Introduction to Exploratory Data Analysis

STATISTICAL THINKING IN PYTHON (PART 1)

Justin Bois

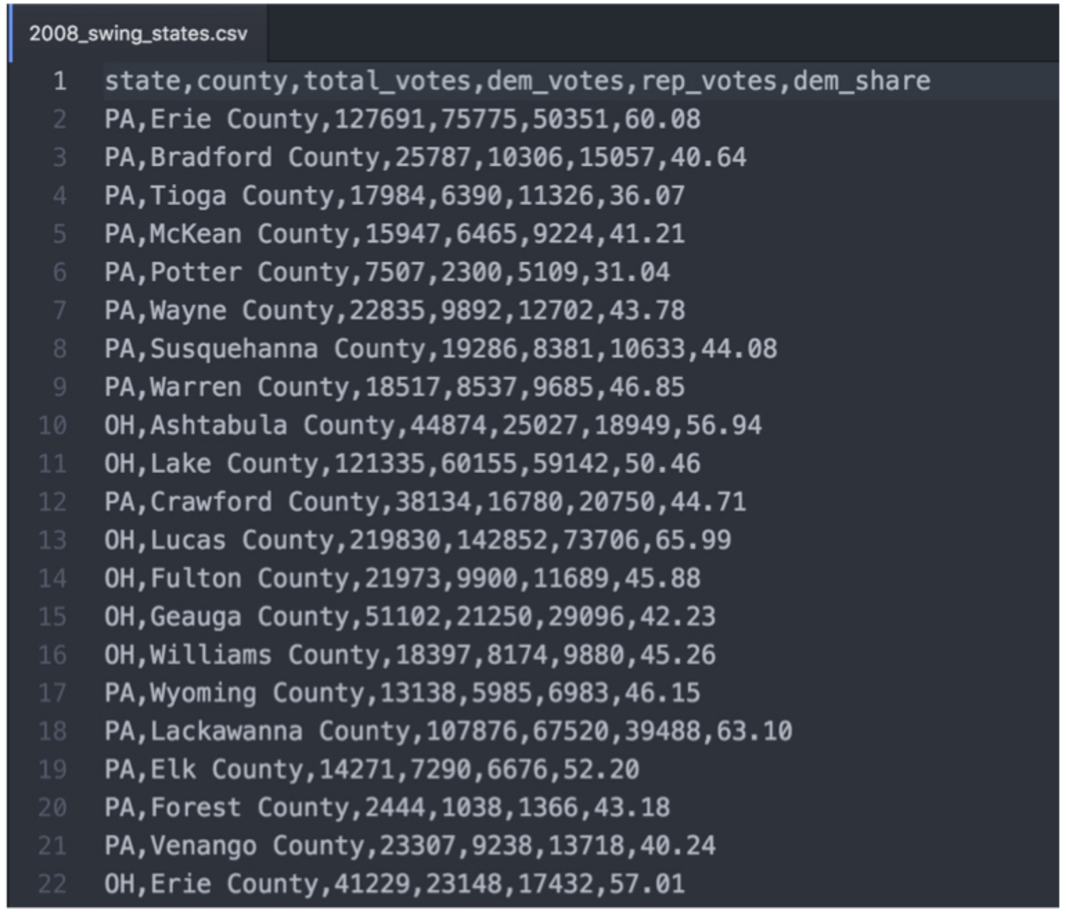
Lecturer at the California Institute of Technology

Exploratory data analysis

- The process of organizing, plotting, and summarizing a data set

“Exploratory data analysis can never be the whole story, but nothing else can serve as the foundation stone.” —John Tukey

2008 US swing state election results



```
state,county,total_votes,dem_votes,rep_votes,dem_share
PA,Erie County,127691,75775,50351,60.08
PA,Bradford County,25787,10306,15057,40.64
PA,Tioga County,17984,6390,11326,36.07
PA,McKean County,15947,6465,9224,41.21
PA,Potter County,7507,2300,5109,31.04
PA,Wayne County,22835,9892,12702,43.78
PA,Susquehanna County,19286,8381,10633,44.08
PA,Warren County,18517,8537,9685,46.85
OH,Ashtabula County,44874,25027,18949,56.94
OH,Lake County,121335,60155,59142,50.46
PA,Crawford County,38134,16780,20750,44.71
OH,Lucas County,219830,142852,73706,65.99
OH,Fulton County,21973,9900,11689,45.88
OH,Geauga County,51102,21250,29096,42.23
OH,Williams County,18397,8174,9880,45.26
PA,Wyoming County,13138,5985,6983,46.15
PA,Lackawanna County,107876,67520,39488,63.10
PA,Elk County,14271,7290,6676,52.20
PA,Forest County,2444,1038,1366,43.18
PA,Venango County,23307,9238,13718,40.24
OH,Erie County,41229,23148,17432,57.01
```

[1] Data retrieved from Data.gov (https://www.data.gov/)

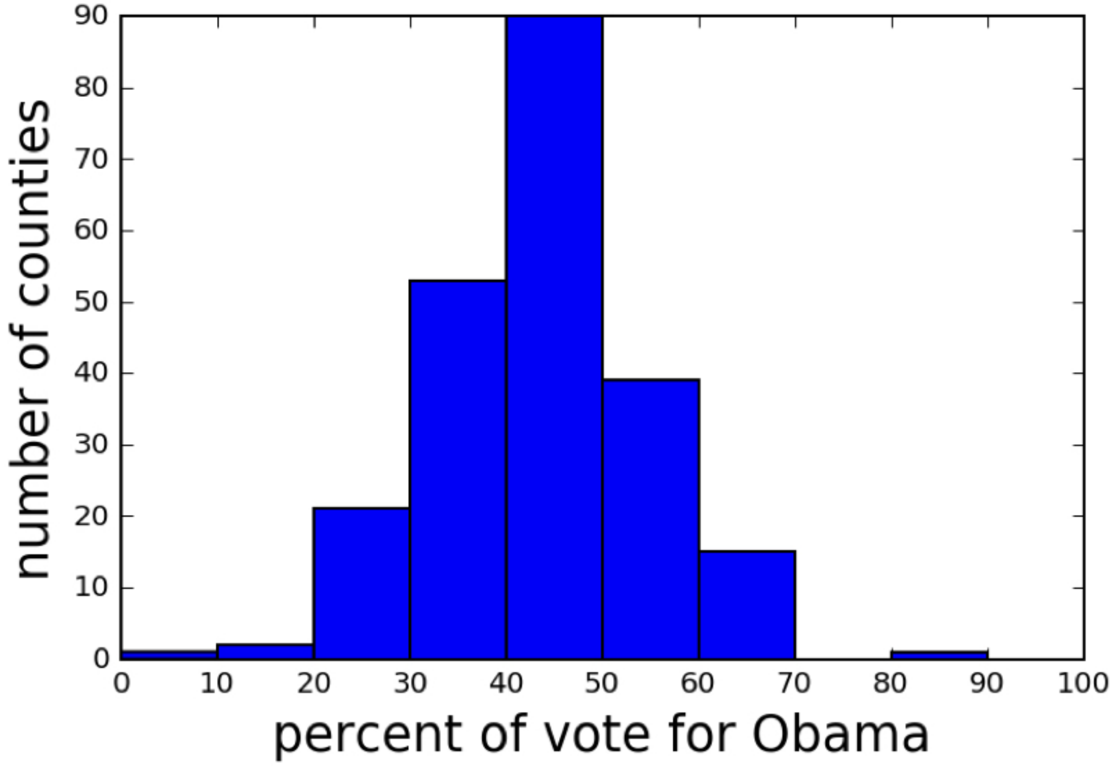
2008 US swing state election results

```python
import pandas as pd
df_swing = pd.read_csv('2008_swing_states.csv')
df_swing[['state', 'county', 'dem_share']]
```

```
  state               county  dem_share
0    PA          Erie County      60.08
1    PA      Bradford County      40.64
2    PA         Tioga County      36.07
3    PA        McKean County      41.21
4    PA        Potter County      31.04
5    PA         Wayne County      43.78
6    PA   Susquehanna County      44.08
7    PA        Warren County      46.85
8    OH     Ashtabula County      56.94
```

[1] Data retrieved from Data.gov (https://www.data.gov/)

2008 US swing state election results



[1] Data retrieved from Data.gov (https://www.data.gov/)

Let's practice!

