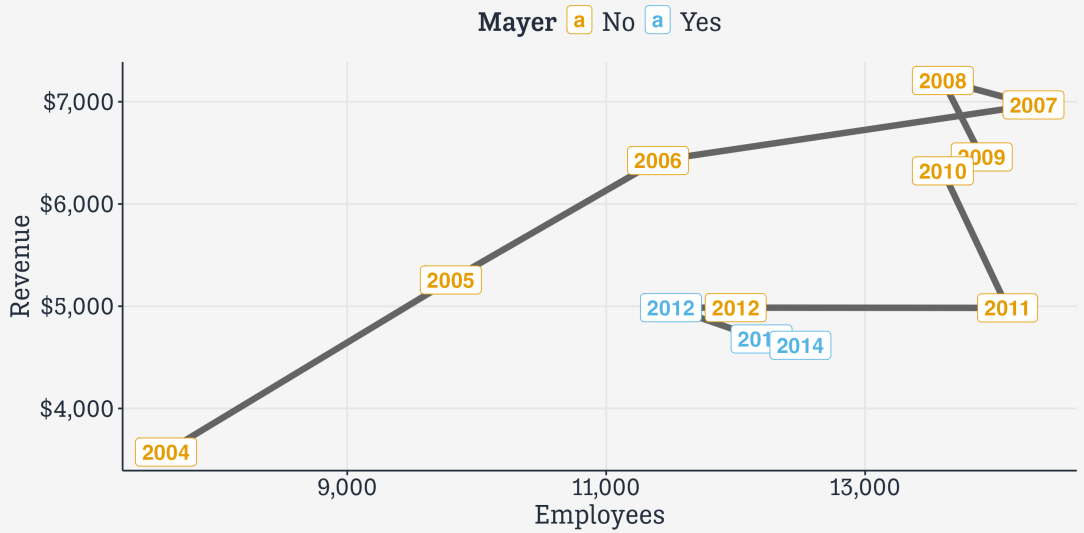
Option 1

```
yahoo ▷
  ggplot(mapping =
           aes(x = Employees,
               y = Revenue)) +
  geom_path(color = "gray40",
            linewidth = rel(2)) +
  geom_label(aes(color = Mayer,
                 label = Year),
             size = rel(5),
             fontface = "bold") +
  scale_y_continuous(labels = label_dollar())
```



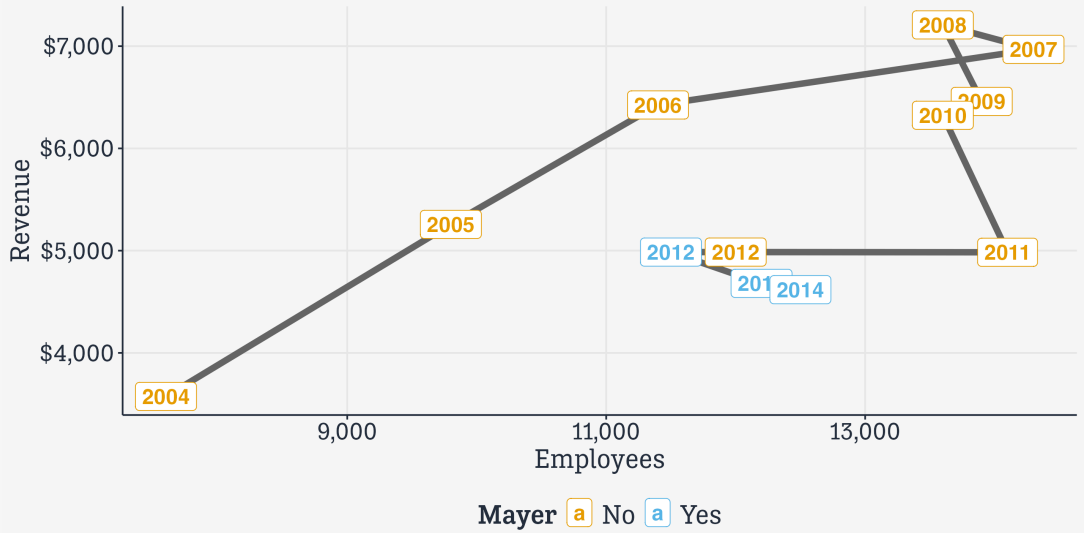
Option 1

```
yahoo ▷
  ggplot(mapping =
           aes(x = Employees,
               y = Revenue)) +
  geom_path(color = "gray40",
            linewidth = rel(2)) +
  geom_label(aes(color = Mayer,
                 label = Year),
             size = rel(5),
             fontface = "bold") +
  scale_y_continuous(labels = label_dollar()) +
  scale_x_continuous(labels = label_comma())
```



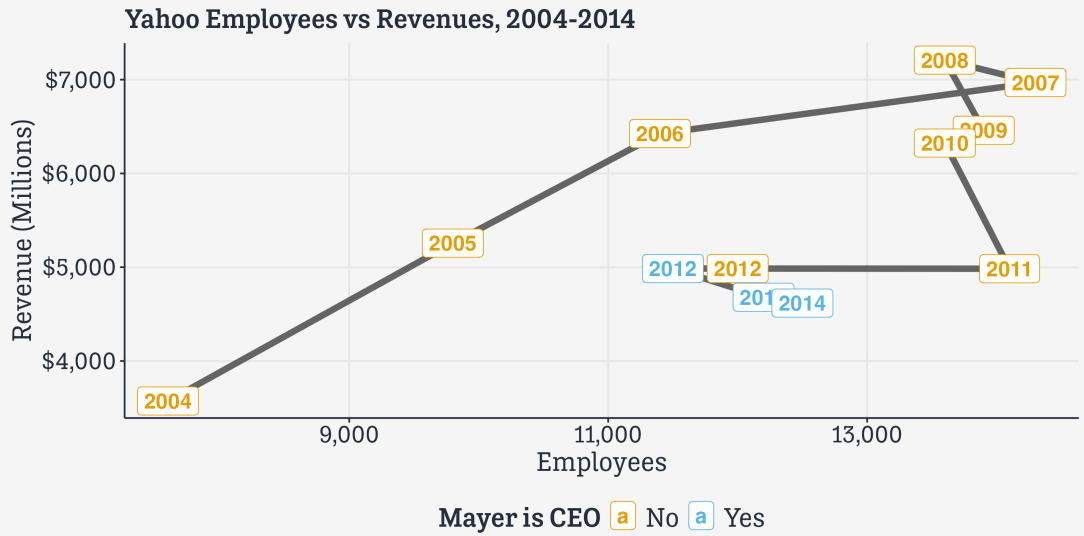
Option 1

```
yahoo ▷
  ggplot(mapping =
           aes(x = Employees,
               y = Revenue)) +
  geom_path(color = "gray40",
            linewidth = rel(2)) +
  geom_label(aes(color = Mayer,
                 label = Year),
             size = rel(5),
             fontface = "bold") +
  scale_y_continuous(labels = label_dollar()) +
  scale_x_continuous(labels = label_comma()) +
  theme(legend.position = "bottom")
```



Option 1

```
yahoo ▷
  ggplot(mapping =
           aes(x = Employees,
               y = Revenue)) +
  geom_path(color = "gray40",
            linewidth = rel(2)) +
  geom_label(aes(color = Mayer,
                 label = Year),
             size = rel(5),
             fontface = "bold") +
  scale_y_continuous(labels = label_dollar()) +
  scale_x_continuous(labels = label_comma()) +
  theme(legend.position = "bottom") +
  labs(color = "Mayer is CEO",
       x = "Employees", y = "Revenue (Millions)",
       title = "Yahoo Employees vs Revenues, 2004-2014")
```

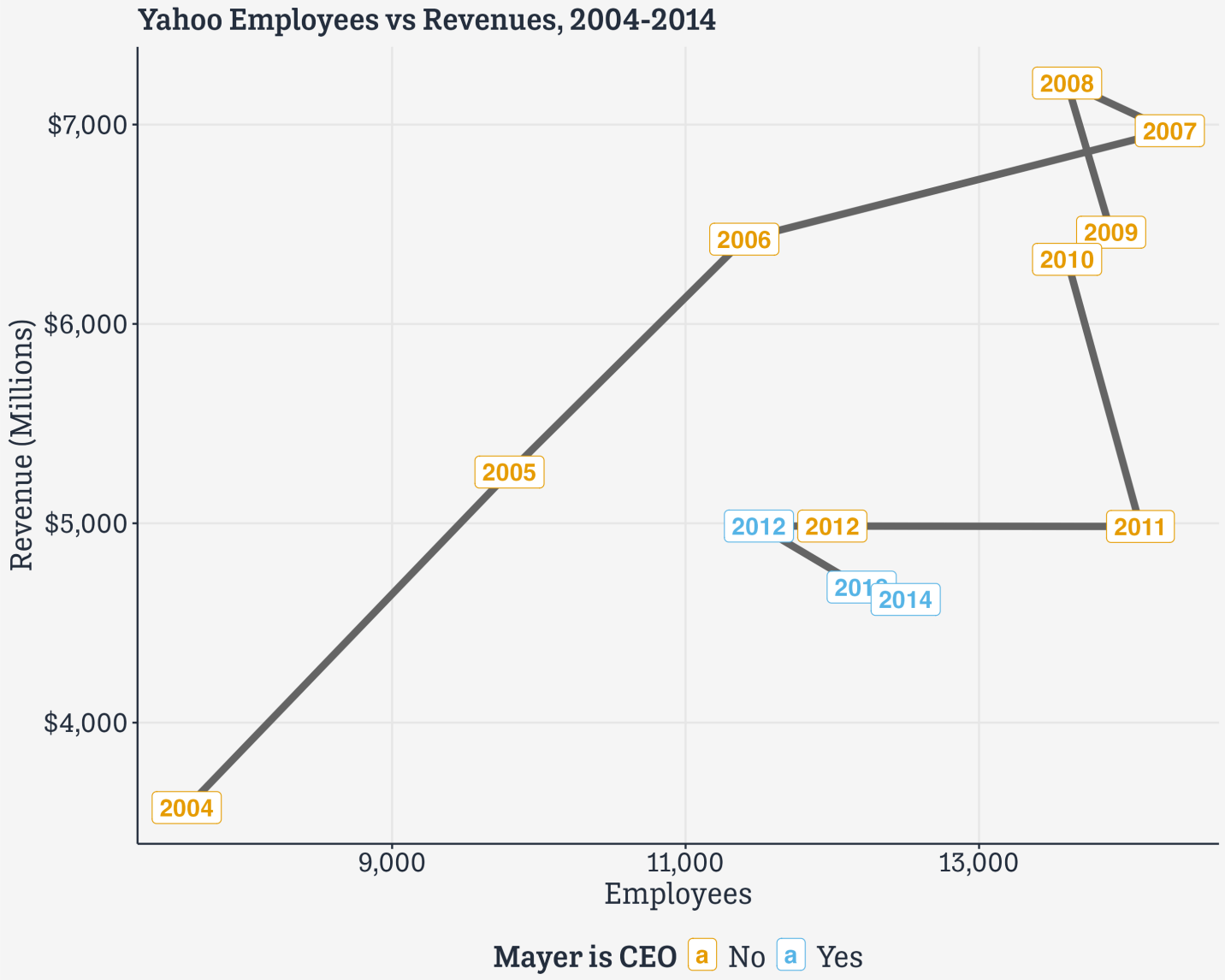


Option 1

```
yahoo ▷
  ggplot(mapping =
           aes(x = Employees,
               y = Revenue)) +
  geom_path(color = "gray40",
            linewidth = rel(2)) +
  geom_label(aes(color = Mayer,
                 label = Year),
             size = rel(5),
             fontface = "bold") +
  scale_y_continuous(labels = label_dollar()) +
  scale_x_continuous(labels = label_comma()) +
  theme(legend.position = "bottom") +
  labs(color = "Mayer is CEO",
       x = "Employees", y = "Revenue (Millions)",
       title = "Yahoo Employees vs Revenues, 2004-2014")
  yahoo1
```

Option 1

```
yahoo ▷
  ggplot(mapping =
           aes(x = Employees,
               y = Revenue)) +
  geom_path(color = "gray40",
            linewidth = rel(2)) +
  geom_label(aes(color = Mayer,
                 label = Year),
             size = rel(5),
             fontface = "bold") +
  scale_y_continuous(labels = label_dollar()) +
  scale_x_continuous(labels = label_comma()) +
  theme(legend.position = "bottom") +
  labs(color = "Mayer is CEO",
       x = "Employees", y = "Revenue (Millions)",
       title = "Yahoo Employees vs Revenues, 2004-2014")
  yahoo1
```



Redrawn with `geom_path()`

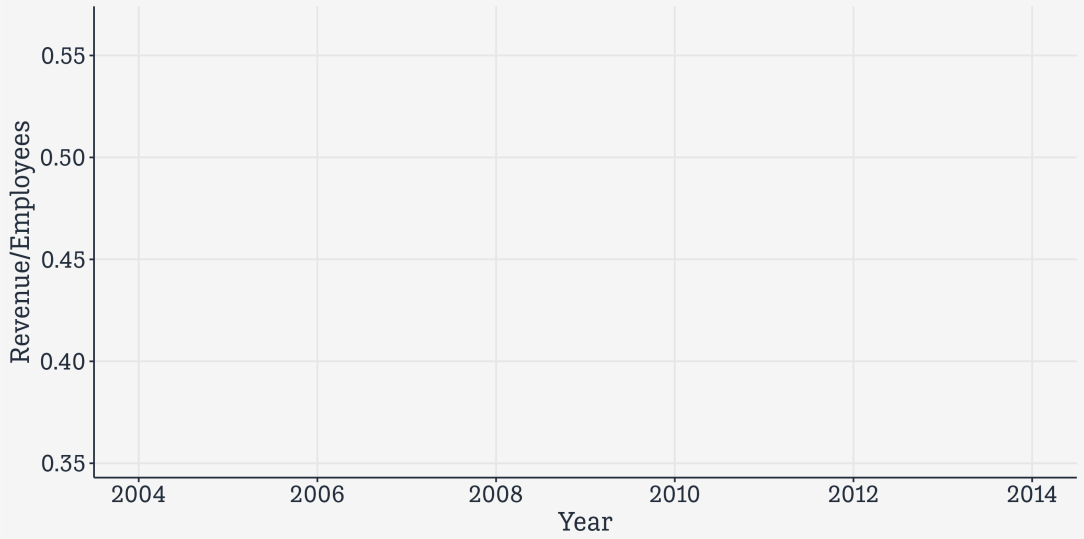
Alternatively ...

```
yahoo
```

```
# A tibble: 12 × 4
    Year Revenue Employees Mayer
   <dbl>   <dbl>     <dbl> <chr>
 1  2004    3574      7600 No
 2  2005    5257      9800 No
 3  2006    6425     11400 No
 4  2007    6969     14300 No
 5  2008    7208     13600 No
 6  2009    6460     13900 No
 7  2010    6324     13600 No
 8  2011    4984     14100 No
 9  2012    4986     12000 No
10  2012    4986     11500 Yes
11  2013    4680     12200 Yes
12  2014    4618     12500 Yes
```

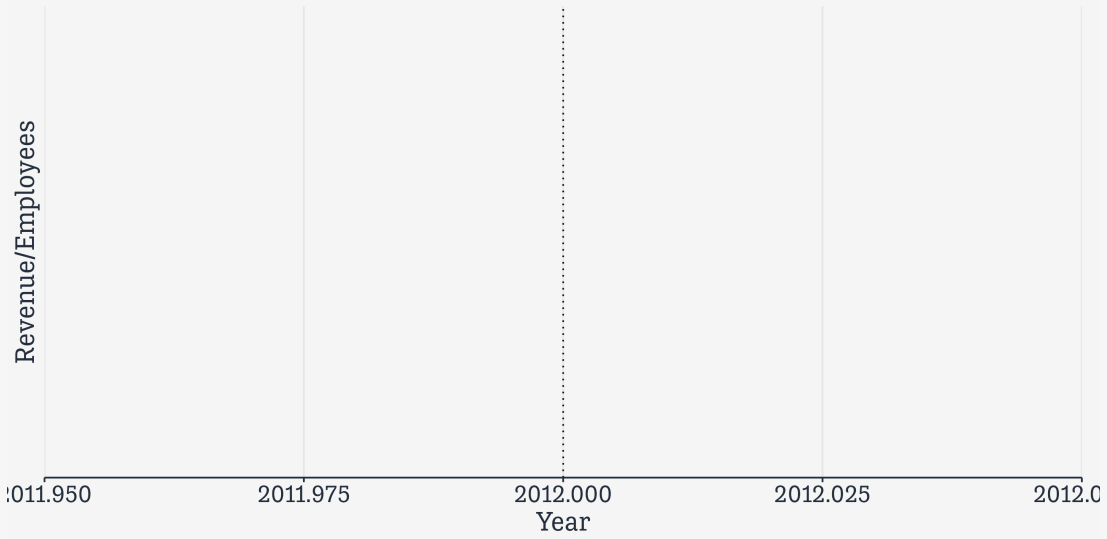
Alternatively ...

```
yahoo ▷
  ggplot(mapping =
           aes(x = Year,
               y = Revenue/Employees))
```



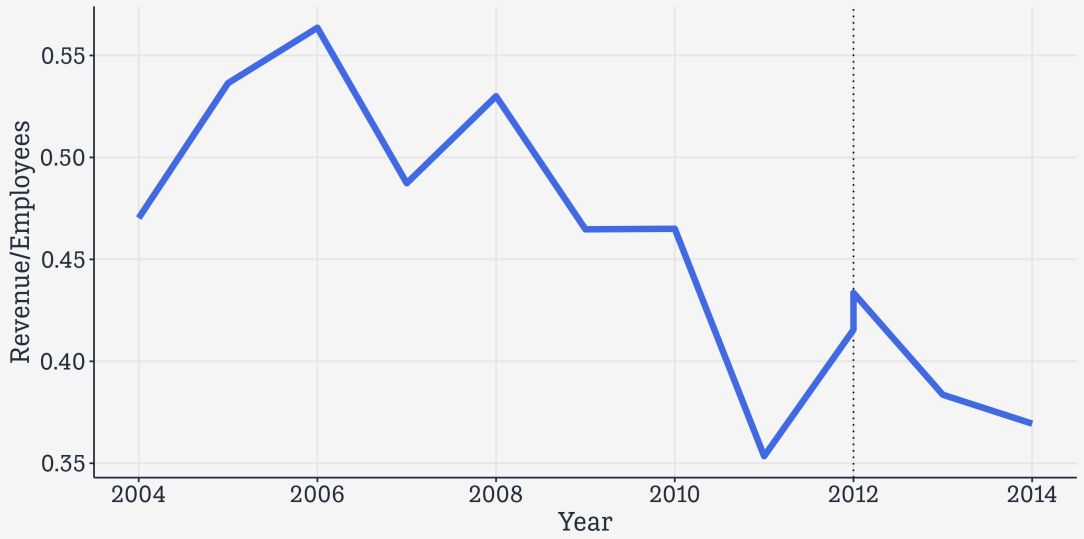
Alternatively ...

```
yahoo ▷
  ggplot(mapping =
           aes(x = Year,
               y = Revenue/Employees)) +
  geom_vline(xintercept = 2012,
             linewidth = rel(0.5),
             linetype = "dotted")
```



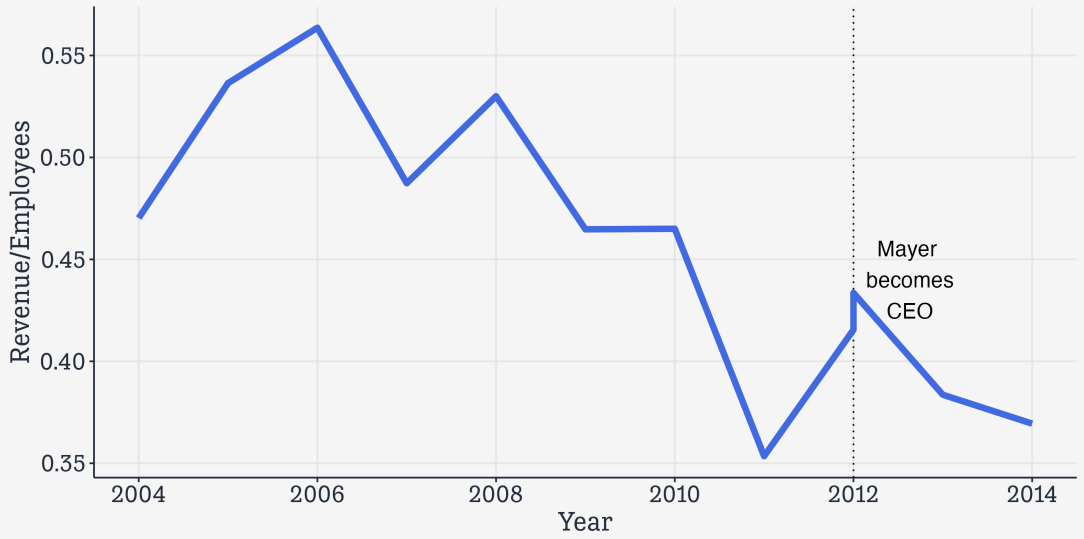
Alternatively ...

```
yahoo ▷
  ggplot(mapping =
           aes(x = Year,
               y = Revenue/Employees)) +
  geom_vline(xintercept = 2012,
             linewidth = rel(0.5),
             linetype = "dotted") +
  geom_line(color = "royalblue", linewidth = rel(2))
```



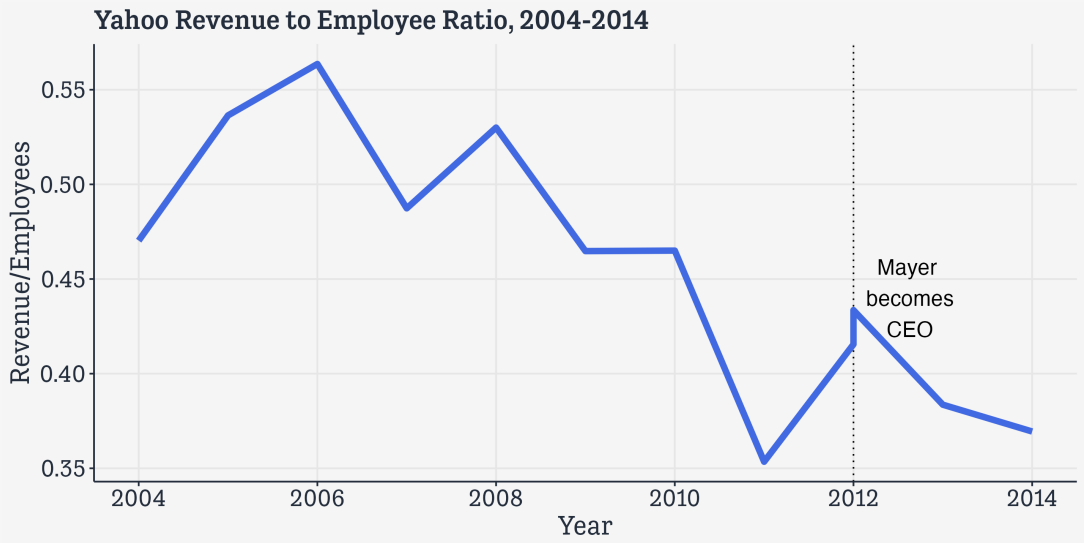
Alternatively ...

```
yahoo ▷
  ggplot(mapping =
           aes(x = Year,
               y = Revenue/Employees)) +
  geom_vline(xintercept = 2012,
             linewidth = rel(0.5),
             linetype = "dotted") +
  geom_line(color = "royalblue", linewidth = rel(2)) +
  annotate("text", x = 2012.6, y = 0.44,
           label = "Mayer\n becomes\n CEO", size = rel(5)
```



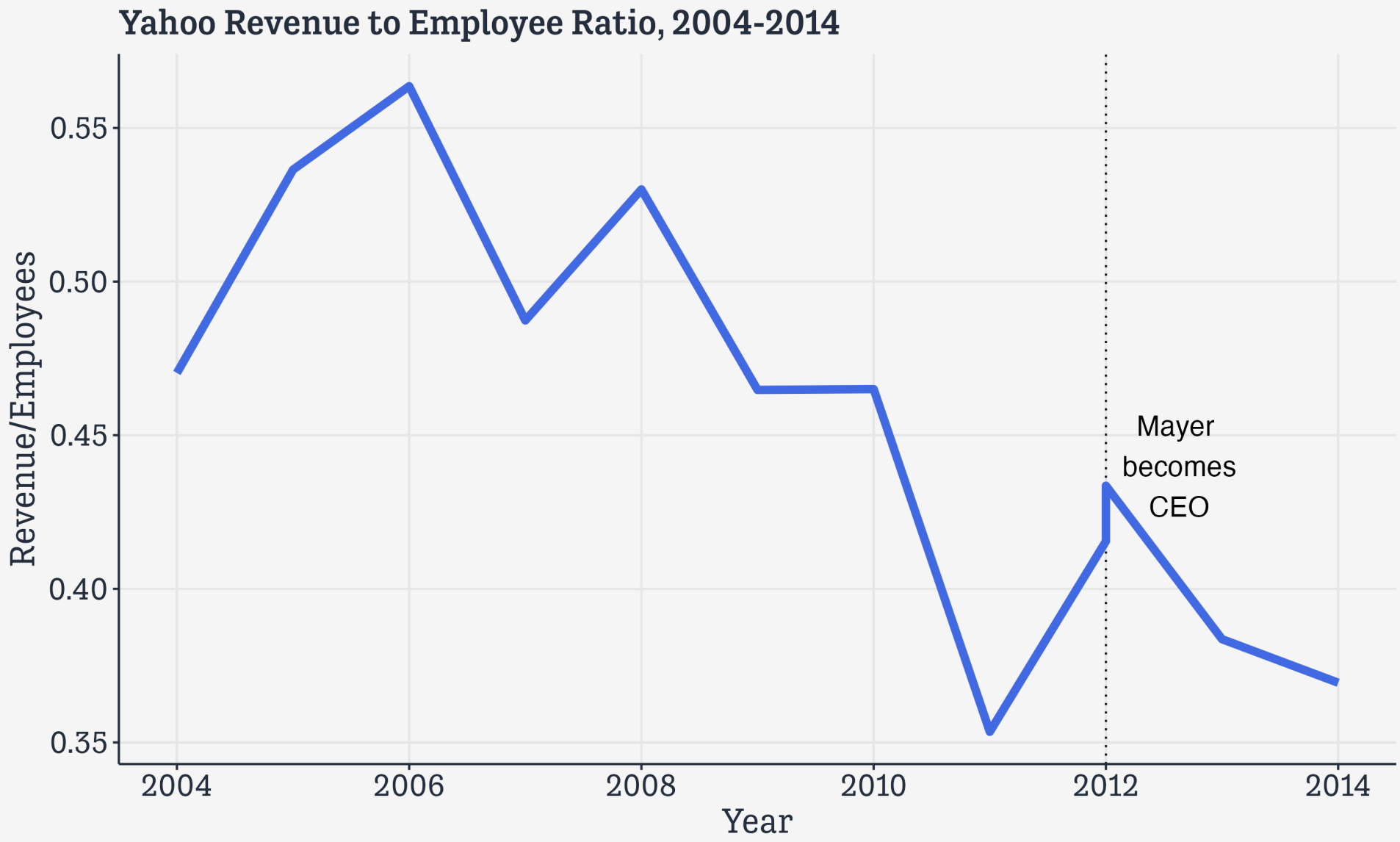
Alternatively ...

```
yahoo ▷
  ggplot(mapping =
           aes(x = Year,
               y = Revenue/Employees)) +
  geom_vline(xintercept = 2012,
             linewidth = rel(0.5),
             linetype = "dotted") +
  geom_line(color = "royalblue", linewidth = rel(2)) +
  annotate("text", x = 2012.6, y = 0.44,
           label = "Mayer\n becomes\n CEO", size = rel(5)
  labs(title = "Yahoo Revenue to Employee Ratio, 2004-201
       x = "Year",
       y = "Revenue/Employees")
```



Alternatively ...

