complete

Data Cleaning

Load Assets

```
library(tidyverse)
```

```
Warning: package 'lubridate' was built under R version 4.4.2
```

```
── Attaching core tidyverse packages ──────────────────────── tidyverse 2.0.0 ──
✓ dplyr     1.1.4     ✓ readr     2.1.5
✓ forcats   1.0.0     ✓ stringr   1.5.1
✓ ggplot2   3.5.1     ✓ tibble    3.2.1
✓ lubridate 1.9.4     ✓ tidyr     1.3.1
✓ purrr     1.0.2
── Conflicts ────────────────────────────────────────── tidyverse_conflicts() ──
✖ dplyr::filter() masks stats::filter()
✖ dplyr::lag()    masks stats::lag()
ℹ Use the conflicted package (<http://conflicted.r-lib.org/>) to force all conflicts to become
errors
```

```
library(readxl)
library(writexl)

full <- read_excel("data/bds_data.xlsx", sheet = "BDS")
patents <- read_excel("data/bds_data.xlsx", sheet = "Patents")
stem_edu <- read_excel("data/S&EDegrees2000-2018.xlsx")
```

```
New names:
• `2018-All S&E degrees/all higher education degrees (Percent)` -> `2018-All
  S&E degrees/all higher education degrees (Percent)...58`
• `2018-All S&E degrees/all higher education degrees (Percent)` -> `2018-All
  S&E degrees/all higher education degrees (Percent)...59`
```

```
employment_growth <- read_excel("data/bds_data.xlsx", sheet = "Copy of Total Employment Growth")
sector_growth <- read_excel("data/bds_data.xlsx", sheet = "Info Employment Growth")
vc <- read_excel("data/Wide Data Set.xlsx", sheet = "VC #", skip = 1)
```

Make datasets long

```
patents <- patents |>
  pivot_longer(cols = 2:27, values_to = "Number of Utility Patents", names_to = "Year") |>
```

```
  mutate(Year = as.numeric(Year))

stem_edu <- stem_edu |>
  head(51) |>
  pivot_longer(cols = 2:59, values_to = "Number", names_to = "Year") |>
  mutate(Number = as.numeric(Number))

vc <- vc |>
  pivot_longer(cols = 2:27, values_to = "Number of Firms Receiving VC", names_to = "Year") |>
  mutate(Year = as.numeric(Year))
```

Clean S&E Dataset and Fix Formatting

```
se_degrees <- stem_edu |>
  filter(str_detect(Year, "conferred")) |>
  mutate(Year = str_sub(Year, 1, 4), Year = as.numeric(Year)) |>
  rename("S&E Degrees" = Number)

total_degrees <- stem_edu |>
  filter(str_detect(Year, "All higher")) |>
  mutate(Year = str_sub(Year, 1, 4), Year = as.numeric(Year)) |>
  rename("Total Degrees" = Number)

se_degree_proportion <- stem_edu  |>
  filter(str_detect(Year, "All S&E")) |>
  mutate(Year = str_sub(Year, 1, 4), Year = as.numeric(Year)) |>
  distinct() |>
  rename("Proportion of S&E" = Number)
```

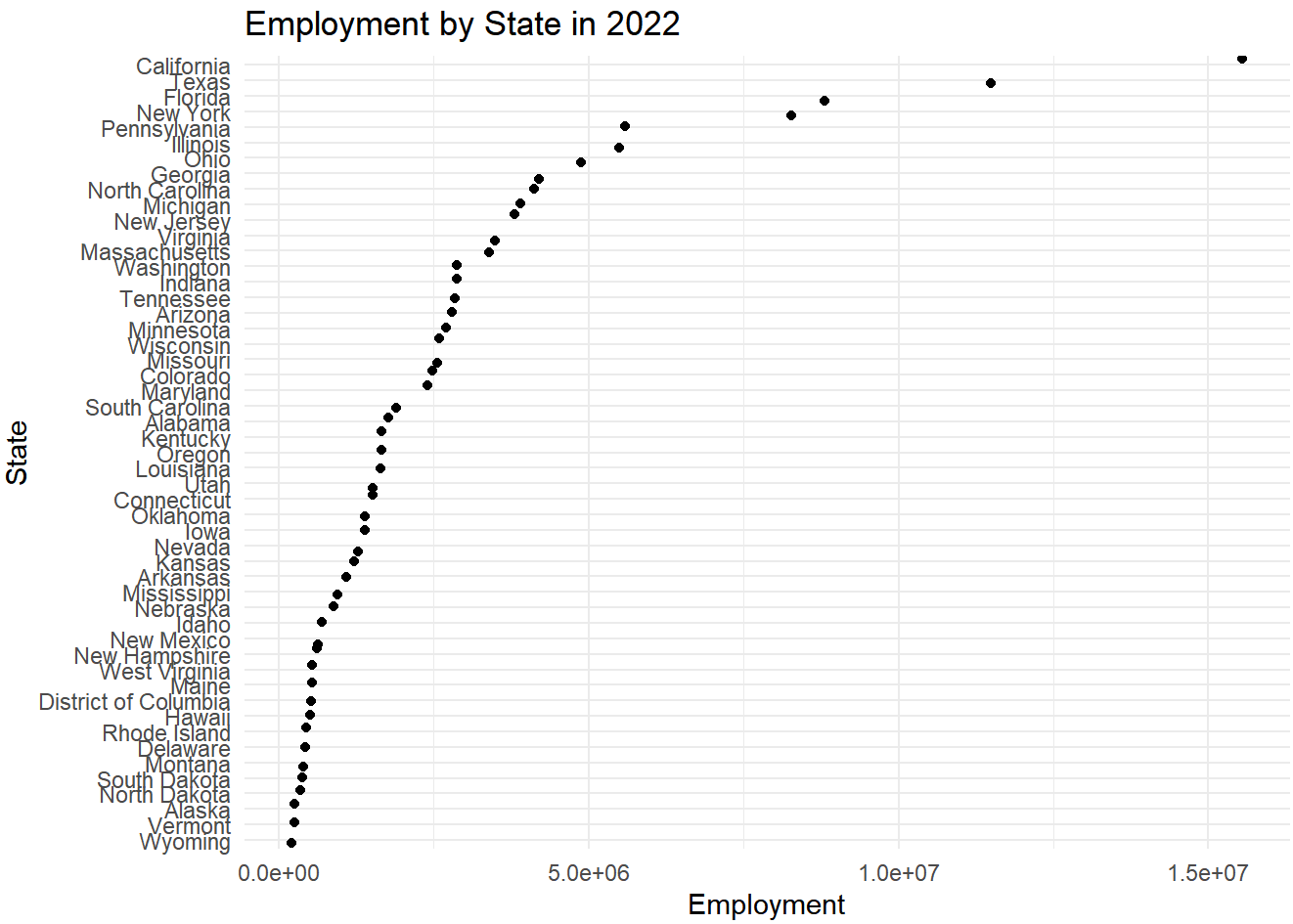
Full, long dataset of all the variables of every state in every year

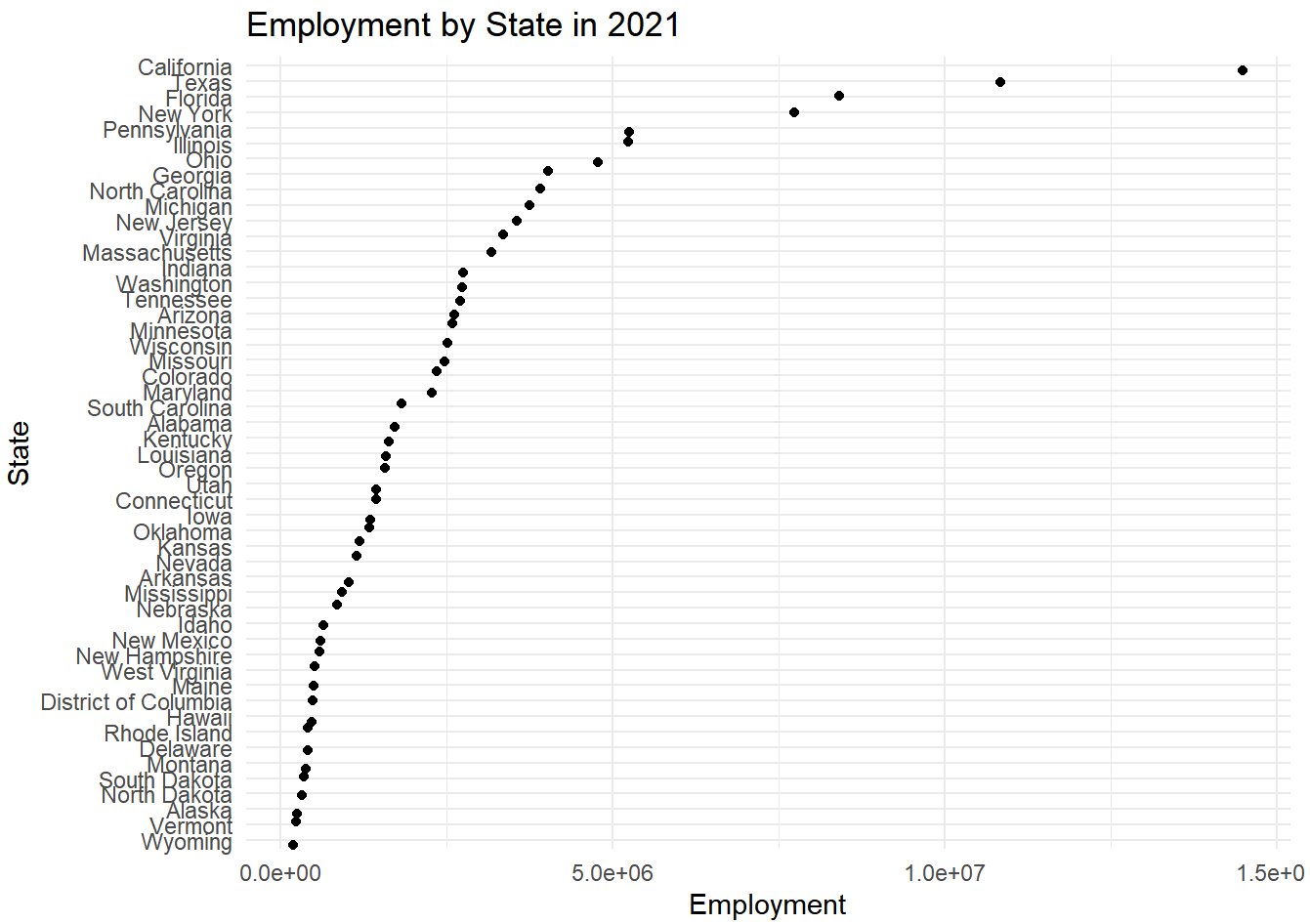
```
full <- full |>
  left_join(patents, join_by(State, Year)) |>
  left_join(se_degrees, join_by(State, Year)) |>
  left_join(total_degrees, join_by(State, Year)) |>
  left_join(se_degree_proportion, join_by(State, Year)) |>
  left_join(vc, join_by(State, Year))

write_xlsx(full, "data/full_dataset.xlsx")

full <- full |>
  mutate(State = factor(State))
```

Plots

Separate plots for every year of states vs selected variable

```
years <- unique(full$Year)

for (y in years) {
  full_filtered <- full |>
    filter(Year == y)

 full_filtered$State <- fct_reorder(full_filtered$State, full_filtered$`Total Employment`)

  plot <- ggplot(full_filtered, aes(x = State, y = `Total Employment`)) +
    geom_jitter() +
    labs(title = paste("Employment by State in", y),
         x = "State",
         y = "Employment") +
    theme_minimal() +
    coord_flip()  # Optional for readability

  print(plot)
}
```




Employment by State in 2021
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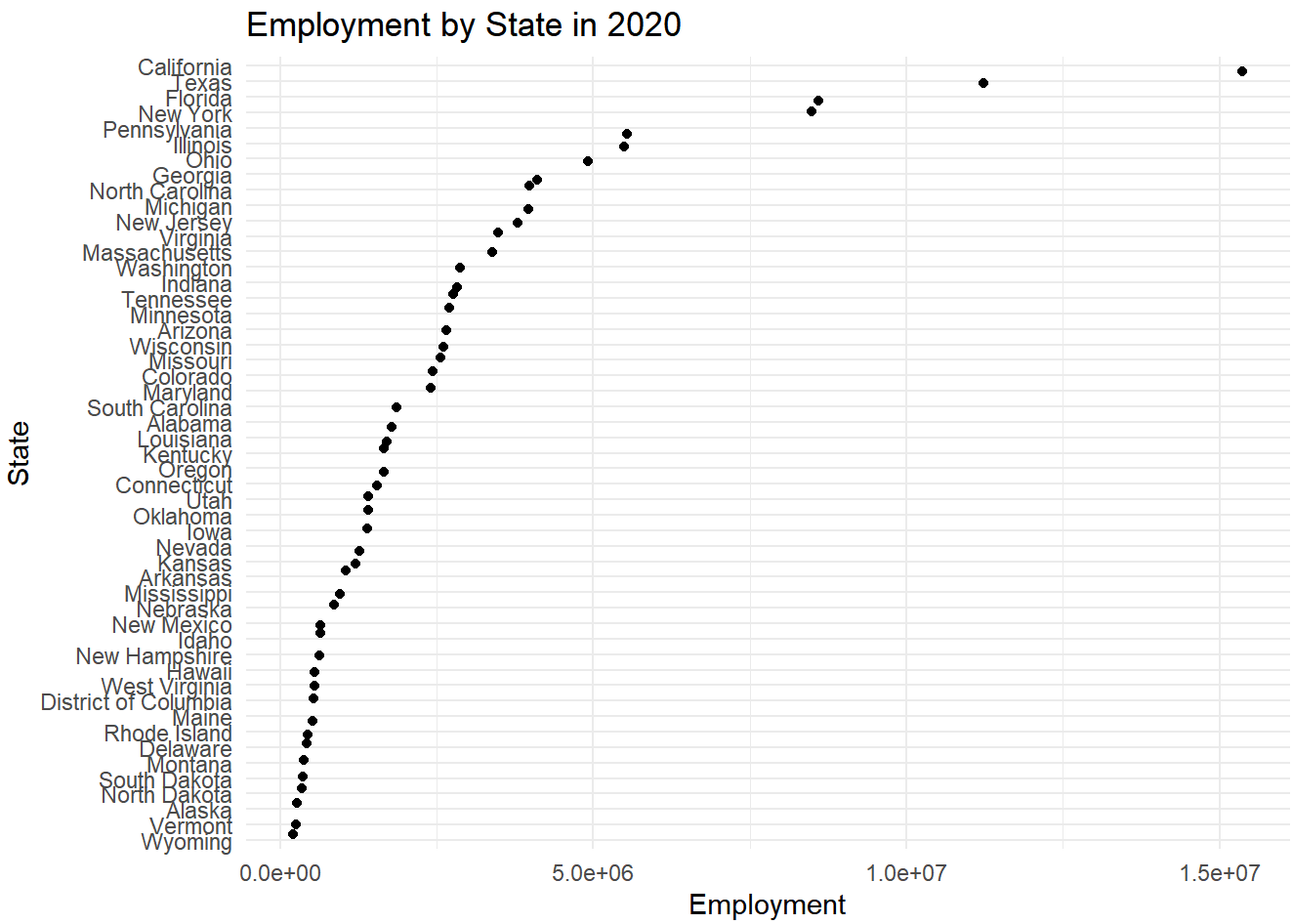
Employment