STATISTICAL THINKING IN PYTHON (PART 1)

Plotting a histogram

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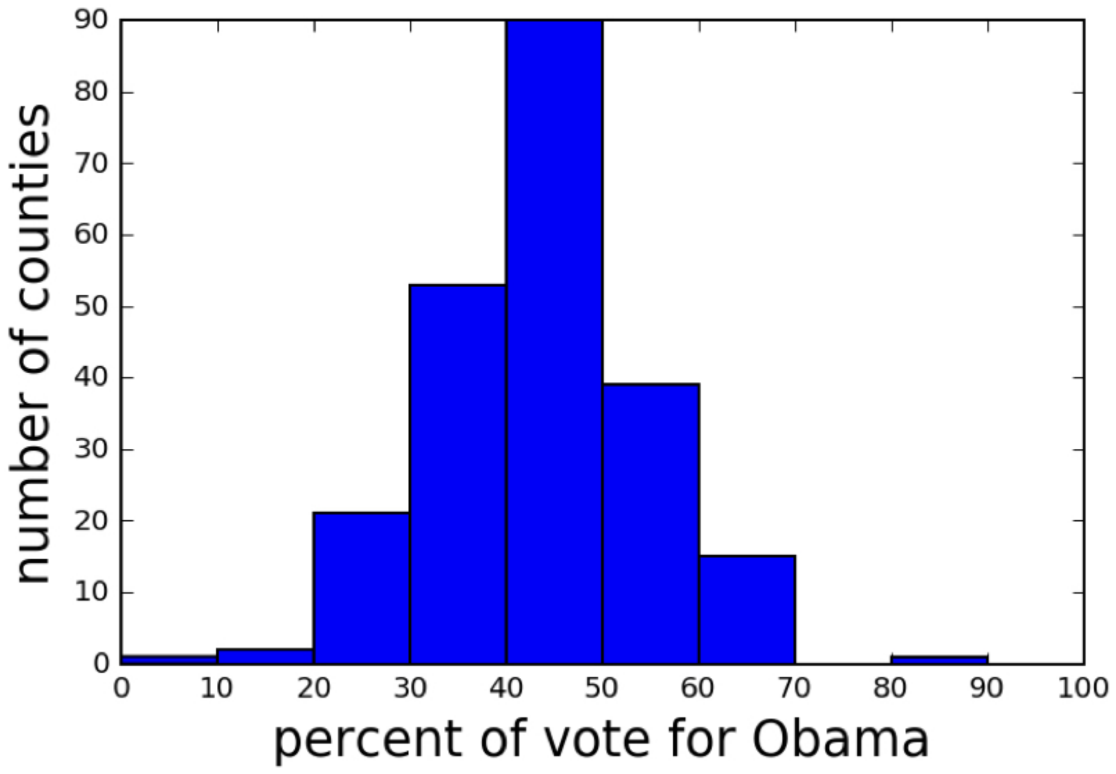
2008 US swing state election results

Data retrieved from Data.gov (https://www.data.gov/)



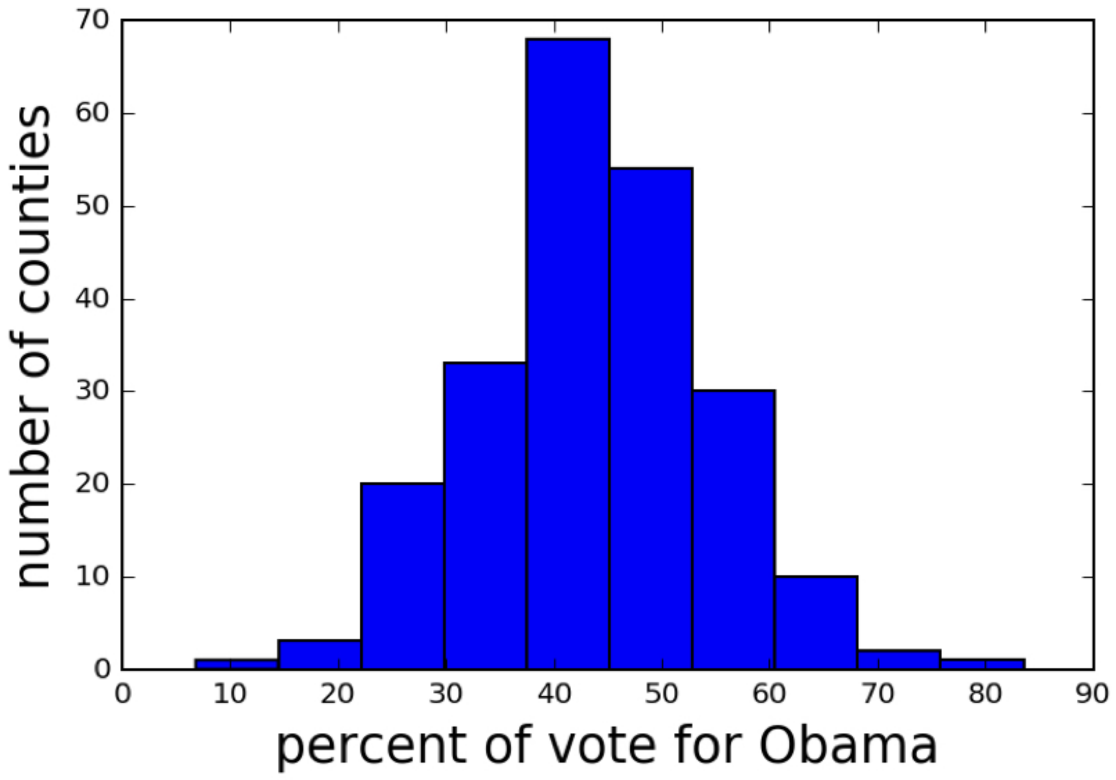
Generating a histogram

```python
import matplotlib.pyplot as plt
_ = plt.hist(df_swing['dem_share'])
_ = plt.xlabel('percent of vote for Obama')
_ = plt.ylabel('number of counties')
plt.show()
```

Always label your axes

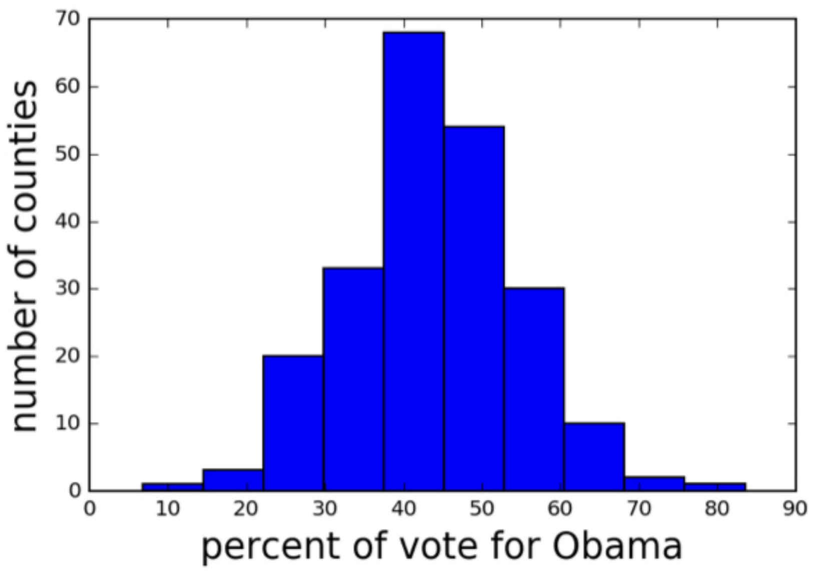
2008 US swing state election results

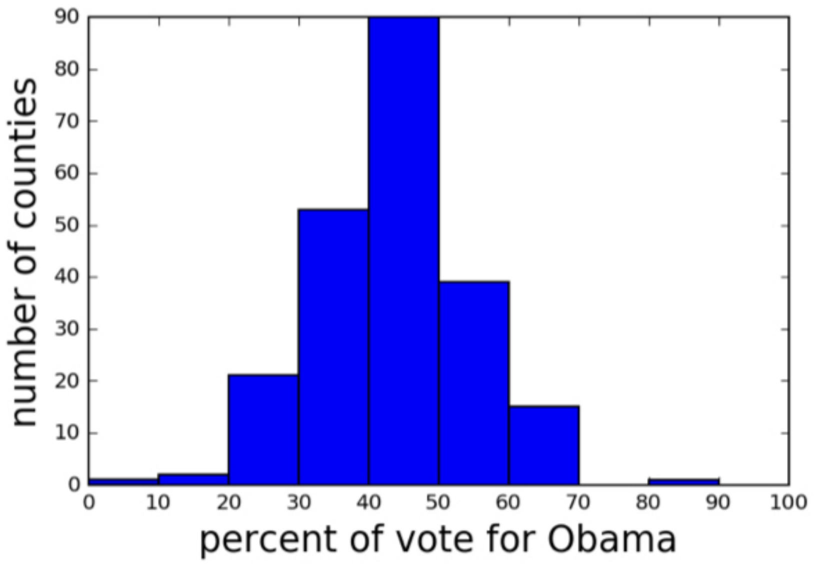
Data retrieved from Data.gov (**https://www.data.gov/**)