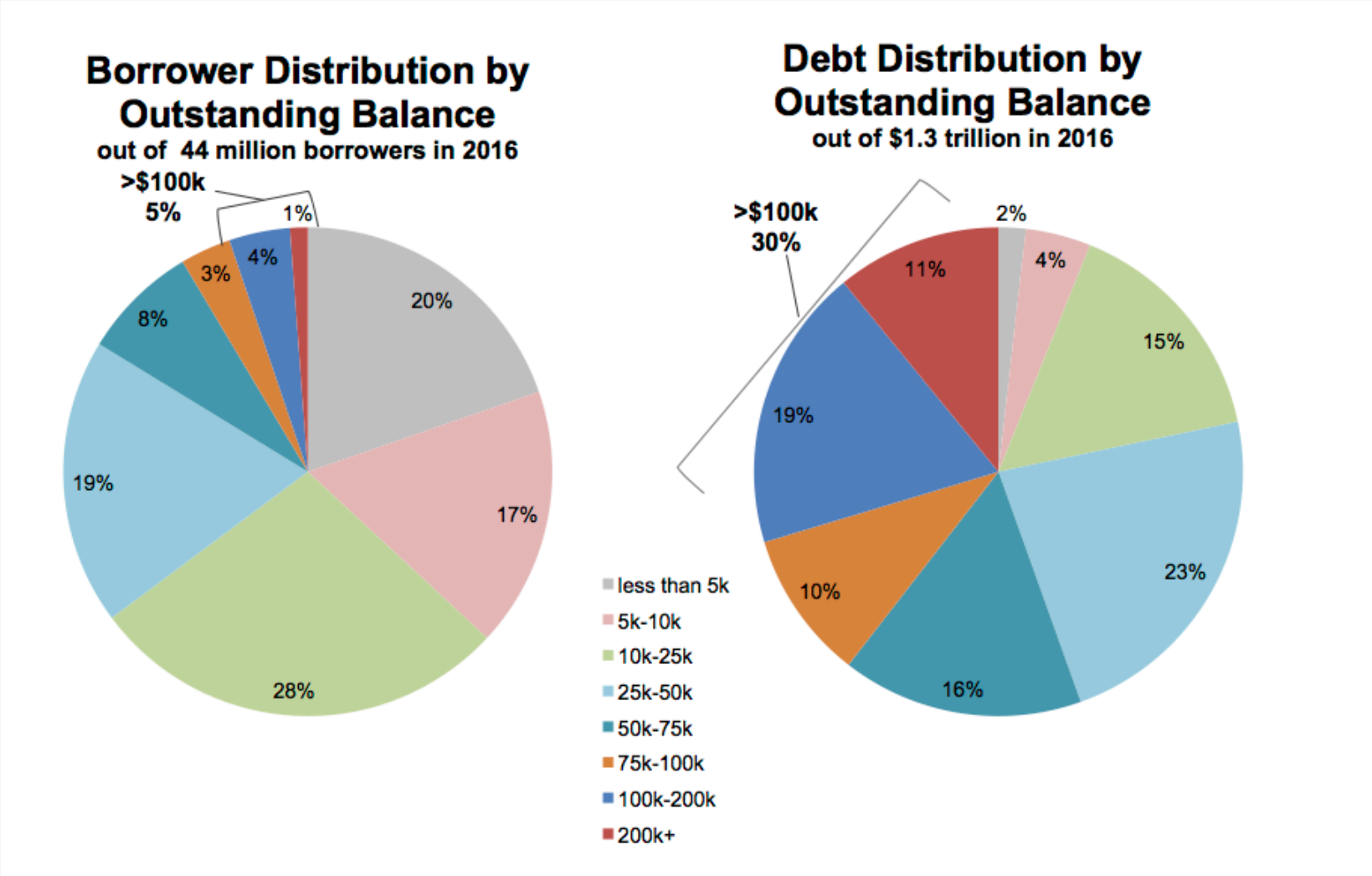
```
yahoo ▷
  ggplot(mapping =
           aes(x = Year,
               y = Revenue/Employees)) +
  geom_vline(xintercept = 2012,
             linewidth = rel(0.5),
             linetype = "dotted") +
  geom_line(color = "royalblue", linewidth = rel(2)) +
  annotate("text", x = 2012.6, y = 0.44,
           label = "Mayer\n becomes\n CEO", size = rel(5)
  labs(title = "Yahoo Revenue to Employee Ratio, 2004-201
       x = "Year",
       y = "Revenue/Employees") ⟶
  yahoo2
```



If you're interested in the ratio, just show the ratio.

Say no to pie

Pie charts are easy to mess up



Federal Reserve Bank of New York.

The data

```
studebt
```

```
# A tibble: 16 × 4
   Debt      type        pct Debtrc
   <ord>     <fct>     <int> <ord>
 1 Under $5  Borrowers    20 Under $5
 2 $5-$10    Borrowers    17 $5-$10
 3 $10-$25   Borrowers    28 $10-$25
 4 $25-$50   Borrowers    19 $25-$50
 5 $50-$75   Borrowers     8 $50-$75
 6 $75-$100  Borrowers     3 $75-$100
 7 $100-$200 Borrowers     4 $100-$200
 8 Over $200 Borrowers     1 Over $200
 9 Under $5  Balances      2 Under $5
10 $5-$10    Balances      4 $5-$10
11 $10-$25   Balances     15 $10-$25
12 $25-$50   Balances     23 $25-$50
13 $50-$75   Balances     16 $50-$75
14 $75-$100  Balances     10 $75-$100
15 $100-$200 Balances     19 $100-$200
16 Over $200 Balances     11 Over $200
```

`Debt` and `Debtrc` are both ordered factors.

A little prep work

```
p_ylab ← "Amount Owed, in thousands of Dollars"
p_title ← "Outstanding Student Loans"
p_subtitle ← "44 million borrowers owe a total of $1.3 trillion"
p_caption ← "Source: FRB NY"

studebt ← studebt ▷
  mutate(type_label = recode(type, "Borrowers" = "Percent of all Borrowers",
                           "Balances" = "Percent of all Balances"))

studebt
```

```
# A tibble: 16 × 5
   Debt      type        pct Debtrc    type_label
   <ord>     <fct>     <int> <ord>     <fct>
 1 Under $5  Borrowers    20 Under $5  Percent of all Borrowers
 2 $5-$10    Borrowers    17 $5-$10    Percent of all Borrowers
 3 $10-$25   Borrowers    28 $10-$25   Percent of all Borrowers
 4 $25-$50   Borrowers    19 $25-$50   Percent of all Borrowers
 5 $50-$75   Borrowers     8 $50-$75   Percent of all Borrowers
 6 $75-$100  Borrowers     3 $75-$100  Percent of all Borrowers
 7 $100-$200 Borrowers     4 $100-$200 Percent of all Borrowers
 8 Over $200 Borrowers     1 Over $200 Percent of all Borrowers
 9 Under $5  Balances      2 Under $5  Percent of all Balances
10 $5-$10    Balances      4 $5-$10    Percent of all Balances
11 $10-$25   Balances     15 $10-$25   Percent of all Balances
12 $25-$50   Balances     23 $25-$50   Percent of all Balances
13 $50-$75   Balances     16 $50-$75   Percent of all Balances
14 $75-$100  Balances     10 $75-$100  Percent of all Balances
15 $100-$200 Balances     19 $100-$200 Percent of all Balances
16 Over $200 Balances     11 Over $200 Percent of all Balances
```

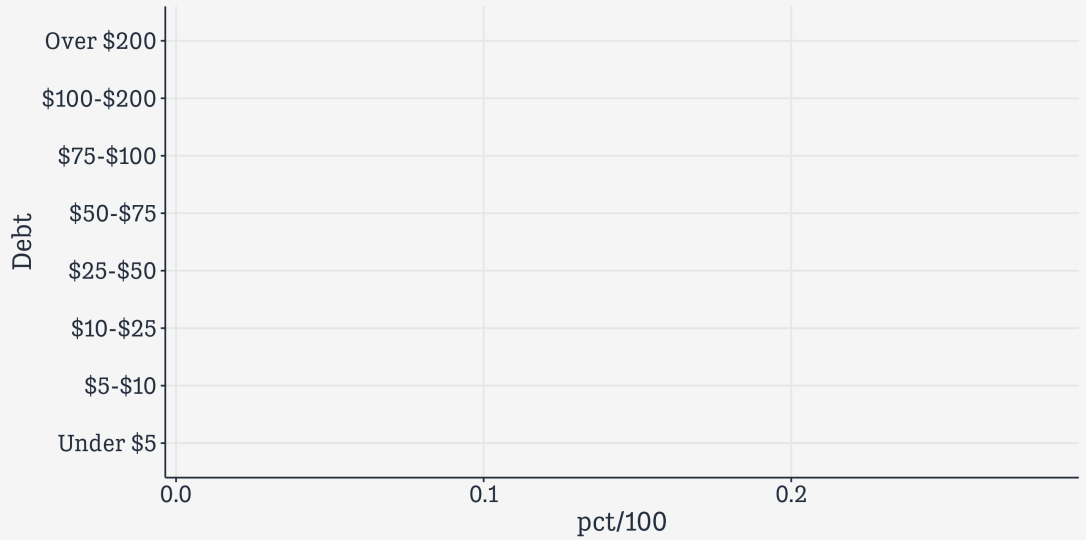
Debt Plot 1

```
studebt
```

```
# A tibble: 16 × 5
   Debt      type        pct Debtrc    type_label
   <ord>     <fct>     <int> <ord>     <fct>
 1 Under $5  Borrowers    20 Under $5  Percent of all Borrowers
 2 $5-$10    Borrowers    17 $5-$10    Percent of all Borrowers
 3 $10-$25   Borrowers    28 $10-$25   Percent of all Borrowers
 4 $25-$50   Borrowers    19 $25-$50   Percent of all Borrowers
 5 $50-$75   Borrowers     8 $50-$75   Percent of all Borrowers
 6 $75-$100  Borrowers     3 $75-$100  Percent of all Borrowers
 7 $100-$200 Borrowers     4 $100-$200 Percent of all Borrowers
 8 Over $200 Borrowers     1 Over $200 Percent of all Borrowers
 9 Under $5  Balances      2 Under $5  Percent of all Balances
10 $5-$10    Balances      4 $5-$10    Percent of all Balances
11 $10-$25   Balances     15 $10-$25   Percent of all Balances
12 $25-$50   Balances     23 $25-$50   Percent of all Balances
13 $50-$75   Balances     16 $50-$75   Percent of all Balances
14 $75-$100  Balances     10 $75-$100  Percent of all Balances
15 $100-$200 Balances     19 $100-$200 Percent of all Balances
16 Over $200 Balances     11 Over $200 Percent of all Balances
```

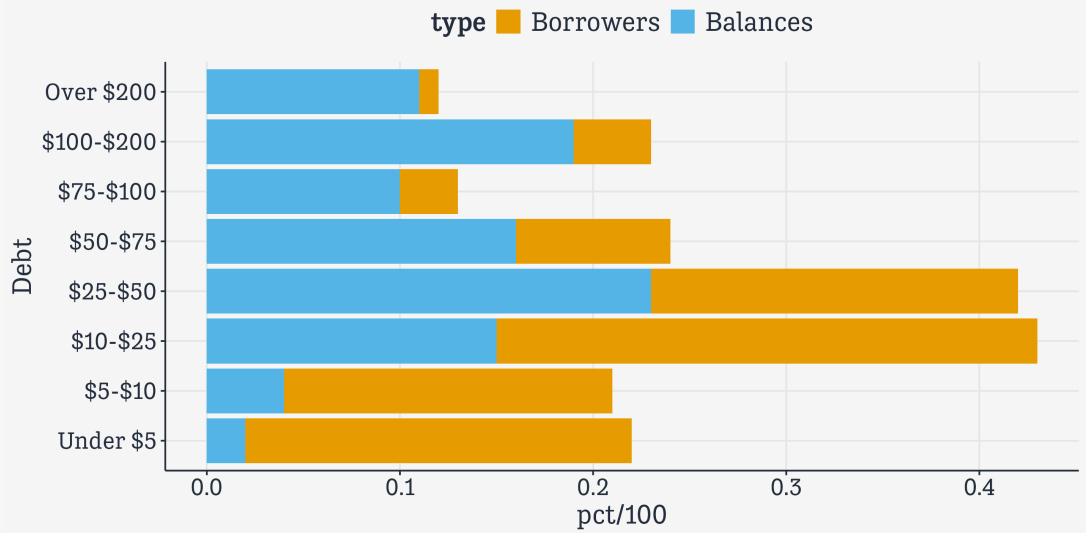
Debt Plot 1

```
studebt ▷
  ggplot(mapping =
           aes(x = pct/100,
               y = Debt,
               fill = type))
```



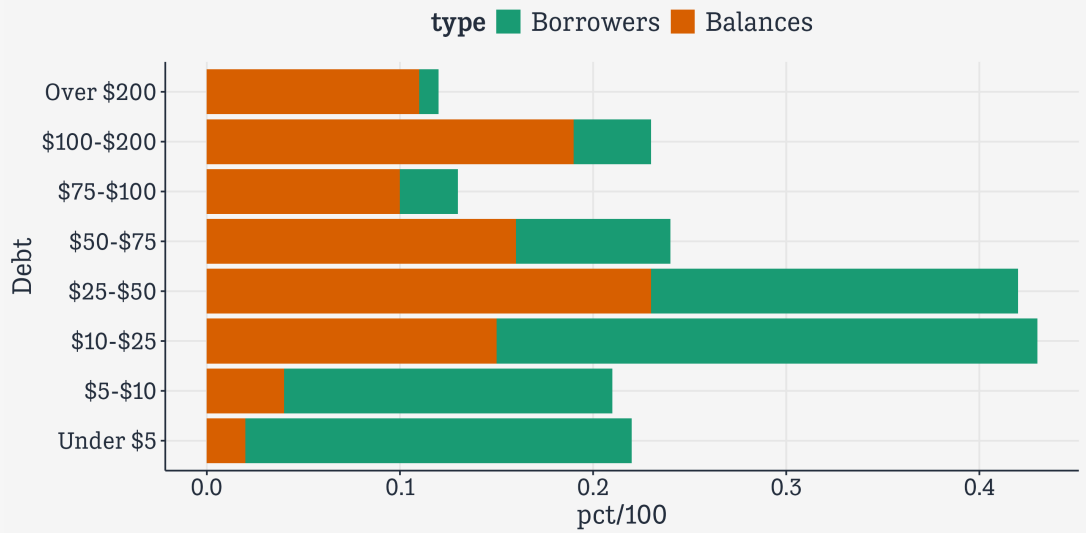
Debt Plot 1

```
studebt ▷
  ggplot(mapping =
           aes(x = pct/100,
               y = Debt,
               fill = type)) +
  geom_col()
```



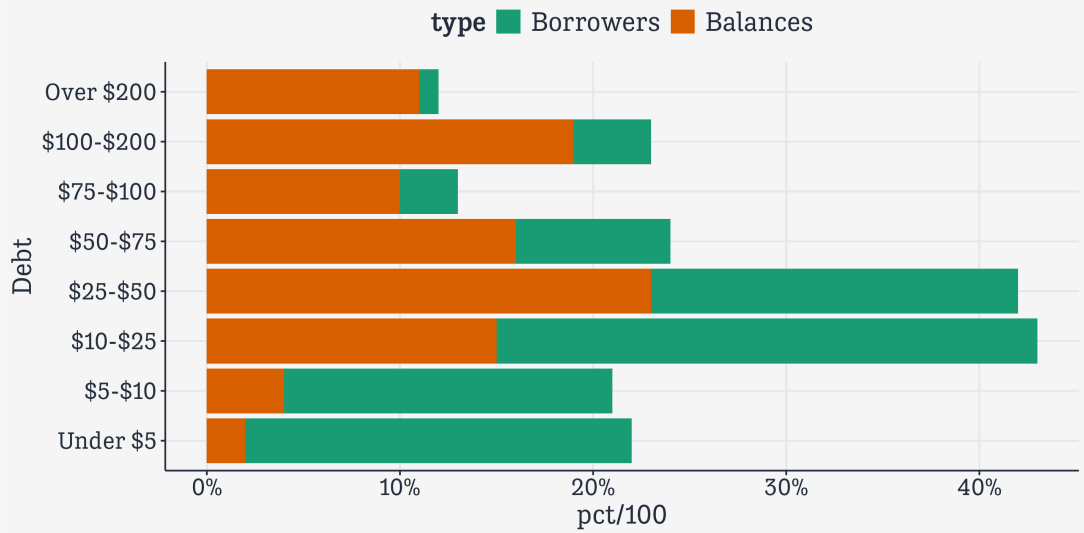
Debt Plot 1

```
studebt ▷
  ggplot(mapping =
           aes(x = pct/100,
               y = Debt,
               fill = type)) +
  geom_col() +
  scale_fill_brewer(type = "qual",
                    palette = "Dark2")
```



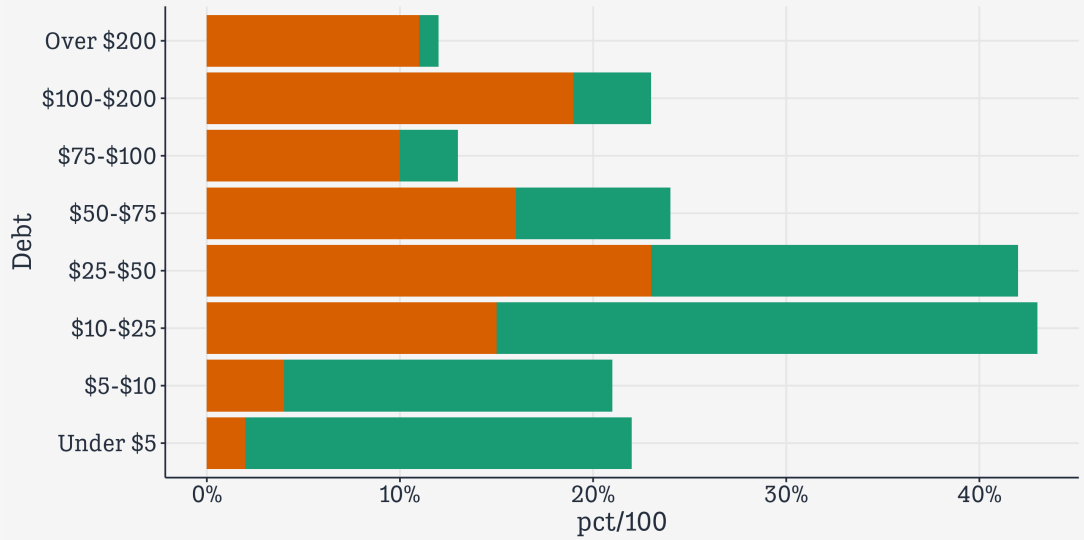
Debt Plot 1

```
studebt ▷
  ggplot(mapping =
           aes(x = pct/100,
               y = Debt,
               fill = type)) +
  geom_col() +
  scale_fill_brewer(type = "qual",
                    palette = "Dark2") +
  scale_x_continuous(labels = label_percent())
```



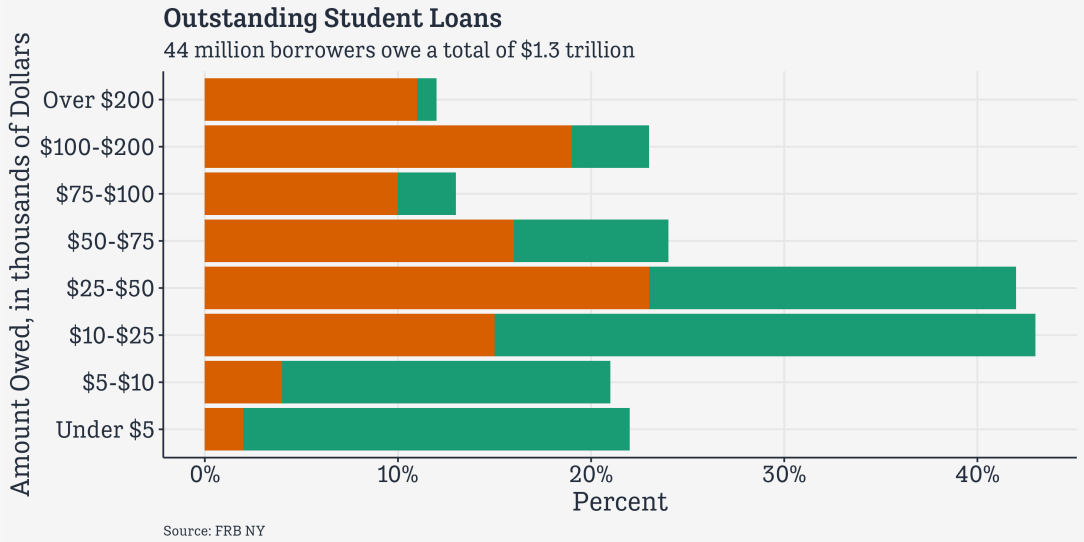
Debt Plot 1

```
studebt ▷
  ggplot(mapping =
           aes(x = pct/100,
               y = Debt,
               fill = type)) +
  geom_col() +
  scale_fill_brewer(type = "qual",
                    palette = "Dark2") +
  scale_x_continuous(labels = label_percent()) +
  guides(fill = "none")
```



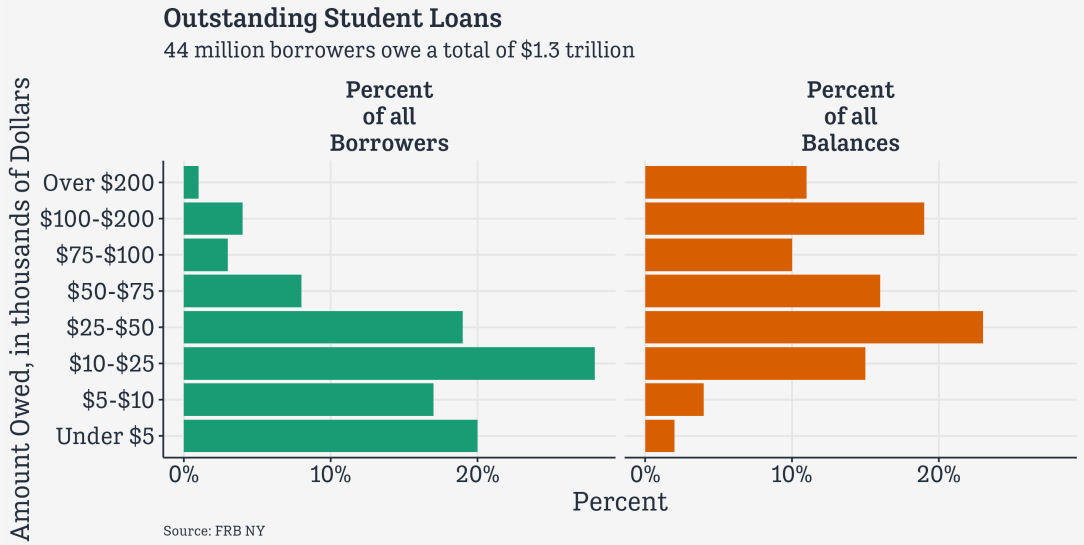
Debt Plot 1

```
studebt ▷
  ggplot(mapping =
           aes(x = pct/100,
               y = Debt,
               fill = type)) +
  geom_col() +
  scale_fill_brewer(type = "qual",
                    palette = "Dark2") +
  scale_x_continuous(labels = label_percent()) +
  guides(fill = "none") +
  labs(x = "Percent",
       y = p_ylab,
       caption = p_caption,
       title = p_title,
       subtitle = p_subtitle)
```