Employment by State in 2020
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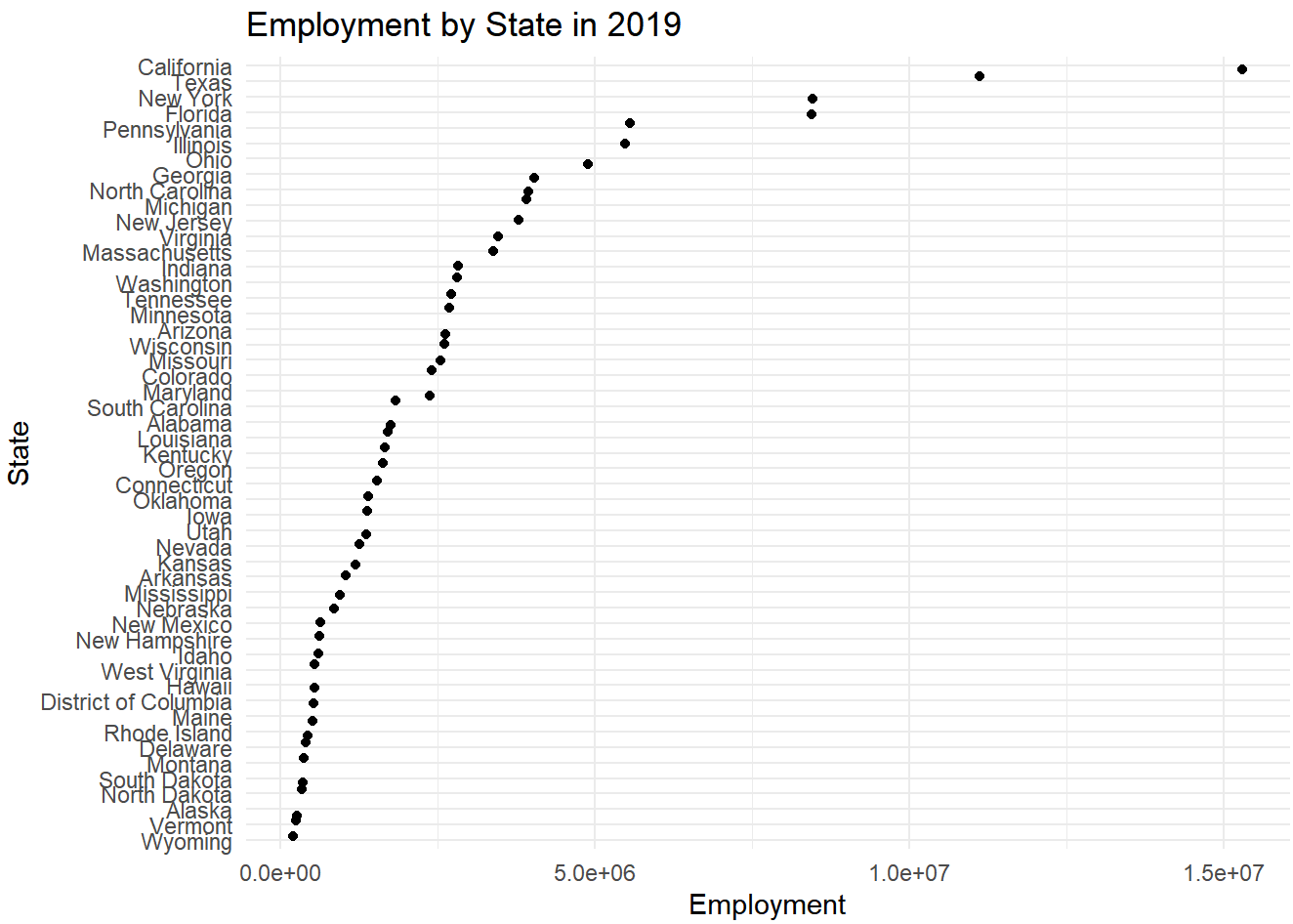
Employment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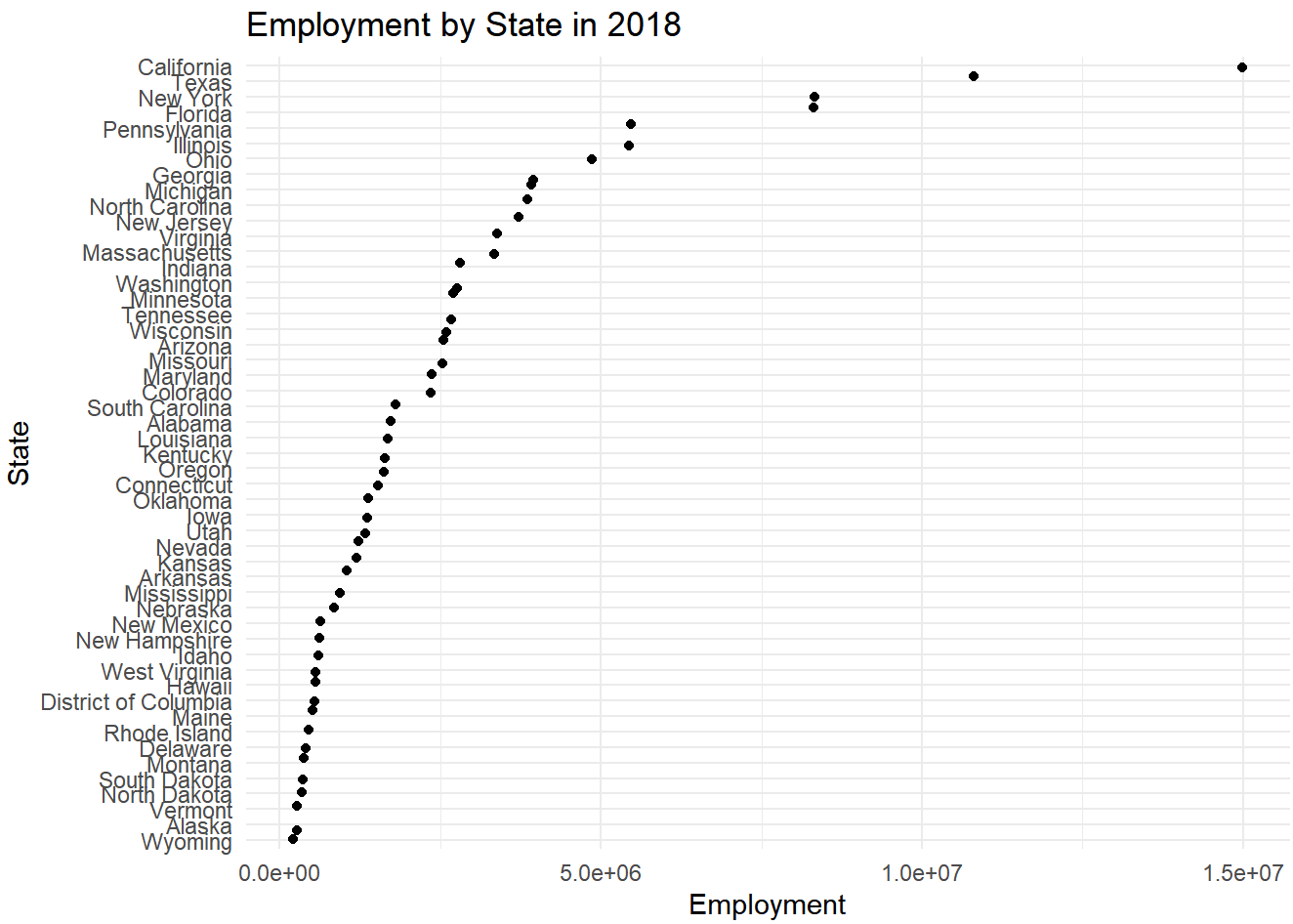
Employment by State in 2018
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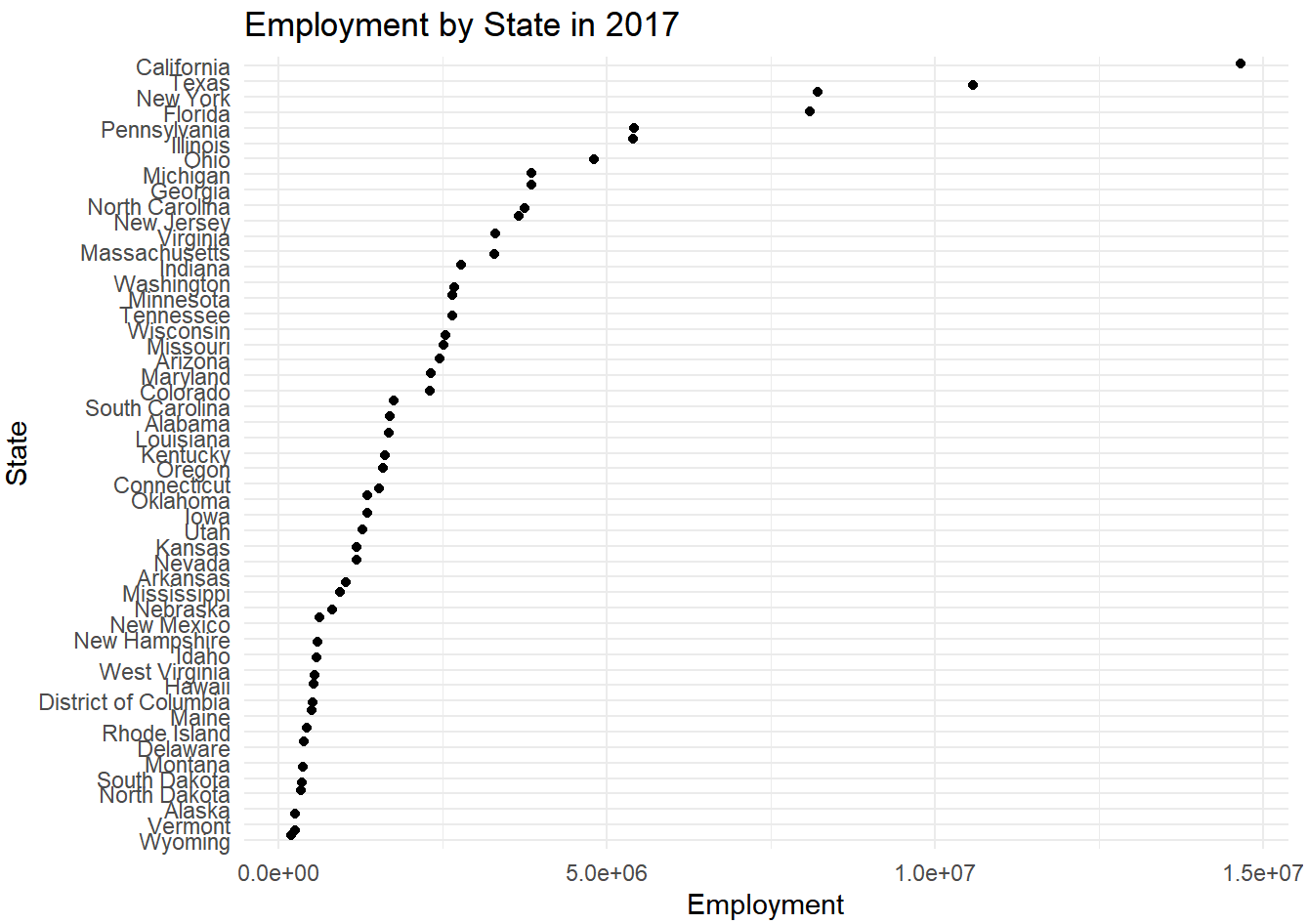
Employment by State in 2017
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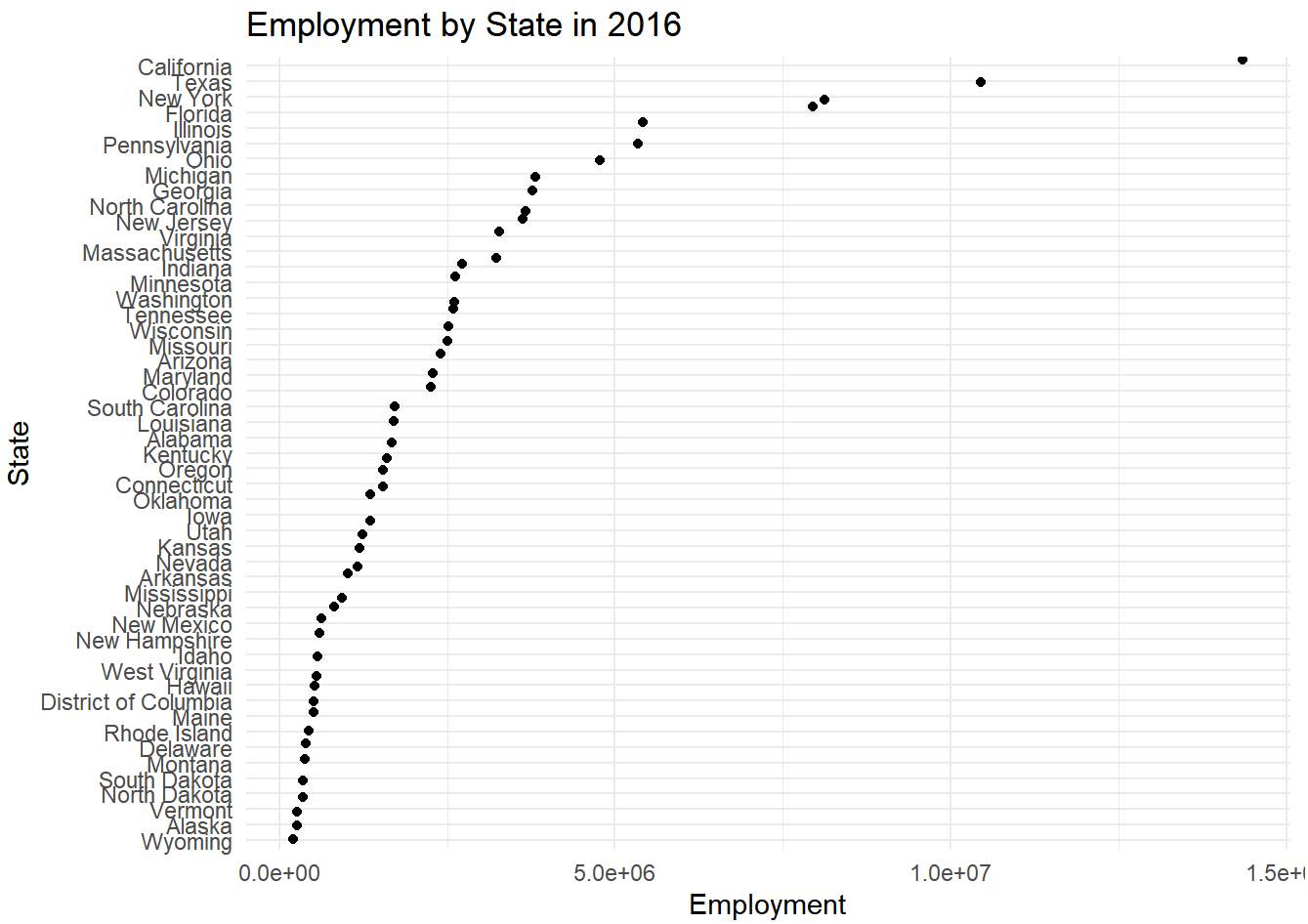
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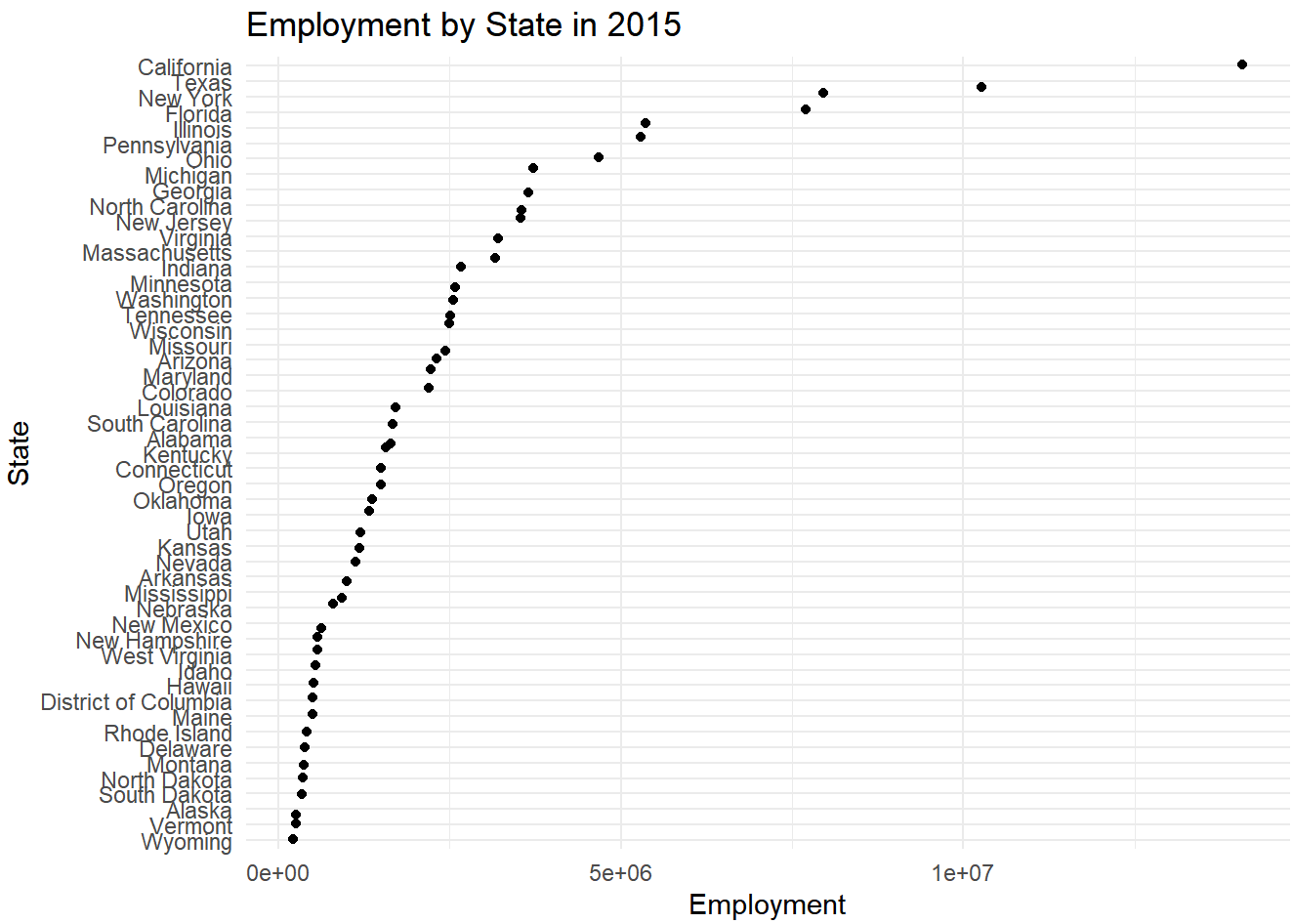
Employment by State in 2015
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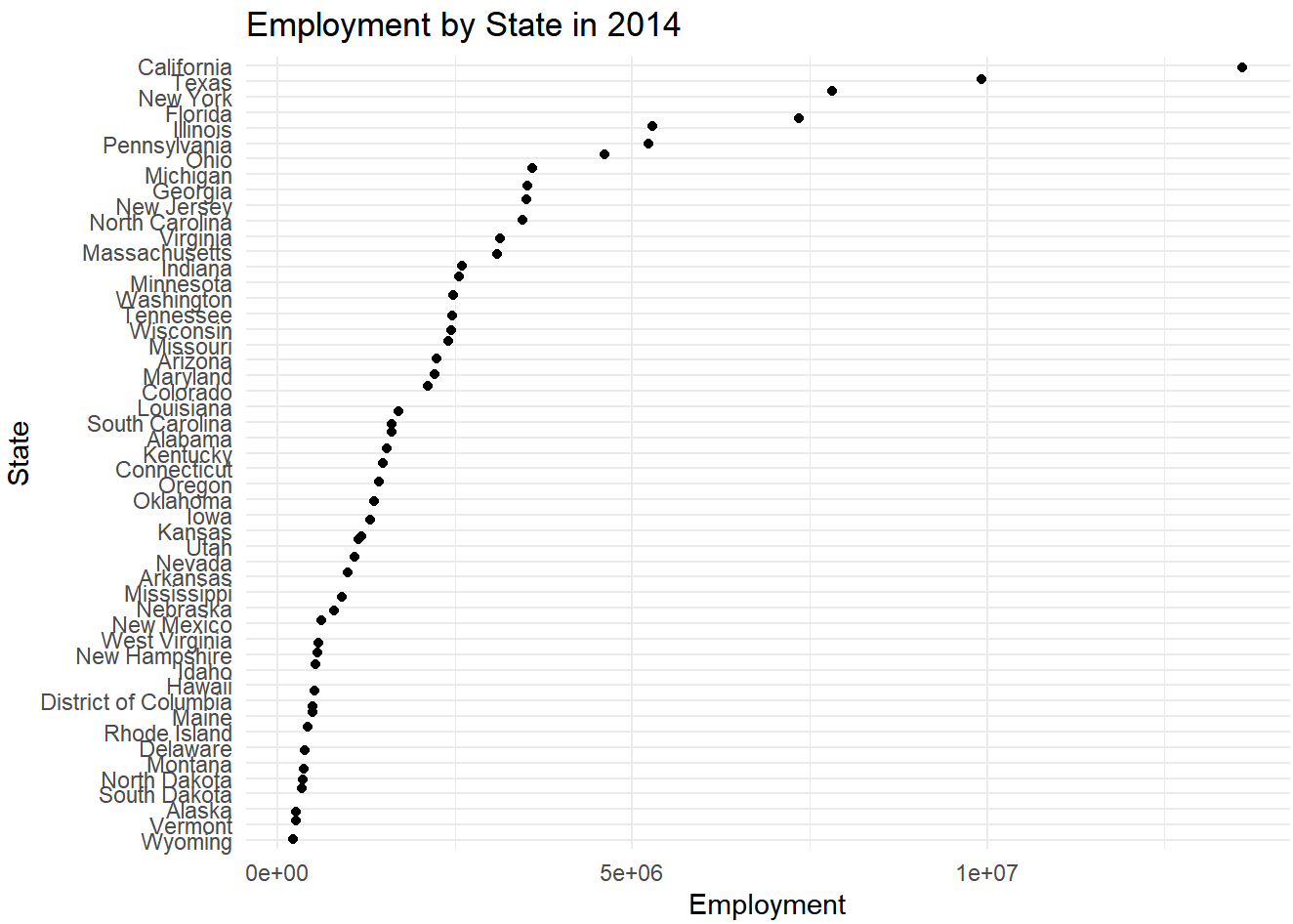
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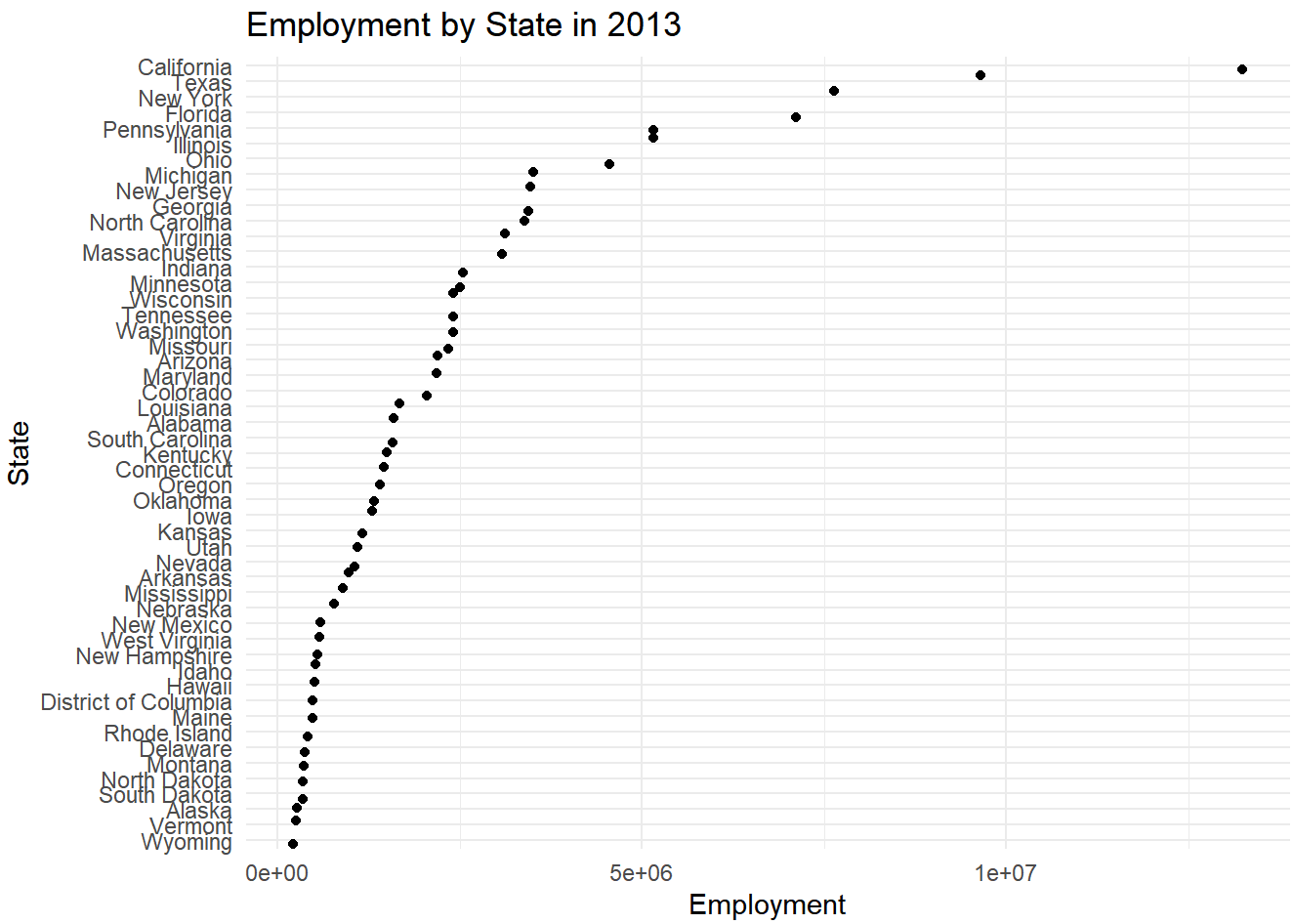
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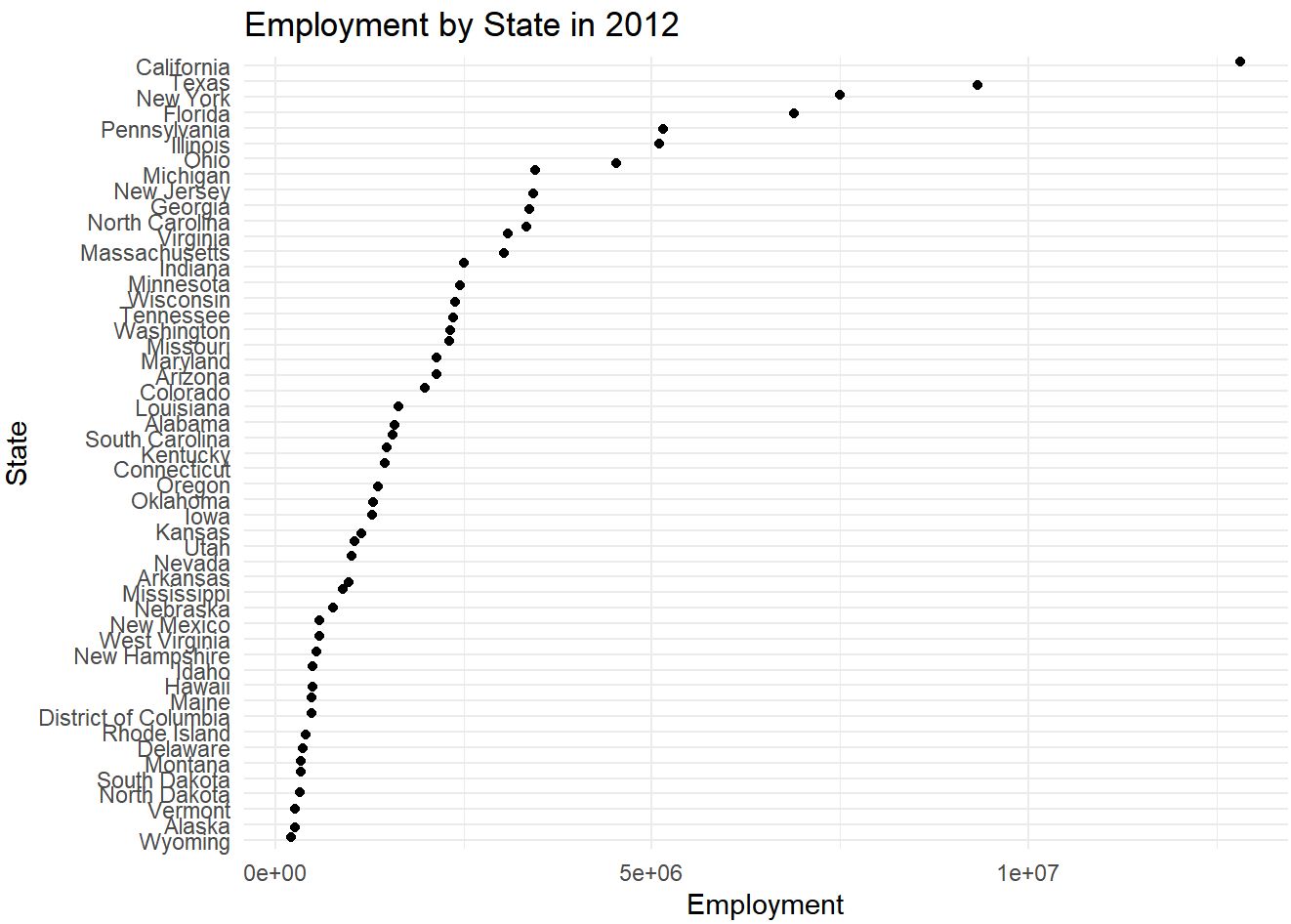
Employment by State in 2012
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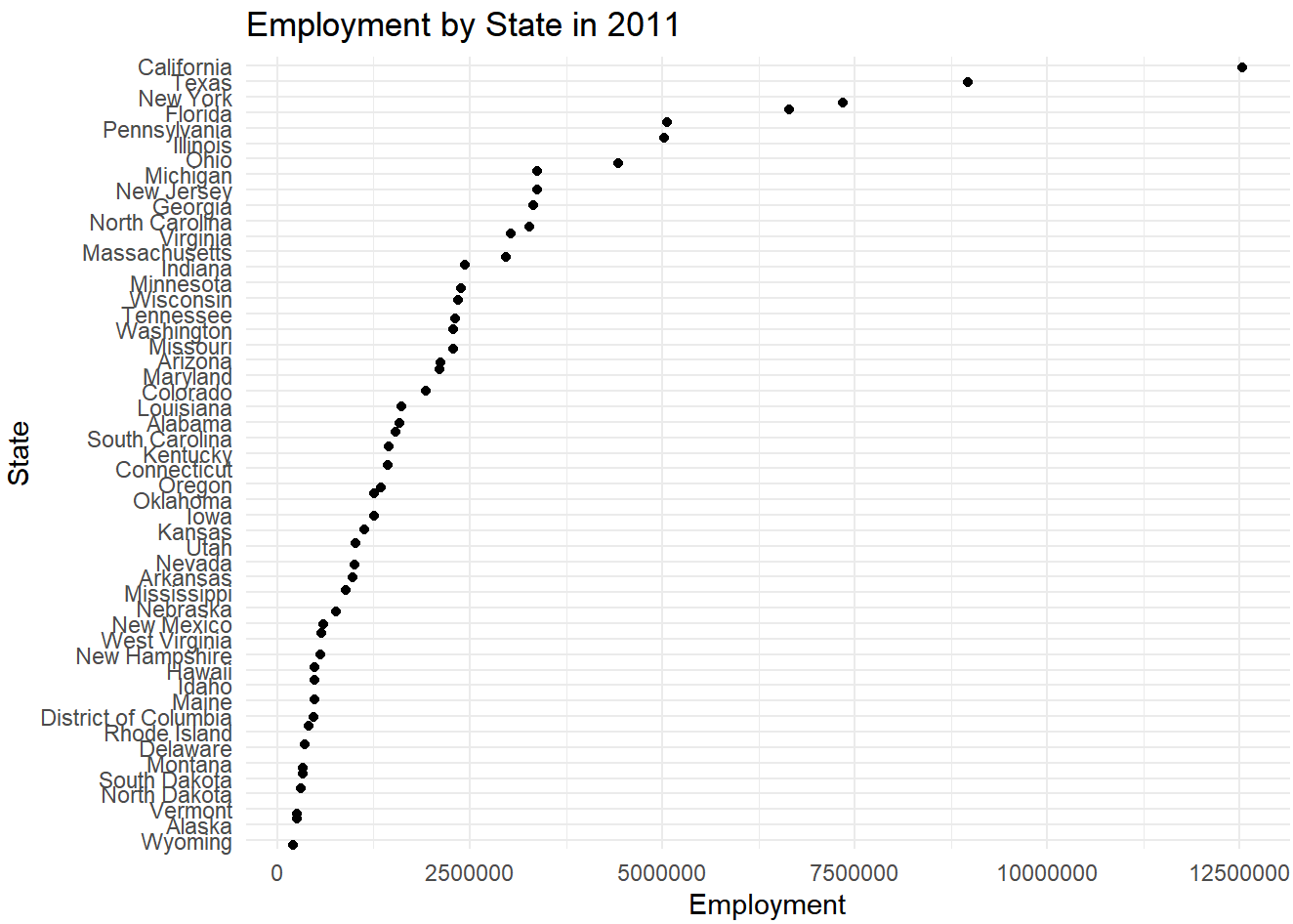
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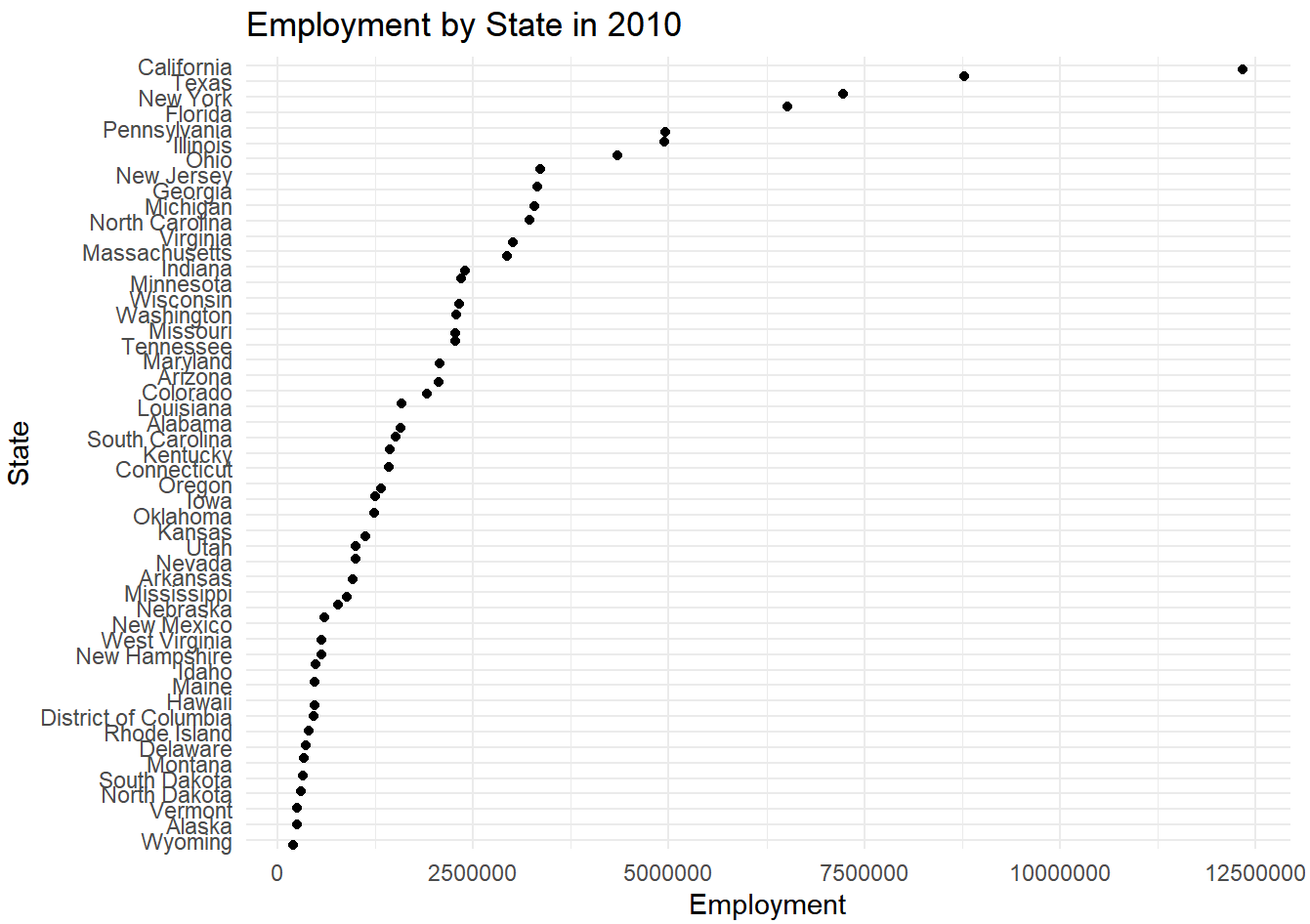
Employment by State in 2010
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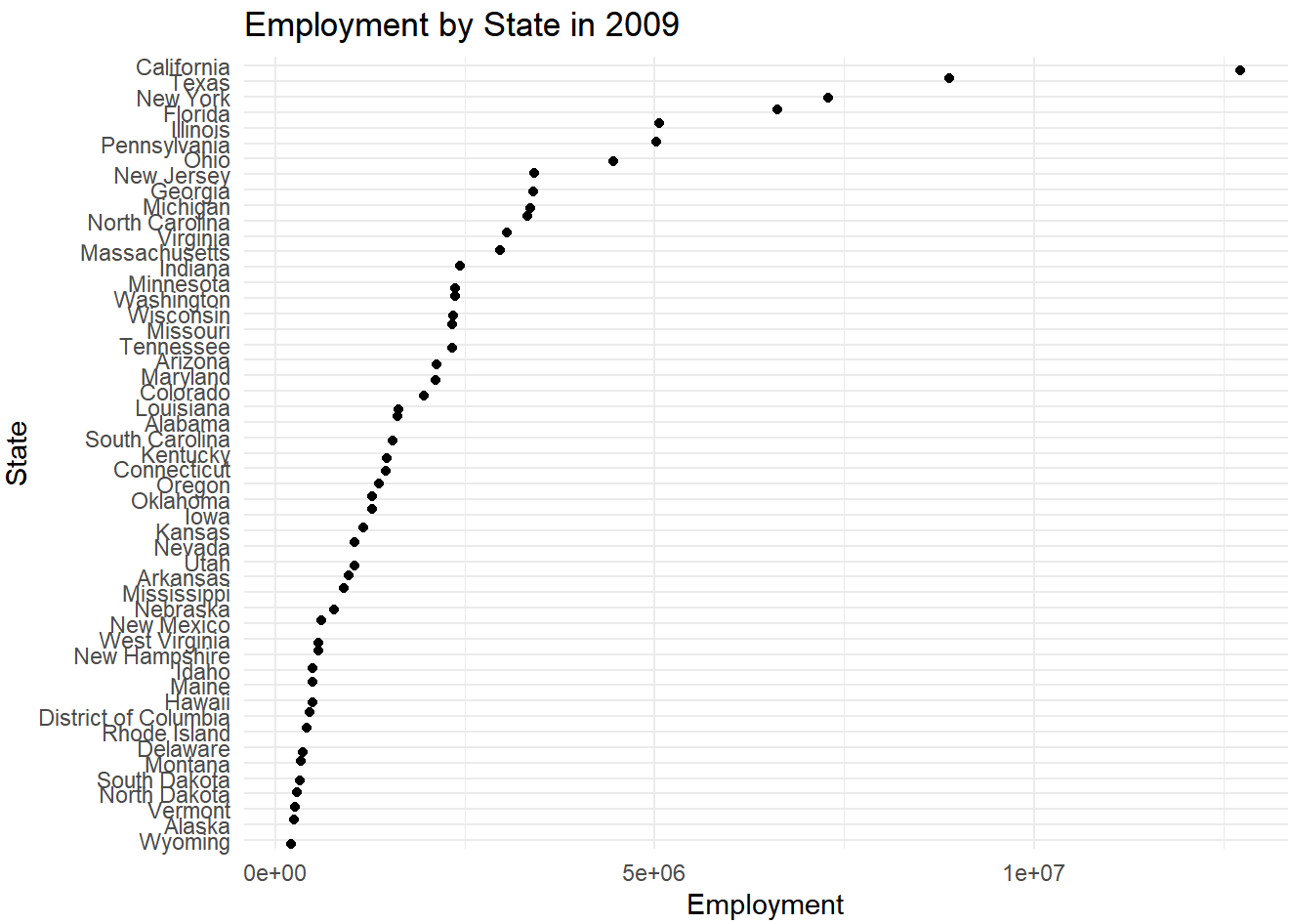
Employment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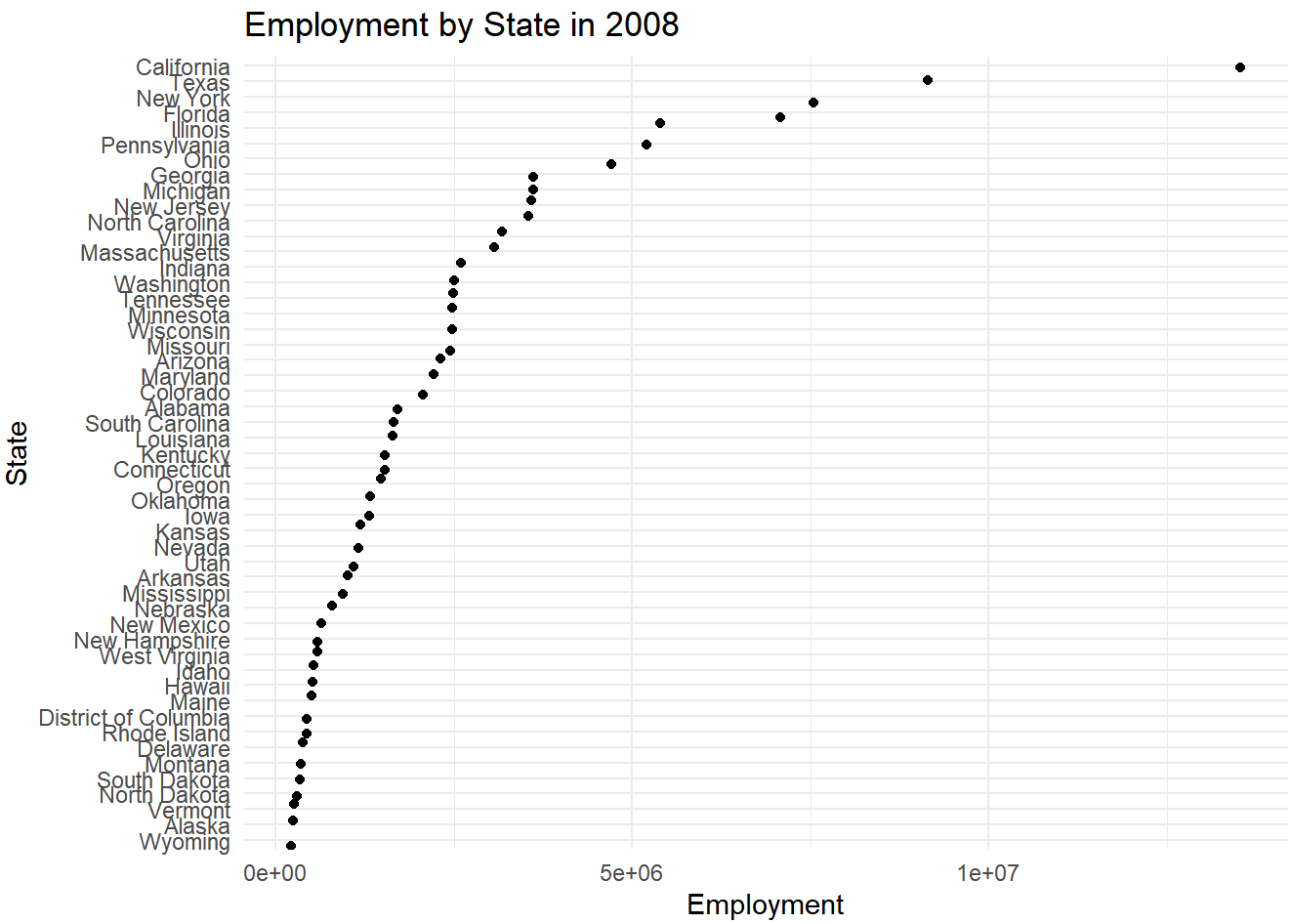
Employment