Histograms with different binning

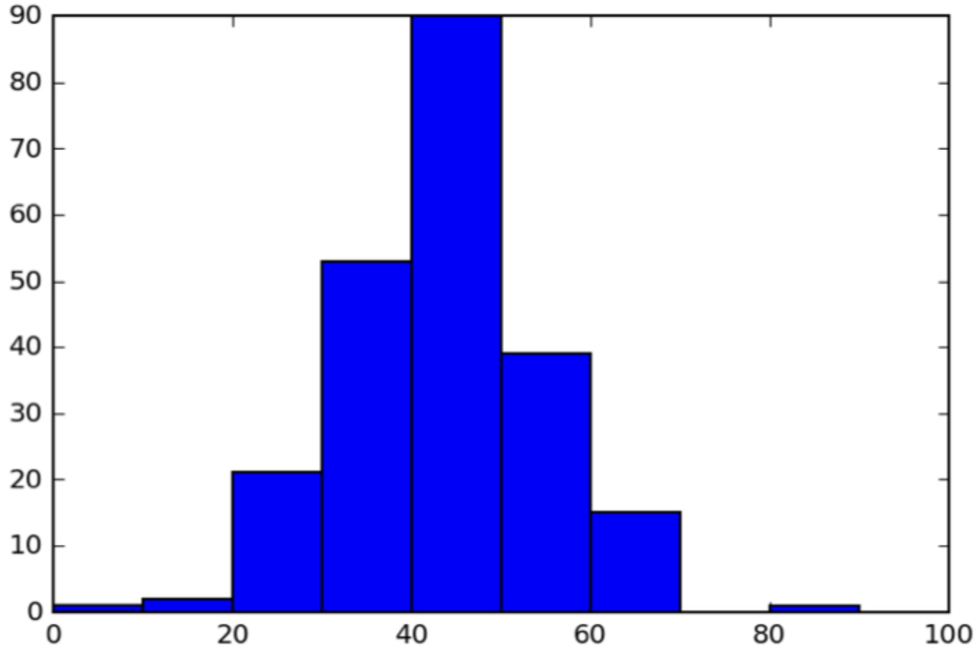
Data retrieved from Data.gov (**https://www.data.gov/**)





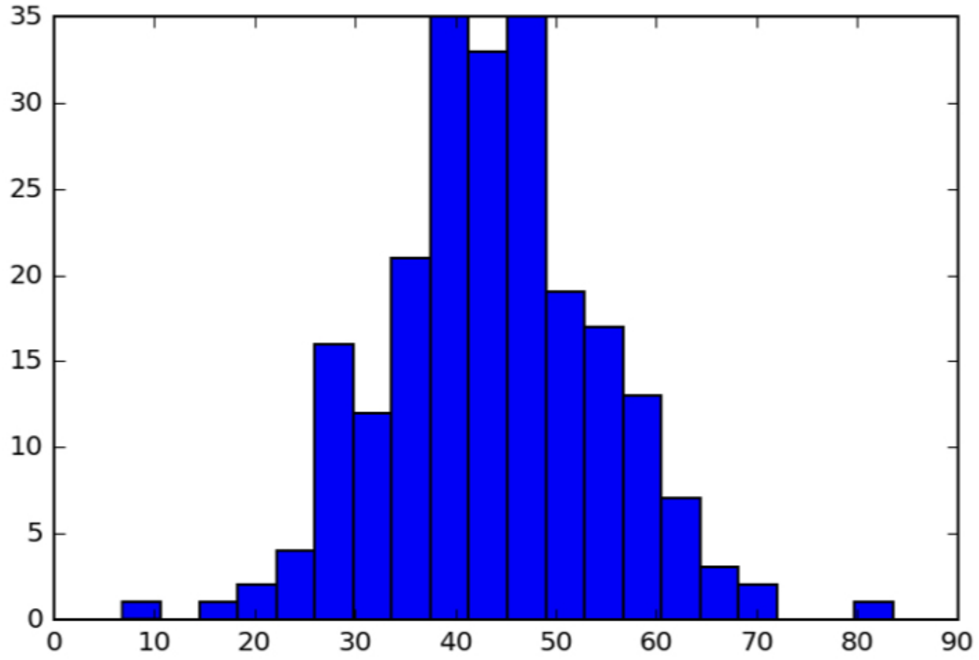
Setting the bins of a histogram

```
bin_edges = [0, 10, 20, 30, 40, 50,
                 60, 70, 80, 90, 100]
_ = plt.hist(df_swing['dem_share'], bins=bin_edges)
plt.show()
```



Setting the bins of a histogram

```
_ = plt.hist(df_swing['dem_share'], bins=20)
plt.show()
```



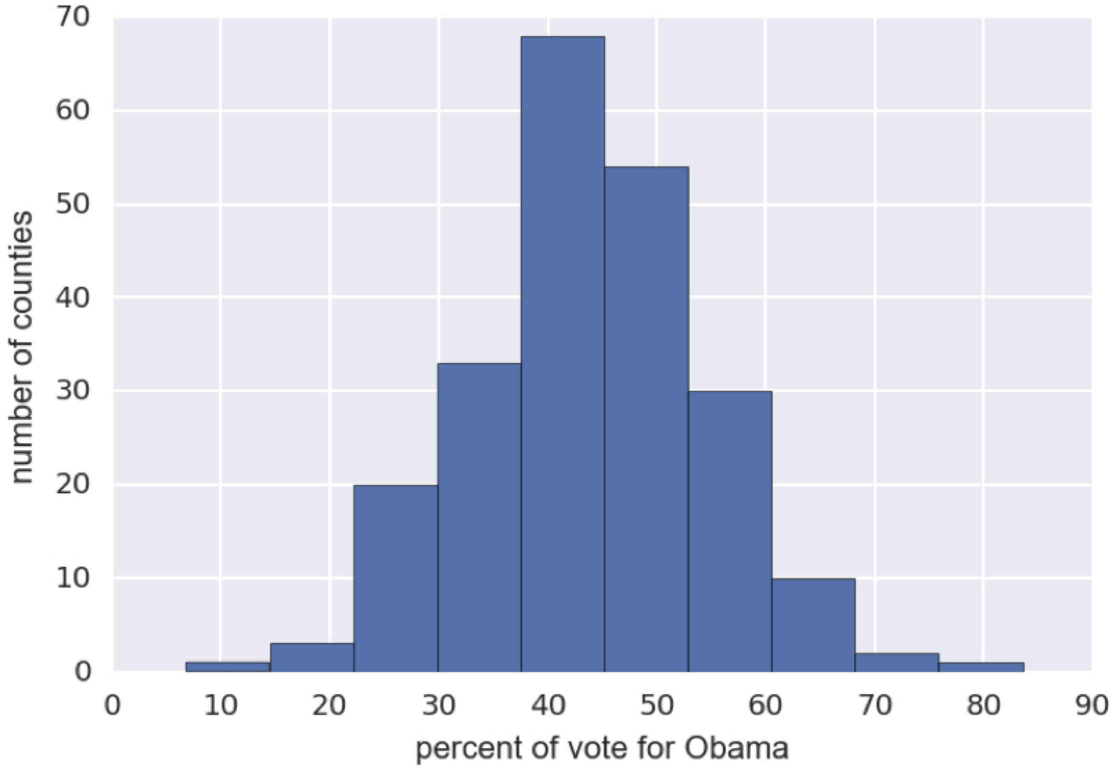
Seaborn

- An excellent Matplotlib-based statistical data visualization package written by Michael Waskom

Setting Seaborn styling

```
import seaborn as sns
sns.set()
_ = plt.hist(df_swing['dem_share'])
_ = plt.xlabel('percent of vote for Obama')
_ = plt.ylabel('number of counties')
plt.show()
```

A Seaborn-styled histogram



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Let's practice!

STATISTICAL THINKING IN PYTHON (PART 1)