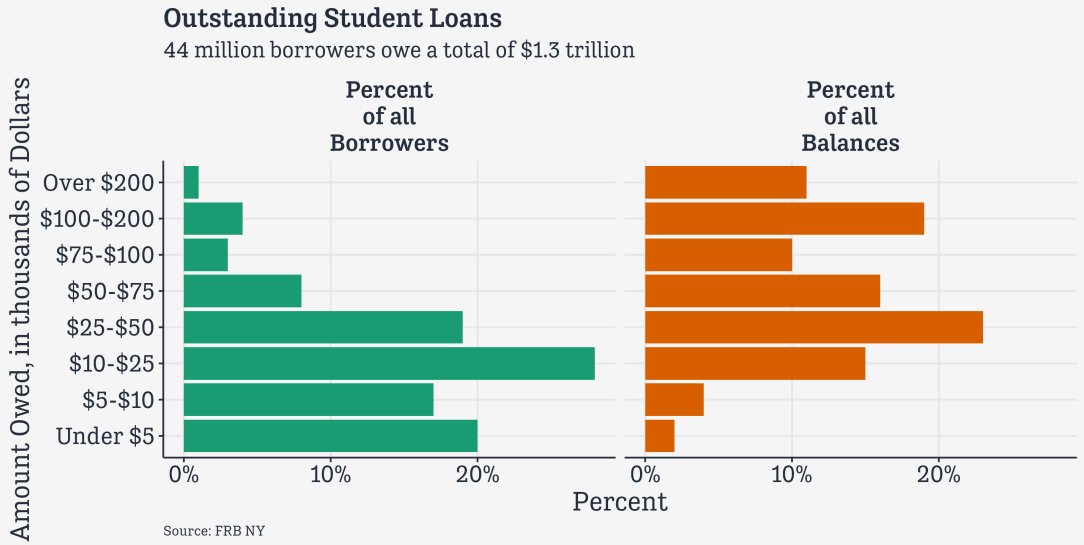
Debt Plot 1

```
studebt ▷
  ggplot(mapping =
           aes(x = pct/100,
               y = Debt,
               fill = type)) +
  geom_col() +
  scale_fill_brewer(type = "qual",
                    palette = "Dark2") +
  scale_x_continuous(labels = label_percent()) +
  guides(fill = "none") +
  labs(x = "Percent",
       y = p_ylab,
       caption = p_caption,
       title = p_title,
       subtitle = p_subtitle) +
  facet_wrap(~ type_label,
             labeller =
               label_wrap_gen(width=10))
```



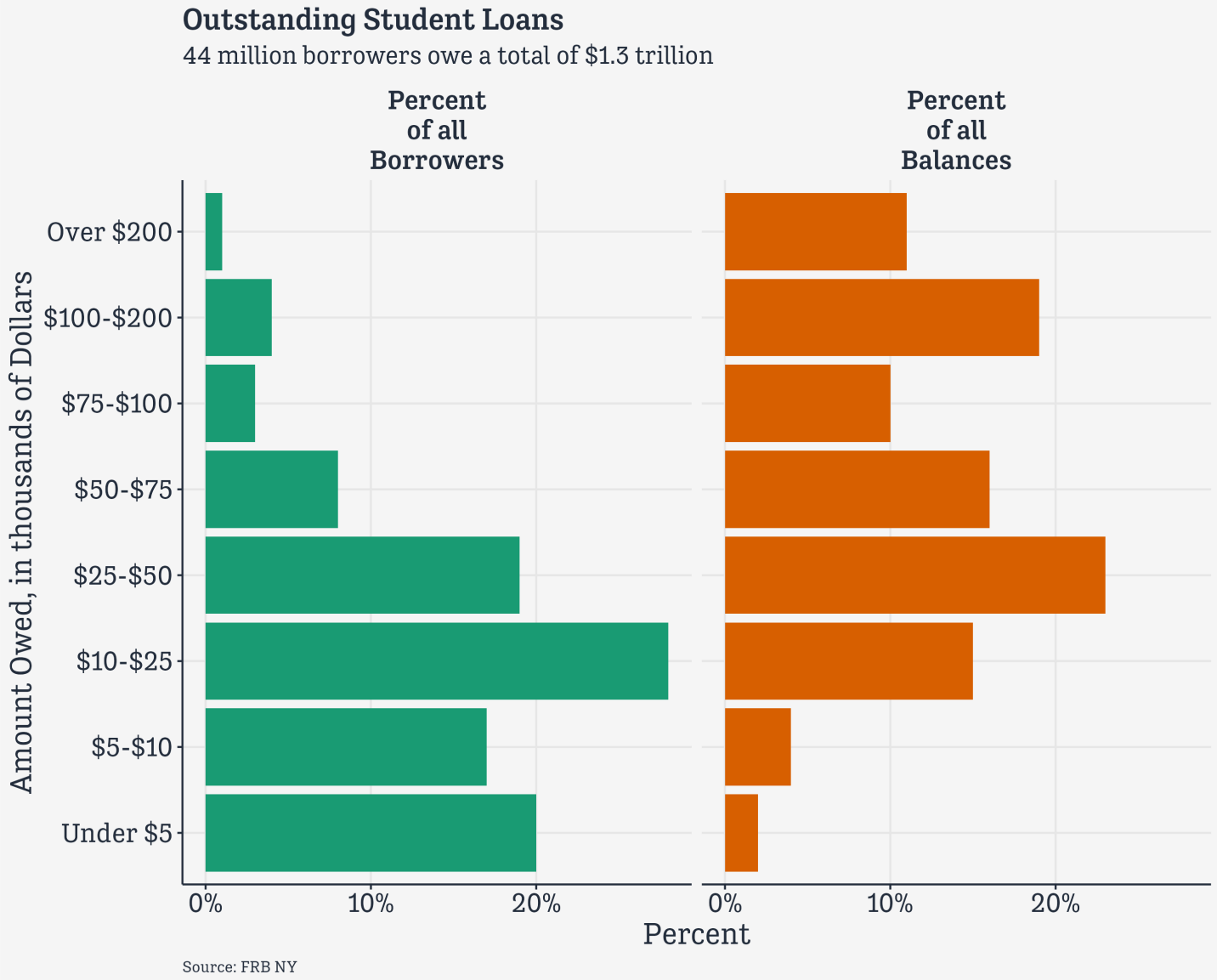
Debt Plot 1

```
studebt ▷
  ggplot(mapping =
           aes(x = pct/100,
               y = Debt,
               fill = type)) +
  geom_col() +
  scale_fill_brewer(type = "qual",
                    palette = "Dark2") +
  scale_x_continuous(labels = label_percent()) +
  guides(fill = "none") +
  labs(x = "Percent",
       y = p_ylab,
       caption = p_caption,
       title = p_title,
       subtitle = p_subtitle) +
  facet_wrap(~ type_label,
             labeller =
               label_wrap_gen(width=10)) +
    theme(strip.text.x =
          element_text(face = "bold"))
```



Debt Plot 1

```
studebt ▷
  ggplot(mapping =
           aes(x = pct/100,
               y = Debt,
               fill = type)) +
  geom_col() +
  scale_fill_brewer(type = "qual",
                    palette = "Dark2") +
  scale_x_continuous(labels = label_percent()) +
  guides(fill = "none") +
  labs(x = "Percent",
       y = p_ylab,
       caption = p_caption,
       title = p_title,
       subtitle = p_subtitle) +
  facet_wrap(~ type_label,
             labeller =
               label_wrap_gen(width=10)) +
    theme(strip.text.x =
          element_text(face = "bold")) →
  p1_debt
```



Pies redrawn as facets

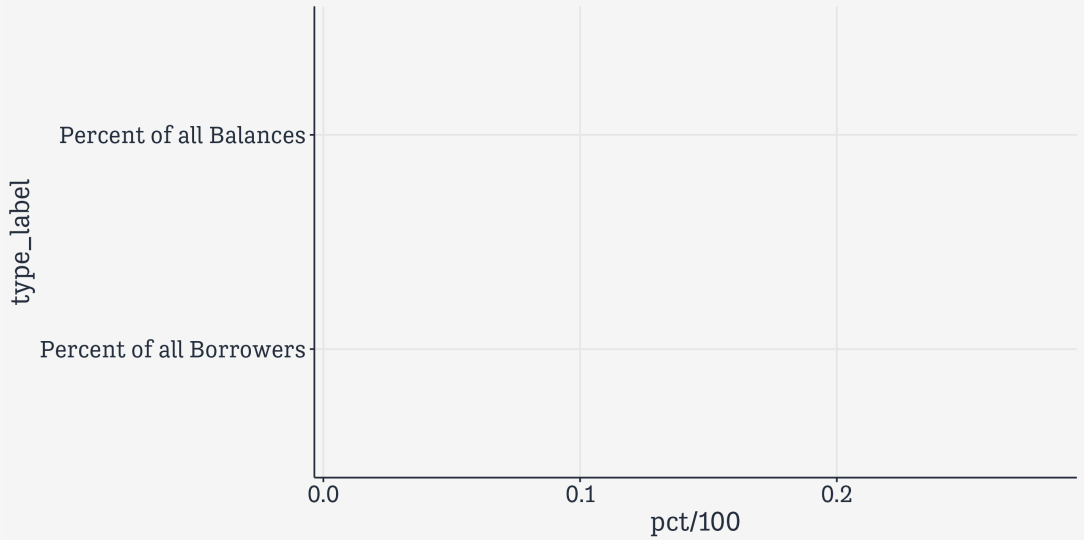
Alternatively, a kind of stacked bar chart

```
studebt
```

```
# A tibble: 16 × 5
   Debt      type        pct Debtrc    type_label
   <ord>     <fct>     <int> <ord>     <fct>
 1 Under $5  Borrowers    20 Under $5  Percent of all Borrowers
 2 $5-$10    Borrowers    17 $5-$10    Percent of all Borrowers
 3 $10-$25   Borrowers    28 $10-$25   Percent of all Borrowers
 4 $25-$50   Borrowers    19 $25-$50   Percent of all Borrowers
 5 $50-$75   Borrowers     8 $50-$75   Percent of all Borrowers
 6 $75-$100  Borrowers     3 $75-$100  Percent of all Borrowers
 7 $100-$200 Borrowers     4 $100-$200 Percent of all Borrowers
 8 Over $200 Borrowers     1 Over $200 Percent of all Borrowers
 9 Under $5  Balances      2 Under $5  Percent of all Balances
10 $5-$10    Balances      4 $5-$10    Percent of all Balances
11 $10-$25   Balances     15 $10-$25   Percent of all Balances
12 $25-$50   Balances     23 $25-$50   Percent of all Balances
13 $50-$75   Balances     16 $50-$75   Percent of all Balances
14 $75-$100  Balances     10 $75-$100  Percent of all Balances
15 $100-$200 Balances     19 $100-$200 Percent of all Balances
16 Over $200 Balances     11 Over $200 Percent of all Balances
```

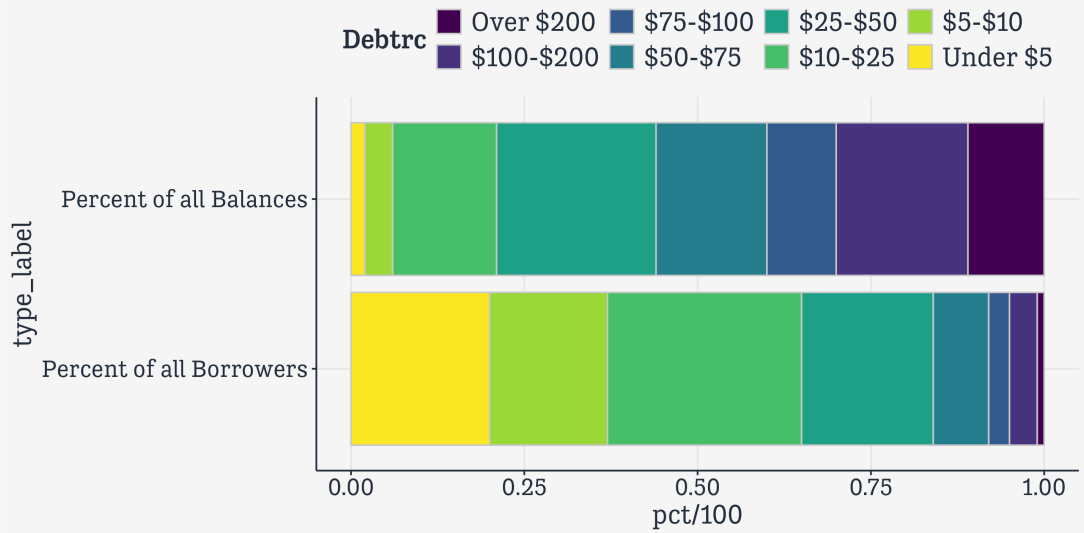
Alternatively, a kind of stacked bar chart

```
studebt ▷
  ggplot(mapping = aes(x = pct/100,
                       y = type_label,
                       fill = Debtrc))
```



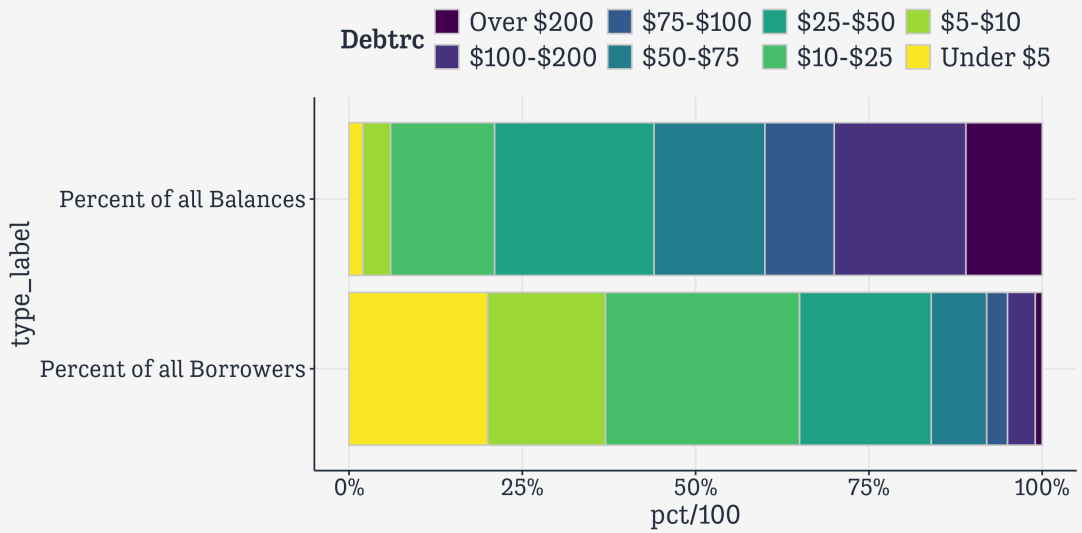
Alternatively, a kind of stacked bar chart

```
studebt ▷
  ggplot(mapping = aes(x = pct/100,
                       y = type_label,
                       fill = Debtrc)) +
  geom_col(color = "gray80")
```



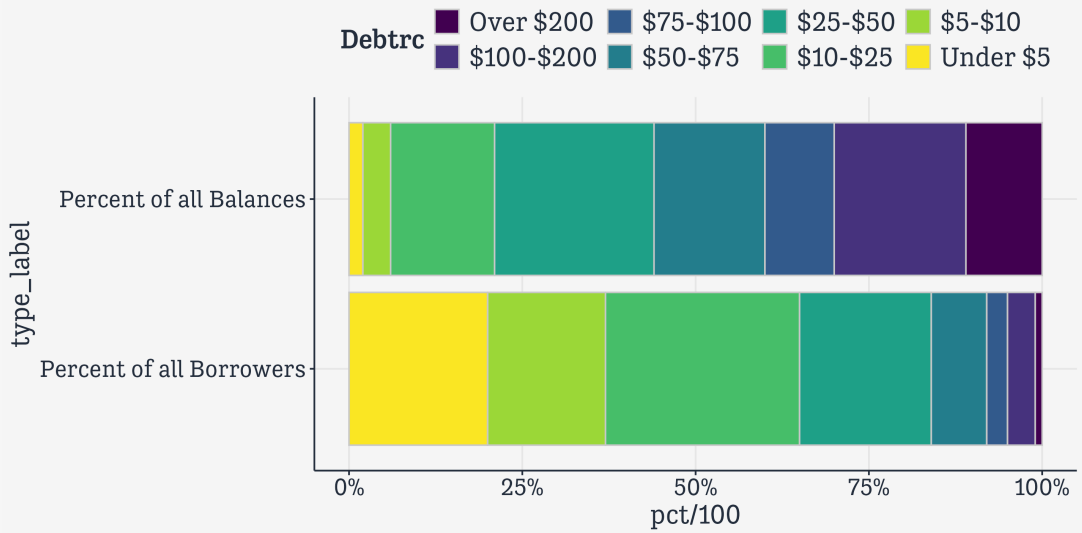
Alternatively, a kind of stacked bar chart

```
studebt ▷
  ggplot(mapping = aes(x = pct/100,
                       y = type_label,
                       fill = Debtrc)) +
  geom_col(color = "gray80") +
  scale_x_continuous(labels =
                       label_percent())
```



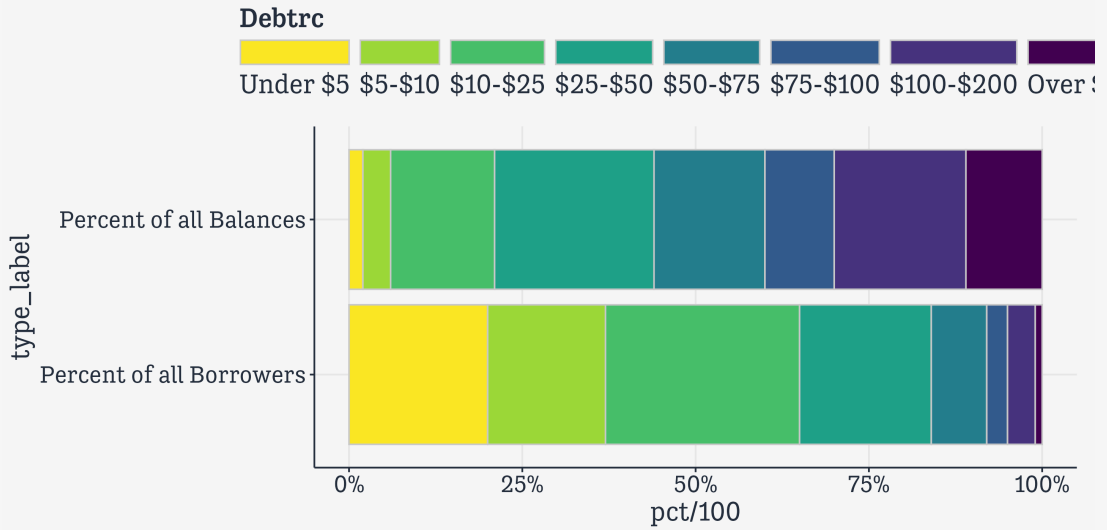
Alternatively, a kind of stacked bar chart

```
studebt ▷
  ggplot(mapping = aes(x = pct/100,
                       y = type_label,
                       fill = Debtrc)) +
  geom_col(color = "gray80") +
  scale_x_continuous(labels =
                       label_percent()) +
  scale_fill_viridis_d()
```



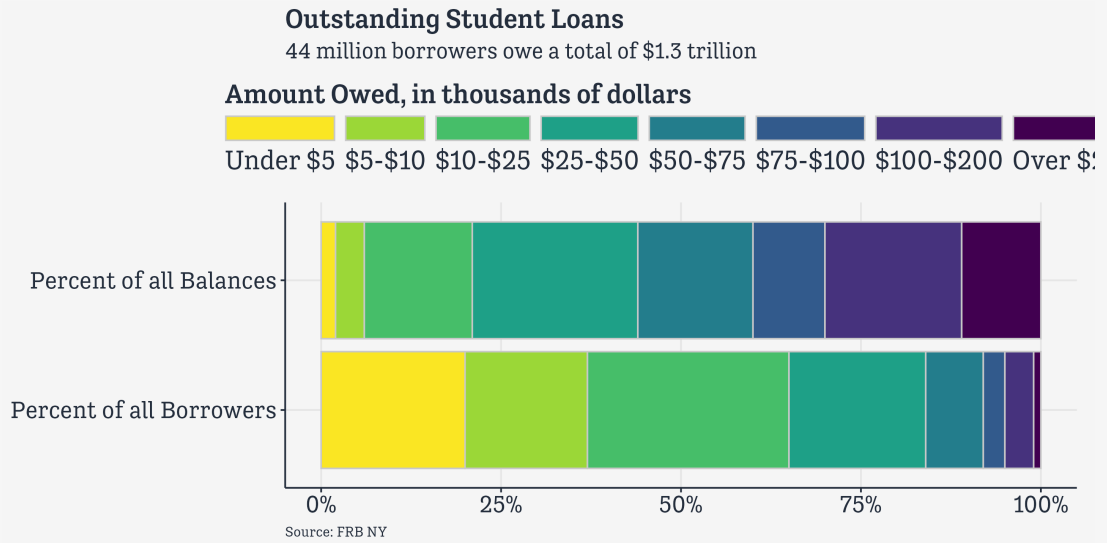
Alternatively, a kind of stacked bar chart

```
studebt ▷
  ggplot(mapping = aes(x = pct/100,
                       y = type_label,
                       fill = Debtrc)) +
  geom_col(color = "gray80") +
  scale_x_continuous(labels =
                       label_percent()) +
  scale_fill_viridis_d() +
  guides(fill =
           guide_legend(reverse = TRUE,
                        title.position = "top",
                        label.position = "bottom",
                        keywidth = 3,
                        nrow = 1))
```



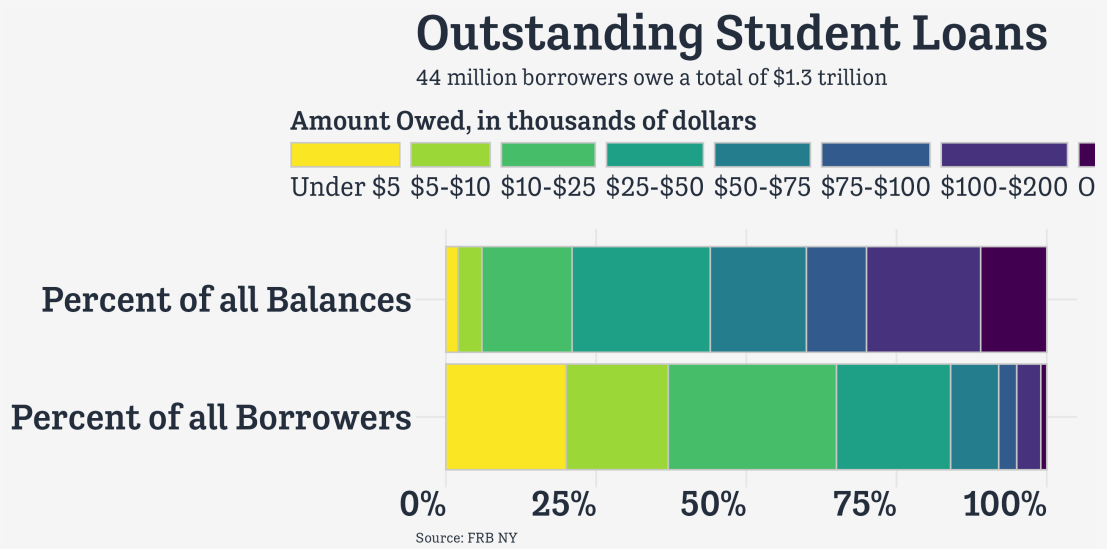
Alternatively, a kind of stacked bar chart

```
studebt ▷
  ggplot(mapping = aes(x = pct/100,
                       y = type_label,
                       fill = Debtrc)) +
  geom_col(color = "gray80") +
  scale_x_continuous(labels =
                       label_percent()) +
  scale_fill_viridis_d() +
  guides(fill =
           guide_legend(reverse = TRUE,
                        title.position = "top",
                        label.position = "bottom",
                        keywidth = 3,
                        nrow = 1)) +
  labs(x = NULL, y = NULL,
       fill = "Amount Owed, in thousands of dollars",
       caption = p_caption, title = p_title,
       subtitle = p_subtitle)
```



Alternatively, a kind of stacked bar chart

```
studebt ▷
  ggplot(mapping = aes(x = pct/100,
                       y = type_label,
                       fill = Debtrc)) +
  geom_col(color = "gray80") +
  scale_x_continuous(labels =
                       label_percent()) +
  scale_fill_viridis_d() +
  guides(fill =
           guide_legend(reverse = TRUE,
                        title.position = "top",
                        label.position = "bottom",
                        keywidth = 3,
                        nrow = 1)) +
  labs(x = NULL, y = NULL,
       fill = "Amount Owed, in thousands of dollars",
       caption = p_caption, title = p_title,
       subtitle = p_subtitle) +
  theme(legend.position = "top",
        plot.title = element_text(size = rel(2.8)),
        axis.text = element_text(face = "bold",
                hjust = 1,
                size = rel(2)),
          axis.ticks.length = unit(0, "cm"),
          axis.line = element_blank(),
          panel.grid = element_blank())
```

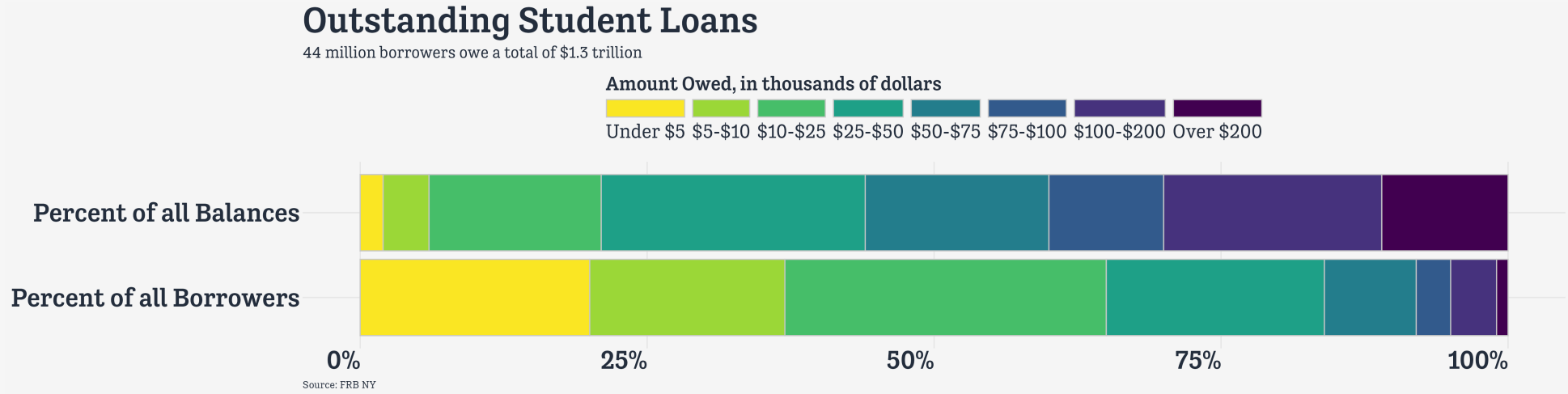


Alternatively, a kind of stacked bar chart

```
studebt ▷
  ggplot(mapping = aes(x = pct/100,
                       y = type_label,
                       fill = Debtrc)) +
  geom_col(color = "gray80") +
  scale_x_continuous(labels =
                       label_percent()) +
  scale_fill_viridis_d() +
  guides(fill =
           guide_legend(reverse = TRUE,
                        title.position = "top",
                        label.position = "bottom",
                        keywidth = 3,
                        nrow = 1)) +
  labs(x = NULL, y = NULL,
       fill = "Amount Owed, in thousands of dollars",
       caption = p_caption, title = p_title,
       subtitle = p_subtitle) +
  theme(legend.position = "top",
        plot.title = element_text(size = rel(2.8)),
        axis.text = element_text(face = "bold",
                hjust = 1,
                size = rel(2)),
          axis.ticks.length = unit(0, "cm"),
          axis.line = element_blank(),
          panel.grid = element_blank()) →
  p_debt2
```

Alternatively, a kind of stacked bar chart

```
studebt ▷
  ggplot(mapping = aes(x = pct/100,
                       y = type_label,
                       fill = Debtrc)) +
  geom_col(color = "gray80") +
  scale_x_continuous(labels =
                       label_percent()) +
  scale_fill_viridis_d() +
  guides(fill =
           guide_legend(reverse = TRUE,
                        title.position = "top",
                        label.position = "bottom",
                        keywidth = 3,
                        nrow = 1)) +
  labs(x = NULL, y = NULL,
       fill = "Amount Owed, in thousands of dollars",
       caption = p_caption, title = p_title,
       subtitle = p_subtitle) +
  theme(legend.position = "top",
        plot.title = element_text(size = rel(2.8)),
        axis.text = element_text(face = "bold",
                hjust = 1,
                size = rel(2)),
          axis.ticks.length = unit(0, "cm"),
          axis.line = element_blank(),
          panel.grid = element_blank()) →
  p_debt2
```



Pies redrawn as sideways-stacked columns

Working with complex surveys

As always, our question is “What’s the smoothest way for me to get a tidy table of results I need to hand off to `ggplot`?”