Employment by State in 2008
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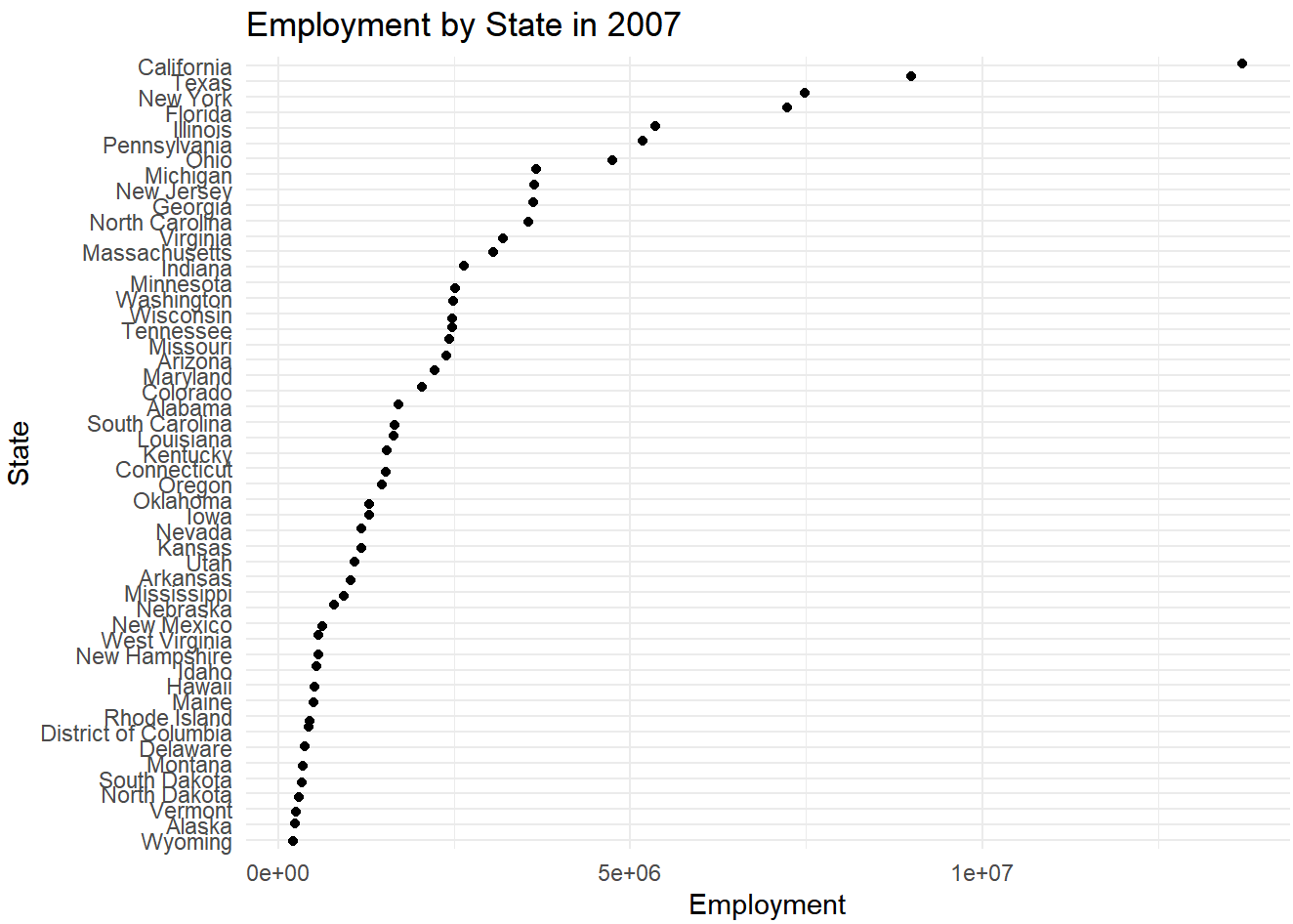
Employment by State in 2007
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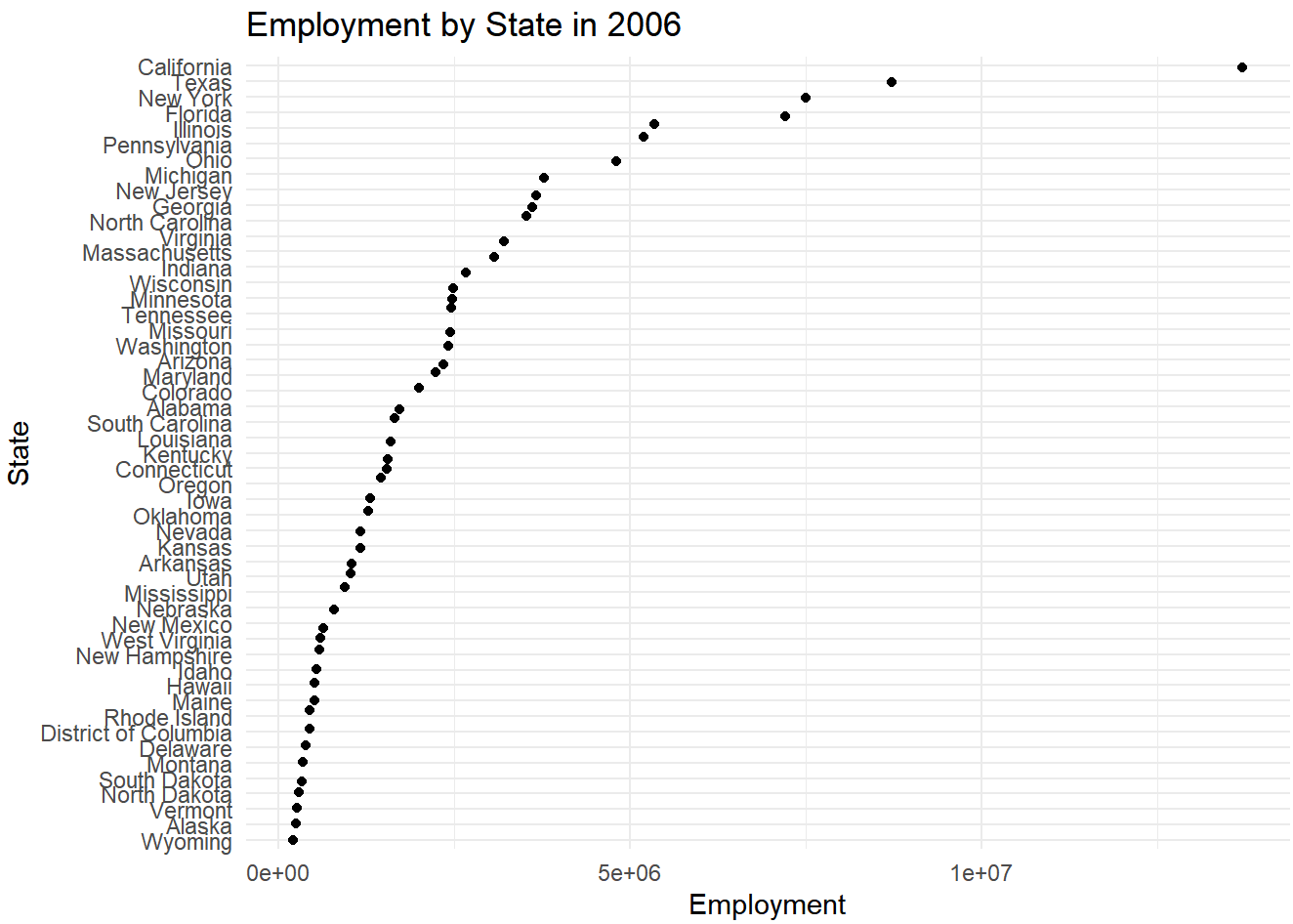
Employment