Plot all of your data: Bee swarm plots

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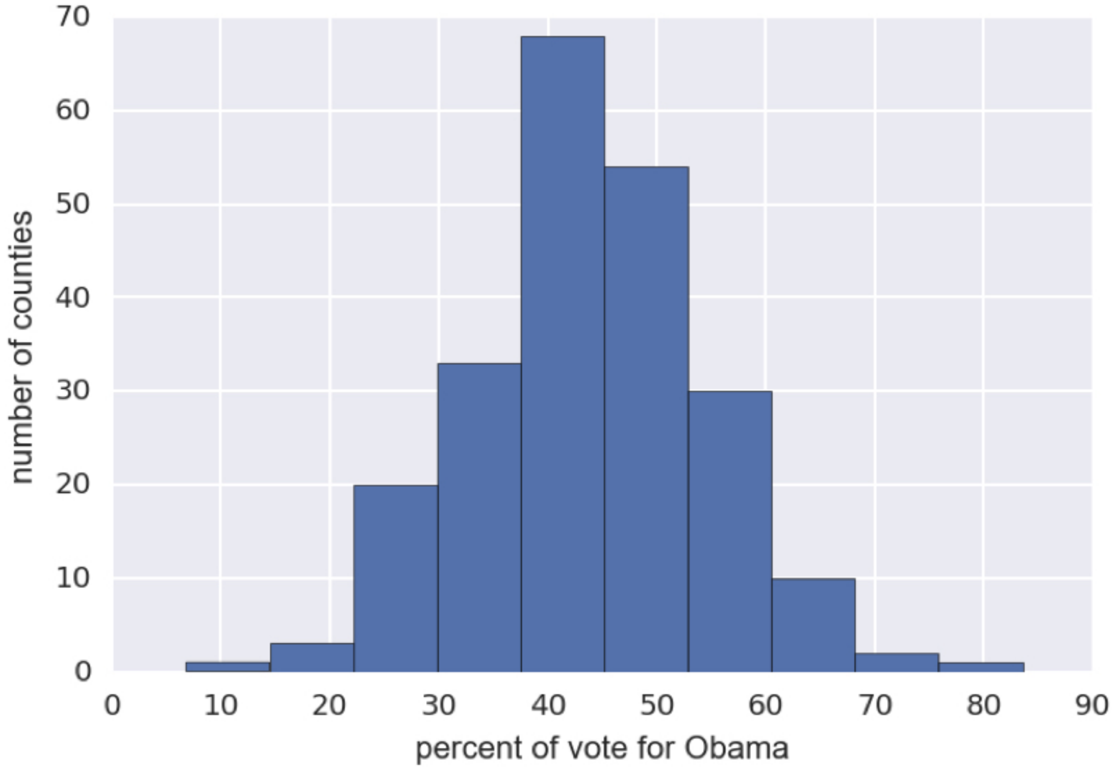

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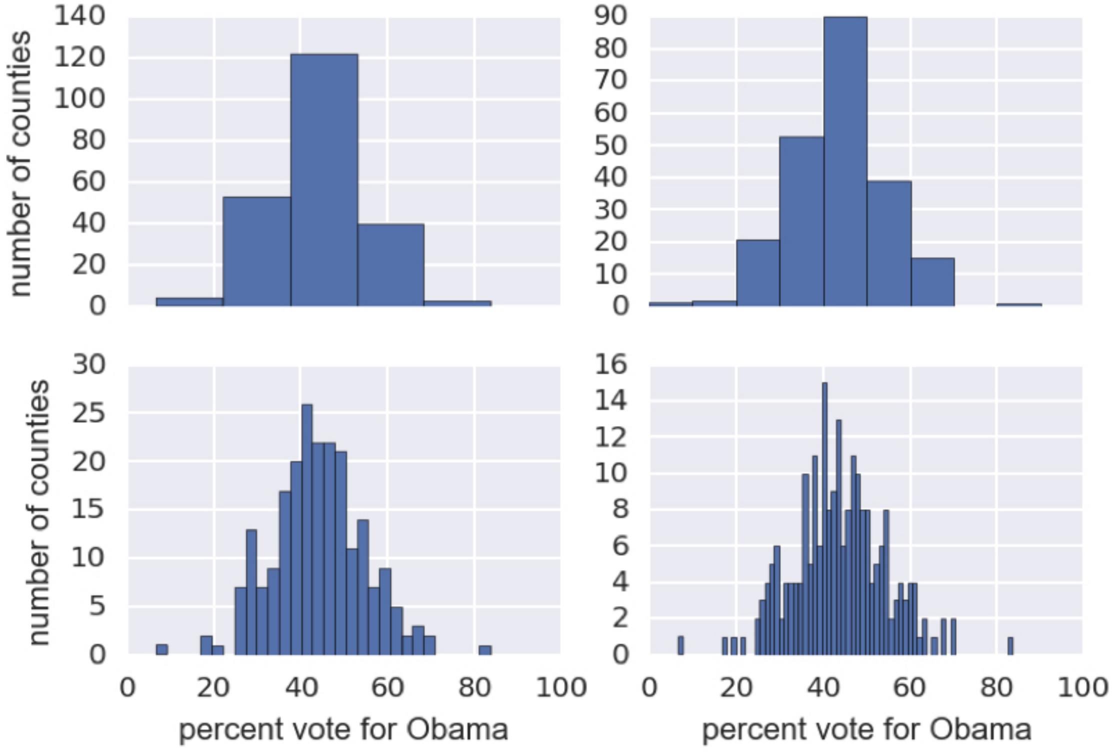
2008 US swing state election results

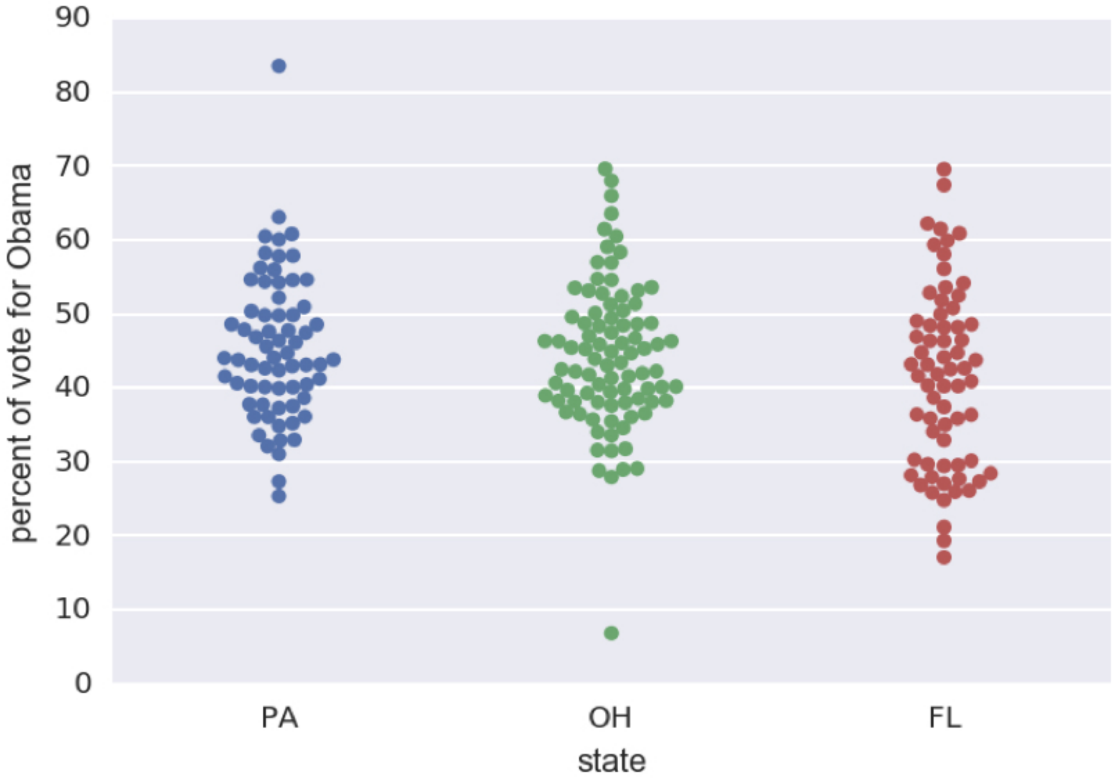


[1] Data retrieved from Data.gov (https://www.data.gov/)

Binning bias

- The same data may be interpreted differently depending on choice of bins

Bee swarm plot



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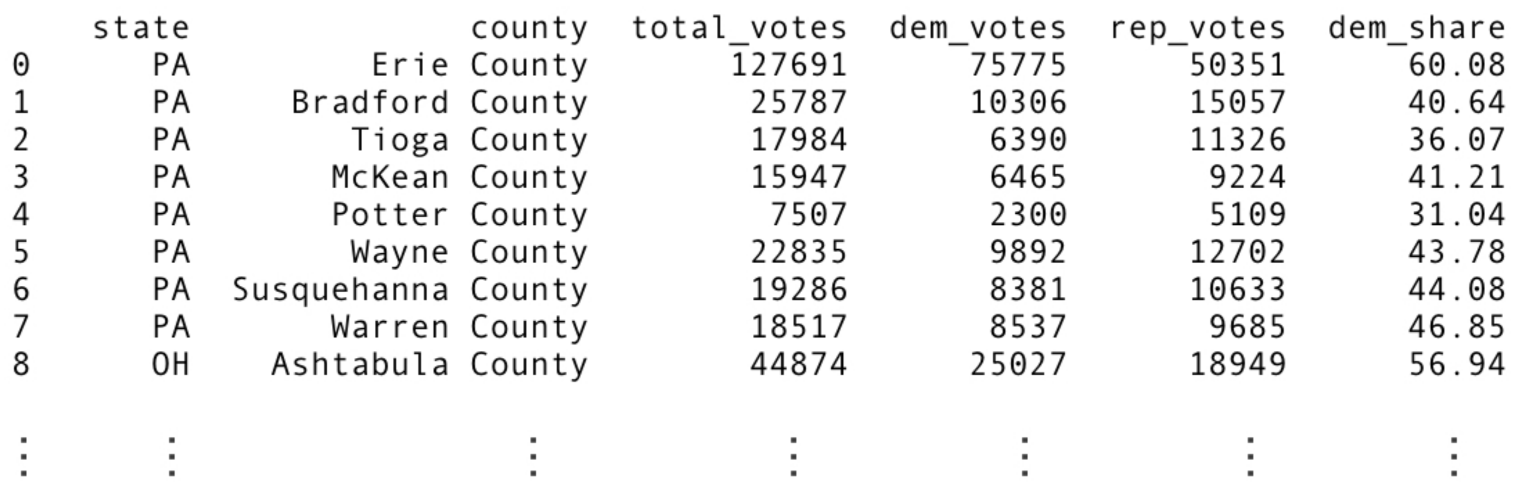
Organization of the data frame