For complex surveys, we use `survey`, the standard package for survey analysis in R, and `srvyr`, a helper package designed to integrate what `survey` can do with the Tiydverse framework.

```
## Load the packages
library(survey)
library(srvyr)
```

Example: The GSS again

This time, a small piece of the full GSS from the early 1970s to 2018.

```
gss_lon
```

```
# A tibble: 62,466 × 25
    year    id ballot age   degree race  sex   siblings kids  bigregion income16
   <dbl> <dbl> <labe> <lab> <fct>  <fct> <fct> <fct>    <fct> <fct>     <fct>
 1  1972     1 NA     23    Bache… White Fema… 3        0     Midwest   <NA>
 2  1972     2 NA     70    Lt Hi… White Male  4        4+    Midwest   <NA>
 3  1972     3 NA     48    High … White Fema… 5        4+    Midwest   <NA>
 4  1972     4 NA     27    Bache… White Fema… 5        0     Midwest   <NA>
 5  1972     5 NA     61    High … White Fema… 2        2     Midwest   <NA>
 6  1972     6 NA     26    High … White Male  1        0     Midwest   <NA>
 7  1972     7 NA     28    High … White Male  6+       2     Midwest   <NA>
 8  1972     8 NA     27    Bache… White Male  1        0     Midwest   <NA>
 9  1972     9 NA     21    High … Black Fema… 2        2     South     <NA>
10  1972    10 NA     30    High … Black Fema… 6+       4+    South     <NA>
# ℹ 62,456 more rows
# ℹ 14 more variables: religion <fct>, marital <fct>, padeg <fct>, madeg <fct>,
#   partyid <fct>, polviews <fct>, happy <fct>, partners_rc <fct>, grass <fct>,
#   zodiac <fct>, pres12 <labelled>, wtssall <dbl>, vpsu <dbl>, vstrat <dbl>
```

Add the weighting information

```r
# These details are dependent on the kind of survey you're working with
options(survey.lonely.psu = "adjust")
options(na.action="na.pass")

gss_svy ← gss_lon ▷
  filter(year > 1974) ▷
  mutate(stratvar = interaction(year, vstrat)) ▷
  as_survey_design(ids = vpsu,
                   strata = stratvar,
                   weights = wtssall,
                   nest = TRUE)

gss_svy # Now it's no longer simply a tibble
```

```
Stratified 1 - level Cluster Sampling design (with replacement)
With (4399) clusters.
Called via srvyr
Sampling variables:
  - ids: vpsu
  - strata: stratvar
  - weights: wtssall
Data variables:
  - year (dbl), id (dbl), ballot (labelled), age (labelled), degree (fct), race
    (fct), sex (fct), siblings (fct), kids (fct), bigregion (fct), income16
    (fct), religion (fct), marital (fct), padeg (fct), madeg (fct), partyid
    (fct), polviews (fct), happy (fct), partners_rc (fct), grass (fct), zodiac
    (fct), pres12 (labelled), wtssall (dbl), vpsu (dbl), vstrat (dbl), stratvar
    (fct)
```

Trends in the happy measure

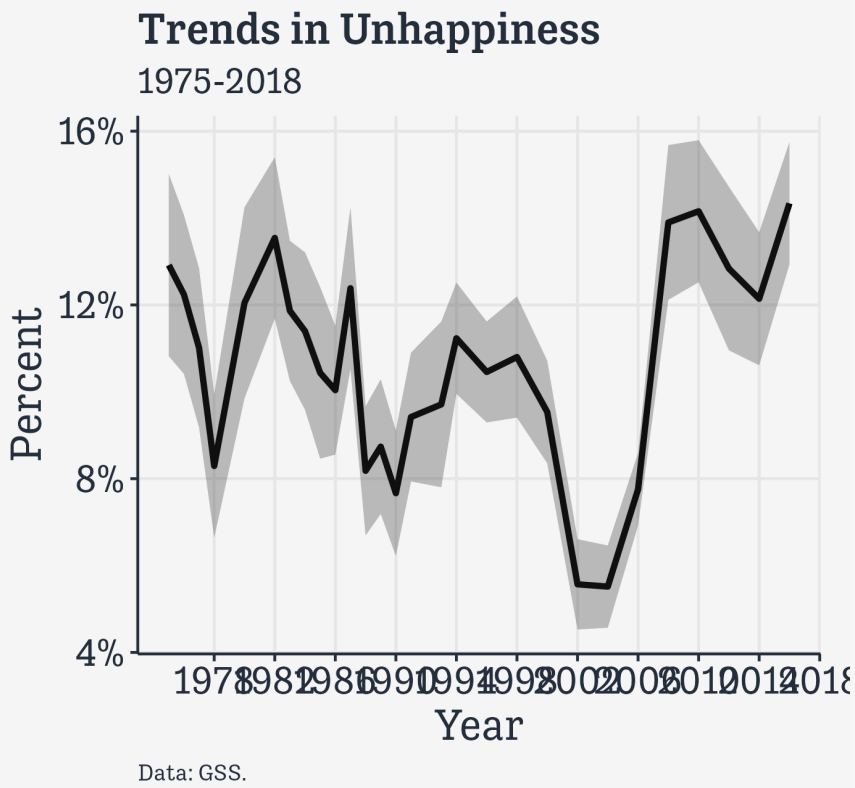
```
out_hap ← gss_svy ▷
    group_by(year, happy)  ▷
    summarize(prop = survey_mean(na.rm = TRUE, vartype = "ci"))

out_hap
```

```
# A tibble: 111 × 5
# Groups:   year [28]
    year happy            prop prop_low prop_upp
   <dbl> <fct>           <dbl>    <dbl>    <dbl>
 1  1975 Very Happy    0.333   0.304     0.361
 2  1975 Pretty Happy  0.534   0.504     0.565
 3  1975 Not Too Happy 0.129   0.108     0.150
 4  1975 <NA>          0.00375 0.000362  0.00714
 5  1976 Very Happy    0.348   0.321     0.376
 6  1976 Pretty Happy  0.529   0.504     0.555
 7  1976 Not Too Happy 0.122   0.104     0.141
 8  1977 Very Happy    0.357   0.330     0.384
 9  1977 Pretty Happy  0.532   0.504     0.560
10  1977 Not Too Happy 0.110   0.0918    0.128
# ℹ 101 more rows
```

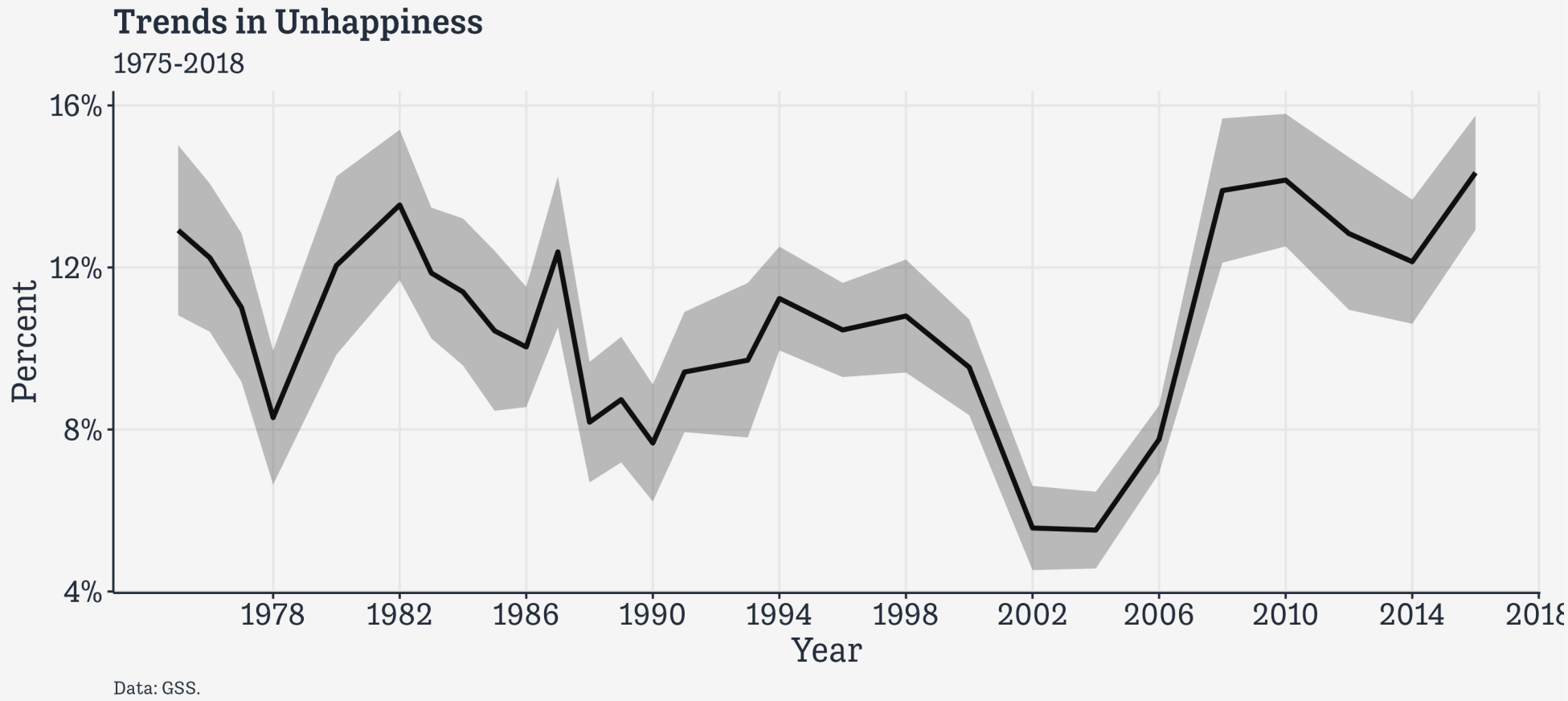
Once again, it's now a tidy tibble, and we know what to do with those.

Trends in the happy measure

```
out_hap ▷
  filter(happy == "Not Too Happy") ▷
  ggplot(mapping = aes(x = year,
                       y = prop,
                       ymin = prop_low,
                       ymax = prop_upp)) +
  geom_line(linewidth = 1.2) +
  geom_ribbon(alpha = 0.3) +
  scale_x_continuous(breaks =
                       seq(1978, 2018, 4)) +
  scale_y_continuous(labels =
                       label_percent(accuracy = 1)) +
  labs(x = "Year",
    y = "Percent",
    title = "Trends in Unhappiness",
    subtitle = "1975-2018",
    caption = "Data: GSS.")
```



With a better aspect ratio



A more complex example

```
gss_svy ▷
  filter(year %in% seq(1976, 2016, by = 4)) ▷
  group_by(year, race, degree) ▷
  summarize(prop = survey_mean(na.rm = TRUE))
```

```
# A tibble: 162 × 5
# Groups:   year, race [30]
    year race  degree            prop prop_se
   <dbl> <fct> <fct>            <dbl>   <dbl>
 1  1976 White Lt High School 0.327   0.0160
 2  1976 White High School    0.517   0.0161
 3  1976 White Junior College 0.0128  0.00298
 4  1976 White Bachelor       0.101   0.00955
 5  1976 White Graduate       0.0392  0.00642
 6  1976 White <NA>           0.00285 0.00151
 7  1976 Black Lt High School 0.558   0.0603
 8  1976 Black High School    0.335   0.0476
 9  1976 Black Junior College 0.0423  0.0192
10  1976 Black Bachelor       0.0577  0.0238
# ℹ 152 more rows
```

Let's put that in an object

```
out_yrd ← gss_svy ▷
  filter(year %in% seq(1976, 2016, by = 4)) ▷
  group_by(year, race, degree) ▷
  summarize(prop = survey_mean(na.rm = TRUE))
```

Check the sums

```
out_yrd ▷
  group_by(year, race) ▷
  summarize(tot = sum(prop))
```

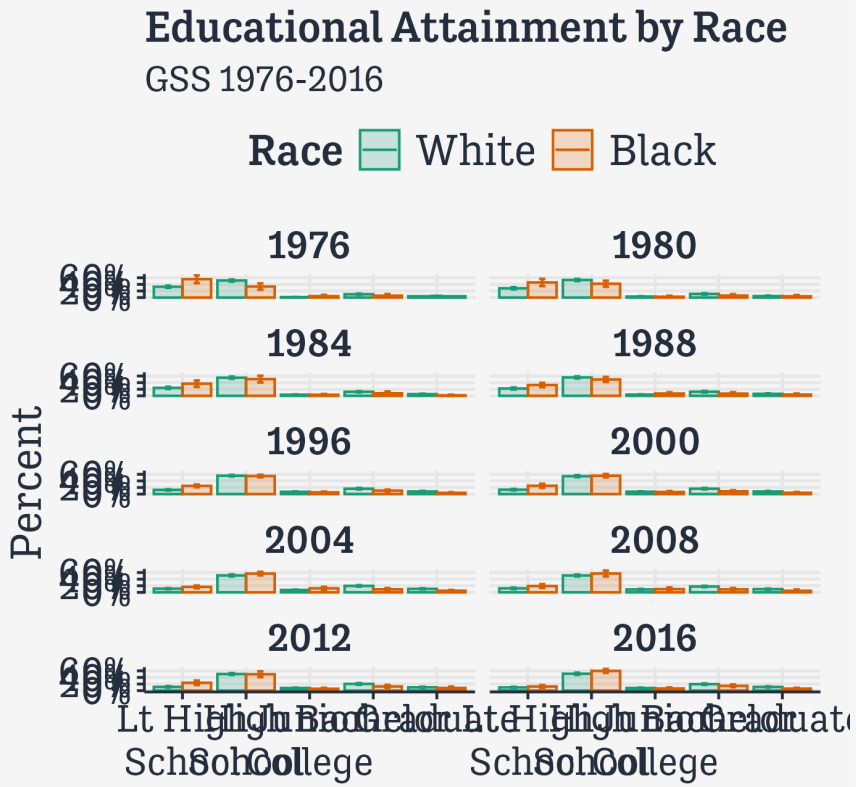
```
# A tibble: 30 × 3
# Groups:   year [10]
    year race    tot
   <dbl> <fct> <dbl>
 1  1976 White  1.00
 2  1976 Black  1.00
 3  1976 Other  1
 4  1980 White  1.00
 5  1980 Black  1
 6  1980 Other  1
 7  1984 White  1.00
 8  1984 Black  1.00
 9  1984 Other  1
10  1988 White  1.00
# ℹ 20 more rows
```

Set up the plot

```
p ← out_yrd ▷
  drop_na() ▷
  filter(race %nin% "Other") ▷
  ggplot(mapping = aes(x = degree,
                       y = prop,
                       ymin = prop - 2*prop_se,
                       ymax = prop + 2*prop_se,
                       fill = race,
                       color = race,
                       group = race))

dodge_w ← position_dodge(width = 0.9)
```

Draw the plot

```
p + geom_col(position = dodge_w, alpha = 0.2) +
    geom_errorbar(position = dodge_w, width = 0.2) +
    scale_x_discrete(labels = wrap_format(10)) +
    scale_y_continuous(labels = label_percent()) +
    scale_color_brewer(type = "qual",
                       palette = "Dark2") +
    scale_fill_brewer(type = "qual",
                      palette = "Dark2") +
    labs(title = "Educational Attainment by Race",
         subtitle = "GSS 1976-2016",
         fill = "Race",
         color = "Race",
         x = NULL, y = "Percent") +
    facet_wrap(~ year, ncol = 2)
```

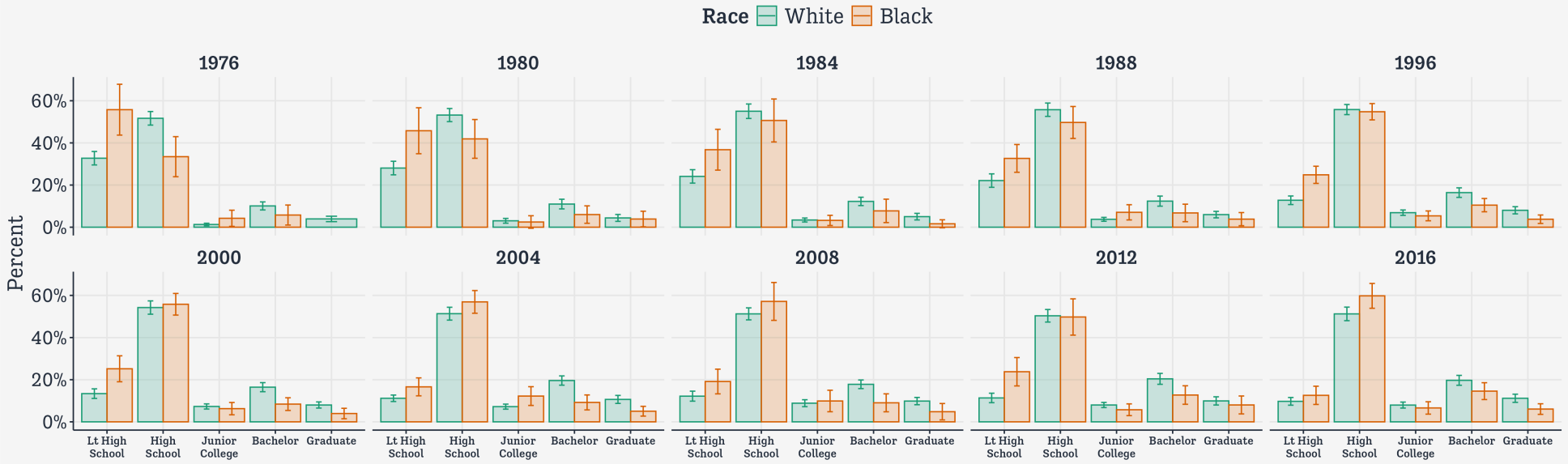


In full (but switch to rows)

```
p_out ← p +
  geom_col(position = dodge_w, alpha = 0.2) +
  geom_errorbar(position = dodge_w, width = 0.2) +
  scale_x_discrete(labels = wrap_format(10)) +
  scale_y_continuous(labels = label_percent()) +
  scale_color_brewer(type = "qual",
                     palette = "Dark2") +
  scale_fill_brewer(type = "qual",
                    palette = "Dark2") +
  labs(title = "Educational Attainment by Race",
       subtitle = "GSS 1976-2016",
       fill = "Race",
       color = "Race",
       x = NULL, y = "Percent") +
  facet_wrap(~ year, nrow = 2) +
  theme(axis.text.x =
          element_text(size = rel(0.6),
                       face = "bold"))
```

Educational Attainment by Race

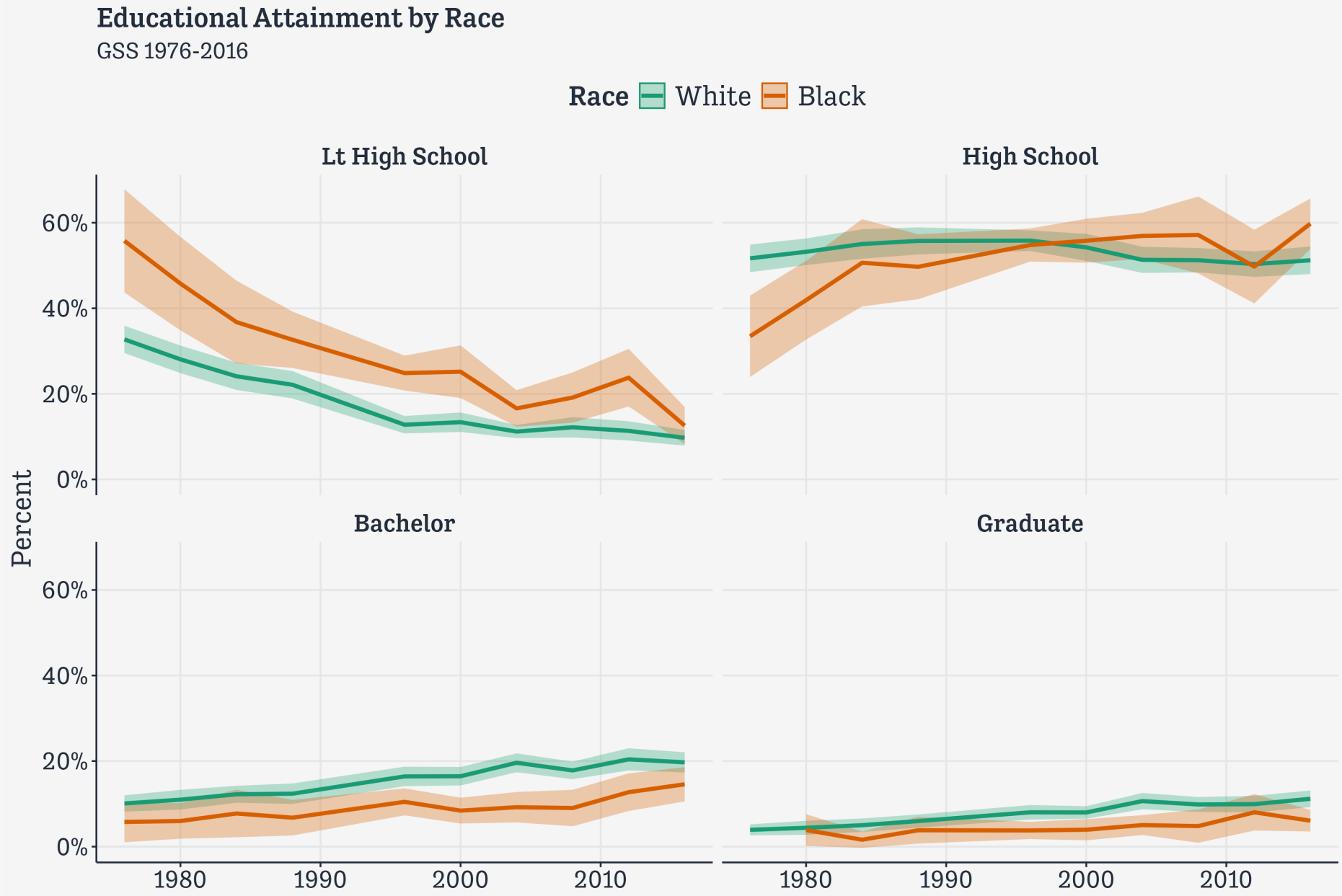
GSS 1976-2016



Is this figure effective? Not really!