Employment by State in 2006
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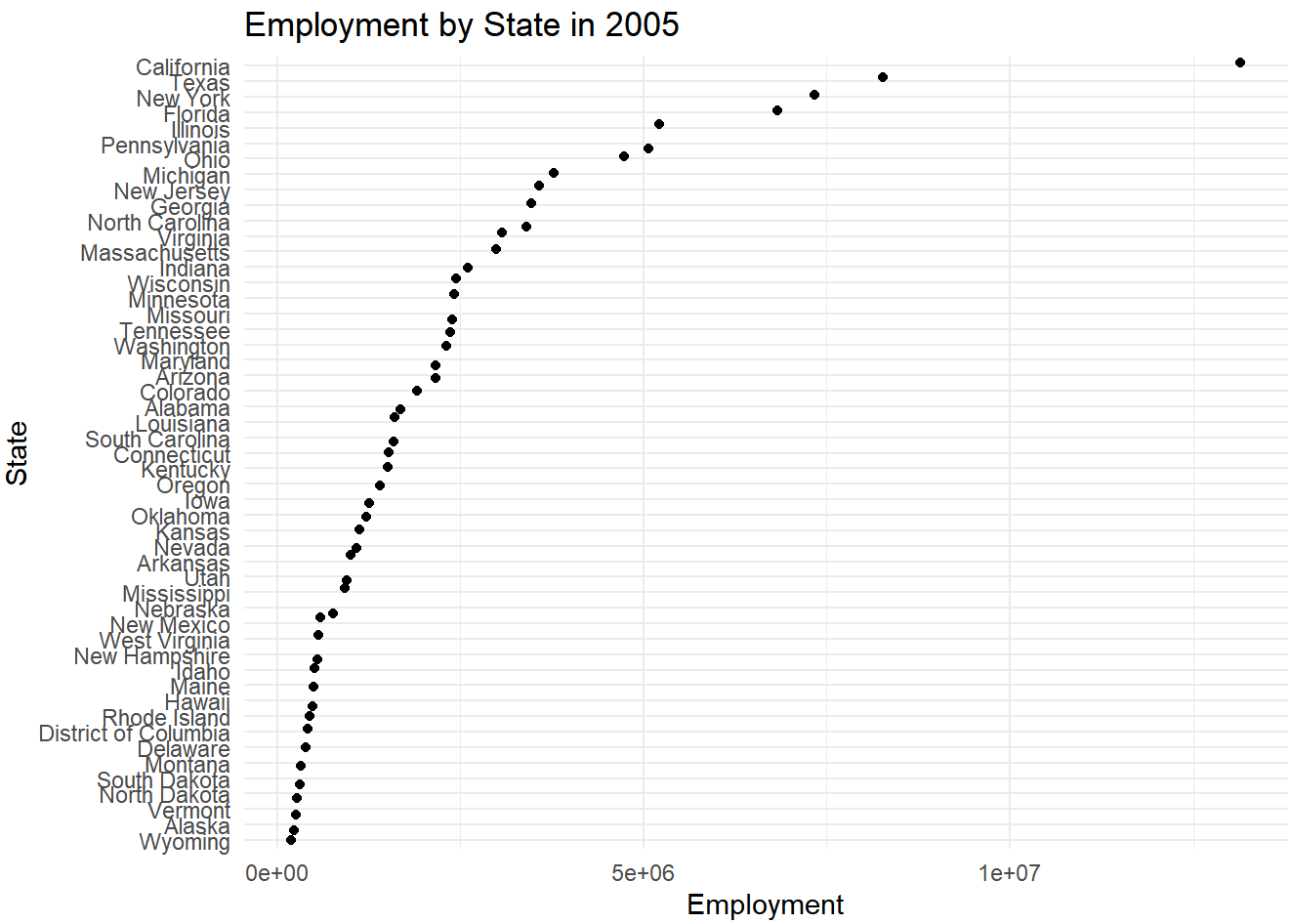
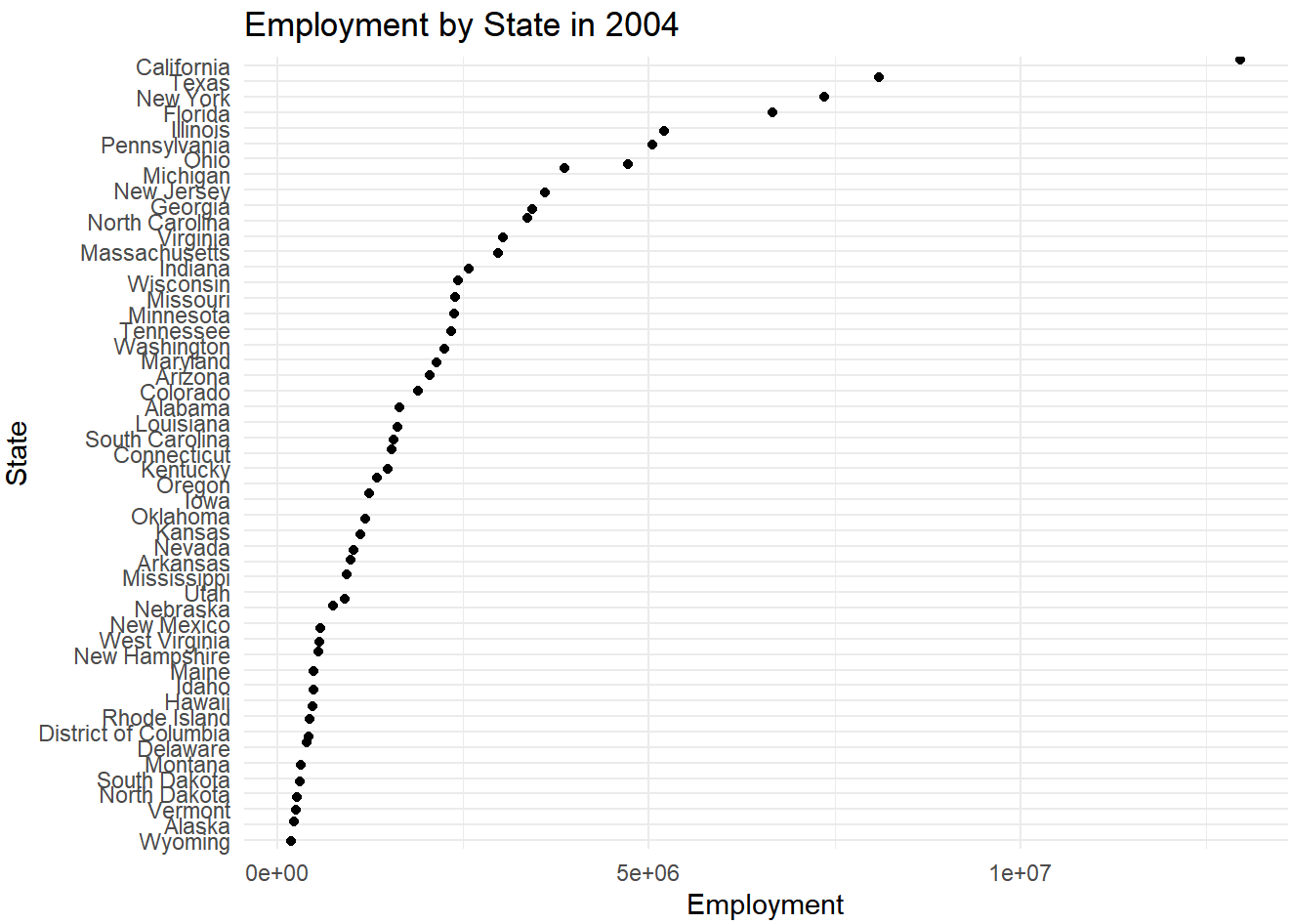
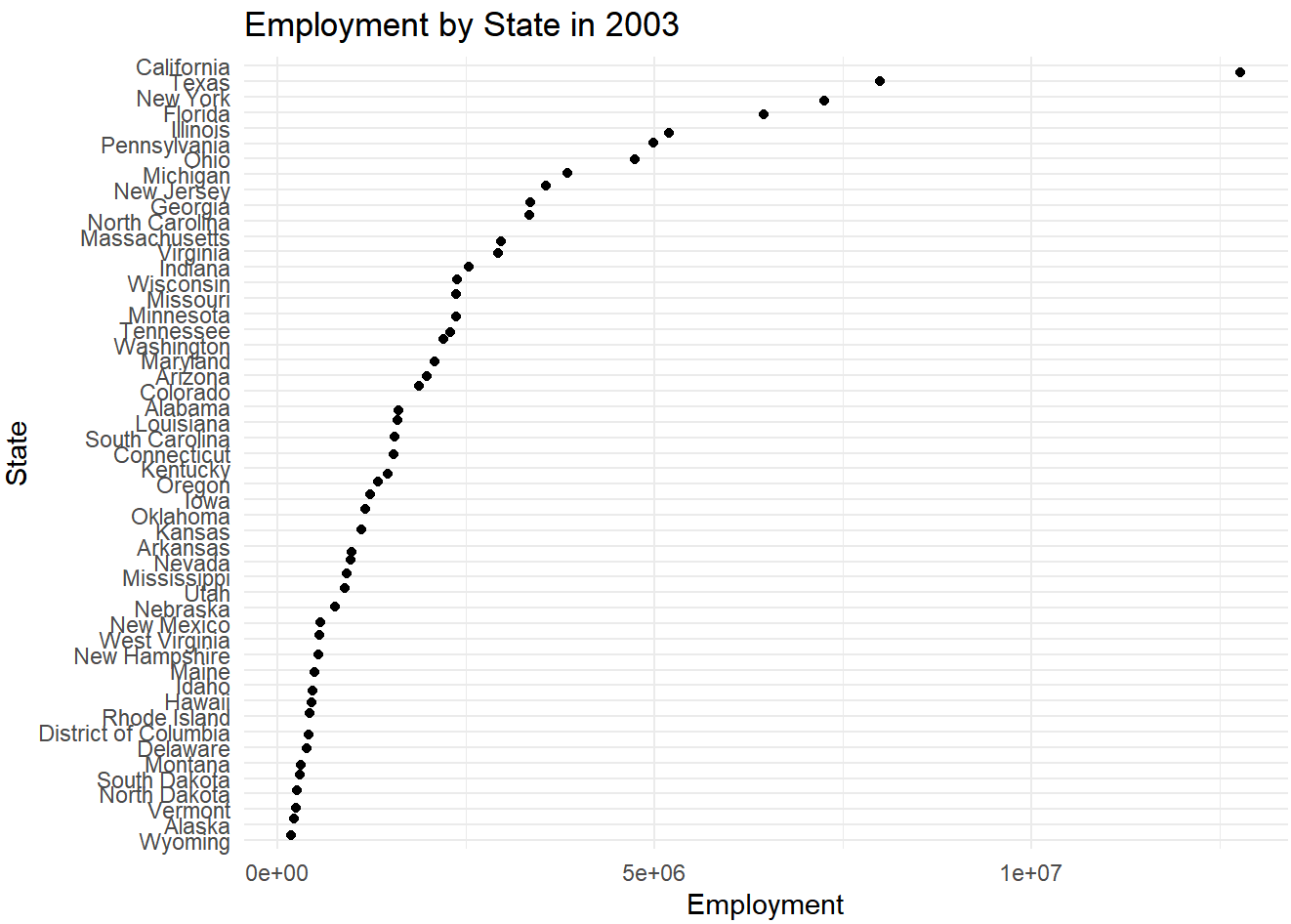
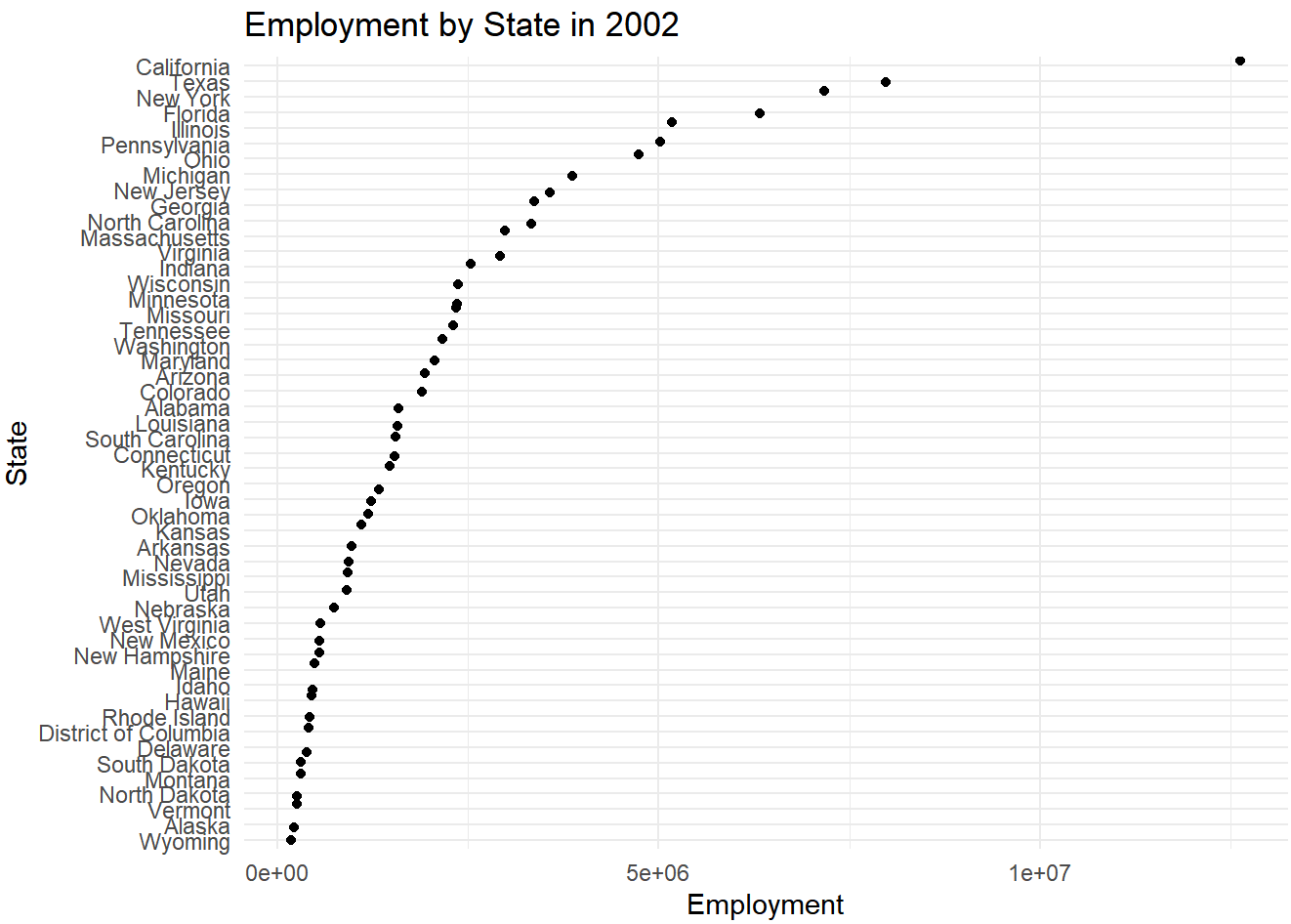
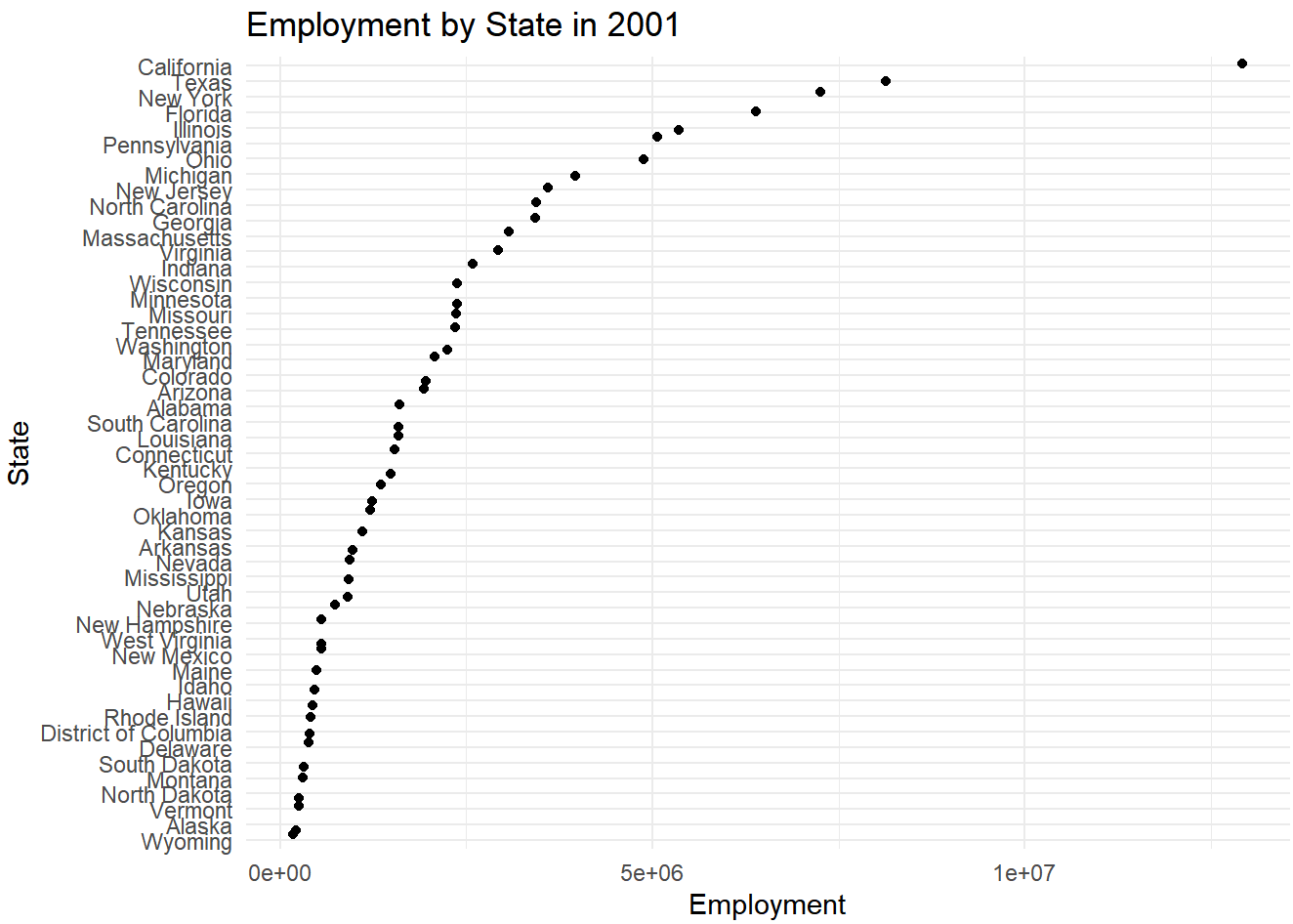
Employment