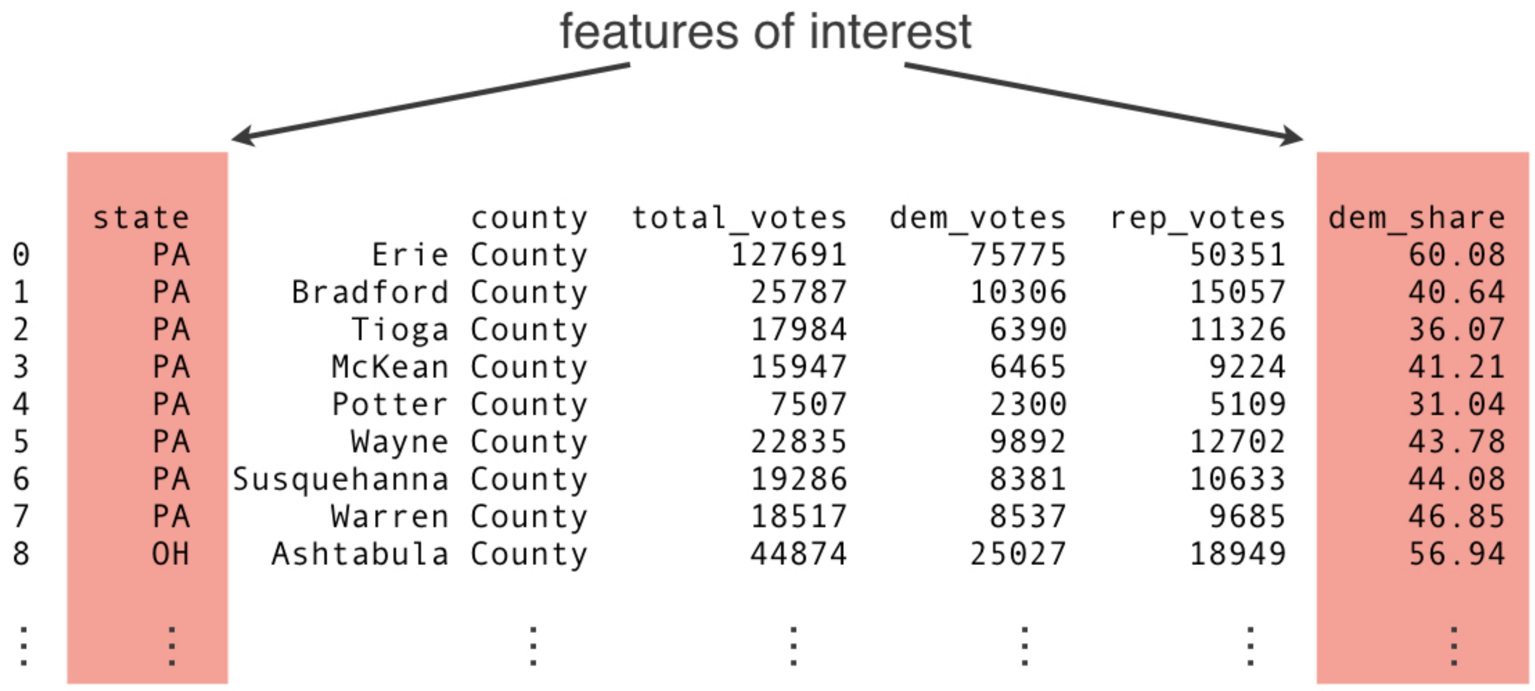


```
    state             county  total_votes  dem_votes  rep_votes  dem_share
0      PA        Erie County       127691      75775      50351      60.08
1      PA    Bradford County        25787      10306      15057      40.64
2      PA       Tioga County        17984       6390      11326      36.07
3      PA      McKean County        15947       6465       9224      41.21
4      PA      Potter County         7507       2300       5109      31.04
5      PA       Wayne County        22835       9892      12702      43.78
6      PA Susquehanna County        19286       8381      10633      44.08
7      PA      Warren County        18517       8537       9685      46.85
8      OH   Ashtabula County        44874      25027      18949      56.94

⋮       ⋮                  ⋮            ⋮          ⋮          ⋮          ⋮
```

[1] Data retrieved from Data.gov (https://www.data.gov/)

Organization of the data frame

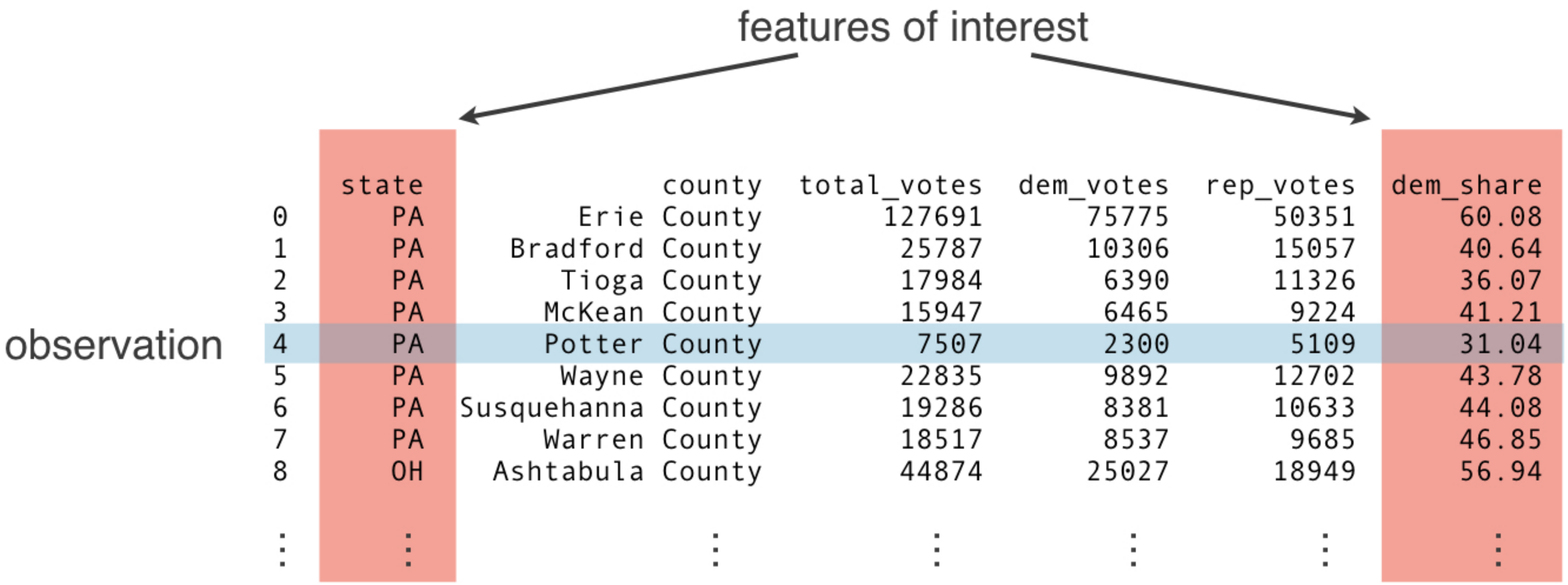


features of interest

```
  state                 county  total_votes  dem_votes  rep_votes  dem_share
0    PA            Erie County       127691      75775      50351      60.08
1    PA        Bradford County        25787      10306      15057      40.64
2    PA           Tioga County        17984       6390      11326      36.07
3    PA          McKean County        15947       6465       9224      41.21
4    PA          Potter County         7507       2300       5109      31.04
5    PA           Wayne County        22835       9892      12702      43.78
6    PA     Susquehanna County        19286       8381      10633      44.08
7    PA          Warren County        18517       8537       9685      46.85
8    OH       Ashtabula County        44874      25027      18949      56.94

⋮     ⋮                      ⋮            ⋮          ⋮          ⋮          ⋮
```