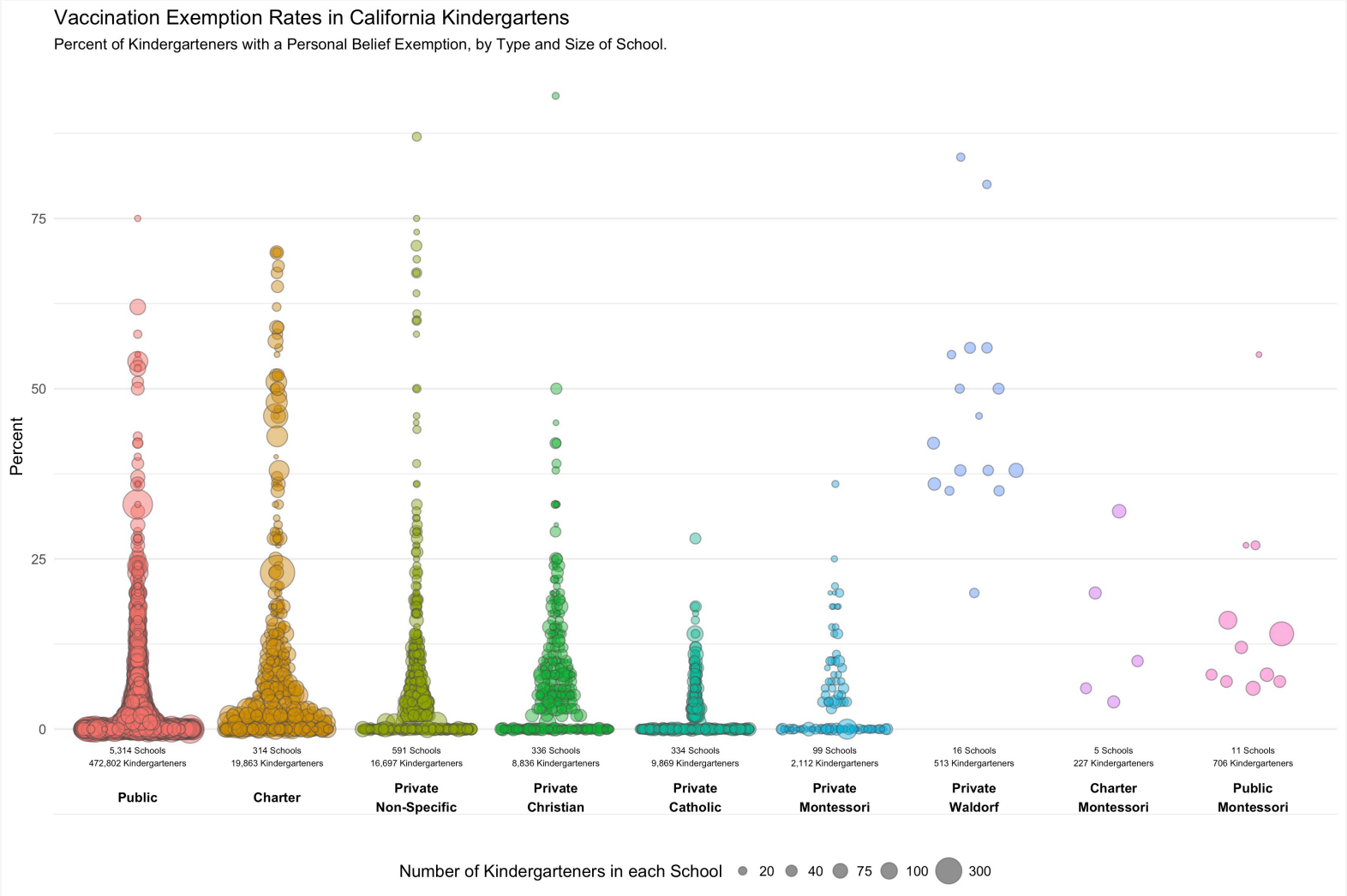
Let's try a different view

```
p ← out_yrd ▷
  drop_na() ▷
  filter(race %nin% "Other",
         degree %nin% "Junior College") ▷
  ggplot(mapping = aes(x = year, y = prop,
                       ymin = prop - 2*prop_se,
                       ymax = prop + 2*prop_se,
                       fill = race, color = race,
                       group = race))

p_out ← p +
  geom_ribbon(mapping = aes(color = NULL),
              alpha = 0.3) +
  geom_line(linewidth = rel(1.25)) +
  scale_y_continuous(labels = label_percent()) +
  scale_color_brewer(type = "qual", palette = "Dark2") +
  scale_fill_brewer(type = "qual", palette = "Dark2") +
  facet_wrap(~ degree, ncol = 2) +
  labs(title = "Educational Attainment by Race",
       subtitle = "GSS 1976-2016", fill = "Race",
       color = "Race", x = NULL, y = "Percent")
```


Educational Attainment by Race
GSS 1976-2016
Race White Black
Lt High School
High School
Bachelor
Graduate
Percent
60%
40%
20%
0%
1980
1990
2000
2010

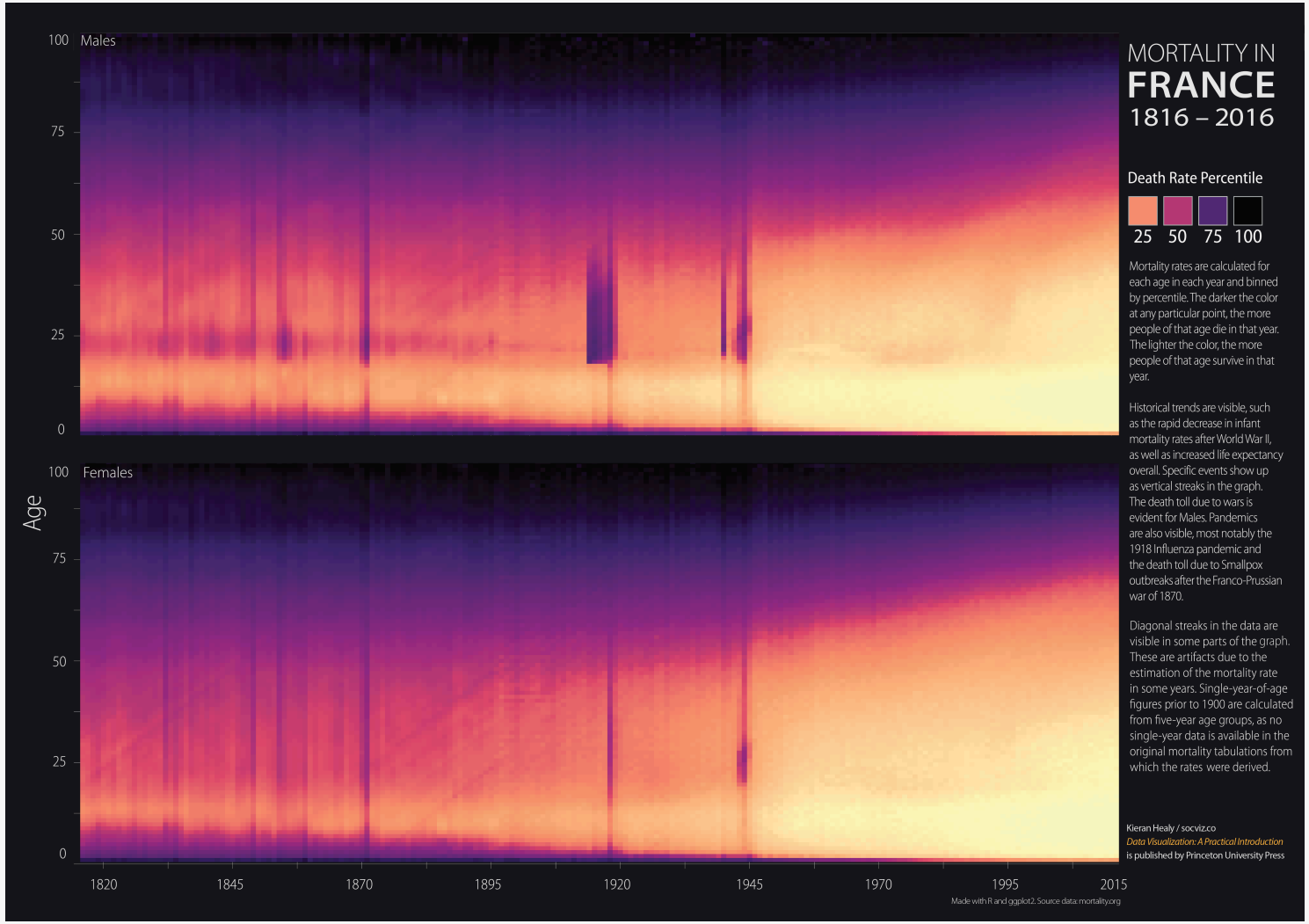
But I want a pony

Show ponies



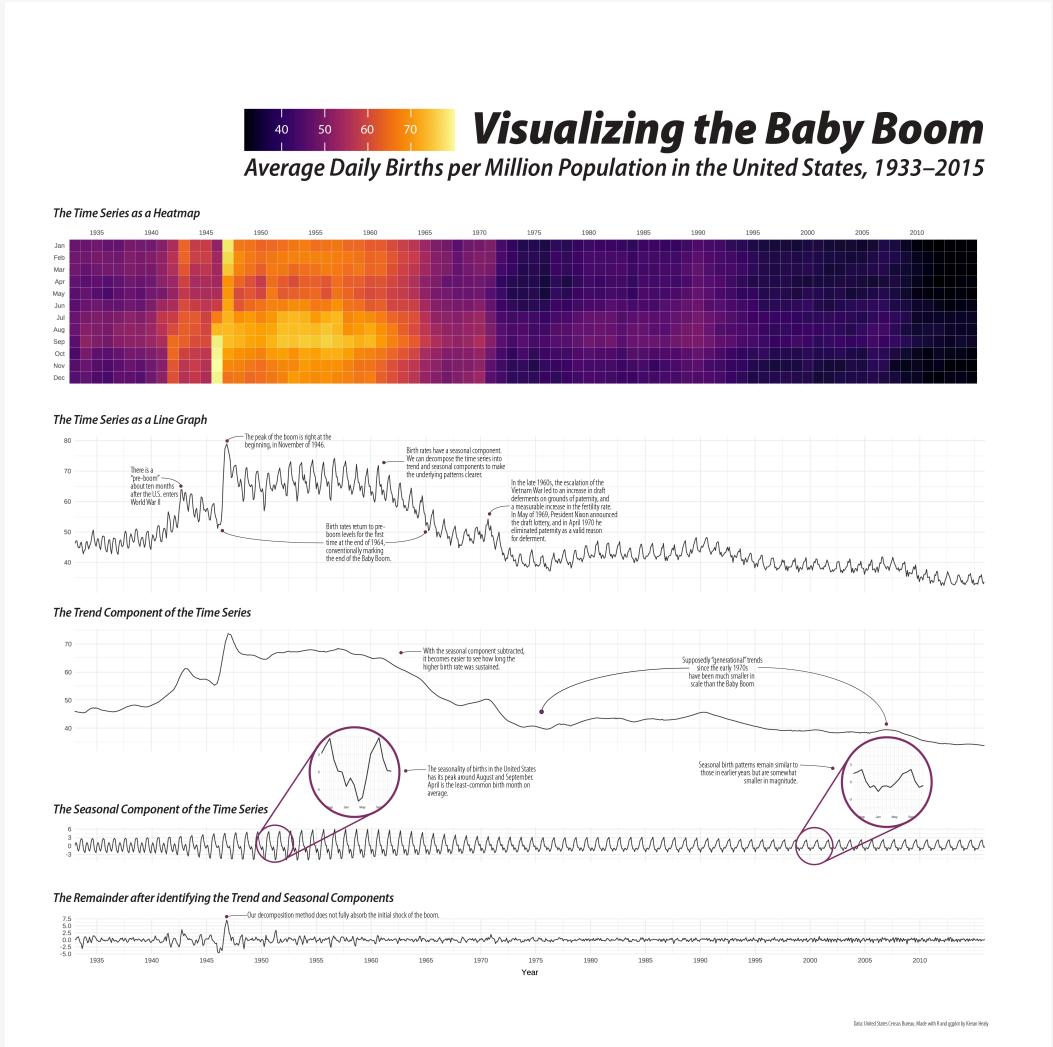
Beeswarm plot

Show ponies



Mortality in France

Show ponies



The Baby Boom

OK boomer

The demog package

```
# remotes::install_github("kjhealy/demog")
# library(demog)

okboomer
```

```
# A tibble: 1,644 × 12
    year month n_days births total_pop births_pct births_pct_day date
   <dbl> <dbl>  <dbl>  <dbl>     <dbl>      <dbl>          <dbl> <date>
 1  1938     1     31  51820  41215000    0.00126           40.6 1938-01-01
 2  1938     2     28  47421  41215000    0.00115           41.1 1938-02-01
 3  1938     3     31  54887  41215000    0.00133           43.0 1938-03-01
 4  1938     4     30  54623  41215000    0.00133           44.2 1938-04-01
 5  1938     5     31  56853  41215000    0.00138           44.5 1938-05-01
 6  1938     6     30  53145  41215000    0.00129           43.0 1938-06-01
 7  1938     7     31  53214  41215000    0.00129           41.6 1938-07-01
 8  1938     8     31  50444  41215000    0.00122           39.5 1938-08-01
 9  1938     9     30  50545  41215000    0.00123           40.9 1938-09-01
10  1938    10     31  50079  41215000    0.00122           39.2 1938-10-01
# ℹ 1,634 more rows
# ℹ 4 more variables: seasonal <dbl>, trend <dbl>, remainder <dbl>,
#   country <chr>
```

Boomer Line Graph

```
okboomer
```

```
# A tibble: 1,644 × 12
    year month n_days births total_pop births_pct births_pct_day date
   <dbl> <dbl>  <dbl>  <dbl>     <dbl>      <dbl>           <dbl> <date>
 1  1938     1     31  51820  41215000    0.00126            40.6 1938-01-01
 2  1938     2     28  47421  41215000    0.00115            41.1 1938-02-01
 3  1938     3     31  54887  41215000    0.00133            43.0 1938-03-01
 4  1938     4     30  54623  41215000    0.00133            44.2 1938-04-01
 5  1938     5     31  56853  41215000    0.00138            44.5 1938-05-01
 6  1938     6     30  53145  41215000    0.00129            43.0 1938-06-01
 7  1938     7     31  53214  41215000    0.00129            41.6 1938-07-01
 8  1938     8     31  50444  41215000    0.00122            39.5 1938-08-01
 9  1938     9     30  50545  41215000    0.00123            40.9 1938-09-01
10  1938    10     31  50079  41215000    0.00122            39.2 1938-10-01
# ℹ 1,634 more rows
# ℹ 4 more variables: seasonal <dbl>, trend <dbl>, remainder <dbl>,
#   country <chr>
```

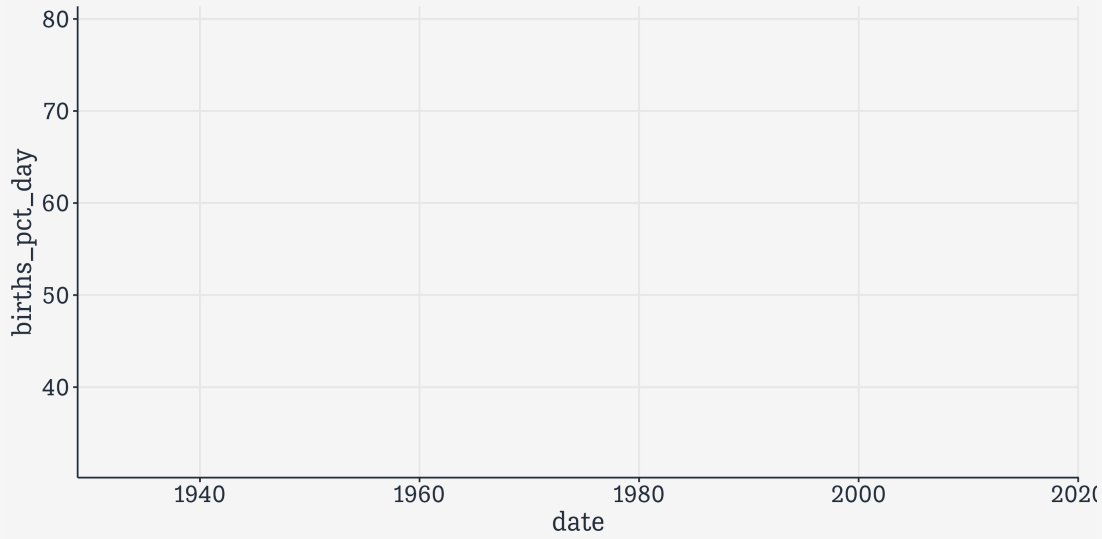
Boomer Line Graph

```
okboomer |>
    filter(country == "United States")
```

```
# A tibble: 996 × 12
    year month n_days births total_pop births_pct births_pct_day date
   <dbl> <dbl>  <dbl>  <dbl>     <dbl>      <dbl>           <dbl> <date>
 1  1933     1     31 180545 125579000    0.00144            46.4 1933-01-01
 2  1933     2     28 165986 125579000    0.00132            47.2 1933-02-01
 3  1933     3     31 183762 125579000    0.00146            47.2 1933-03-01
 4  1933     4     30 171354 125579000    0.00136            45.5 1933-04-01
 5  1933     5     31 174811 125579000    0.00139            44.9 1933-05-01
 6  1933     6     30 169255 125579000    0.00135            44.9 1933-06-01
 7  1933     7     31 180880 125579000    0.00144            46.5 1933-07-01
 8  1933     8     31 181856 125579000    0.00145            46.7 1933-08-01
 9  1933     9     30 167637 125579000    0.00133            44.5 1933-09-01
10  1933    10     31 167055 125579000    0.00133            42.9 1933-10-01
# ℹ 986 more rows
# ℹ 4 more variables: seasonal <dbl>, trend <dbl>, remainder <dbl>,
#   country <chr>
```

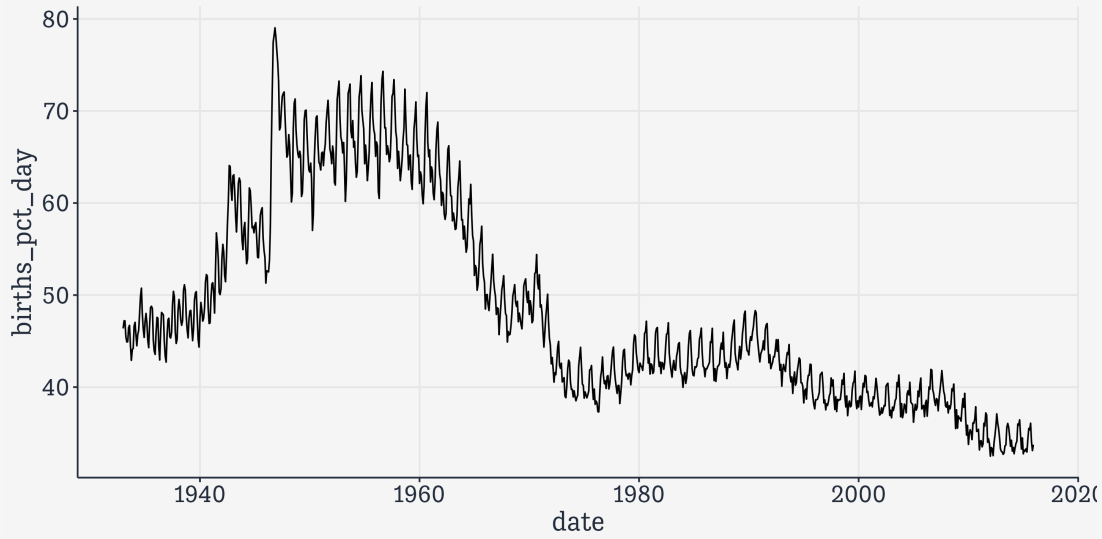
Boomer Line Graph

```
okboomer ▷
    filter(country == "United States")  ▷
    ggplot(aes(x = date, y = births_pct_day))
```



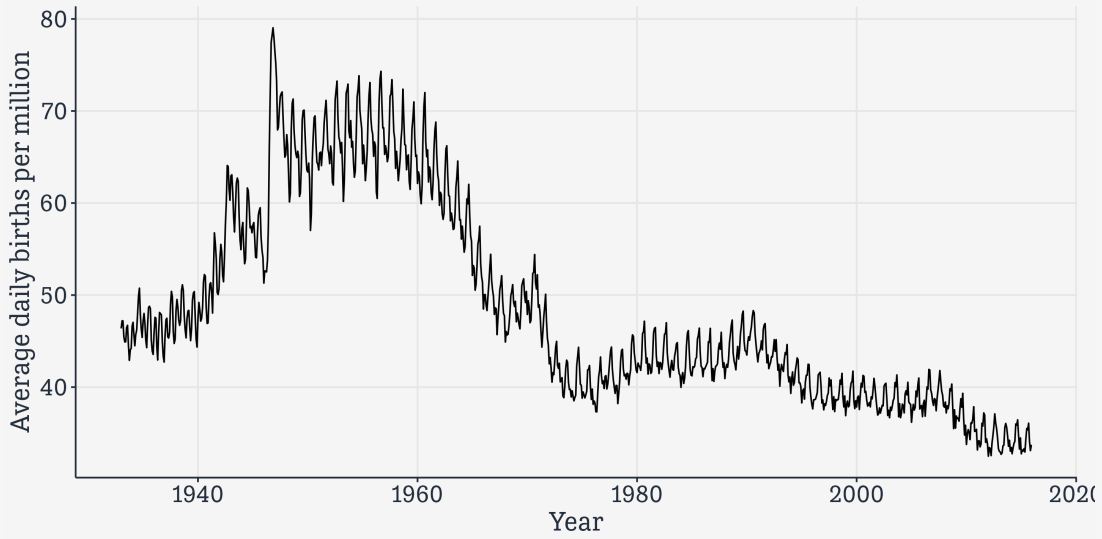
Boomer Line Graph

```
okboomer ▷
    filter(country == "United States")  ▷
    ggplot(aes(x = date, y = births_pct_day)) +
    geom_line(linewidth = 0.5)
```



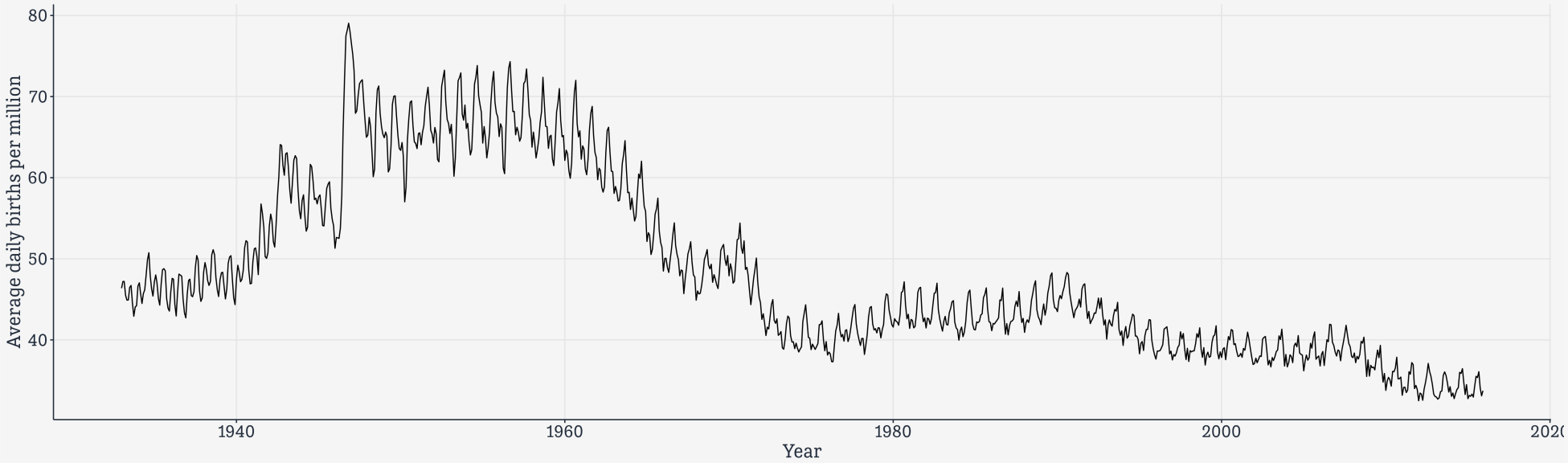
Boomer Line Graph

```
okboomer |>
    filter(country == "United States")  |>
    ggplot(aes(x = date, y = births_pct_day)) +
    geom_line(linewidth = 0.5) +
    labs(x = "Year",
         y = "Average daily births per million")
```



Boomer Line Graph

```
okboomer |>
    filter(country == "United States")  |>
    ggplot(aes(x = date, y = births_pct_day)) +
    geom_line(linewidth = 0.5) +
    labs(x = "Year",
         y = "Average daily births per million") ->
  p_lineboom
```



The Baby Boom.