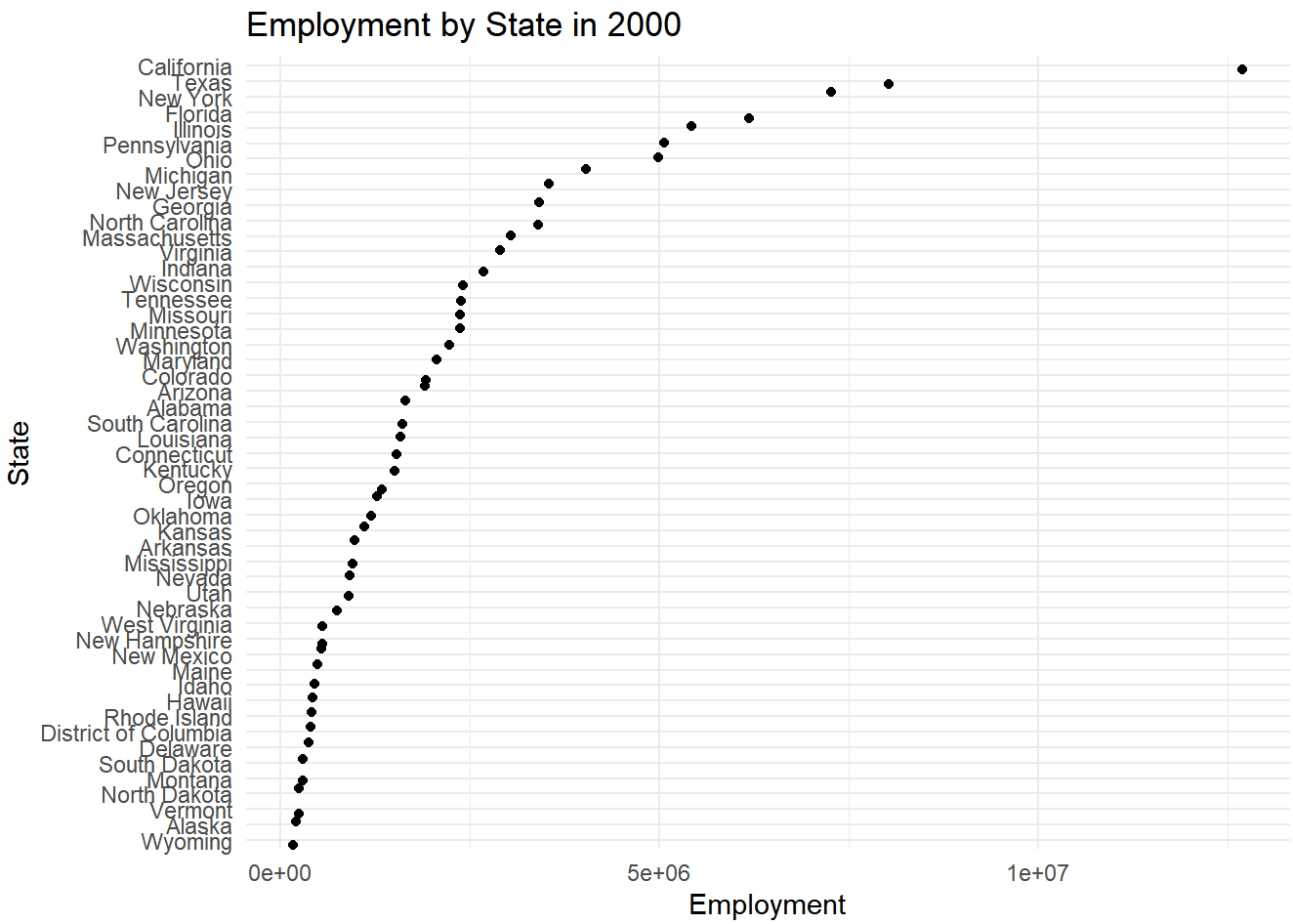

Employment by State in 2005
State
California
Texas
New York
Florida
Illinois
Pennsylvania
Ohio
Michigan
New Jersey
Georgia
North Carolina
Virginia
Massachusetts
Indiana
Wisconsin
Minnesota
Missouri
Tennessee
Washington
Maryland
Arizona
Colorado
Alabama
Louisiana
South Carolina
Connecticut
Kentucky
Oregon
Iowa
Oklahoma
Kansas
Nevada
Arkansas
Utah
Mississippi
Nebraska
New Mexico
West Virginia
New Hampshire
Idaho
Maine
Hawaii
Rhode Island
District of Columbia
Delaware
Montana
South Dakota
North Dakota
Vermont
Alaska
Wyoming
0e+00
5e+06
1e+07
Employment


Employment by State in 2004
California
Texas
New York
Florida
Illinois
Pennsylvania
Ohio
Michigan
New Jersey
Georgia
North Carolina
Virginia
Massachusetts
Indiana
Wisconsin
Missouri
Minnesota
Tennessee
Washington
Maryland
Arizona
Colorado
Alabama
Louisiana
South Carolina
Connecticut
Kentucky
Oregon
Iowa
Oklahoma
Kansas
Nevada
Arkansas
Mississippi
Utah
Nebraska
New Mexico
West Virginia
New Hampshire
Maine
Idaho
Hawaii
Rhode Island
District of Columbia
Delaware
Montana
South Dakota
North Dakota
Vermont
Alaska
Wyoming
State
0e+00
5e+06
1e+07
Employment


Employment by State in 2003
State
California
Texas
New York
Florida
Illinois
Pennsylvania
Ohio
Michigan
New Jersey
Georgia
North Carolina
Massachusetts
Virginia
Indiana
Wisconsin
Missouri
Minnesota
Tennessee
Washington
Maryland
Arizona
Colorado
Alabama
Louisiana
South Carolina
Connecticut
Kentucky
Oregon
Iowa
Oklahoma
Kansas
Arkansas
Nevada
Mississippi
Utah
Nebraska
New Mexico
West Virginia
New Hampshire
Maine
Idaho
Hawaii
Rhode Island
District of Columbia
Delaware
Montana
South Dakota
North Dakota
Vermont
Alaska
Wyoming
0e+00
5e+06
1e+07
Employment


Employment by State in 2002
California
Texas
New York
Florida
Illinois
Pennsylvania
Ohio
Michigan
New Jersey
Georgia
North Carolina
Massachusetts
Virginia
Indiana
Wisconsin
Minnesota
Missouri
Tennessee
Washington
Maryland
Arizona
Colorado
Alabama
Louisiana
South Carolina
Connecticut
Kentucky
Oregon
Iowa
Oklahoma
Kansas
Arkansas
Nevada
Mississippi
Utah
Nebraska
West Virginia
New Mexico
New Hampshire
Maine
Idaho
Hawaii
Rhode Island
District of Columbia
Delaware
South Dakota
Montana
North Dakota
Vermont
Alaska
Wyoming
State
0e+00
5e+06
1e+07
Employment

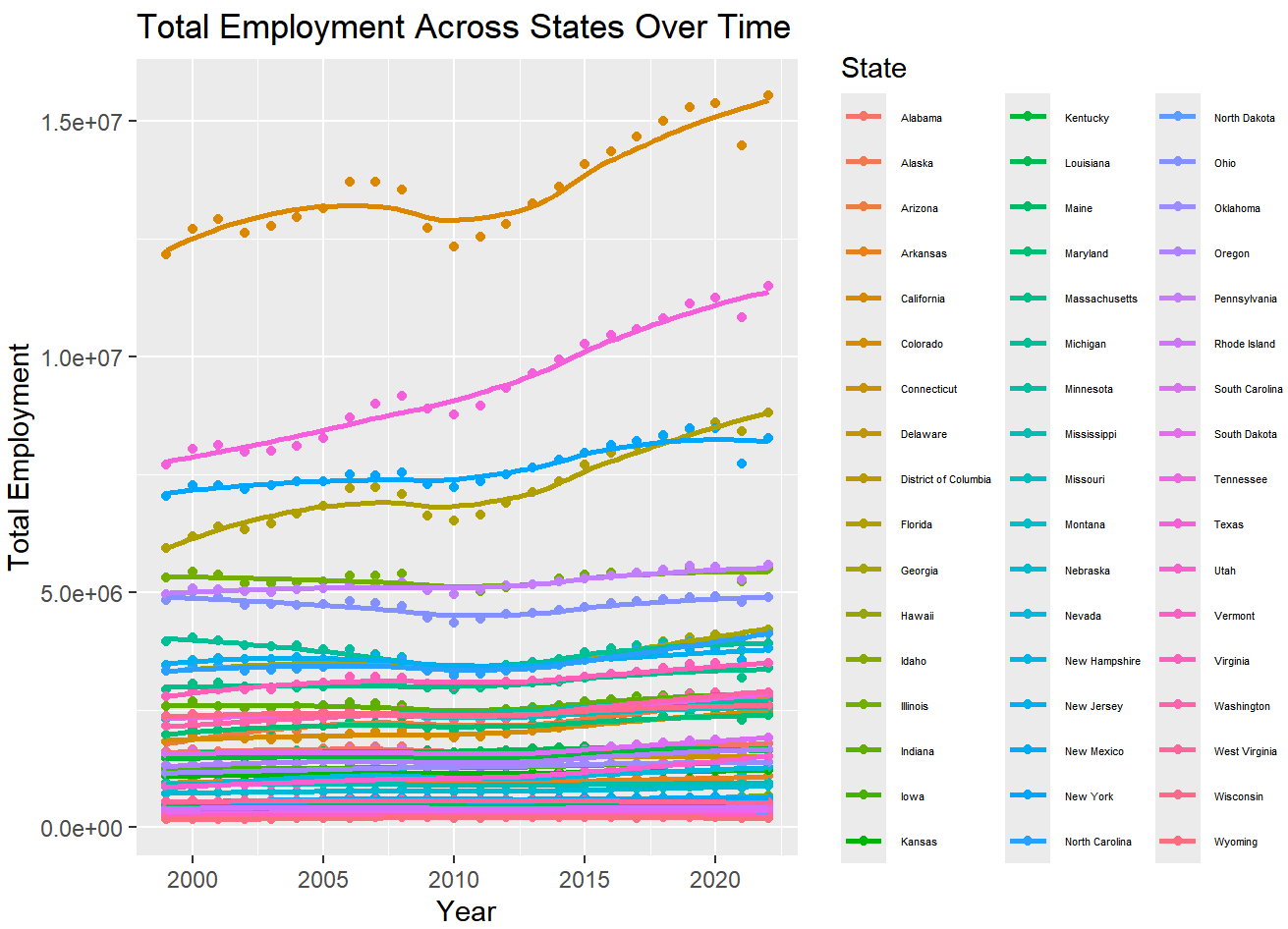

Employment by State in 2001
State
California
Texas
New York
Florida
Illinois
Pennsylvania
Ohio
Michigan
New Jersey
North Carolina
Georgia
Massachusetts
Virginia
Indiana
Wisconsin
Minnesota
Missouri
Tennessee
Washington
Maryland
Colorado
Arizona
Alabama
South Carolina
Louisiana
Connecticut
Kentucky
Oregon
Iowa
Oklahoma
Kansas
Arkansas
Nevada
Mississippi
Utah
Nebraska
New Hampshire
West Virginia
New Mexico
Maine
Idaho
Hawaii
Rhode Island
District of Columbia
Delaware
South Dakota
Montana
North Dakota
Vermont
Alaska
Wyoming
0e+00
5e+06
1e+07
Employment


Employment by State in 2000
State
California
Texas
New York
Florida
Illinois
Pennsylvania
Ohio
Michigan
New Jersey
Georgia
North Carolina
Massachusetts
Virginia
Indiana
Wisconsin
Tennessee
Missouri
Minnesota
Washington
Maryland
Colorado
Arizona
Alabama
South Carolina
Louisiana
Connecticut
Kentucky
Oregon
Iowa
Oklahoma
Kansas
Arkansas
Mississippi
Nevada
Utah
Nebraska
West Virginia
New Hampshire
New Mexico
Maine
Idaho
Hawaii
Rhode Island
District of Columbia
Delaware
South Dakota
Montana
North Dakota
Vermont
Alaska
Wyoming
0e+00
5e+06
1e+07
Employment

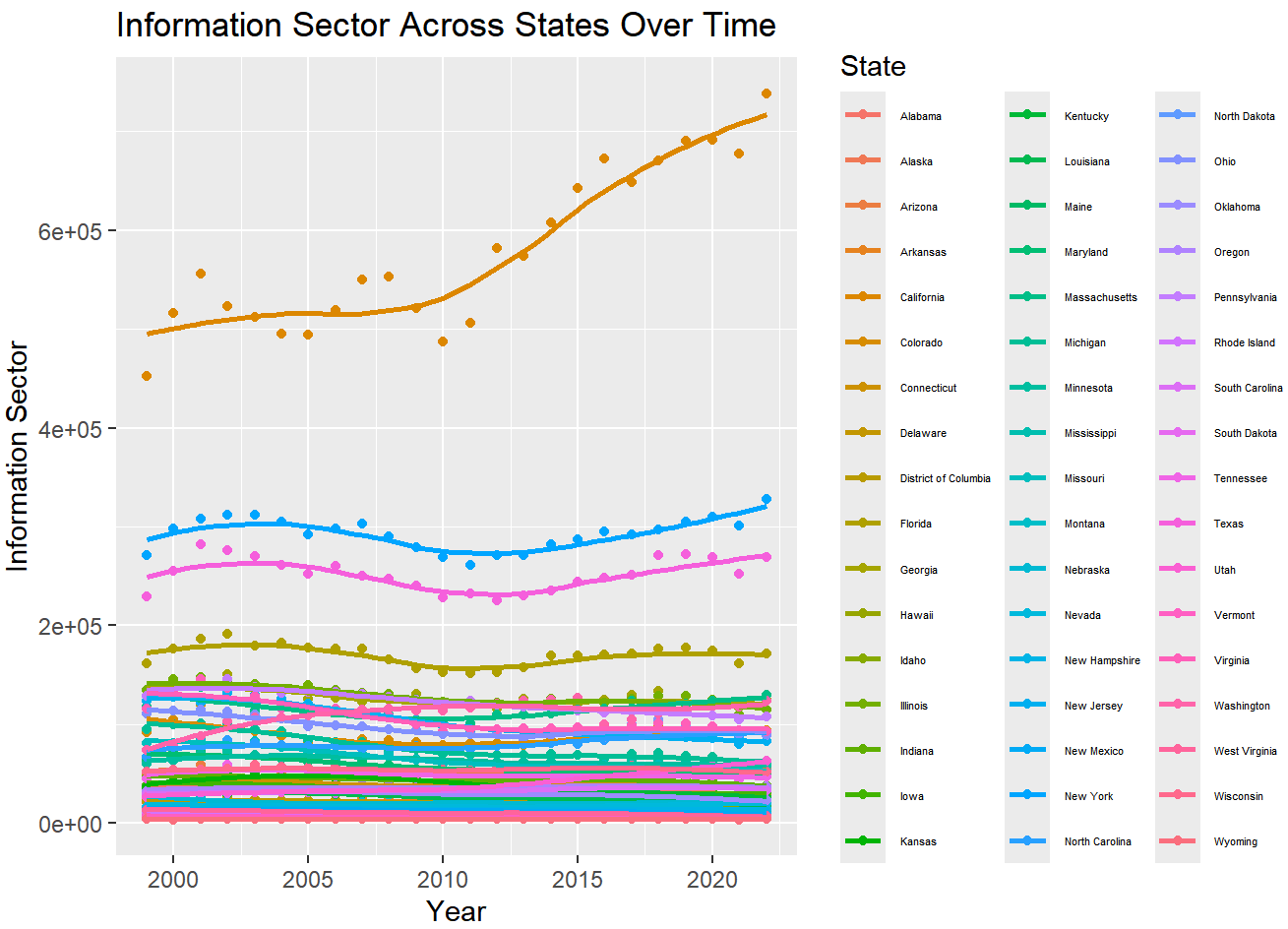
Separate plots for each variable trend over time, with separate lines for every state

```
variables <- c("Total Employment", "Information Sector", "Net Job Creation",
               "Establishment Births", "Establishment, Firm Deaths",
               "Number of Utility Patents", "Proportion of S&E",
               "Number of Firms Receiving VC")

# Loop through each variable and generate the plot
suppressWarnings(for (v in variables) {
  plot <- ggplot(full, aes(x = Year, y = .data[[v]], color = State)) +
    geom_point() +
    geom_smooth(se = FALSE) +
    labs(title = paste(v, "Across States Over Time"),
         x = "Year",
         y = v) +
    theme(legend.position = "right",
        legend.text = element_text(size = 4))

  print(plot)
})
```

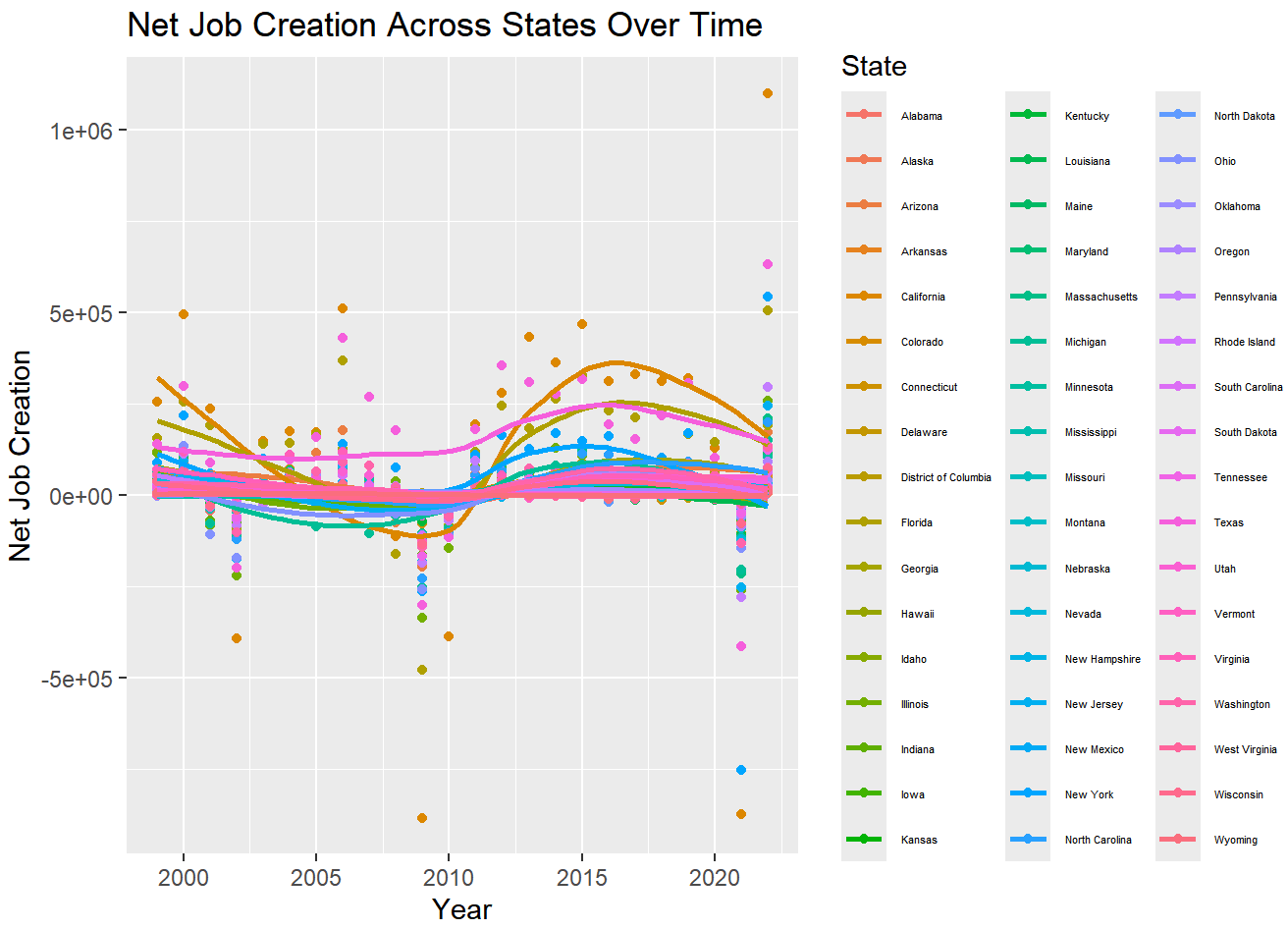
```
`geom_smooth()` using method = 'loess' and formula = 'y ~ x'
```