Organization of the data frame



features of interest

observation

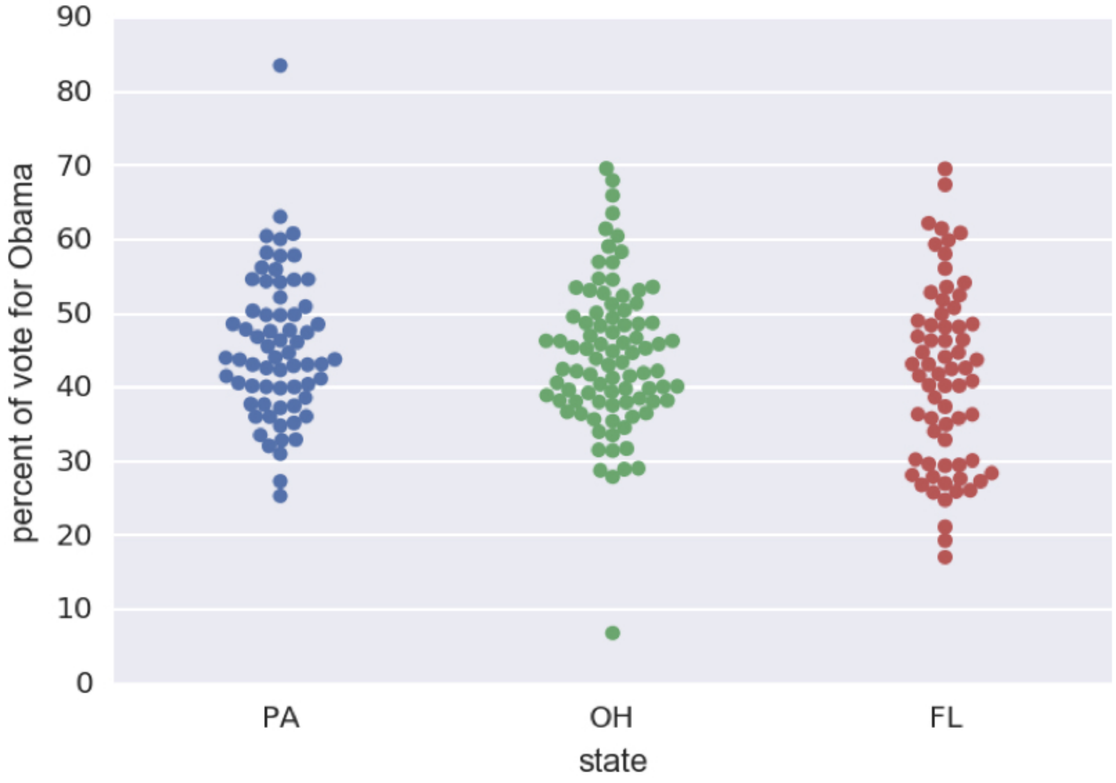
```
  state            county  total_votes  dem_votes  rep_votes  dem_share
0    PA       Erie County       127691      75775      50351      60.08
1    PA   Bradford County        25787      10306      15057      40.64
2    PA      Tioga County        17984       6390      11326      36.07
3    PA     McKean County        15947       6465       9224      41.21
4    PA     Potter County         7507       2300       5109      31.04
5    PA      Wayne County        22835       9892      12702      43.78
6    PA Susquehanna County       19286       8381      10633      44.08
7    PA     Warren County        18517       8537       9685      46.85
8    OH  Ashtabula County        44874      25027      18949      56.94

⋮     ⋮              ⋮             ⋮          ⋮          ⋮          ⋮
```

Generating a bee swarm plot

```
_ = sns.swarmplot(x='state', y='dem_share', data=df_swing)
_ = plt.xlabel('state')
_ = plt.ylabel('percent of vote for Obama')
plt.show()
```

2008 US swing state election results



[1] Data retrieved from Data.gov (https://www.data.gov/)

Let's practice!

STATISTICAL THINKING IN PYTHON (PART 1)

Plot all of your data: ECDFs

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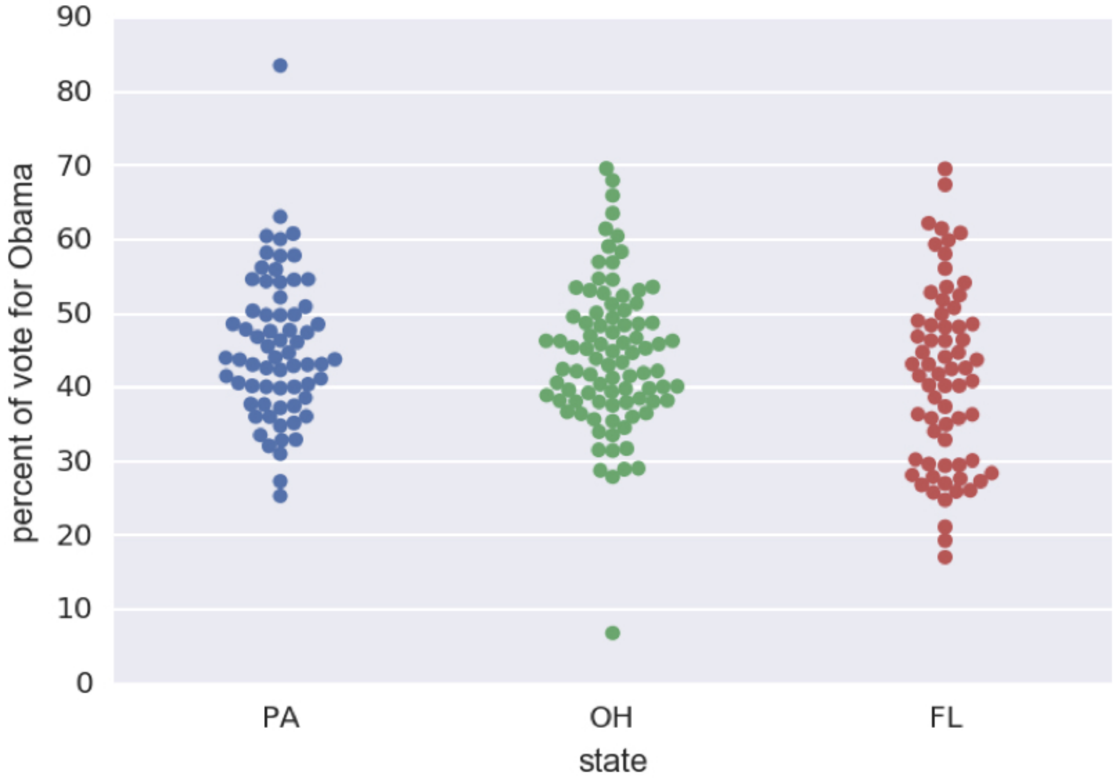
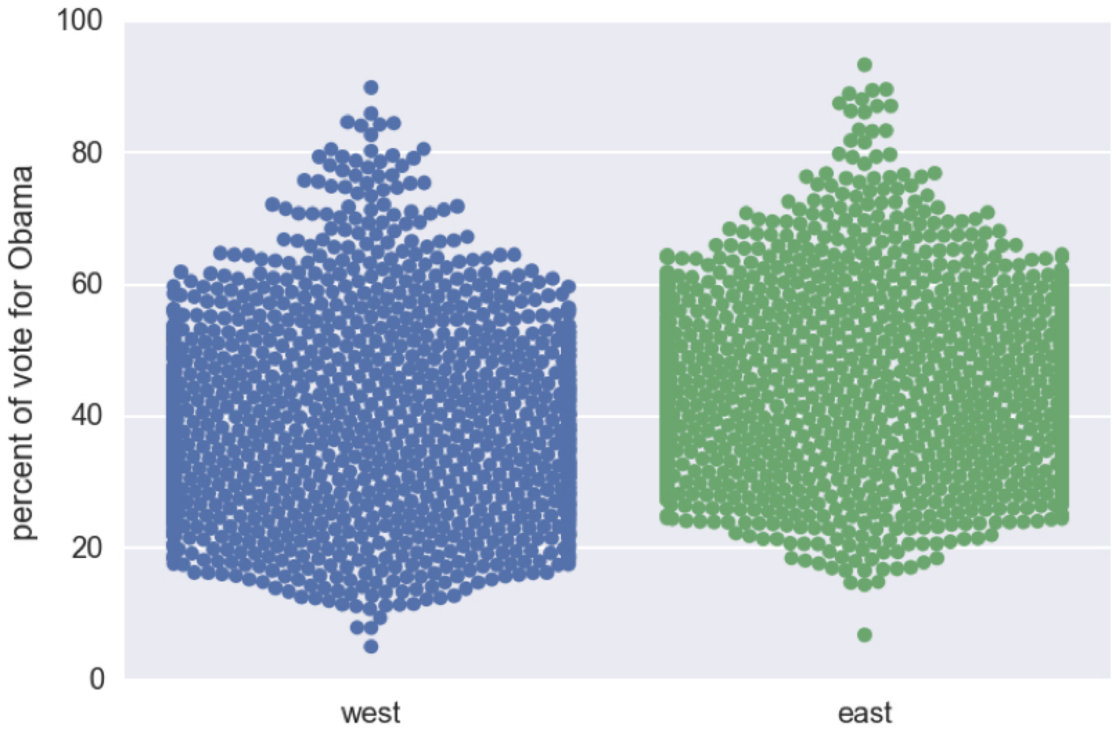
2008 US swing state election results