Tiled Heatmap

```
okboomer
```

```
# A tibble: 1,644 × 12
    year month n_days births total_pop births_pct births_pct_day date
   <dbl> <dbl>  <dbl>  <dbl>     <dbl>      <dbl>          <dbl> <date>
 1  1938     1     31  51820  41215000    0.00126           40.6 1938-01-01
 2  1938     2     28  47421  41215000    0.00115           41.1 1938-02-01
 3  1938     3     31  54887  41215000    0.00133           43.0 1938-03-01
 4  1938     4     30  54623  41215000    0.00133           44.2 1938-04-01
 5  1938     5     31  56853  41215000    0.00138           44.5 1938-05-01
 6  1938     6     30  53145  41215000    0.00129           43.0 1938-06-01
 7  1938     7     31  53214  41215000    0.00129           41.6 1938-07-01
 8  1938     8     31  50444  41215000    0.00122           39.5 1938-08-01
 9  1938     9     30  50545  41215000    0.00123           40.9 1938-09-01
10  1938    10     31  50079  41215000    0.00122           39.2 1938-10-01
# ℹ 1,634 more rows
# ℹ 4 more variables: seasonal <dbl>, trend <dbl>, remainder <dbl>,
#   country <chr>
```

Tiled Heatmap

```
okboomer |>
  filter(country == "United States")
```

```
# A tibble: 996 × 12
    year month n_days births total_pop births_pct births_pct_day date
   <dbl> <dbl>  <dbl>  <dbl>     <dbl>      <dbl>          <dbl> <date>
 1  1933     1     31 180545 125579000    0.00144           46.4 1933-01-01
 2  1933     2     28 165986 125579000    0.00132           47.2 1933-02-01
 3  1933     3     31 183762 125579000    0.00146           47.2 1933-03-01
 4  1933     4     30 171354 125579000    0.00136           45.5 1933-04-01
 5  1933     5     31 174811 125579000    0.00139           44.9 1933-05-01
 6  1933     6     30 169255 125579000    0.00135           44.9 1933-06-01
 7  1933     7     31 180880 125579000    0.00144           46.5 1933-07-01
 8  1933     8     31 181856 125579000    0.00145           46.7 1933-08-01
 9  1933     9     30 167637 125579000    0.00133           44.5 1933-09-01
10  1933    10     31 167055 125579000    0.00133           42.9 1933-10-01
# ℹ 986 more rows
# ℹ 4 more variables: seasonal <dbl>, trend <dbl>, remainder <dbl>,
#   country <chr>
```

Tiled Heatmap

```
okboomer |>
  filter(country == "United States") |>
    mutate(year_fct =
             factor(year,
                    levels = unique(year),
                    ordered = TRUE),
           month_fct = factor(month,
                              levels = rev(c(1:12)),
                              labels = rev(c("Jan", "Feb",
                                  "Mar", "Apr", "May",
                                  "Jun", "Jul", "Aug",
                                  "Sep", "Oct", "Nov", "Dec")),
                              ordered = TRUE))
```

```
# A tibble: 996 × 14
    year month n_days births total_pop births_pct births_pct_day date
   <dbl> <dbl>  <dbl>  <dbl>     <dbl>      <dbl>          <dbl> <date>
 1  1933     1     31 180545 125579000    0.00144           46.4 1933-01-01
 2  1933     2     28 165986 125579000    0.00132           47.2 1933-02-01
 3  1933     3     31 183762 125579000    0.00146           47.2 1933-03-01
 4  1933     4     30 171354 125579000    0.00136           45.5 1933-04-01
 5  1933     5     31 174811 125579000    0.00139           44.9 1933-05-01
 6  1933     6     30 169255 125579000    0.00135           44.9 1933-06-01
 7  1933     7     31 180880 125579000    0.00144           46.5 1933-07-01
 8  1933     8     31 181856 125579000    0.00145           46.7 1933-08-01
 9  1933     9     30 167637 125579000    0.00133           44.5 1933-09-01
10  1933    10     31 167055 125579000    0.00133           42.9 1933-10-01
# ℹ 986 more rows
# ℹ 6 more variables: seasonal <dbl>, trend <dbl>, remainder <dbl>,
#   country <chr>, year_fct <ord>, month_fct <ord>
```

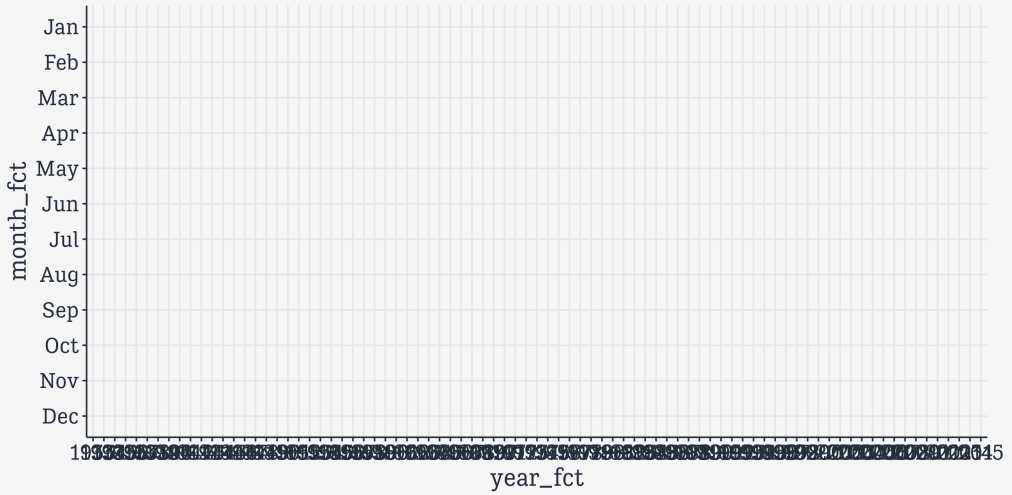
Tiled Heatmap

```
okboomer |>
  filter(country == "United States") |>
    mutate(year_fct =
             factor(year,
                    levels = unique(year),
                    ordered = TRUE),
           month_fct = factor(month,
                              levels = rev(c(1:12)),
                              labels = rev(c("Jan", "Feb",
                                  "Mar", "Apr", "May",
                                  "Jun", "Jul", "Aug",
                                  "Sep", "Oct", "Nov", "Dec")),
                              ordered = TRUE)) |>
    select(year, month, year_fct, month_fct, everything())
```

```
# A tibble: 996 × 14
    year month year_fct month_fct n_days births total_pop births_pct
   <dbl> <dbl> <ord>    <ord>      <dbl>  <dbl>     <dbl>      <dbl>
 1  1933     1 1933     Jan           31 180545 125579000    0.00144
 2  1933     2 1933     Feb           28 165986 125579000    0.00132
 3  1933     3 1933     Mar           31 183762 125579000    0.00146
 4  1933     4 1933     Apr           30 171354 125579000    0.00136
 5  1933     5 1933     May           31 174811 125579000    0.00139
 6  1933     6 1933     Jun           30 169255 125579000    0.00135
 7  1933     7 1933     Jul           31 180880 125579000    0.00144
 8  1933     8 1933     Aug           31 181856 125579000    0.00145
 9  1933     9 1933     Sep           30 167637 125579000    0.00133
10  1933    10 1933     Oct           31 167055 125579000    0.00133
# ℹ 986 more rows
# ℹ 6 more variables: births_pct_day <dbl>, date <date>, seasonal <dbl>,
#   trend <dbl>, remainder <dbl>, country <chr>
```

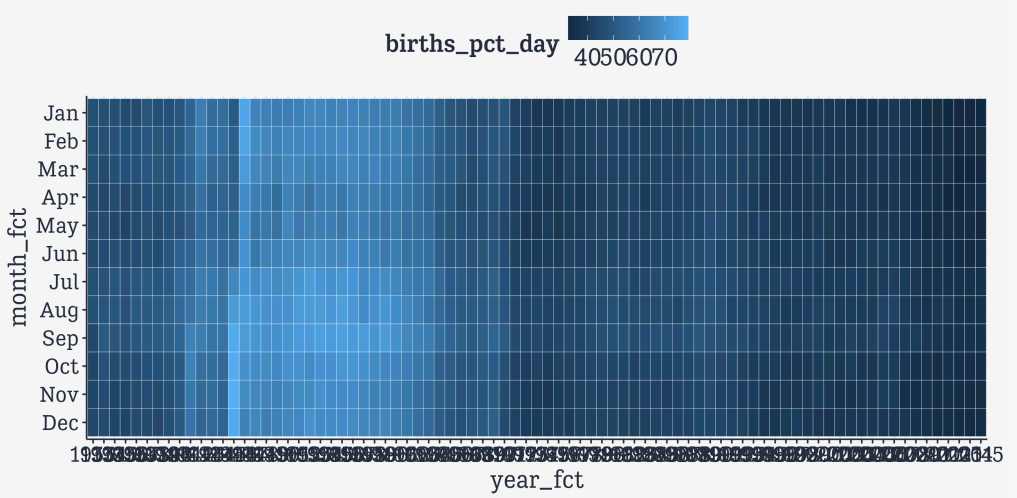
Tiled Heatmap

```
okboomer ▷
  filter(country == "United States") ▷
    mutate(year_fct =
             factor(year,
                    levels = unique(year),
                    ordered = TRUE),
           month_fct = factor(month,
                              levels = rev(c(1:12)),
                              labels = rev(c("Jan", "Feb",
                                  "Mar", "Apr", "May",
                                  "Jun", "Jul", "Aug",
                                  "Sep", "Oct", "Nov", "Dec")),
                              ordered = TRUE)) ▷
    select(year, month, year_fct, month_fct, everything()) ▷
    ggplot(aes(x = year_fct, y = month_fct))
```



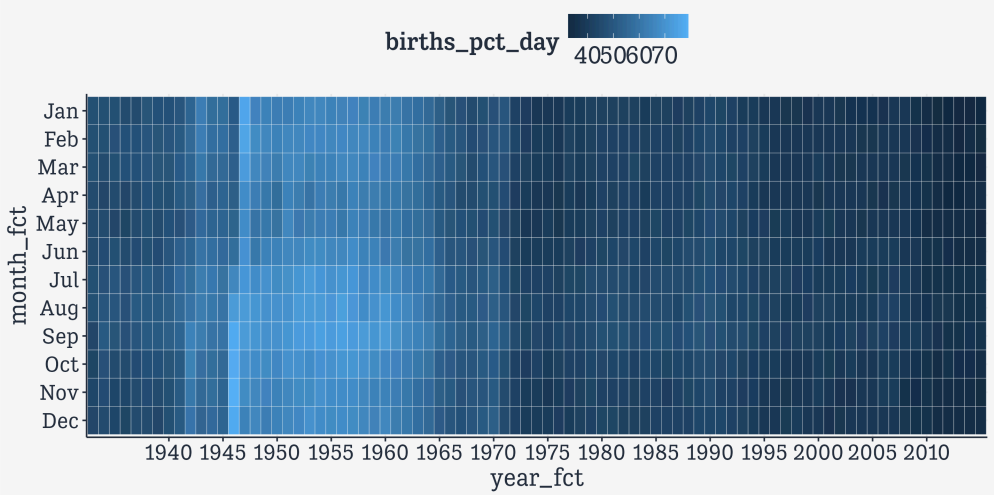
Tiled Heatmap

```
okboomer ▷
  filter(country == "United States") ▷
    mutate(year_fct =
             factor(year,
                    levels = unique(year),
                    ordered = TRUE),
           month_fct = factor(month,
                              levels = rev(c(1:12)),
                              labels = rev(c("Jan", "Feb",
                                  "Mar", "Apr", "May",
                                  "Jun", "Jul", "Aug",
                                  "Sep", "Oct", "Nov", "Dec")),
                              ordered = TRUE)) ▷
    select(year, month, year_fct, month_fct, everything()) ▷
    ggplot(aes(x = year_fct, y = month_fct)) +
    geom_tile(mapping = aes(fill = births_pct_day),
              color = "white")
```



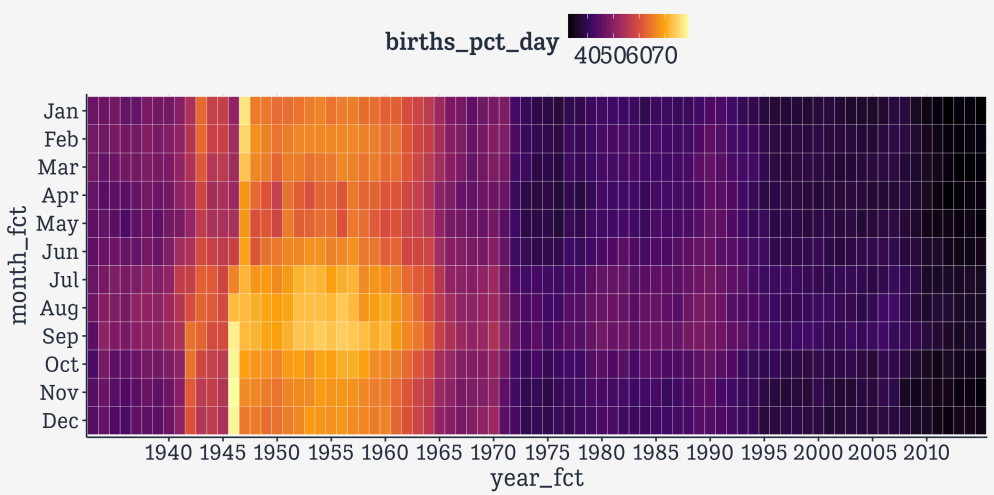
Tiled Heatmap

```
okboomer ▷
  filter(country == "United States") ▷
    mutate(year_fct =
             factor(year,
                    levels = unique(year),
                    ordered = TRUE),
           month_fct = factor(month,
                              levels = rev(c(1:12)),
                              labels = rev(c("Jan", "Feb",
                                  "Mar", "Apr", "May",
                                  "Jun", "Jul", "Aug",
                                  "Sep", "Oct", "Nov", "Dec")),
                              ordered = TRUE)) ▷
    select(year, month, year_fct, month_fct, everything()) ▷
    ggplot(aes(x = year_fct, y = month_fct)) +
    geom_tile(mapping = aes(fill = births_pct_day),
              color = "white") +
   scale_x_discrete(breaks = seq(1940, 2010, 5))
```



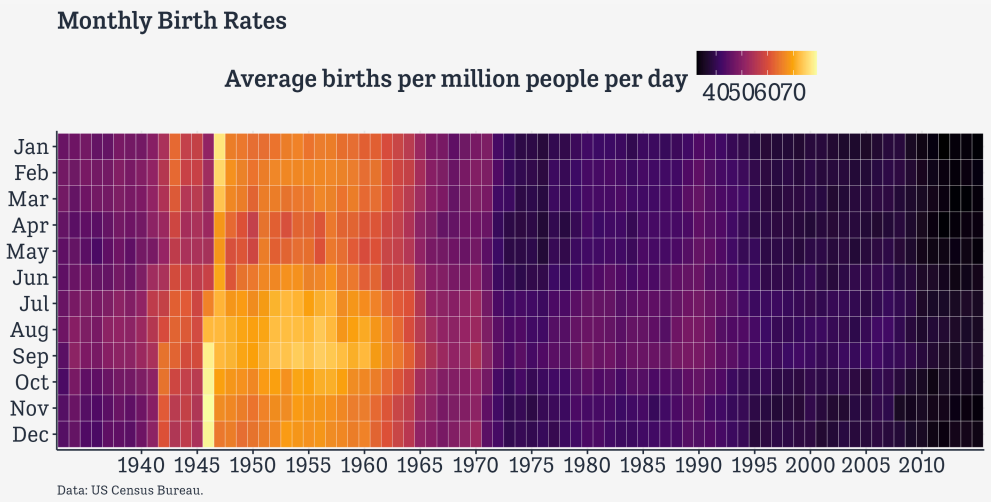
Tiled Heatmap

```
okboomer |>
  filter(country == "United States") |>
    mutate(year_fct =
             factor(year,
                    levels = unique(year),
                    ordered = TRUE),
           month_fct = factor(month,
                              levels = rev(c(1:12)),
                              labels = rev(c("Jan", "Feb",
                                  "Mar", "Apr", "May",
                                  "Jun", "Jul", "Aug",
                                  "Sep", "Oct", "Nov", "Dec")),
                              ordered = TRUE)) |>
    select(year, month, year_fct, month_fct, everything()) |>
    ggplot(aes(x = year_fct, y = month_fct)) +
    geom_tile(mapping = aes(fill = births_pct_day),
              color = "white") +
   scale_x_discrete(breaks = seq(1940, 2010, 5)) +
   scale_fill_viridis_c(option = "B")
```



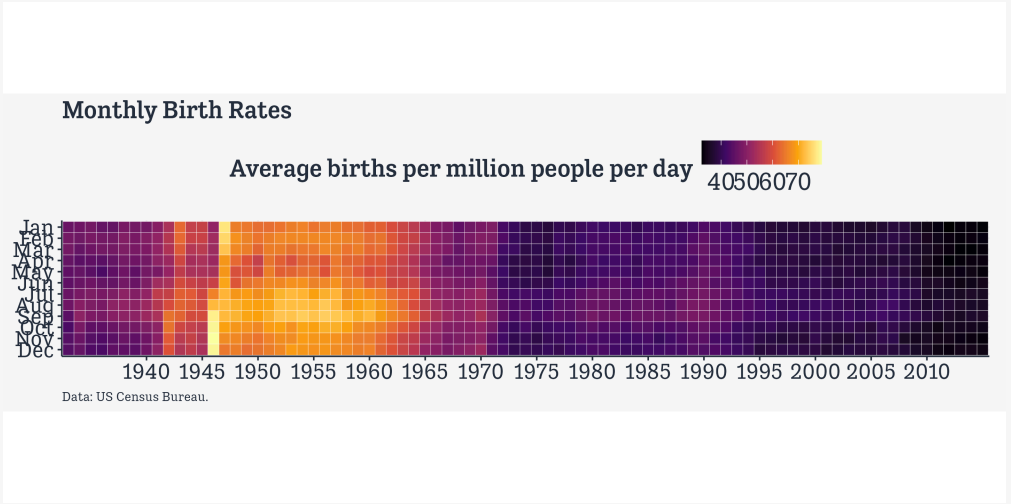
Tiled Heatmap

```
okboomer ▷
  filter(country == "United States") ▷
    mutate(year_fct =
             factor(year,
                    levels = unique(year),
                    ordered = TRUE),
           month_fct = factor(month,
                              levels = rev(c(1:12)),
                              labels = rev(c("Jan", "Feb",
                                  "Mar", "Apr", "May",
                                  "Jun", "Jul", "Aug",
                                  "Sep", "Oct", "Nov", "Dec")),
                              ordered = TRUE)) ▷
    select(year, month, year_fct, month_fct, everything()) ▷
    ggplot(aes(x = year_fct, y = month_fct)) +
    geom_tile(mapping = aes(fill = births_pct_day),
              color = "white") +
   scale_x_discrete(breaks = seq(1940, 2010, 5)) +
   scale_fill_viridis_c(option = "B") +
  labs(x = NULL, y = NULL,
       title = "Monthly Birth Rates",
       fill = "Average births per million people per day",
         caption = "Data: US Census Bureau.")
```



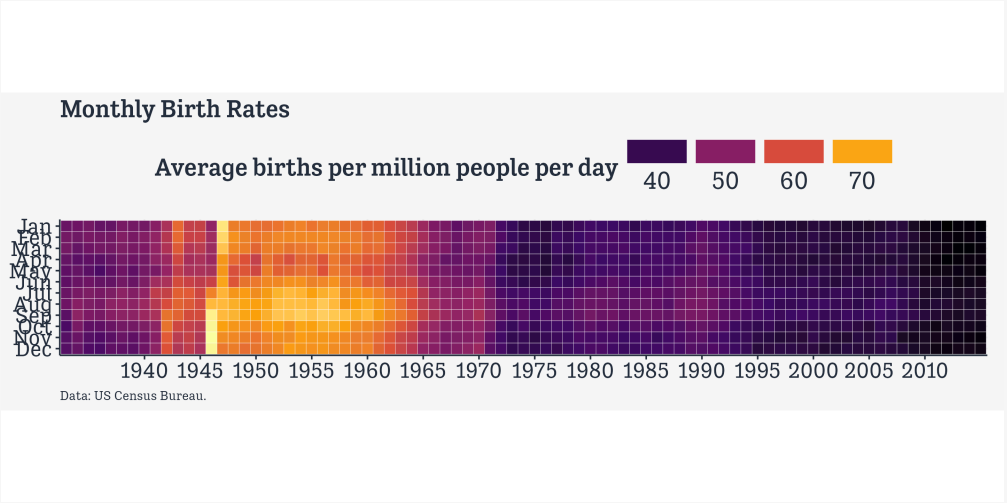
Tiled Heatmap

```
okboomer |>
  filter(country == "United States") |>
    mutate(year_fct =
             factor(year,
                    levels = unique(year),
                    ordered = TRUE),
           month_fct = factor(month,
                              levels = rev(c(1:12)),
                              labels = rev(c("Jan", "Feb",
                                  "Mar", "Apr", "May",
                                  "Jun", "Jul", "Aug",
                                  "Sep", "Oct", "Nov", "Dec")),
                              ordered = TRUE)) |>
    select(year, month, year_fct, month_fct, everything()) |>
    ggplot(aes(x = year_fct, y = month_fct)) +
    geom_tile(mapping = aes(fill = births_pct_day),
              color = "white") +
   scale_x_discrete(breaks = seq(1940, 2010, 5)) +
   scale_fill_viridis_c(option = "B") +
  labs(x = NULL, y = NULL,
       title = "Monthly Birth Rates",
       fill = "Average births per million people per day",
         caption = "Data: US Census Bureau.") +
  coord_fixed()
```



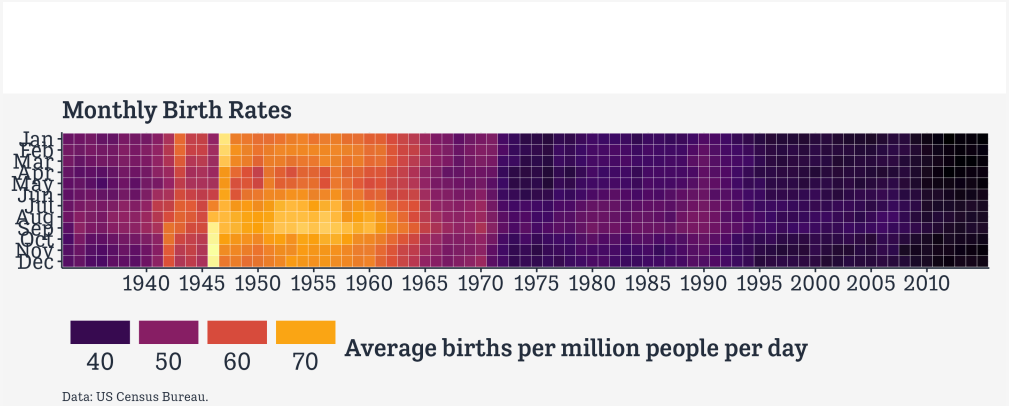
Tiled Heatmap

```
okboomer ▷
  filter(country == "United States") ▷
    mutate(year_fct =
             factor(year,
                    levels = unique(year),
                    ordered = TRUE),
           month_fct = factor(month,
                              levels = rev(c(1:12)),
                              labels = rev(c("Jan", "Feb",
                                  "Mar", "Apr", "May",
                                  "Jun", "Jul", "Aug",
                                  "Sep", "Oct", "Nov", "Dec")),
                              ordered = TRUE)) ▷
    select(year, month, year_fct, month_fct, everything()) ▷
    ggplot(aes(x = year_fct, y = month_fct)) +
    geom_tile(mapping = aes(fill = births_pct_day),
              color = "white") +
   scale_x_discrete(breaks = seq(1940, 2010, 5)) +
   scale_fill_viridis_c(option = "B") +
  labs(x = NULL, y = NULL,
       title = "Monthly Birth Rates",
       fill = "Average births per million people per day",
         caption = "Data: US Census Bureau.") +
  coord_fixed() +
  guides(fill = guide_legend(keywidth = 3,
                     label.position = "bottom"))
```



Tiled Heatmap

```
okboomer ▷
  filter(country == "United States") ▷
    mutate(year_fct =
             factor(year,
                    levels = unique(year),
                    ordered = TRUE),
           month_fct = factor(month,
                              levels = rev(c(1:12)),
                              labels = rev(c("Jan", "Feb",
                                  "Mar", "Apr", "May",
                                  "Jun", "Jul", "Aug",
                                  "Sep", "Oct", "Nov", "Dec")),
                              ordered = TRUE)) ▷
    select(year, month, year_fct, month_fct, everything()) ▷
    ggplot(aes(x = year_fct, y = month_fct)) +
    geom_tile(mapping = aes(fill = births_pct_day),
              color = "white") +
   scale_x_discrete(breaks = seq(1940, 2010, 5)) +
   scale_fill_viridis_c(option = "B") +
  labs(x = NULL, y = NULL,
       title = "Monthly Birth Rates",
       fill = "Average births per million people per day",
         caption = "Data: US Census Bureau.") +
  coord_fixed() +
  guides(fill = guide_legend(keywidth = 3,
                     label.position = "bottom")) +
  theme(legend.position = "bottom",
        legend.title.position = "right",
        legend.justification = "left")
```

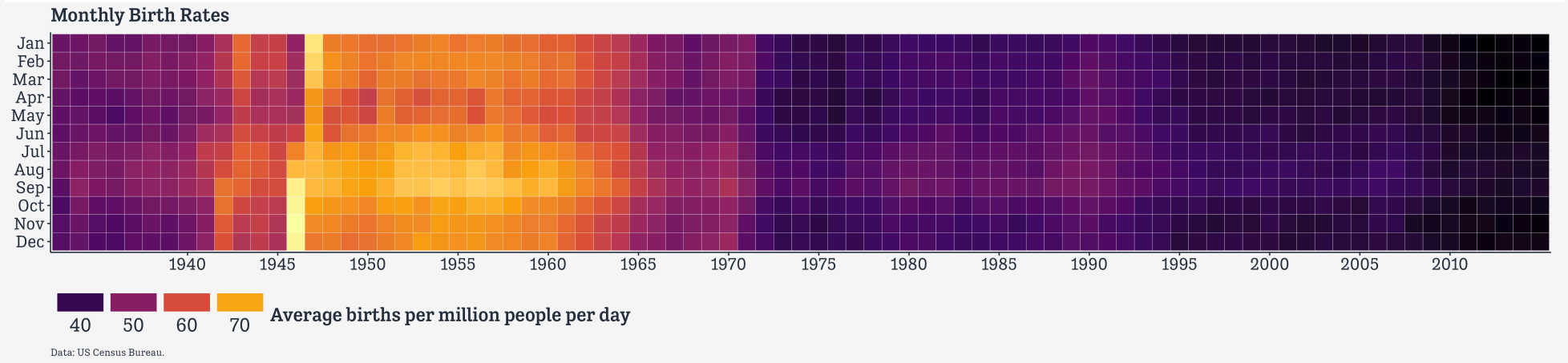


Tiled Heatmap

```
okboomer ▷
  filter(country == "United States") ▷
    mutate(year_fct =
             factor(year,
                    levels = unique(year),
                    ordered = TRUE),
           month_fct = factor(month,
                              levels = rev(c(1:12)),
                              labels = rev(c("Jan", "Feb",
                                  "Mar", "Apr", "May",
                                  "Jun", "Jul", "Aug",
                                  "Sep", "Oct", "Nov", "Dec")),
                              ordered = TRUE)) ▷
    select(year, month, year_fct, month_fct, everything()) ▷
    ggplot(aes(x = year_fct, y = month_fct)) +
    geom_tile(mapping = aes(fill = births_pct_day),
              color = "white") +
   scale_x_discrete(breaks = seq(1940, 2010, 5)) +
   scale_fill_viridis_c(option = "B") +
  labs(x = NULL, y = NULL,
       title = "Monthly Birth Rates",
       fill = "Average births per million people per day",
         caption = "Data: US Census Bureau.") +
  coord_fixed() +
  guides(fill = guide_legend(keywidth = 3,
                     label.position = "bottom")) +
  theme(legend.position = "bottom",
        legend.title.position = "right",
        legend.justification = "left") →
  p_tileboom
```