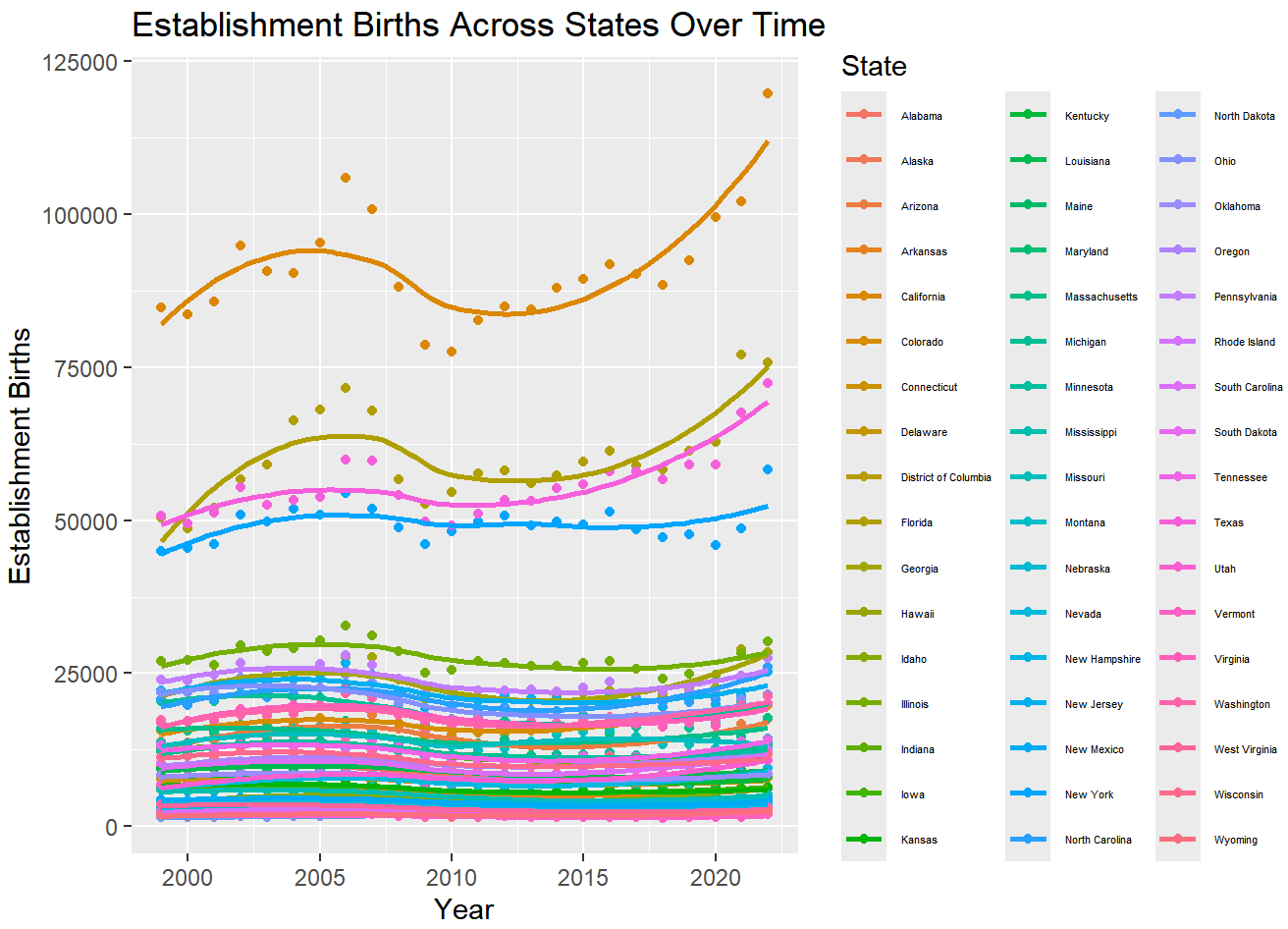

```
`geom_smooth()` using method = 'loess' and formula = 'y ~ x'
```



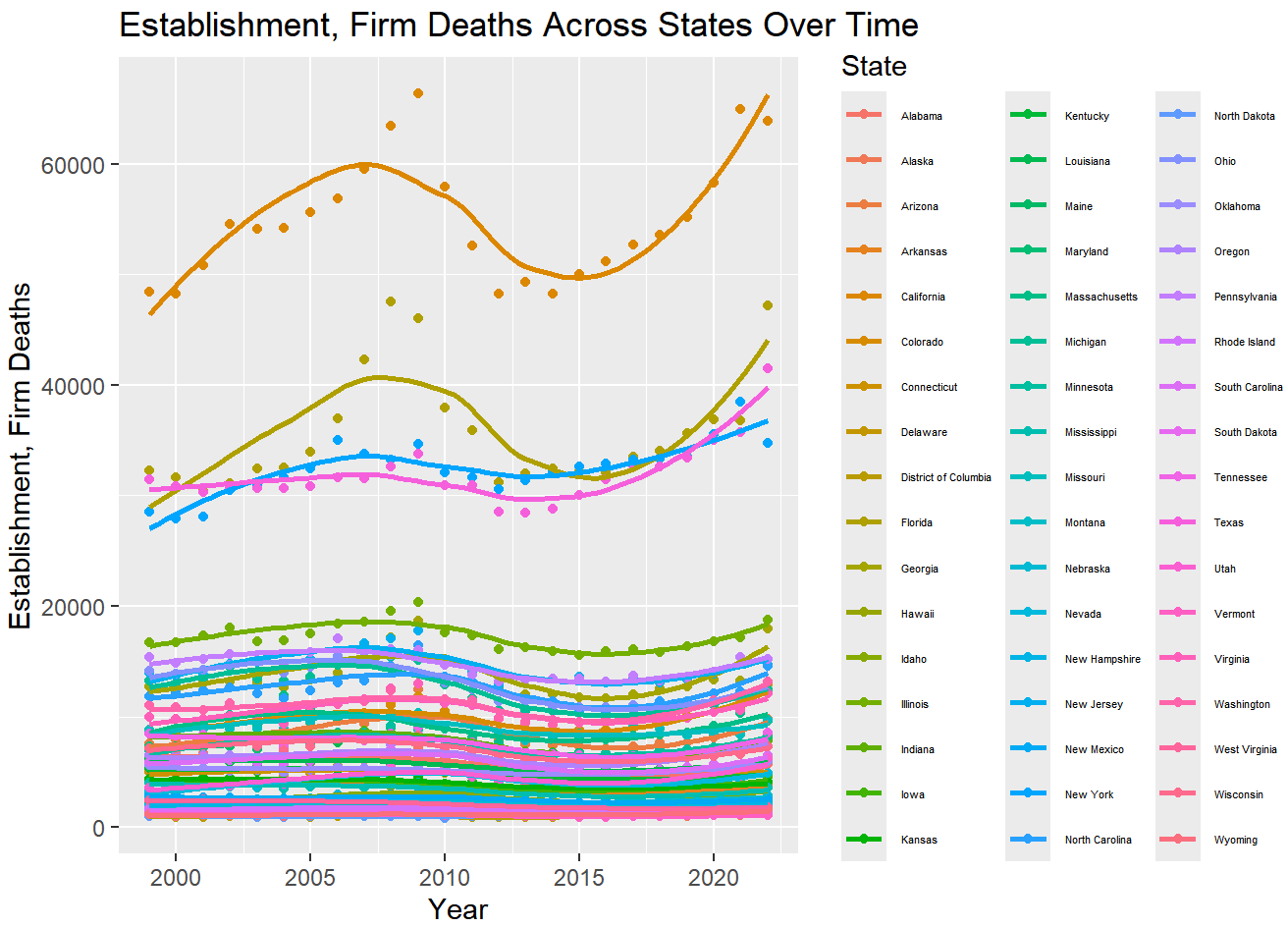

```
`geom_smooth()` using method = 'loess' and formula = 'y ~ x'
```



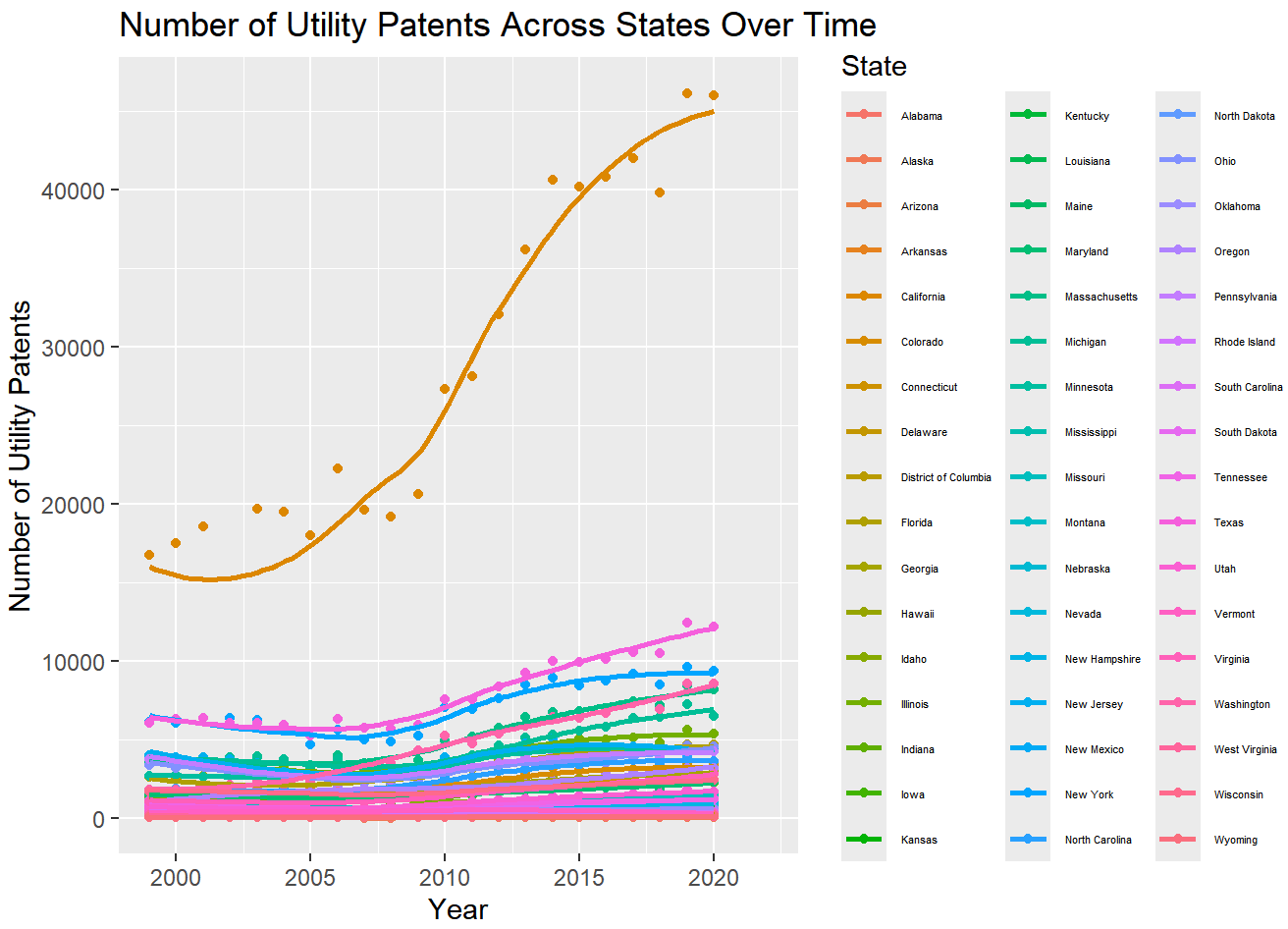

```
`geom_smooth()` using method = 'loess' and formula = 'y ~ x'
```



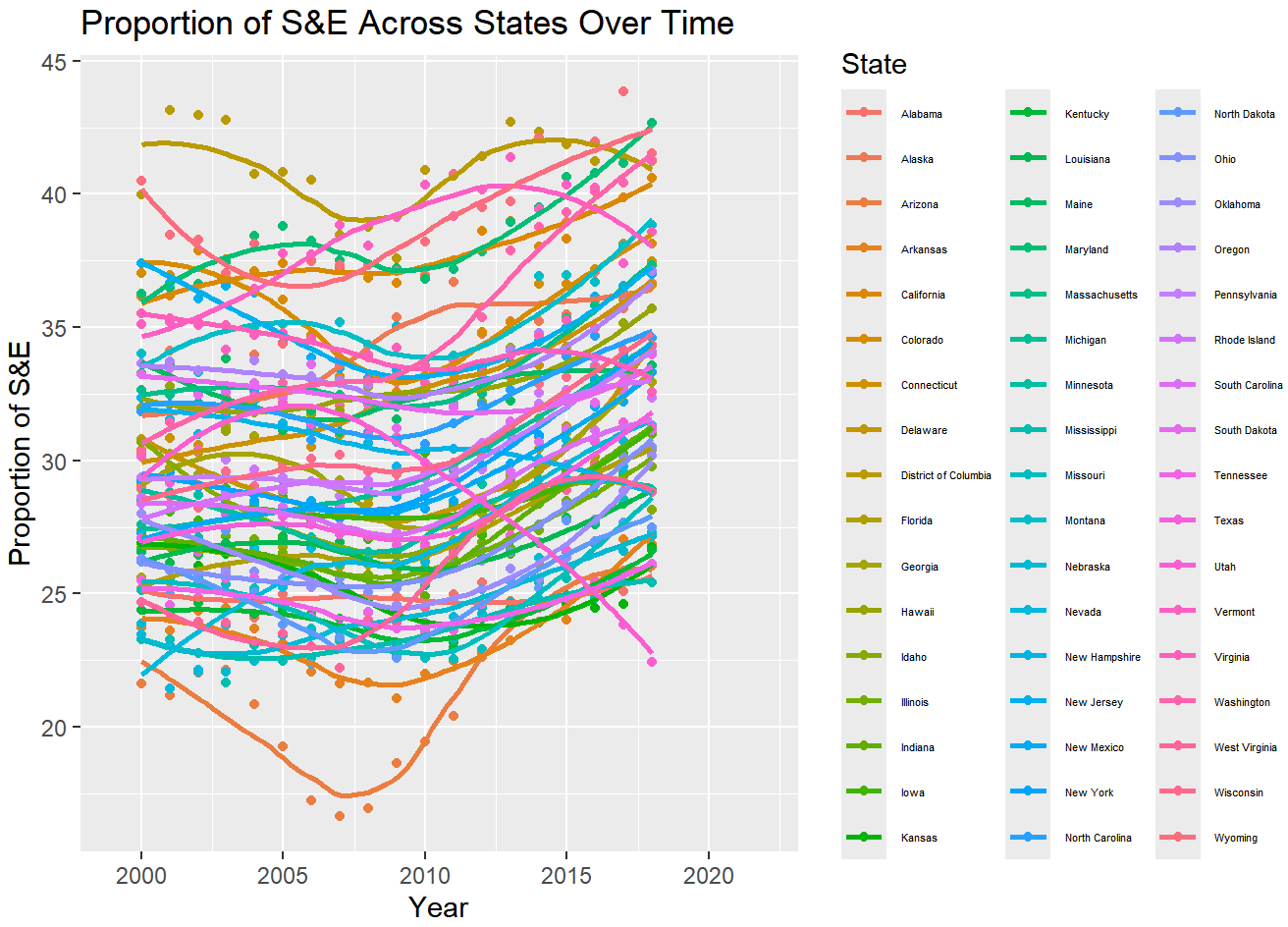

```
`geom_smooth()` using method = 'loess' and formula = 'y ~ x'
```



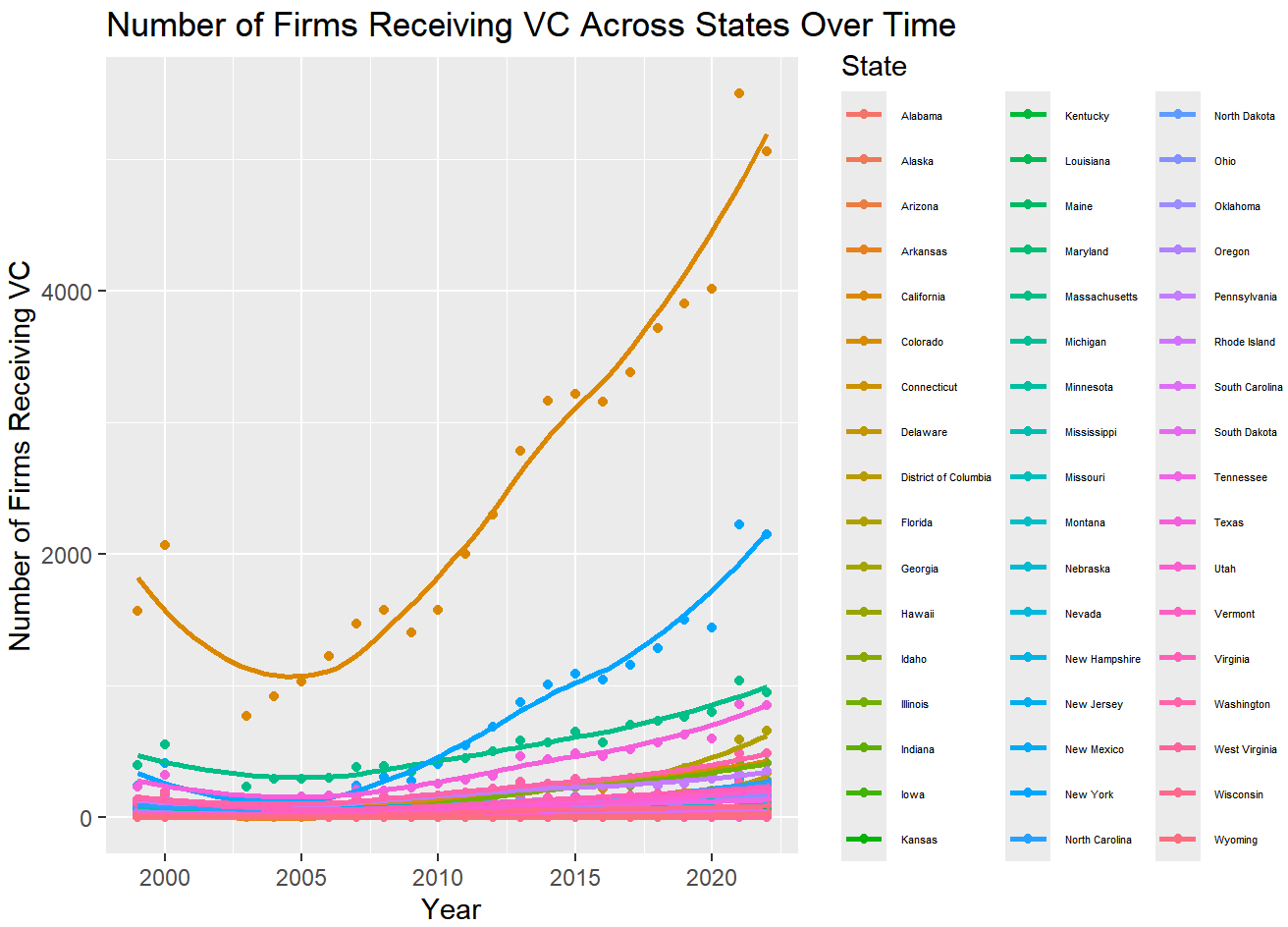

```
`geom_smooth()` using method = 'loess' and formula = 'y ~ x'
```




```
`geom_smooth()` using method = 'loess' and formula = 'y ~ x'
```



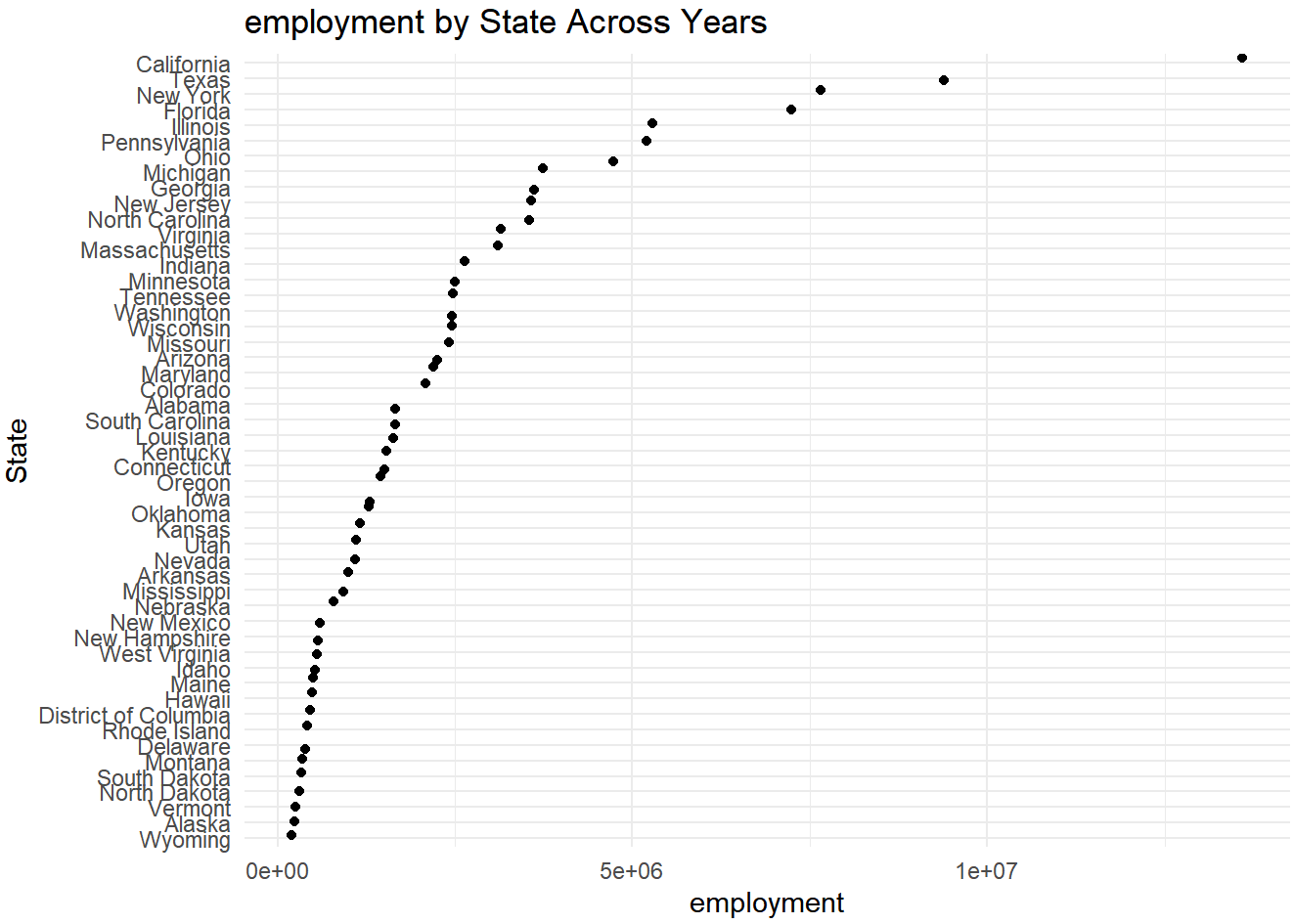

```
`geom_smooth()` using method = 'loess' and formula = 'y ~ x'
```