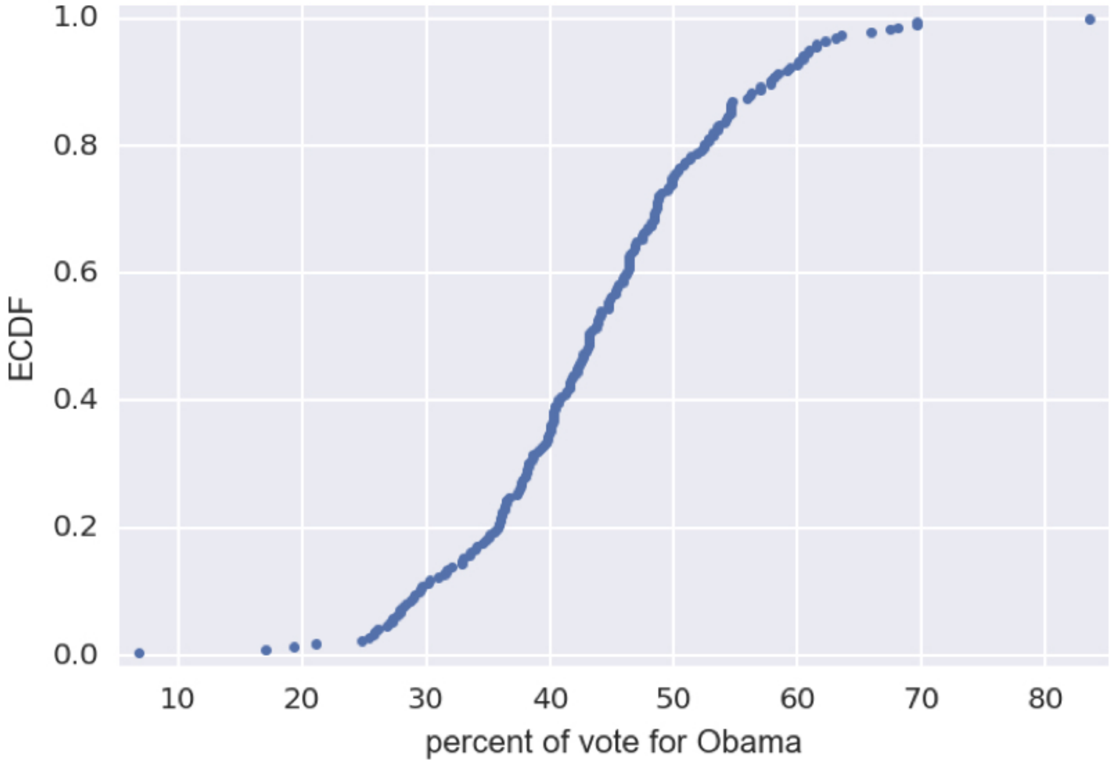
[1] Data retrieved from Data.gov (https://www.data.gov/)

2008 US election results: East and West



[1] Data retrieved from Data.gov (https://www.data.gov/)

Empirical cumulative distribution function (ECDF)



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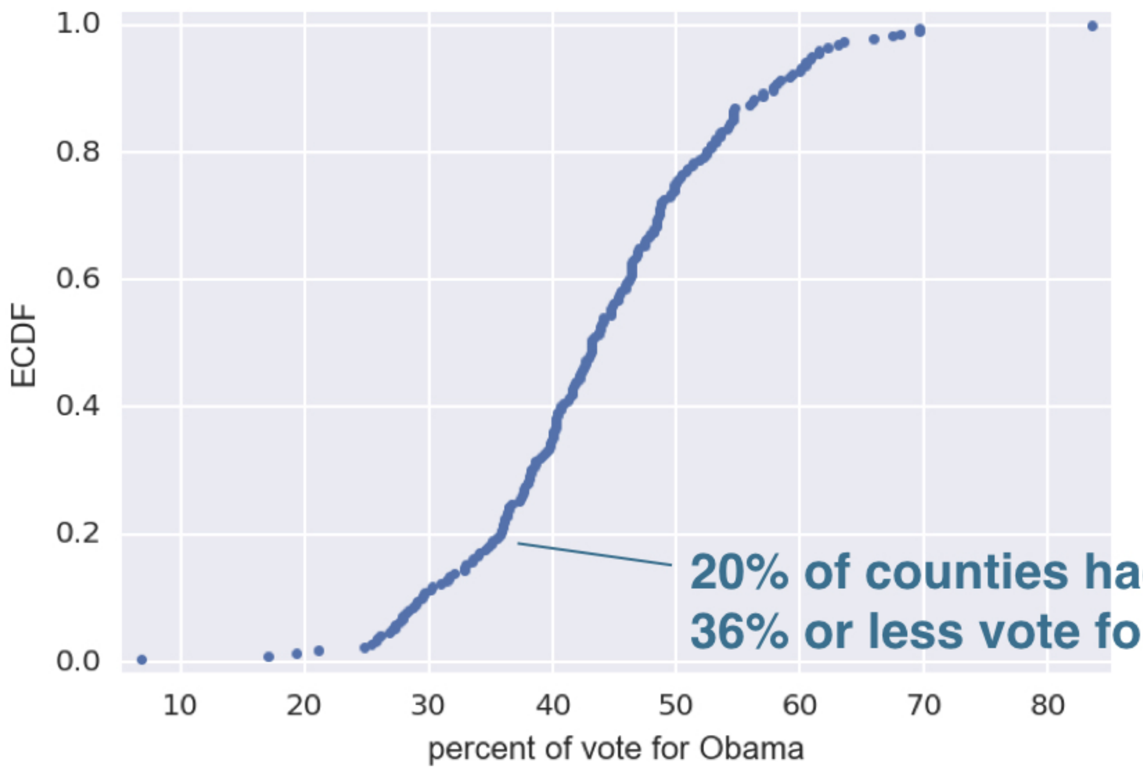
Empirical cumulative distribution function (ECDF)



20% of counties had
36% or less vote for Obama

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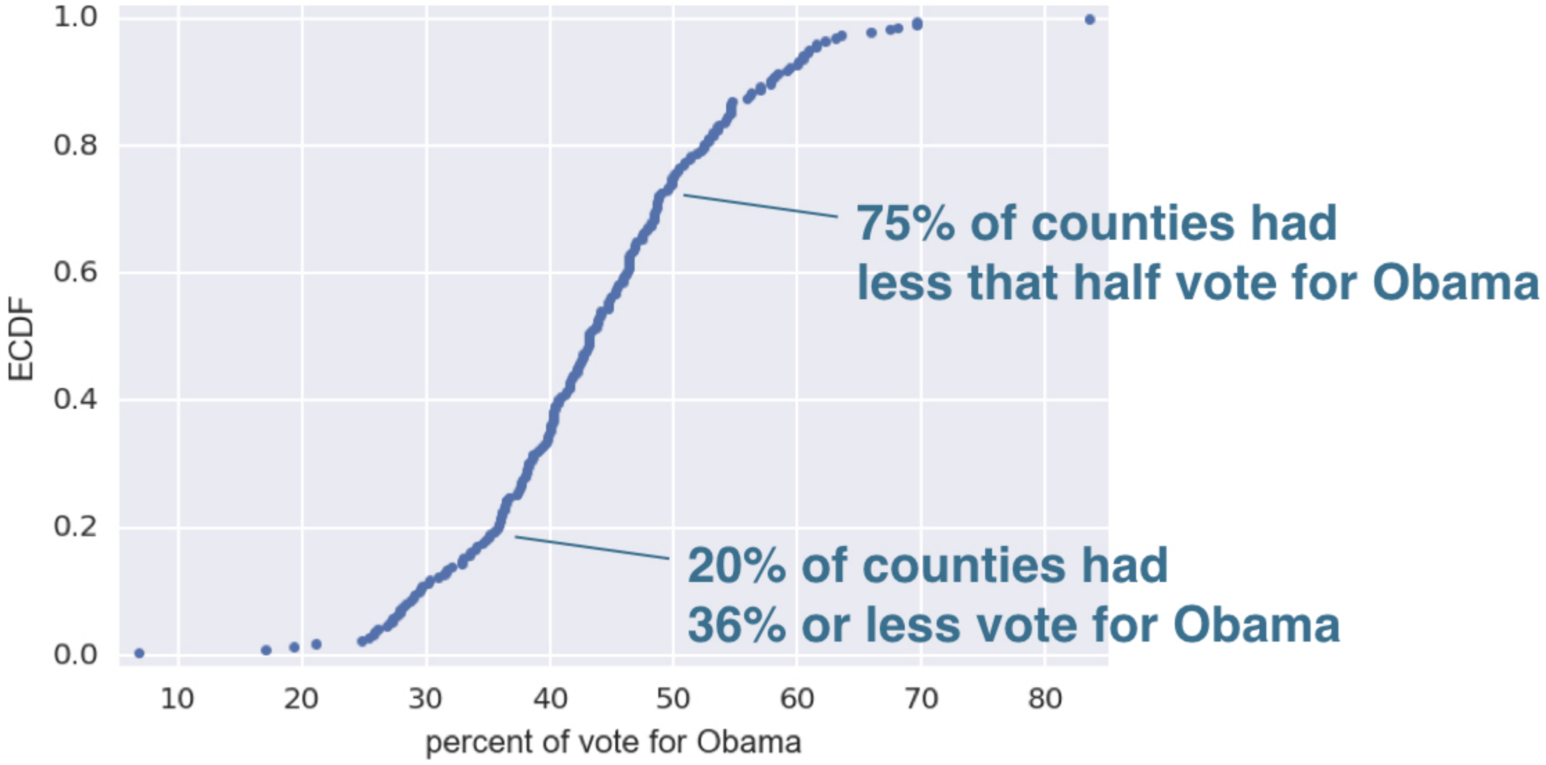
Empirical cumulative distribution function (ECDF)