Tiled Heatmap

```
okboomer ▷
  filter(country == "United States") ▷
    mutate(year_fct =
             factor(year,
                    levels = unique(year),
                    ordered = TRUE),
           month_fct = factor(month,
                              levels = rev(c(1:12)),
                              labels = rev(c("Jan", "Feb",
                                  "Mar", "Apr", "May",
                                  "Jun", "Jul", "Aug",
                                  "Sep", "Oct", "Nov", "Dec")),
                              ordered = TRUE)) ▷
    select(year, month, year_fct, month_fct, everything()) ▷
    ggplot(aes(x = year_fct, y = month_fct)) +
    geom_tile(mapping = aes(fill = births_pct_day),
              color = "white") +
   scale_x_discrete(breaks = seq(1940, 2010, 5)) +
   scale_fill_viridis_c(option = "B") +
  labs(x = NULL, y = NULL,
       title = "Monthly Birth Rates",
       fill = "Average births per million people per day",
         caption = "Data: US Census Bureau.") +
  coord_fixed() +
  guides(fill = guide_legend(keywidth = 3,
                     label.position = "bottom")) +
  theme(legend.position = "bottom",
        legend.title.position = "right",
        legend.justification = "left") →
  p_tileboom
```



The Baby Boom as a tiled temporal heatmap

Beeswarms and bespoke labels

The cavax package

```
# remotes::install_github("kjhealy/cavax)
library(cavax)

cavax
```

```
# A tibble: 7,032 × 13
     code county name  type  district city  enrollment pbe_pct exempt med_exempt
    <dbl> <chr>  <chr> <chr> <chr>    <chr>       <dbl>   <dbl>  <dbl>      <dbl>
 1 1.10e5 ALAME… FAME… PUBL… ALAMEDA… NEWA…        109      13  12.8         0
 2 6.00e6 ALAME… COX … PUBL… ALAMEDA… OAKL…        115       1   0.87        0.87
 3 6.00e6 ALAME… LAZE… PUBL… ALAMEDA… OAKL…         40       0   0           0
 4 1.24e5 ALAME… YU M… PUBL… ALAMEDA… OAKL…         52      10   9.62        0
 5 6.10e6 ALAME… AMEL… PUBL… ALAMEDA… ALAM…        128       2   1.56        0
 6 6.11e6 ALAME… BAY … PUBL… ALAMEDA… ALAM…         70       1   1.43        0
 7 6.09e6 ALAME… DONA… PUBL… ALAMEDA… ALAM…        100       3   3           0
 8 6.09e6 ALAME… EDIS… PUBL… ALAMEDA… ALAM…         70       1   1.43        0
 9 6.09e6 ALAME… FRAN… PUBL… ALAMEDA… ALAM…         95       1   1.05        1.05
10 6.09e6 ALAME… FRAN… PUBL… ALAMEDA… ALAM…         50       2   2           0
# ℹ 7,022 more rows
# ℹ 3 more variables: rel_exempt <dbl>, mwc <fct>, kind <fct>
```

Here we will do some custom manual labeling.

Aux Info Panel

```
library(ggbeeswarm)
```

Aux Info Panel

```
library(ggbeeswarm)
make_comma ← scales::label_comma()
```

Aux Info Panel

```
library(ggbeeswarm)
make_comma ← scales::label_comma()

cavax
```

```
# A tibble: 7,032 × 13
     code county name  type  district city  enrollment pbe_pct exempt
med_exempt
    <dbl> <chr>  <chr> <chr> <chr>    <chr>       <dbl>   <dbl>  <dbl>
<dbl>
 1 1.10e5 ALAME… FAME… PUBL… ALAMEDA… NEWA…         109      13  12.8         0
 2 6.00e6 ALAME… COX … PUBL… ALAMEDA… OAKL…         115       1   0.87
0.87
 3 6.00e6 ALAME… LAZE… PUBL… ALAMEDA… OAKL…          40       0   0           0
 4 1.24e5 ALAME… YU M… PUBL… ALAMEDA… OAKL…          52      10   9.62        0
 5 6.10e6 ALAME… AMEL… PUBL… ALAMEDA… ALAM…         128       2   1.56        0
 6 6.11e6 ALAME… BAY … PUBL… ALAMEDA… ALAM…          70       1   1.43        0
 7 6.09e6 ALAME… DONA… PUBL… ALAMEDA… ALAM…         100       3   3           0
 8 6.09e6 ALAME… EDIS… PUBL… ALAMEDA… ALAM…          70       1   1.43        0
 9 6.09e6 ALAME… FRAN… PUBL… ALAMEDA… ALAM…          95       1   1.05
1.05
10 6.09e6 ALAME… FRAN… PUBL… ALAMEDA… ALAM…          50       2   2           0
# ℹ 7,022 more rows
# ℹ 3 more variables: rel_exempt <dbl>, mwc <fct>, kind <fct>
```

Aux Info Panel

```
library(ggbeeswarm)
make_comma ← scales::label_comma()

cavax ▷
  group_by(mwc)
```

```
# A tibble: 7,032 × 13
# Groups:   mwc [11]
     code county name  type  district city  enrollment pbe_pct exempt
med_exempt
    <dbl> <chr>  <chr> <chr> <chr>    <chr>       <dbl>   <dbl>  <dbl>
<dbl>
 1 1.10e5 ALAME… FAME… PUBL… ALAMEDA… NEWA…         109      13  12.8         0
 2 6.00e6 ALAME… COX … PUBL… ALAMEDA… OAKL…         115       1   0.87
0.87
 3 6.00e6 ALAME… LAZE… PUBL… ALAMEDA… OAKL…          40       0   0           0
 4 1.24e5 ALAME… YU M… PUBL… ALAMEDA… OAKL…          52      10   9.62        0
 5 6.10e6 ALAME… AMEL… PUBL… ALAMEDA… ALAM…         128       2   1.56        0
 6 6.11e6 ALAME… BAY … PUBL… ALAMEDA… ALAM…          70       1   1.43        0
 7 6.09e6 ALAME… DONA… PUBL… ALAMEDA… ALAM…         100       3   3           0
 8 6.09e6 ALAME… EDIS… PUBL… ALAMEDA… ALAM…          70       1   1.43        0
 9 6.09e6 ALAME… FRAN… PUBL… ALAMEDA… ALAM…          95       1   1.05
1.05
10 6.09e6 ALAME… FRAN… PUBL… ALAMEDA… ALAM…          50       2   2           0
# ℹ 7,022 more rows
# ℹ 3 more variables: rel_exempt <dbl>, mwc <fct>, kind <fct>
```

Aux Info Panel

```
library(ggbeeswarm)
make_comma ← scales::label_comma()

cavax ▷
  group_by(mwc) ▷
  summarize(n_schools=n(),
            n_students = sum(enrollment, na.rm=TRUE))
```

```
# A tibble: 11 × 3
   mwc                          n_schools n_students
   <fct>                            <int>      <dbl>
 1 Public                            5314     472802
 2 Charter                            314      19863
 3 Private Non-Specific               591      16697
 4 Private Christian                  336       8836
 5 Private Catholic                   334       9869
 6 Private Montessori                  99       2112
 7 Private Waldorf                     16        513
 8 Charter Montessori                   5        227
 9 Public Montessori                   11        706
10 Private Christian Montessori         4         78
11 Private Jewish/Islamic               8        237
```

Aux Info Panel

```
library(ggbeeswarm)
make_comma ← scales::label_comma()

cavax ▷
  group_by(mwc) ▷
  summarize(n_schools=n(),
            n_students = sum(enrollment, na.rm=TRUE)) ▷
  drop_na()
```

```
# A tibble: 11 × 3
   mwc                          n_schools n_students
   <fct>                            <int>      <dbl>
 1 Public                            5314     472802
 2 Charter                            314      19863
 3 Private Non-Specific               591      16697
 4 Private Christian                  336       8836
 5 Private Catholic                   334       9869
 6 Private Montessori                  99       2112
 7 Private Waldorf                     16        513
 8 Charter Montessori                   5        227
 9 Public Montessori                   11        706
10 Private Christian Montessori         4         78
11 Private Jewish/Islamic               8        237
```

Aux Info Panel

```
library(ggbeeswarm)
make_comma ← scales::label_comma()

cavax ▷
  group_by(mwc) ▷
  summarize(n_schools=n(),
            n_students = sum(enrollment, na.rm=TRUE)) ▷
  drop_na() ▷
  mutate(n_schools_fmt = make_comma(n_schools),
         n_students_fmt = make_comma(n_students),
         info_schools = paste(n_schools_fmt, "Schools Enrolling")
         info_students = paste(n_students_fmt, "Kindergarteners")
```

```
# A tibble: 11 × 7
   mwc            n_schools n_students n_schools_fmt n_students_fmt
info_schools
   <fct>              <int>      <dbl> <chr>         <chr>          <chr>
 1 Public              5314     472802 5,314         472,802        5,314
Schoo…
 2 Charter              314      19863 314           19,863         314
Schools…
 3 Private Non-S…       591      16697 591           16,697         591
Schools…
 4 Private Chris…       336       8836 336           8,836          336
Schools…
 5 Private Catho…       334       9869 334           9,869          334
Schools…
 6 Private Monte…        99       2112 99            2,112          99 Schools
…
 7 Private Waldo…        16        513 16            513            16 Schools
…
 8 Charter Monte…         5        227 5             227            5 Schools
E…
 9 Public Montes…        11        706 11            706            11 Schools
…
10 Private Chris…         4         78 4             78             4 Schools
E…
11 Private Jewis…         8        237 8             237            8 Schools
```

Aux Info Panel

```
library(ggbeeswarm)
make_comma ← scales::label_comma()

cavax ▷
  group_by(mwc) ▷
  summarize(n_schools=n(),
            n_students = sum(enrollment, na.rm=TRUE)) ▷
  drop_na() ▷
  mutate(n_schools_fmt = make_comma(n_schools),
         n_students_fmt = make_comma(n_students),
         info_schools = paste(n_schools_fmt, "Schools Enrolling")
         info_students = paste(n_students_fmt, "Kindergarteners")
  aux_info
```

A little kludge

```
## This is not an efficient way to do this
aux_info
```

```
# A tibble: 11 × 7
   mwc            n_schools n_students n_schools_fmt n_students_fmt
info_schools
   <fct>              <int>      <dbl> <chr>         <chr>
<chr>
 1 Public              5314     472802 5,314         472,802
5,314 Schoo…
 2 Charter              314      19863 314           19,863         314
Schools…
 3 Private Non-S…       591      16697 591           16,697         591
Schools…
 4 Private Chris…       336       8836 336           8,836          336
Schools…
 5 Private Catho…       334       9869 334           9,869          334
Schools…
 6 Private Monte…        99       2112 99            2,112          99
Schools …
 7 Private Waldo…        16        513 16            513            16
Schools …
 8 Charter Monte…         5        227 5             227            5
Schools E…
 9 Public Montes…        11        706 11            706            11
Schools …
10 Private Chris…         4         78 4             78             4
Schools E…
```

A little kludge

```
## This is not an efficient way to do this
aux_info ▷
  select(mwc, info_schools, info_students)
```

```
# A tibble: 11 × 3
   mwc                          info_schools            info_students
   <fct>                        <chr>                   <chr>
 1 Public                       5,314 Schools Enrolling 472,802
Kindergarteners
 2 Charter                      314 Schools Enrolling   19,863
Kindergarteners
 3 Private Non-Specific         591 Schools Enrolling   16,697
Kindergarteners
 4 Private Christian            336 Schools Enrolling   8,836
Kindergarteners
 5 Private Catholic             334 Schools Enrolling   9,869
Kindergarteners
 6 Private Montessori           99 Schools Enrolling    2,112
Kindergarteners
 7 Private Waldorf              16 Schools Enrolling    513
Kindergarteners
 8 Charter Montessori           5 Schools Enrolling     227
Kindergarteners
 9 Public Montessori            11 Schools Enrolling    706
Kindergarteners
10 Private Christian Montessori 4 Schools Enrolling     78
Kindergarteners
11 Private Jewish/Islamic       8 Schools Enrolling     237
Kindergarteners
```

A little kludge

```
## This is not an efficient way to do this
aux_info ▷
  select(mwc, info_schools, info_students) ▷
  mutate(across(everything(), as.character))
```

```
# A tibble: 11 × 3
   mwc                          info_schools            info_students
   <chr>                        <chr>                   <chr>
 1 Public                       5,314 Schools Enrolling 472,802
Kindergarteners
 2 Charter                      314 Schools Enrolling   19,863
Kindergarteners
 3 Private Non-Specific         591 Schools Enrolling   16,697
Kindergarteners
 4 Private Christian            336 Schools Enrolling   8,836
Kindergarteners
 5 Private Catholic             334 Schools Enrolling   9,869
Kindergarteners
 6 Private Montessori           99 Schools Enrolling    2,112
Kindergarteners
 7 Private Waldorf              16 Schools Enrolling    513
Kindergarteners
 8 Charter Montessori           5 Schools Enrolling     227
Kindergarteners
 9 Public Montessori            11 Schools Enrolling    706
Kindergarteners
10 Private Christian Montessori 4 Schools Enrolling     78
Kindergarteners
11 Private Jewish/Islamic       8 Schools Enrolling     237
Kindergarteners
```

A little kludge

```
## This is not an efficient way to do this
aux_info ▷
  select(mwc, info_schools, info_students) ▷
  mutate(across(everything(), as.character)) ▷
  group_by(mwc)
```

```
# A tibble: 11 × 3
# Groups:   mwc [11]
   mwc                          info_schools            info_students
   <chr>                        <chr>                   <chr>
 1 Public                       5,314 Schools Enrolling 472,802
Kindergarteners
 2 Charter                      314 Schools Enrolling   19,863
Kindergarteners
 3 Private Non-Specific         591 Schools Enrolling   16,697
Kindergarteners
 4 Private Christian            336 Schools Enrolling   8,836
Kindergarteners
 5 Private Catholic             334 Schools Enrolling   9,869
Kindergarteners
 6 Private Montessori           99 Schools Enrolling    2,112
Kindergarteners
 7 Private Waldorf              16 Schools Enrolling    513
Kindergarteners
 8 Charter Montessori           5 Schools Enrolling     227
Kindergarteners
 9 Public Montessori            11 Schools Enrolling    706
Kindergarteners
10 Private Christian Montessori 4 Schools Enrolling     78
Kindergarteners
11 Private Jewish/Islamic       8 Schools Enrolling     237
```

A little kludge

```
## This is not an efficient way to do this
aux_info ▷
  select(mwc, info_schools, info_students) ▷
  mutate(across(everything(), as.character)) ▷
  group_by(mwc) ▷
  group_keys()
```

```
# A tibble: 11 × 1
   mwc
   <chr>
 1 Charter
 2 Charter Montessori
 3 Private Catholic
 4 Private Christian
 5 Private Christian Montessori
 6 Private Jewish/Islamic
 7 Private Montessori
 8 Private Non-Specific
 9 Private Waldorf
10 Public
11 Public Montessori
```

A little kludge

```
## This is not an efficient way to do this
aux_info ▷
  select(mwc, info_schools, info_students) ▷
  mutate(across(everything(), as.character)) ▷
  group_by(mwc) ▷
  group_keys() ▷
  pull()
```

```
 [1] "Charter"                      "Charter Montessori"
 [3] "Private Catholic"             "Private Christian"
 [5] "Private Christian Montessori" "Private Jewish/Islamic"
 [7] "Private Montessori"           "Private Non-Specific"
 [9] "Private Waldorf"              "Public"
[11] "Public Montessori"
```

A little kludge

```
## This is not an efficient way to do this
aux_info ▷
  select(mwc, info_schools, info_students) ▷
  mutate(across(everything(), as.character)) ▷
  group_by(mwc) ▷
  group_keys() ▷
  pull() ▷
  as.character()
```

```
 [1] "Charter"                      "Charter Montessori"
 [3] "Private Catholic"             "Private Christian"
 [5] "Private Christian Montessori" "Private Jewish/Islamic"
 [7] "Private Montessori"           "Private Non-Specific"
 [9] "Private Waldorf"              "Public"
[11] "Public Montessori"
```

A little kludge

```
## This is not an efficient way to do this
aux_info ▷
  select(mwc, info_schools, info_students) ▷
  mutate(across(everything(), as.character)) ▷
  group_by(mwc) ▷
  group_keys() ▷
  pull() ▷
  as.character() →
  keys
```

A little kludge

```
## This is not an efficient way to do this
aux_info ▷
  select(mwc, info_schools, info_students) ▷
  mutate(across(everything(), as.character)) ▷
  group_by(mwc) ▷
  group_keys() ▷
  pull() ▷
  as.character() →
  keys

aux_info
```

```
# A tibble: 11 × 7
   mwc            n_schools n_students n_schools_fmt n_students_fmt
info_schools
   <fct>              <int>      <dbl> <chr>         <chr>
<chr>
 1 Public              5314     472802 5,314         472,802
5,314 Schoo…
 2 Charter              314      19863 314           19,863         314
Schools…
 3 Private Non-S…       591      16697 591           16,697         591
Schools…
 4 Private Chris…       336       8836 336           8,836          336
Schools…
 5 Private Catho…       334       9869 334           9,869          334
Schools…
 6 Private Monte…        99       2112 99            2,112          99
Schools …
 7 Private Waldo…        16        513 16            513            16
Schools …
 8 Charter Monte…         5        227 5             227            5
Schools E…
 9 Public Montes…        11        706 11            706            11
Schools …
10 Private Chris…         4         78 4             78             4
Schools E…
```

A little kludge

```
## This is not an efficient way to do this
aux_info |>
  select(mwc, info_schools, info_students) |>
  mutate(across(everything(), as.character)) |>
  group_by(mwc) |>
  group_keys() |>
  pull() |>
  as.character() ->
  keys

aux_info |>
  select(mwc, info_schools, info_students)
```

```
# A tibble: 11 × 3
   mwc                          info_schools            info_students
   <fct>                        <chr>                   <chr>
 1 Public                       5,314 Schools Enrolling 472,802
Kindergarteners
 2 Charter                      314 Schools Enrolling   19,863
Kindergarteners
 3 Private Non-Specific         591 Schools Enrolling   16,697
Kindergarteners
 4 Private Christian            336 Schools Enrolling   8,836
Kindergarteners
 5 Private Catholic             334 Schools Enrolling   9,869
Kindergarteners
 6 Private Montessori           99 Schools Enrolling    2,112
Kindergarteners
 7 Private Waldorf              16 Schools Enrolling    513
Kindergarteners
 8 Charter Montessori           5 Schools Enrolling     227
Kindergarteners
 9 Public Montessori            11 Schools Enrolling    706
Kindergarteners
10 Private Christian Montessori 4 Schools Enrolling     78
Kindergarteners
11 Private Jewish/Islamic       8 Schools Enrolling     237
Kindergarteners
```

A little kludge

```
## This is not an efficient way to do this
aux_info |>
  select(mwc, info_schools, info_students) |>
  mutate(across(everything(), as.character)) |>
  group_by(mwc) |>
  group_keys() |>
  pull() |>
  as.character() ->
  keys

aux_info |>
  select(mwc, info_schools, info_students) |>
  mutate(across(everything(), as.character))
```

```
# A tibble: 11 × 3
   mwc                           info_schools            info_students
   <chr>                         <chr>                   <chr>
 1 Public                        5,314 Schools Enrolling 472,802
Kindergarteners
 2 Charter                       314 Schools Enrolling   19,863
Kindergarteners
 3 Private Non-Specific          591 Schools Enrolling   16,697
Kindergarteners
 4 Private Christian             336 Schools Enrolling   8,836
Kindergarteners
 5 Private Catholic              334 Schools Enrolling   9,869
Kindergarteners
 6 Private Montessori            99 Schools Enrolling    2,112
Kindergarteners
 7 Private Waldorf               16 Schools Enrolling    513
Kindergarteners
 8 Charter Montessori            5 Schools Enrolling     227
Kindergarteners
 9 Public Montessori             11 Schools Enrolling    706
Kindergarteners
10 Private Christian Montessori 4 Schools Enrolling     78
Kindergarteners
11 Private Jewish/Islamic        8 Schools Enrolling     237
Kindergarteners
```

A little kludge

```
## This is not an efficient way to do this
aux_info ▷
  select(mwc, info_schools, info_students) ▷
  mutate(across(everything(), as.character)) ▷
  group_by(mwc) ▷
  group_keys() ▷
  pull() ▷
  as.character() →
  keys

aux_info ▷
  select(mwc, info_schools, info_students) ▷
  mutate(across(everything(), as.character)) ▷
  group_split(mwc)
```

```
<list_of<
  tbl_df<
    mwc          : character
    info_schools : character
    info_students: character
  >
>[11]>
[[1]]
# A tibble: 1 × 3
  mwc     info_schools          info_students
  <chr>   <chr>                 <chr>
1 Charter 314 Schools Enrolling 19,863 Kindergarteners

[[2]]
# A tibble: 1 × 3
  mwc                info_schools        info_students
  <chr>              <chr>               <chr>
1 Charter Montessori 5 Schools Enrolling 227 Kindergarteners

[[3]]
# A tibble: 1 × 3
  mwc              info_schools          info_students
  <chr>            <chr>                 <chr>
1 Private Catholic 334 Schools Enrolling 9,869 Kindergarteners
```

A little kludge

```
## This is not an efficient way to do this
aux_info |>
  select(mwc, info_schools, info_students) |>
  mutate(across(everything(), as.character)) |>
  group_by(mwc) |>
  group_keys() |>
  pull() |>
  as.character() ->
  keys

aux_info |>
  select(mwc, info_schools, info_students) |>
  mutate(across(everything(), as.character)) |>
  group_split(mwc) |>
  set_names(keys)   # There's a better way ...
```

```
<list_of<
  tbl_df<
    mwc          : character
    info_schools : character
    info_students: character
  >
>[11]>
$Charter
# A tibble: 1 × 3
  mwc     info_schools          info_students
  <chr>   <chr>                 <chr>
1 Charter 314 Schools Enrolling 19,863 Kindergarteners

$`Charter Montessori`
# A tibble: 1 × 3
  mwc                info_schools        info_students
  <chr>              <chr>               <chr>
1 Charter Montessori 5 Schools Enrolling 227 Kindergarteners

$`Private Catholic`
# A tibble: 1 × 3
  mwc              info_schools          info_students
  <chr>            <chr>                 <chr>
1 Private Catholic 334 Schools Enrolling 9,869 Kindergarteners
```

A little kludge

```
## This is not an efficient way to do this
aux_info |>
  select(mwc, info_schools, info_students) |>
  mutate(across(everything(), as.character)) |>
  group_by(mwc) |>
  group_keys() |>
  pull() |>
  as.character() ->
  keys

aux_info |>
  select(mwc, info_schools, info_students) |>
  mutate(across(everything(), as.character)) |>
  group_split(mwc) |>
  set_names(keys) |>  # There's a better way ...
  map_chr(.f = paste, sep = "", collapse = "\n")
```

```
                                                                    Charter
                "Charter\n314 Schools Enrolling\n19,863 Kindergarteners"
                                                           Charter Montessori
          "Charter Montessori\n5 Schools Enrolling\n227 Kindergarteners"
                                                            Private Catholic
        "Private Catholic\n334 Schools Enrolling\n9,869 Kindergarteners"
                                                          Private Christian
       "Private Christian\n336 Schools Enrolling\n8,836 Kindergarteners"
                                                  Private Christian Montessori
"Private Christian Montessori\n4 Schools Enrolling\n78 Kindergarteners"
                                                       Private Jewish/Islamic
      "Private Jewish/Islamic\n8 Schools Enrolling\n237 Kindergarteners"
                                                           Private Montessori
       "Private Montessori\n99 Schools Enrolling\n2,112 Kindergarteners"
                                                       Private Non-Specific
  "Private Non-Specific\n591 Schools Enrolling\n16,697 Kindergarteners"
                                                            Private Waldorf
           "Private Waldorf\n16 Schools Enrolling\n513 Kindergarteners"
                                                                     Public
              "Public\n5,314 Schools Enrolling\n472,802 Kindergarteners"
                                                          Public Montessori
          "Public Montessori\n11 Schools Enrolling\n706 Kindergarteners"
```

A little kludge

```
## This is not an efficient way to do this
aux_info ▷
  select(mwc, info_schools, info_students) ▷
  mutate(across(everything(), as.character)) ▷
  group_by(mwc) ▷
  group_keys() ▷
  pull() ▷
  as.character() →
  keys

aux_info ▷
  select(mwc, info_schools, info_students) ▷
  mutate(across(everything(), as.character)) ▷
  group_split(mwc) ▷
  set_names(keys) ▷   # There's a better way ...
  map_chr(.f = paste, sep = "", collapse = "\n") →
  special_x_labs
```