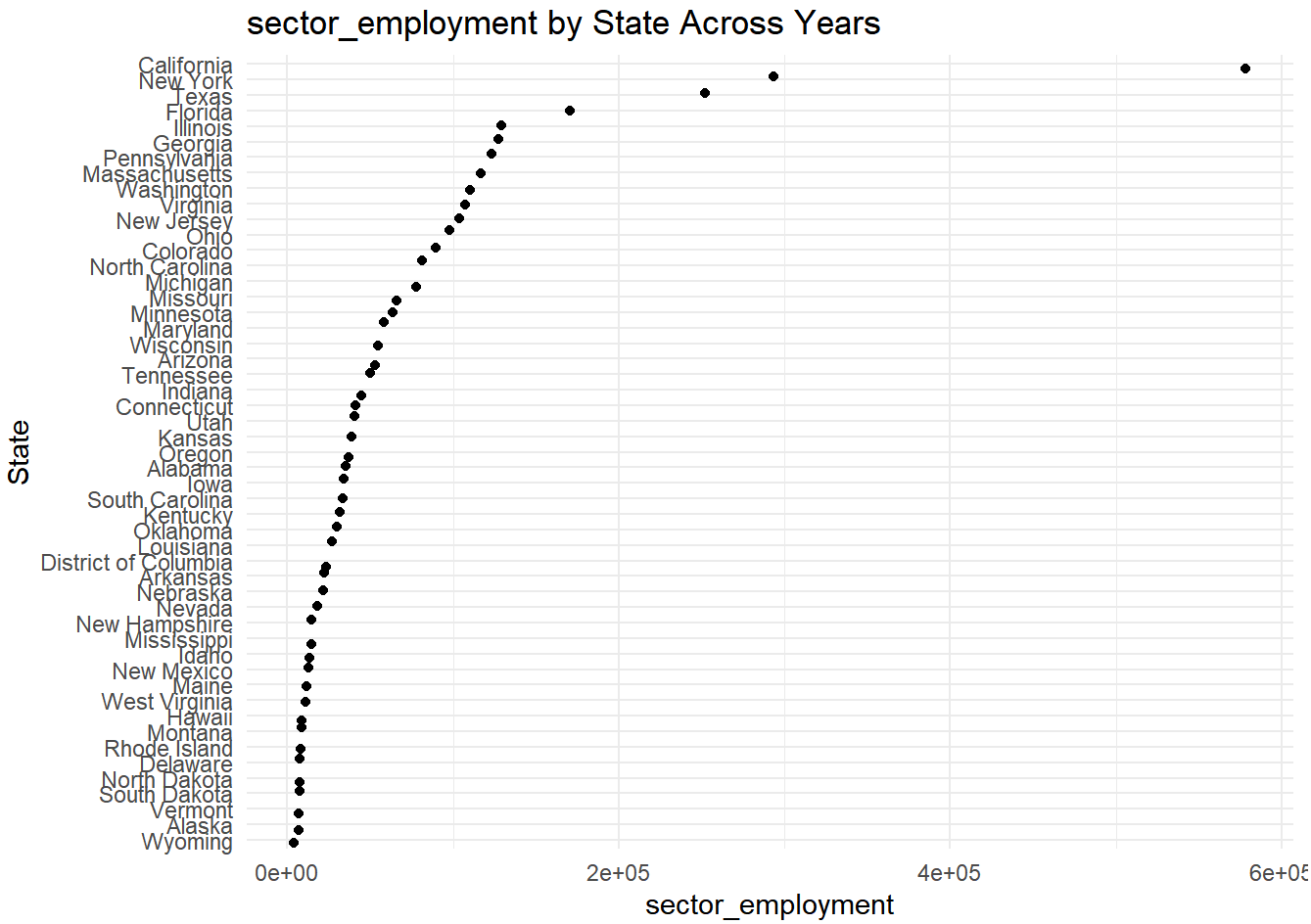


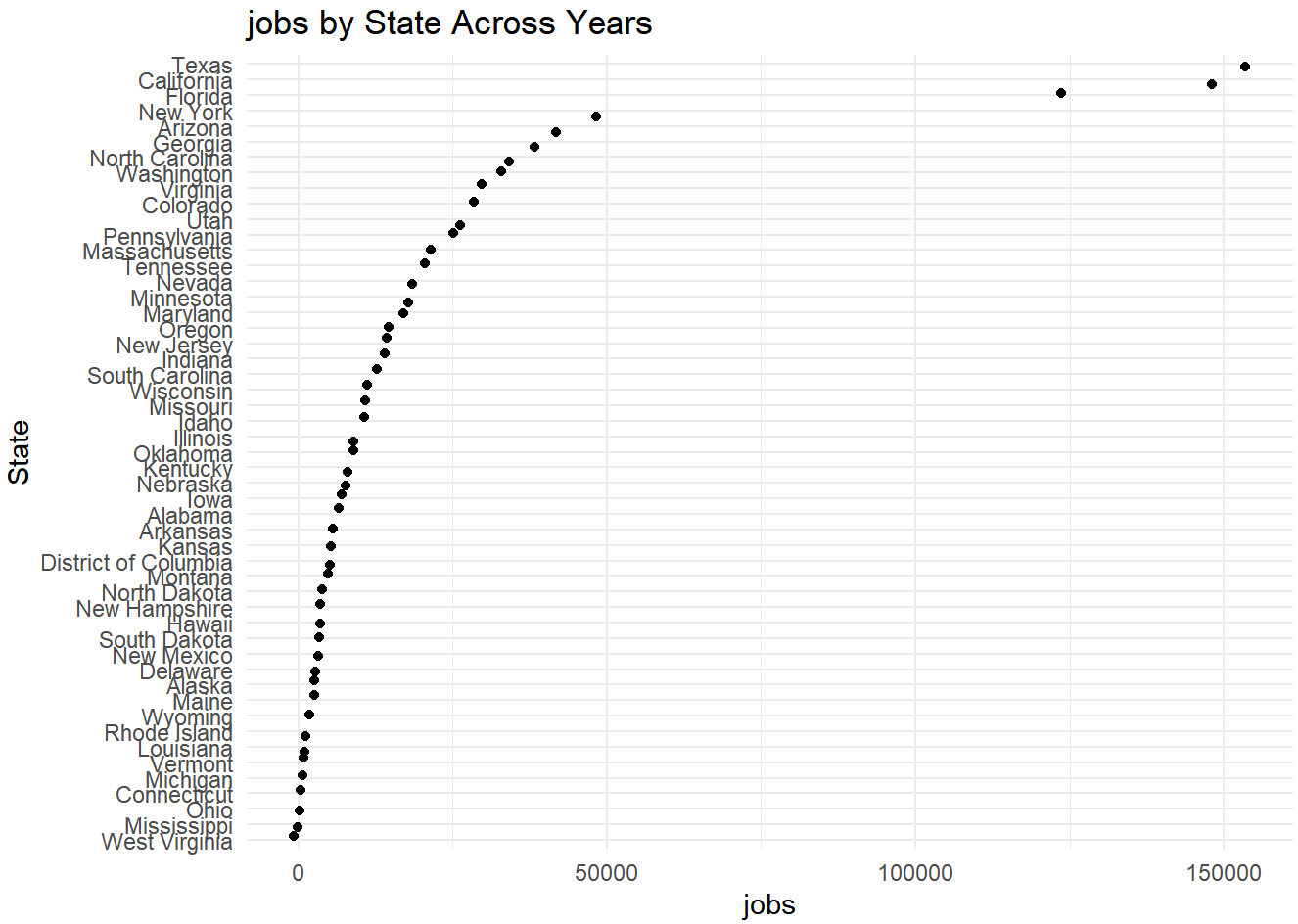
Separate plots for each variable (summarized over time) across states

```
#summary plot

full_summary <- full |>
  group_by(State) |>
  summarise(employment = mean(`Total Employment`, na.rm = TRUE),
            sector_employment = mean(`Information Sector`, na.rm = TRUE),
            jobs = mean(`Net Job Creation`, na.rm = TRUE),
            firms = mean(`Number of Firms`, na.rm = TRUE),
            establishments = mean(`Number of Firms`, na.rm = TRUE),
            births = mean(`Establishment Births`, na.rm = TRUE),
            deaths = mean(`Establishment, Firm Deaths`, na.rm = TRUE),
            patents = mean(`Number of Utility Patents`, na.rm = TRUE),
            se = mean(`Proportion of S&E`, na.rm = TRUE),
            investments = mean(`Number of Firms Receiving VC`, na.rm = TRUE))


summary_variables <- c("employment", "sector_employment", "jobs", "firms",
              "establishments", "births", "deaths", "patents", "se", "investments")
```

```r
for (v in summary_variables) {
  summary_filtered <- full_summary |>
    select(State, all_of(v))  # Use all_of to ensure correct variable selection

  # Reorder State by the values of the variable v from least to most
  summary_filtered$State <- fct_reorder(summary_filtered$State, summary_filtered[[v]])

  plot <- ggplot(summary_filtered, aes(x = State, y = .data[[v]])) +
    geom_jitter() +
    labs(title = paste(v, "by State Across Years"),
         x = "State",
         y = v) +
    theme_minimal() +
    coord_flip()  # Optional for readability

  print(plot)
}
```




sector_employment by State Across Years
State
California
New York
Texas
Florida
Illinois
Georgia
Pennsylvania
Massachusetts
Washington
Virginia
New Jersey
Ohio
Colorado
North Carolina
Michigan
Missouri
Minnesota
Maryland
Wisconsin
Arizona
Tennessee
Indiana
Connecticut
Utah
Kansas
Oregon
Alabama
Iowa
South Carolina
Kentucky
Oklahoma
Louisiana
District of Columbia
Arkansas
Nebraska
Nevada
New Hampshire
Mississippi
Idaho
New Mexico
Maine
West Virginia
Hawaii
Montana
Rhode Island
Delaware
North Dakota
South Dakota
Vermont
Alaska
Wyoming
0e+00
2e+05
4e+05
6e+05
sector_employment


jobs by State Across Years
State
Texas
California
Florida
New York
Arizona
Georgia
North Carolina
Washington
Virginia
Colorado
Utah
Pennsylvania
Massachusetts
Tennessee
Nevada
Minnesota
Maryland
Oregon
New Jersey
Indiana
South Carolina
Wisconsin
Missouri
Idaho
Illinois
Oklahoma
Kentucky
Nebraska
Iowa
Alabama
Arkansas
Kansas
District of Columbia
Montana
North Dakota
New Hampshire
Hawaii
South Dakota
New Mexico
Delaware
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Ohio
Mississippi
West Virginia
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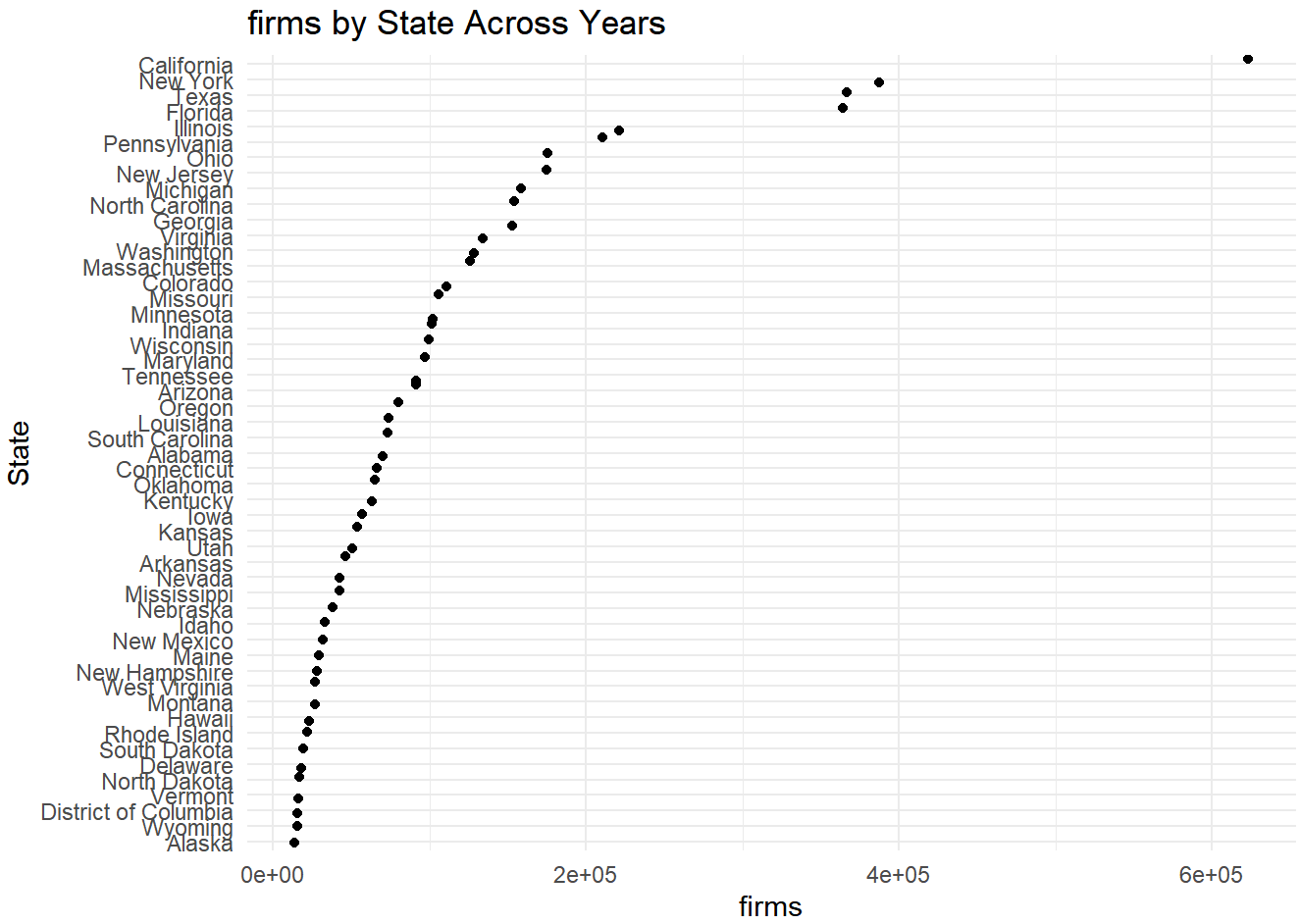
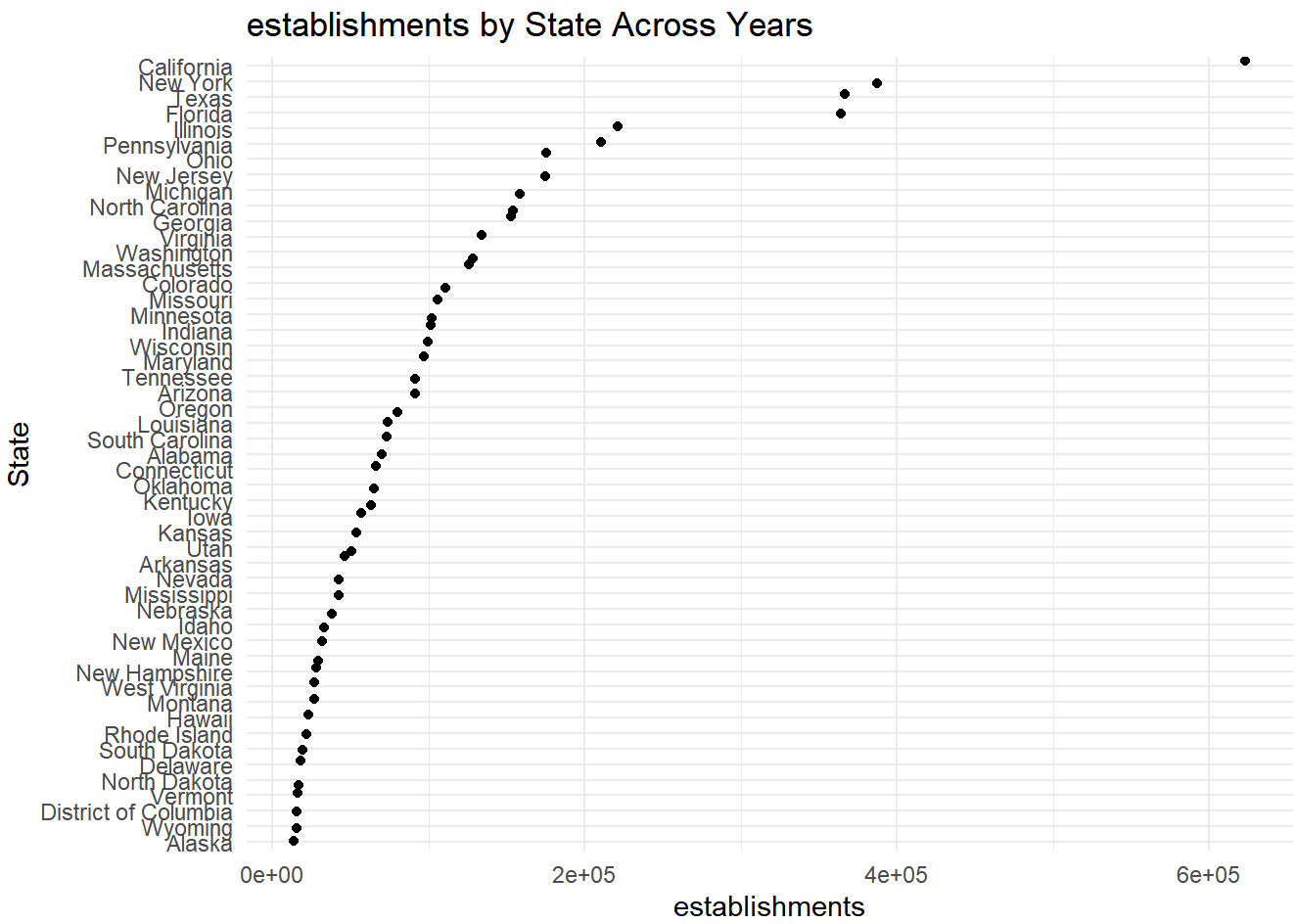
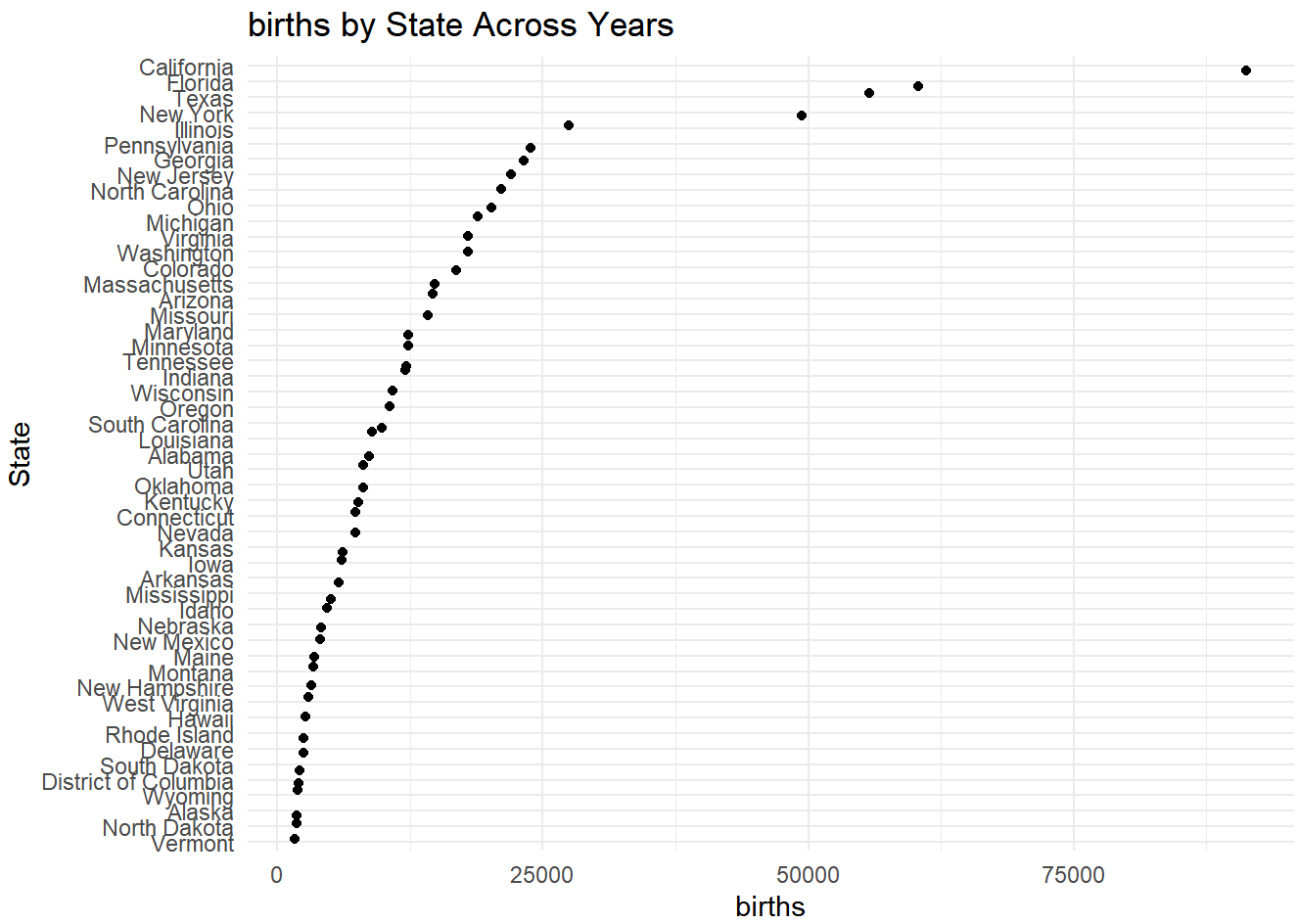
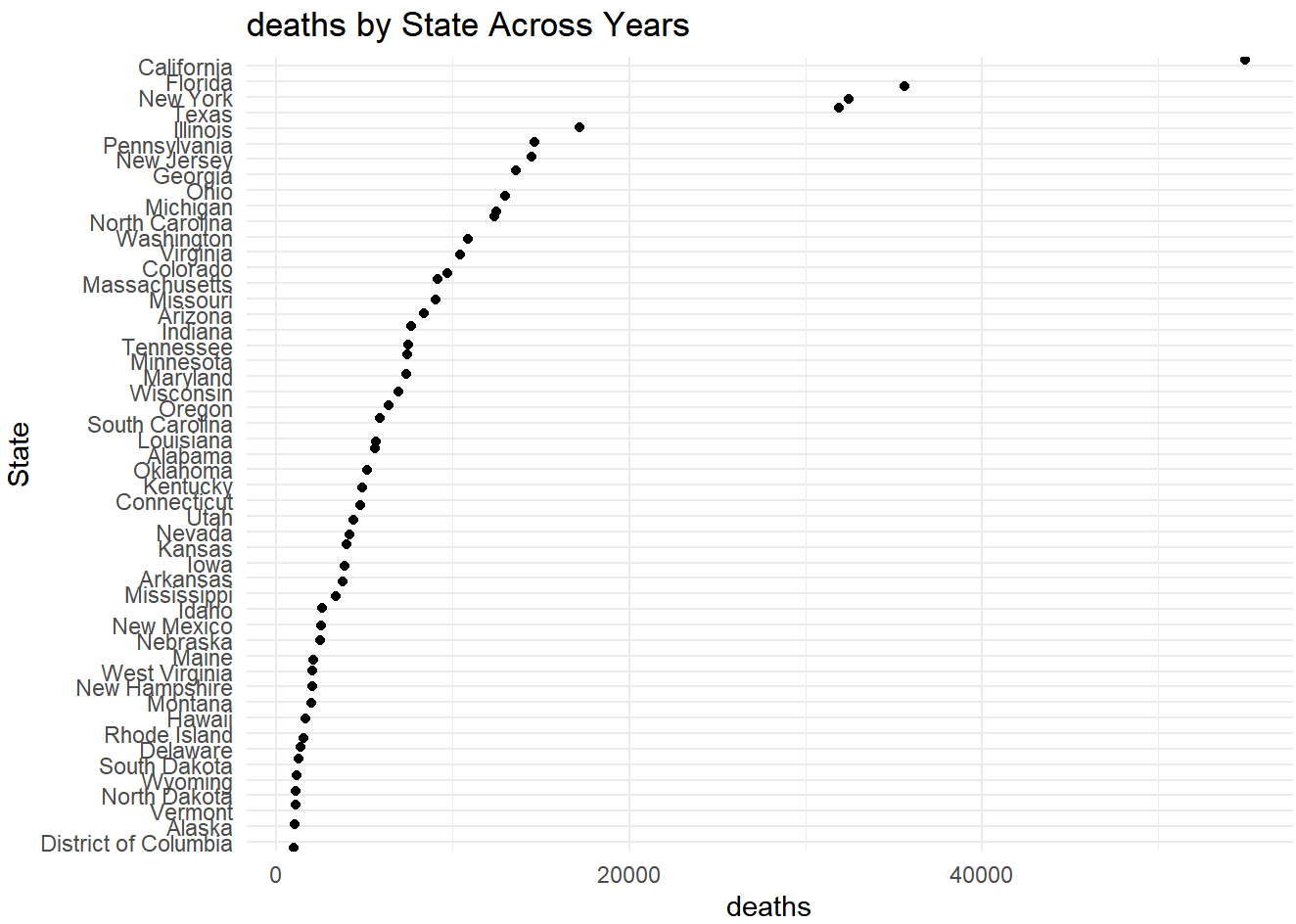
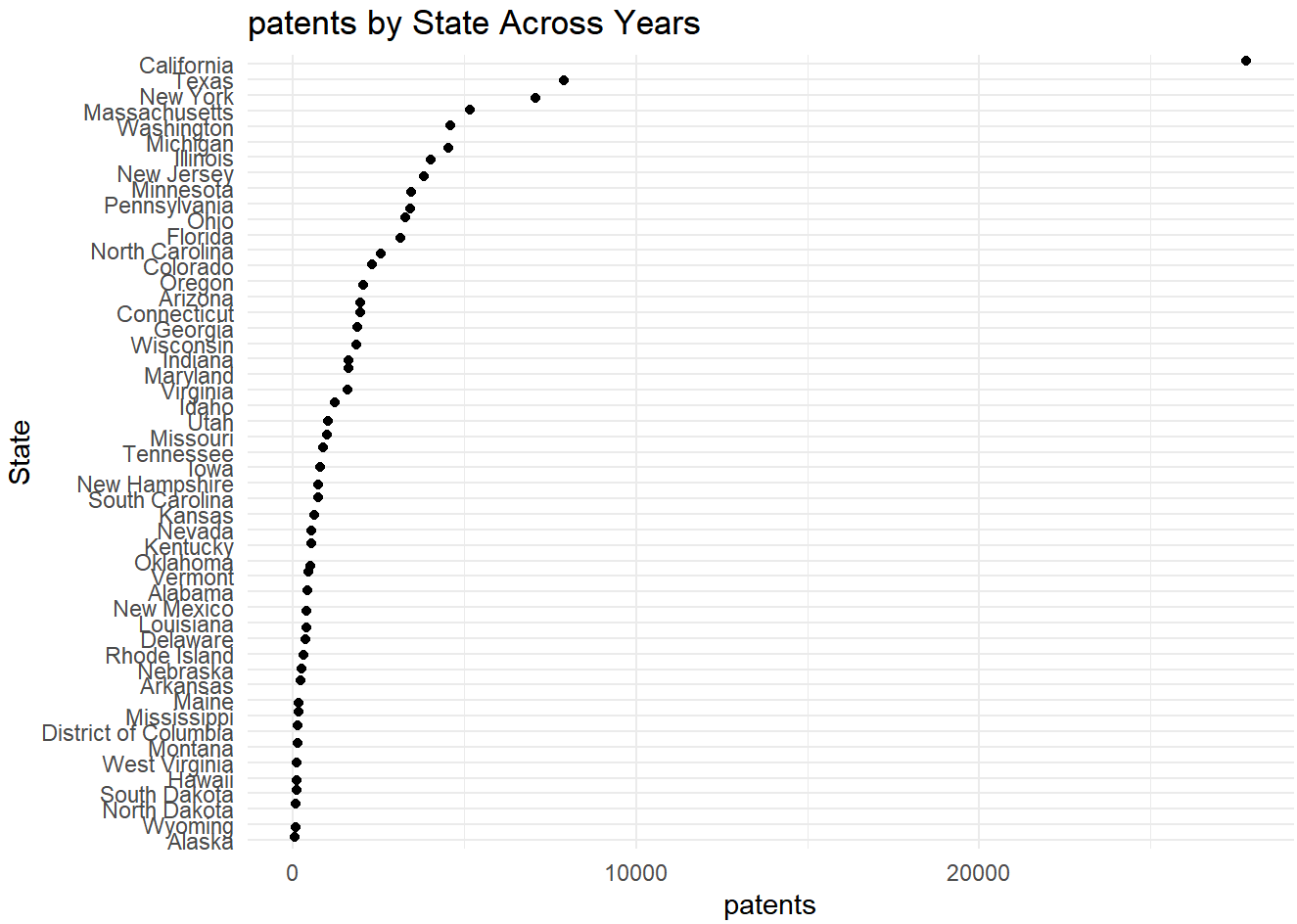
100000
150000
jobs