A little kludge

```
## This is not an efficient way to do this
aux_info ▷
  select(mwc, info_schools, info_students) ▷
  mutate(across(everything(), as.character)) ▷
  group_by(mwc) ▷
  group_keys() ▷
  pull() ▷
  as.character() →
  keys

aux_info ▷
  select(mwc, info_schools, info_students) ▷
  mutate(across(everything(), as.character)) ▷
  group_split(mwc) ▷
  set_names(keys) ▷   # There's a better way ...
  map_chr(.f = paste, sep = "", collapse = "\n") →
  special_x_labs
```

At last, the Beeplot

```
cavax
```

```
# A tibble: 7,032 × 13
     code county name  type  district city  enrollment pbe_pct exempt
med_exempt
    <dbl> <chr>  <chr> <chr> <chr>    <chr>       <dbl>   <dbl>  <dbl>
<dbl>
 1 1.10e5 ALAME… FAME… PUBL… ALAMEDA… NEWA…        109      13  12.8
0
 2 6.00e6 ALAME… COX … PUBL… ALAMEDA… OAKL…        115       1   0.87
0.87
 3 6.00e6 ALAME… LAZE… PUBL… ALAMEDA… OAKL…         40       0   0
0
 4 1.24e5 ALAME… YU M… PUBL… ALAMEDA… OAKL…         52      10   9.62
0
 5 6.10e6 ALAME… AMEL… PUBL… ALAMEDA… ALAM…        128       2   1.56
0
 6 6.11e6 ALAME… BAY … PUBL… ALAMEDA… ALAM…         70       1   1.43
0
 7 6.09e6 ALAME… DONA… PUBL… ALAMEDA… ALAM…        100       3   3
0
 8 6.09e6 ALAME… EDIS… PUBL… ALAMEDA… ALAM…         70       1   1.43
0
 9 6.09e6 ALAME… FRAN… PUBL… ALAMEDA… ALAM…         95       1   1.05
1.05
10 6.09e6 ALAME… FRAN… PUBL… ALAMEDA… ALAM…         50       2   2
0
```

At last, the Beeplot

```
cavax ▷
  filter(mwc %nin% c("Private Christian Montessori",
                     "Charter Montessori",
                     "Private Jewish/Islamic"))
```

```
# A tibble: 7,015 × 13
     code county name  type  district city  enrollment pbe_pct exempt
med_exempt
    <dbl> <chr>  <chr> <chr> <chr>    <chr>       <dbl>   <dbl>  <dbl>
<dbl>
 1 1.10e5 ALAME… FAME… PUBL… ALAMEDA… NEWA…        109      13  12.8
0
 2 6.00e6 ALAME… COX … PUBL… ALAMEDA… OAKL…        115       1   0.87
0.87
 3 6.00e6 ALAME… LAZE… PUBL… ALAMEDA… OAKL…         40       0   0
0
 4 1.24e5 ALAME… YU M… PUBL… ALAMEDA… OAKL…         52      10   9.62
0
 5 6.10e6 ALAME… AMEL… PUBL… ALAMEDA… ALAM…        128       2   1.56
0
 6 6.11e6 ALAME… BAY … PUBL… ALAMEDA… ALAM…         70       1   1.43
0
 7 6.09e6 ALAME… DONA… PUBL… ALAMEDA… ALAM…        100       3   3
0
 8 6.09e6 ALAME… EDIS… PUBL… ALAMEDA… ALAM…         70       1   1.43
0
 9 6.09e6 ALAME… FRAN… PUBL… ALAMEDA… ALAM…         95       1   1.05
1.05
10 6.09e6 ALAME… FRAN… PUBL… ALAMEDA… ALAM…         50       2   2
0
```

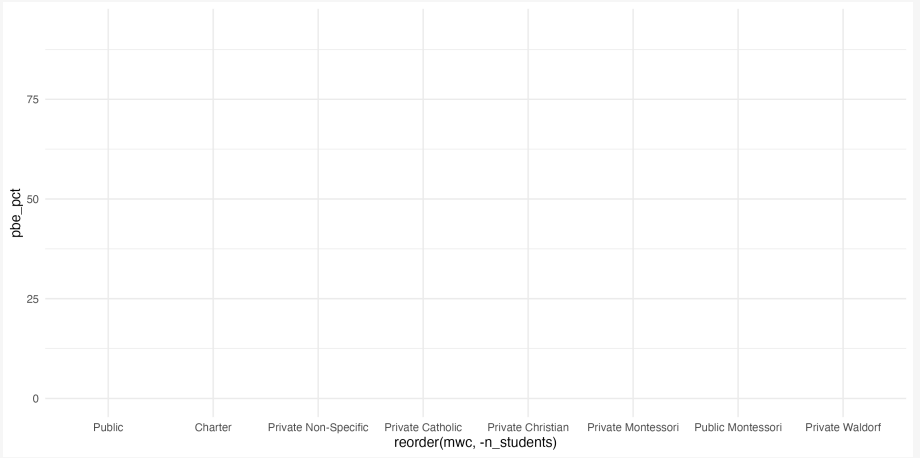
At last, the Beeplot

```
cavax ▷
  filter(mwc %nin% c("Private Christian Montessori",
                     "Charter Montessori",
                     "Private Jewish/Islamic")) ▷
  left_join(aux_info, by = "mwc")
```

```
# A tibble: 7,015 × 19
     code county name  type  district city  enrollment pbe_pct exempt
med_exempt
    <dbl> <chr>  <chr> <chr> <chr>    <chr>       <dbl>   <dbl>  <dbl>
<dbl>
 1 1.10e5 ALAME… FAME… PUBL… ALAMEDA… NEWA…        109      13  12.8
0
 2 6.00e6 ALAME… COX … PUBL… ALAMEDA… OAKL…        115       1   0.87
0.87
 3 6.00e6 ALAME… LAZE… PUBL… ALAMEDA… OAKL…         40       0   0
0
 4 1.24e5 ALAME… YU M… PUBL… ALAMEDA… OAKL…         52      10   9.62
0
 5 6.10e6 ALAME… AMEL… PUBL… ALAMEDA… ALAM…        128       2   1.56
0
 6 6.11e6 ALAME… BAY … PUBL… ALAMEDA… ALAM…         70       1   1.43
0
 7 6.09e6 ALAME… DONA… PUBL… ALAMEDA… ALAM…        100       3   3
0
 8 6.09e6 ALAME… EDIS… PUBL… ALAMEDA… ALAM…         70       1   1.43
0
 9 6.09e6 ALAME… FRAN… PUBL… ALAMEDA… ALAM…         95       1   1.05
1.05
10 6.09e6 ALAME… FRAN… PUBL… ALAMEDA… ALAM…         50       2   2
0
```

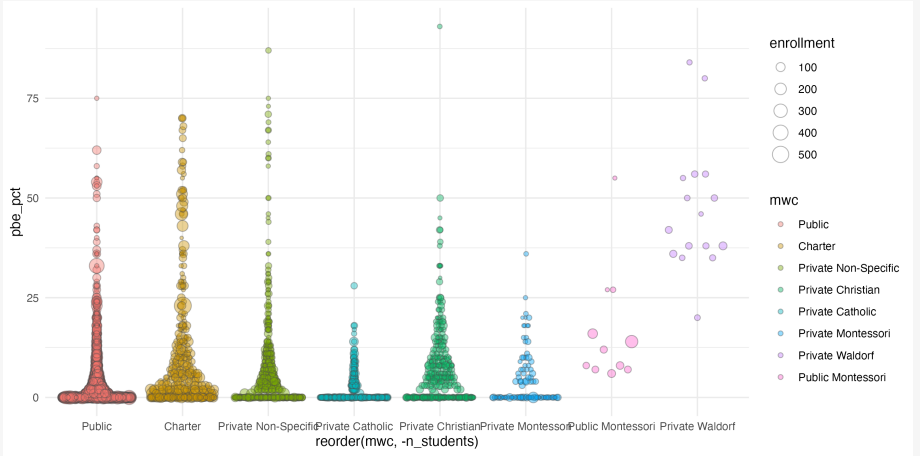
At last, the Beeplot

```
cavax ▷
  filter(mwc %nin% c("Private Christian Montessori",
                     "Charter Montessori",
                     "Private Jewish/Islamic")) ▷
  left_join(aux_info, by = "mwc") ▷
  ggplot(mapping =
           aes(y = pbe_pct,
               x = reorder(mwc, -n_students),
               size = enrollment,
               fill = mwc))
```



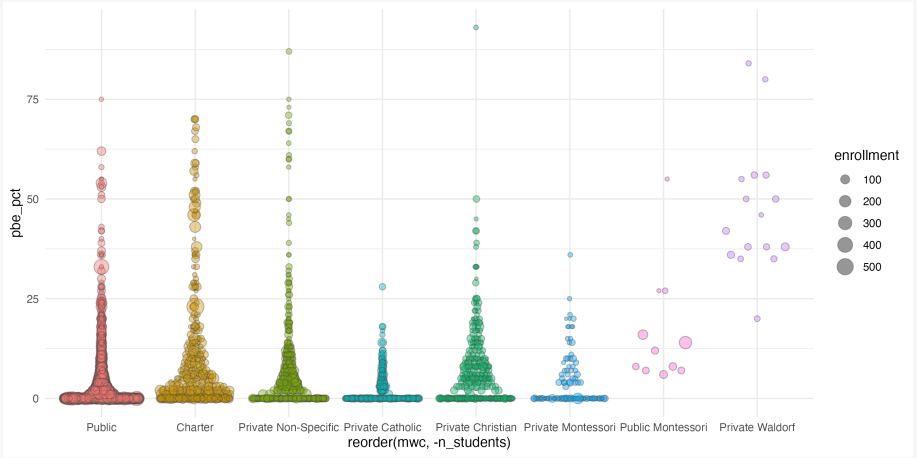
At last, the Beeplot

```
cavax ▷
  filter(mwc %nin% c("Private Christian Montessori",
                     "Charter Montessori",
                     "Private Jewish/Islamic")) ▷
  left_join(aux_info, by = "mwc") ▷
  ggplot(mapping =
           aes(y = pbe_pct,
               x = reorder(mwc, -n_students),
               size = enrollment,
               fill = mwc)) +
  geom_quasirandom(shape=21,
        alpha = 0.4,color="gray30",
        method = "quasirandom",
        varwidth = FALSE,
        bandwidth = 0.9)
```



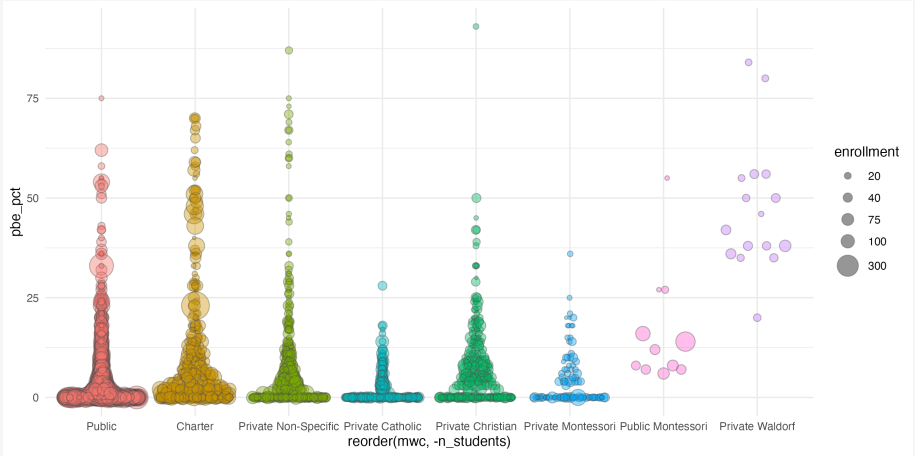
At last, the Beeplot

```
cavax ▷
  filter(mwc %nin% c("Private Christian Montessori",
                     "Charter Montessori",
                     "Private Jewish/Islamic")) ▷
  left_join(aux_info, by = "mwc") ▷
  ggplot(mapping =
           aes(y = pbe_pct,
               x = reorder(mwc, -n_students),
               size = enrollment,
               fill = mwc)) +
  geom_quasirandom(shape=21,
        alpha = 0.4,color="gray30",
        method = "quasirandom",
        varwidth = FALSE,
        bandwidth = 0.9) +
      guides(color = "none",
          shape= "none",
          fill= "none",
          size = guide_legend(override.aes =
                     list(fill = "black")))
```



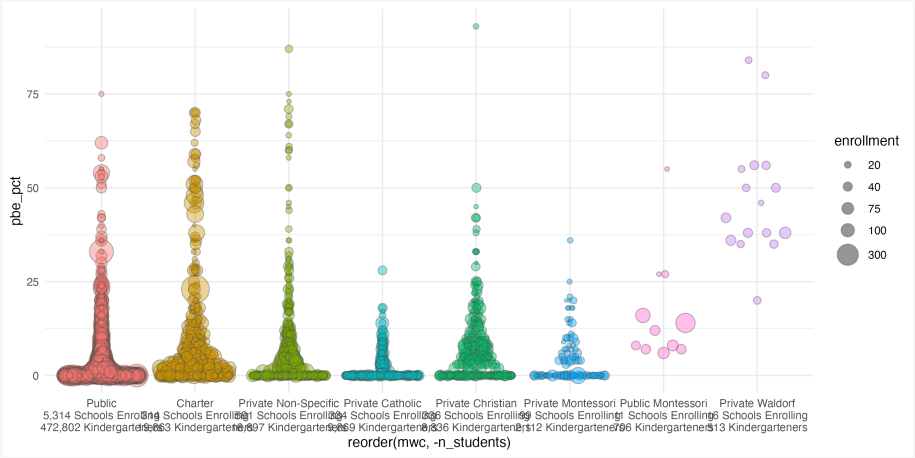
At last, the Beeplot

```
cavax ▷
  filter(mwc %nin% c("Private Christian Montessori",
                     "Charter Montessori",
                     "Private Jewish/Islamic")) ▷
  left_join(aux_info, by = "mwc") ▷
  ggplot(mapping =
           aes(y = pbe_pct,
               x = reorder(mwc, -n_students),
               size = enrollment,
               fill = mwc)) +
  geom_quasirandom(shape=21,
        alpha = 0.4,color="gray30",
        method = "quasirandom",
        varwidth = FALSE,
        bandwidth = 0.9) +
      guides(color = "none",
          shape= "none",
          fill= "none",
          size = guide_legend(override.aes =
                      list(fill = "black"))) +
      scale_size(breaks=c(20, 40, 75, 100, 300),
                    range=c(1,10))
```



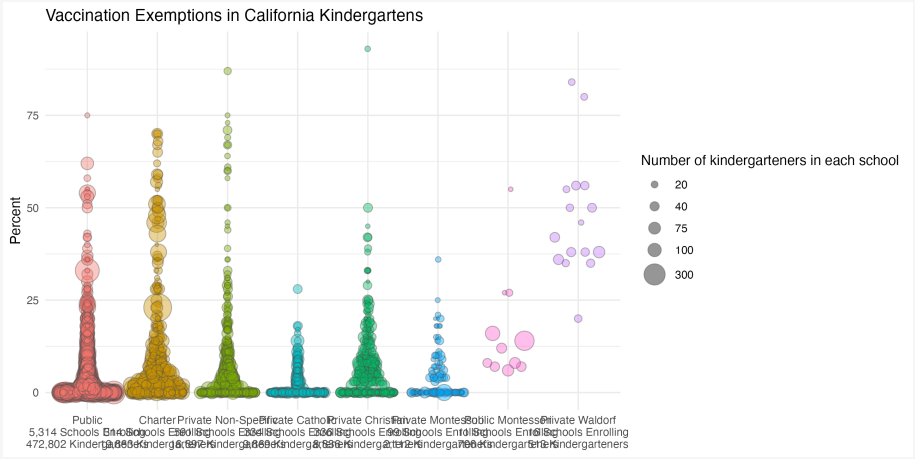
At last, the Beeplot

```
cavax ▷
  filter(mwc %nin% c("Private Christian Montessori",
                     "Charter Montessori",
                     "Private Jewish/Islamic")) ▷
  left_join(aux_info, by = "mwc") ▷
  ggplot(mapping =
           aes(y = pbe_pct,
               x = reorder(mwc, -n_students),
               size = enrollment,
               fill = mwc)) +
  geom_quasirandom(shape=21,
        alpha = 0.4,color="gray30",
        method = "quasirandom",
        varwidth = FALSE,
        bandwidth = 0.9) +
      guides(color = "none",
          shape= "none",
          fill= "none",
          size = guide_legend(override.aes =
                       list(fill = "black"))) +
      scale_size(breaks=c(20, 40, 75, 100, 300),
                  range=c(1,10)) +
      scale_x_discrete(labels = special_x_labs)
```



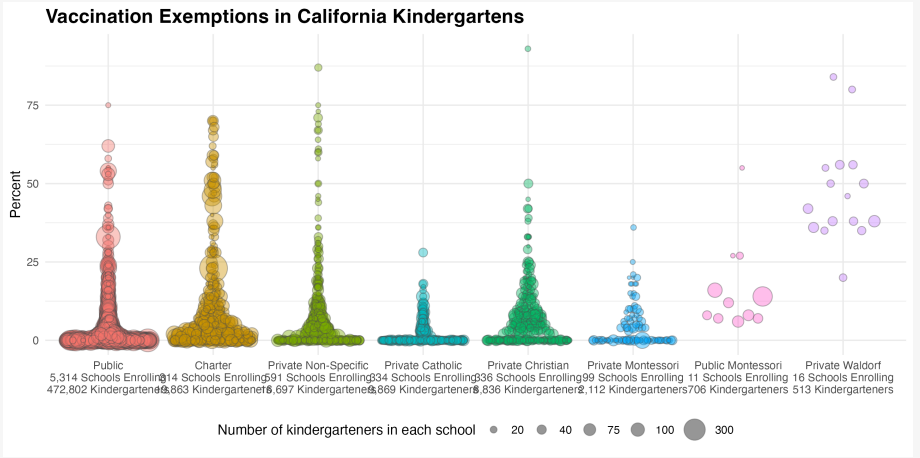
At last, the Beeplot

```
cavax ▷
  filter(mwc %nin% c("Private Christian Montessori",
                     "Charter Montessori",
                     "Private Jewish/Islamic")) ▷
  left_join(aux_info, by = "mwc") ▷
  ggplot(mapping =
           aes(y = pbe_pct,
               x = reorder(mwc, -n_students),
               size = enrollment,
               fill = mwc)) +
  geom_quasirandom(shape=21,
        alpha = 0.4,color="gray30",
        method = "quasirandom",
        varwidth = FALSE,
        bandwidth = 0.9) +
      guides(color = "none",
          shape= "none",
          fill= "none",
          size = guide_legend(override.aes =
                       list(fill = "black"))) +
      scale_size(breaks=c(20, 40, 75, 100, 300),
                 range=c(1,10)) +
      scale_x_discrete(labels = special_x_labs) +
      labs(size = "Number of kindergarteners in each school",
           x = NULL, y = "Percent",
           title = "Vaccination Exemptions in California Kindergartens")
```



At last, the Beeplot

```
cavax ▷
  filter(mwc %nin% c("Private Christian Montessori",
                     "Charter Montessori",
                     "Private Jewish/Islamic")) ▷
  left_join(aux_info, by = "mwc") ▷
  ggplot(mapping =
           aes(y = pbe_pct,
               x = reorder(mwc, -n_students),
               size = enrollment,
               fill = mwc)) +
  geom_quasirandom(shape=21,
        alpha = 0.4,color="gray30",
        method = "quasirandom",
        varwidth = FALSE,
        bandwidth = 0.9) +
      guides(color = "none",
          shape= "none",
          fill= "none",
          size = guide_legend(override.aes =
                    list(fill = "black"))) +
      scale_size(breaks=c(20, 40, 75, 100, 300),
                 range=c(1,10)) +
      scale_x_discrete(labels = special_x_labs) +
      labs(size = "Number of kindergarteners in each school",
           x = NULL, y = "Percent",
           title = "Vaccination Exemptions in California Kindergartens")
        theme(legend.position = "bottom",
              plot.title = element_text(size = rel(1.4),
                                        face = "bold"))
```

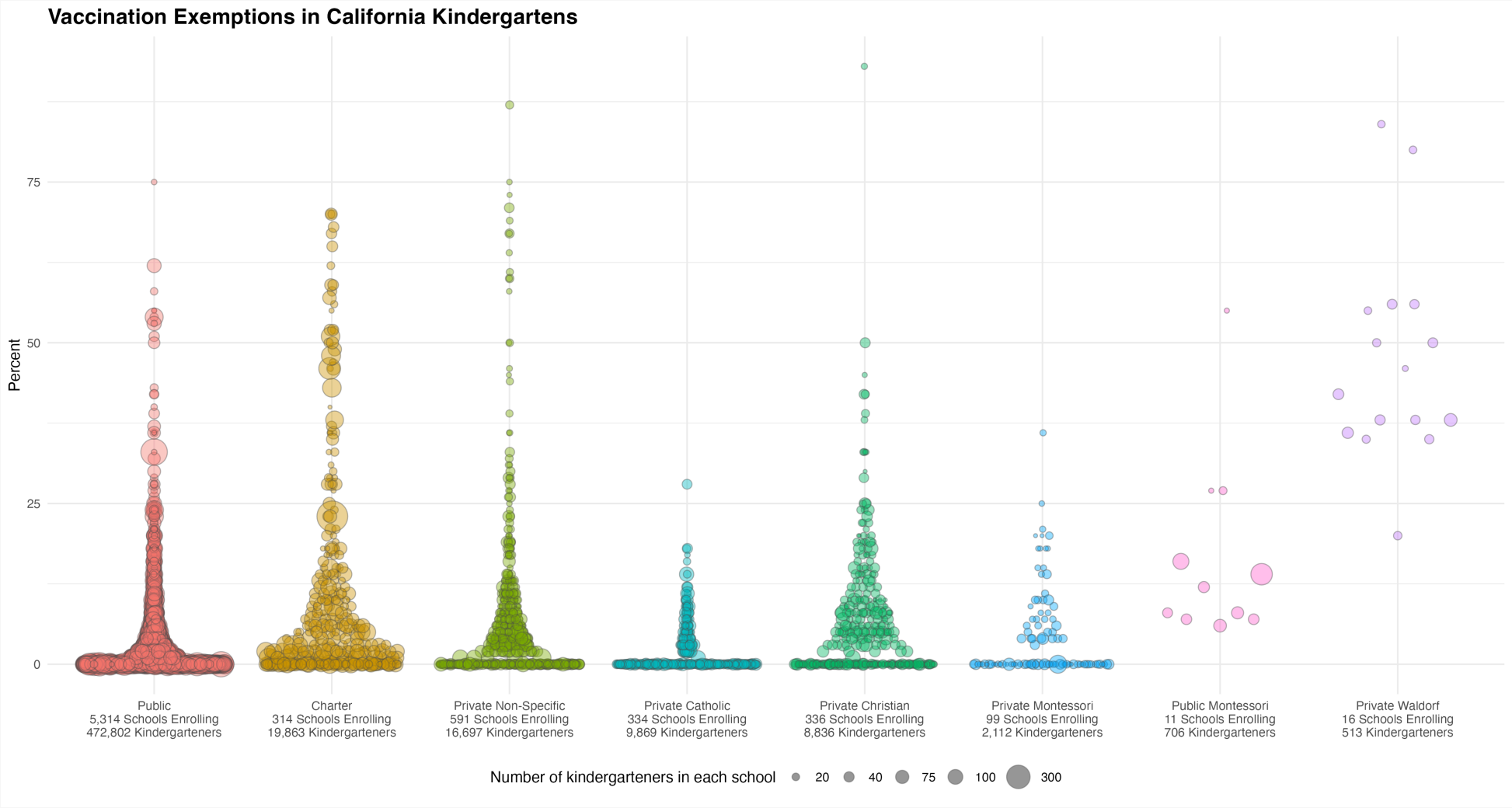


At last, the Beeplot

```
cavax ▷
  filter(mwc %nin% c("Private Christian Montessori",
                     "Charter Montessori",
                     "Private Jewish/Islamic")) ▷
  left_join(aux_info, by = "mwc") ▷
  ggplot(mapping =
           aes(y = pbe_pct,
               x = reorder(mwc, -n_students),
               size = enrollment,
               fill = mwc)) +
  geom_quasirandom(shape=21,
        alpha = 0.4,color="gray30",
        method = "quasirandom",
        varwidth = FALSE,
        bandwidth = 0.9) +
      guides(color = "none",
          shape= "none",
          fill= "none",
          size = guide_legend(override.aes =
                     list(fill = "black"))) +
      scale_size(breaks=c(20, 40, 75, 100, 300),
                 range=c(1,10)) +
      scale_x_discrete(labels = special_x_labs) +
      labs(size = "Number of kindergarteners in each school",
           x = NULL, y = "Percent",
           title = "Vaccination Exemptions in California Kindergartens")
        theme(legend.position = "bottom",
              plot.title = element_text(size = rel(1.4),
                                        face = "bold")) →
  p_bee_main
```

At last, the Beeplot

```
cavax ▷
  filter(mwc %nin% c("Private Christian Montessori",
                     "Charter Montessori",
                     "Private Jewish/Islamic")) ▷
  left_join(aux_info, by = "mwc") ▷
  ggplot(mapping =
           aes(y = pbe_pct,
               x = reorder(mwc, -n_students),
               size = enrollment,
               fill = mwc)) +
  geom_quasirandom(shape=21,
        alpha = 0.4,color="gray30",
        method = "quasirandom",
        varwidth = FALSE,
        bandwidth = 0.9) +
      guides(color = "none",
          shape= "none",
          fill= "none",
          size = guide_legend(override.aes =
                     list(fill = "black"))) +
      scale_size(breaks=c(20, 40, 75, 100, 300),
                 range=c(1,10)) +
      scale_x_discrete(labels = special_x_labs) +
      labs(size = "Number of kindergarteners in each school",
           x = NULL, y = "Percent",
           title = "Vaccination Exemptions in California Kindergartens")
        theme(legend.position = "bottom",
              plot.title = element_text(size = rel(1.4),
                                        face = "bold")) →
  p_bee_main
```



Vaccination Exemptions in California Kindergartens