firms by State Across Years
California
New York
Texas
Florida
Illinois
Pennsylvania
Ohio
New Jersey
Michigan
North Carolina
Georgia
Virginia
Washington
Massachusetts
Colorado
Missouri
Minnesota
Indiana
Wisconsin
Maryland
Tennessee
Arizona
Oregon
Louisiana
South Carolina
Alabama
Connecticut
Oklahoma
Kentucky
Iowa
Kansas
Utah
Arkansas
Nevada
Mississippi
Nebraska
Idaho
New Mexico
Maine
New Hampshire
West Virginia
Montana
Hawaii
Rhode Island
South Dakota
Delaware
North Dakota
Vermont
District of Columbia
Wyoming
Alaska
State
0e+00
2e+05
4e+05
6e+05
firms


establishments by State Across Years
State
California
New York
Texas
Florida
Illinois
Pennsylvania
Ohio
New Jersey
Michigan
North Carolina
Georgia
Virginia
Washington
Massachusetts
Colorado
Missouri
Minnesota
Indiana
Wisconsin
Maryland
Tennessee
Arizona
Oregon
Louisiana
South Carolina
Alabama
Connecticut
Oklahoma
Kentucky
Iowa
Kansas
Utah
Arkansas
Nevada
Mississippi
Nebraska
Idaho
New Mexico
Maine
New Hampshire
West Virginia
Montana
Hawaii
Rhode Island
South Dakota
Delaware
North Dakota
Vermont
District of Columbia
Wyoming
Alaska
0e+00
2e+05
4e+05
6e+05
establishments


births by State Across Years
State
California
Florida
Texas
New York
Illinois
Pennsylvania
Georgia
New Jersey
North Carolina
Ohio
Michigan
Virginia
Washington
Colorado
Massachusetts
Arizona
Missouri
Maryland
Minnesota
Tennessee
Indiana
Wisconsin
Oregon
South Carolina
Louisiana
Alabama
Utah
Oklahoma
Kentucky
Connecticut
Nevada
Kansas
Iowa
Arkansas
Mississippi
Idaho
Nebraska
New Mexico
Maine
Montana
New Hampshire
West Virginia
Hawaii
Rhode Island
Delaware
South Dakota
District of Columbia
Wyoming
Alaska
North Dakota
Vermont
0
25000
50000
75000
births


deaths by State Across Years
California
Florida
New York
Texas
Illinois
Pennsylvania
New Jersey
Georgia
Ohio
Michigan
North Carolina
Washington
Virginia
Colorado
Massachusetts
Missouri
Arizona
Indiana
Tennessee
Minnesota
Maryland
Wisconsin
Oregon
South Carolina
Louisiana
Alabama
Oklahoma
Kentucky
Connecticut
Utah
Nevada
Kansas
Iowa
Arkansas
Mississippi
Idaho
New Mexico
Nebraska
Maine
West Virginia
New Hampshire
Montana
Hawaii
Rhode Island
Delaware
South Dakota
Wyoming
North Dakota
Vermont
Alaska
District of Columbia
State
0
20000
40000
deaths


patents by State Across Years
State
California
Texas
New York
Massachusetts
Washington
Michigan
Illinois
New Jersey
Minnesota
Pennsylvania
Ohio
Florida
North Carolina
Colorado
Oregon
Arizona
Connecticut
Georgia
Wisconsin
Indiana
Maryland
Virginia
Idaho
Utah
Missouri
Tennessee
Iowa
New Hampshire
South Carolina
Kansas
Nevada
Kentucky
Oklahoma
Vermont
Alabama
New Mexico
Louisiana
Delaware
Rhode Island
Nebraska
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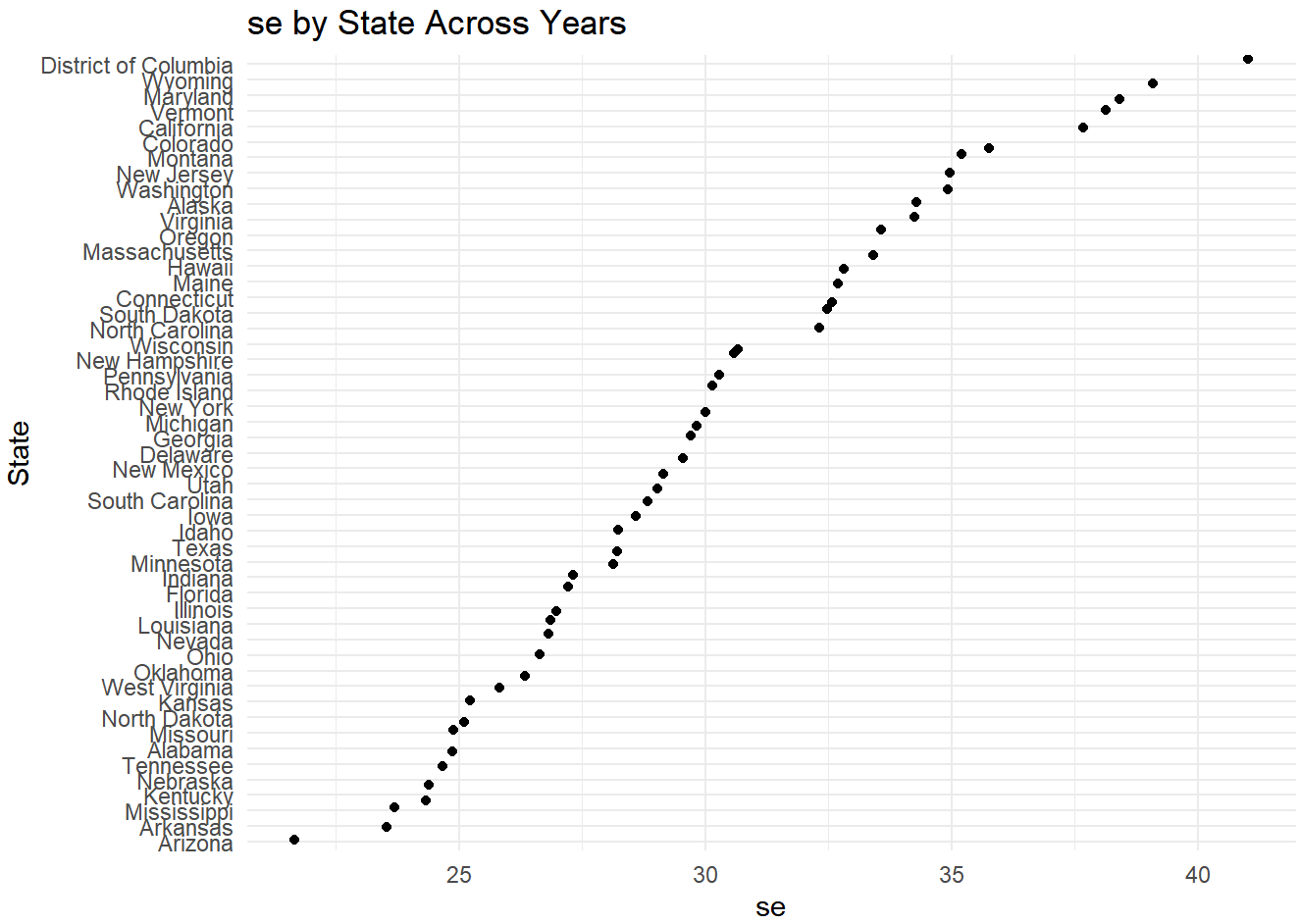
Montana
West Virginia
Hawaii
South Dakota
North Dakota
Wyoming
Alaska
0
10000
20000
patents


se by State Across Years
State
District of Columbia
Wyoming
Maryland
Vermont
California
Colorado
Montana
New Jersey
Washington
Alaska
Virginia
Oregon
Massachusetts
Hawaii
Maine
Connecticut
South Dakota
North Carolina
Wisconsin
New Hampshire
Pennsylvania
Rhode Island
New York
Michigan
Georgia
Delaware
New Mexico
Utah
South Carolina
Iowa
Idaho
Texas
Minnesota
Indiana
Florida
Illinois
Louisiana
Nevada
Ohio
Oklahoma
West Virginia
Kansas
North Dakota
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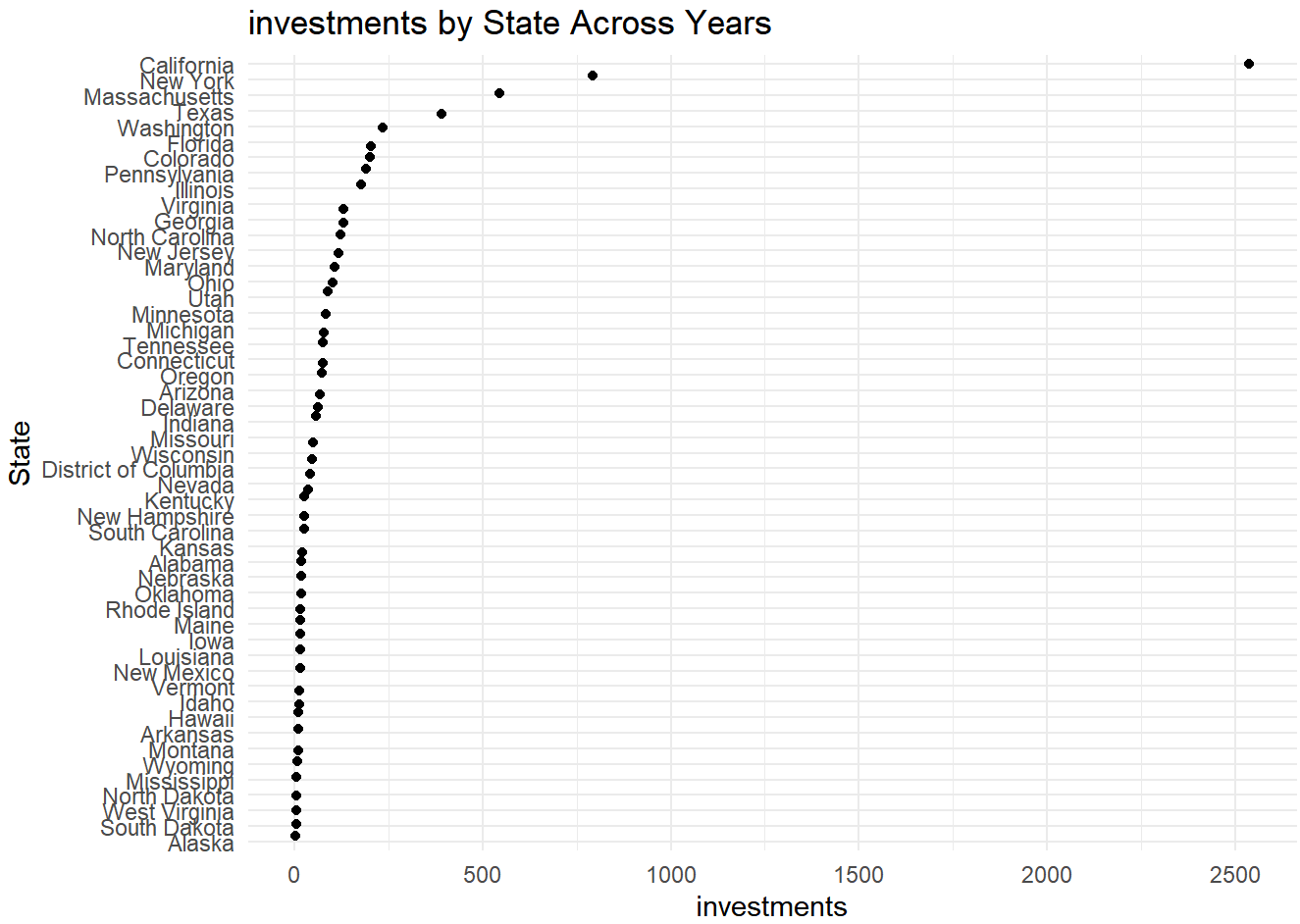
Alabama
Tennessee
Nebraska
Kentucky
Mississippi
Arkansas
Arizona
25
30
35
40
se


investments by State Across Years
State
California
New York
Massachusetts
Texas
Washington
Florida
Colorado
Pennsylvania
Illinois
Virginia
Georgia
North Carolina
New Jersey
Maryland
Ohio
Utah
Minnesota
Michigan
Tennessee
Connecticut
Oregon
Arizona
Delaware
Indiana
Missouri
Wisconsin
District of Columbia
Nevada
Kentucky
New Hampshire
South Carolina
Kansas
Alabama
Nebraska
Oklahoma
Rhode Island
Maine
Iowa
Louisiana
New Mexico
Vermont
Idaho
Hawaii
Arkansas
Montana
Wyoming
Mississippi
North Dakota
West Virginia
South Dakota
Alaska
0
500
1000
1500
2000
2500
investments