75% of counties had
less that half vote for Obama

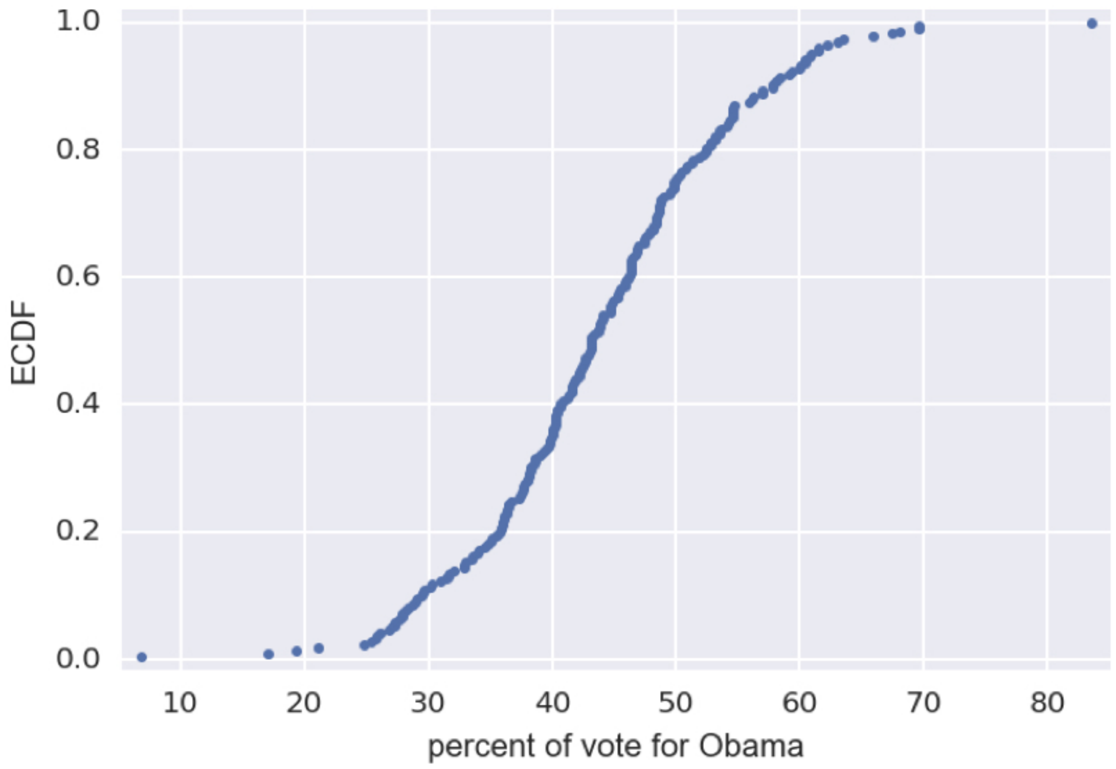
20% of counties had
36% or less vote for Obama

[1] Data retrieved from Data.gov (https://www.data.gov/)

Making an ECDF

```
import numpy as np
x = np.sort(df_swing['dem_share'])
y = np.arange(1, len(x)+1) / len(x)
_ = plt.plot(x, y, marker='.', linestyle='none')
_ = plt.xlabel('percent of vote for Obama')
_ = plt.ylabel('ECDF')
plt.margins(0.02) # Keeps data off plot edges
plt.show()
```

2008 US swing state election ECDF



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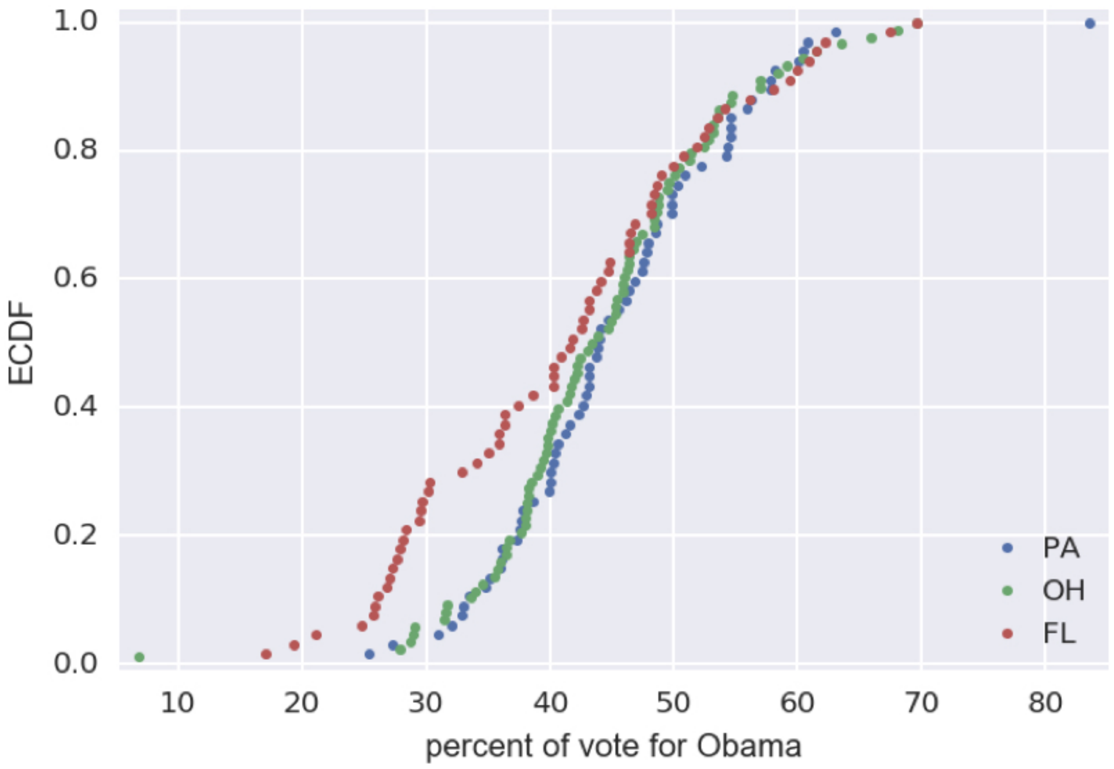
2008 US swing state election ECDFs



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Let's practice!

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Onward toward the whole story!

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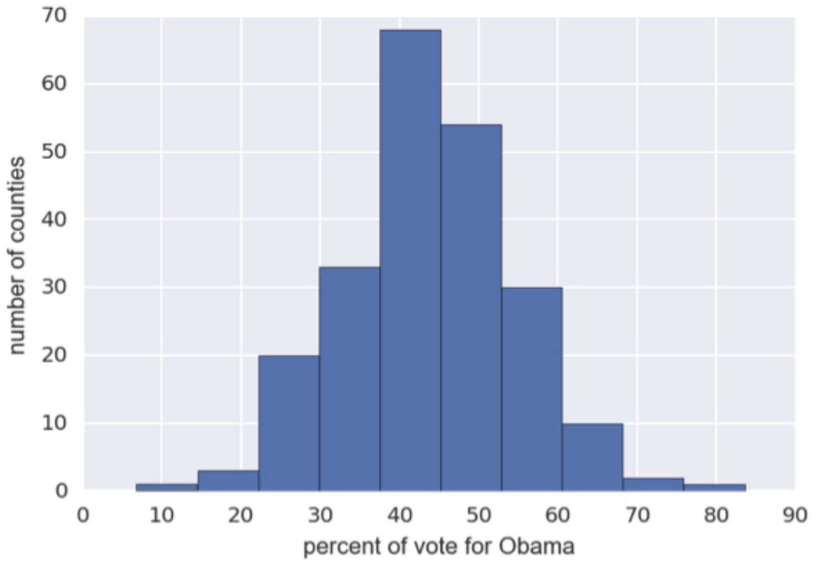
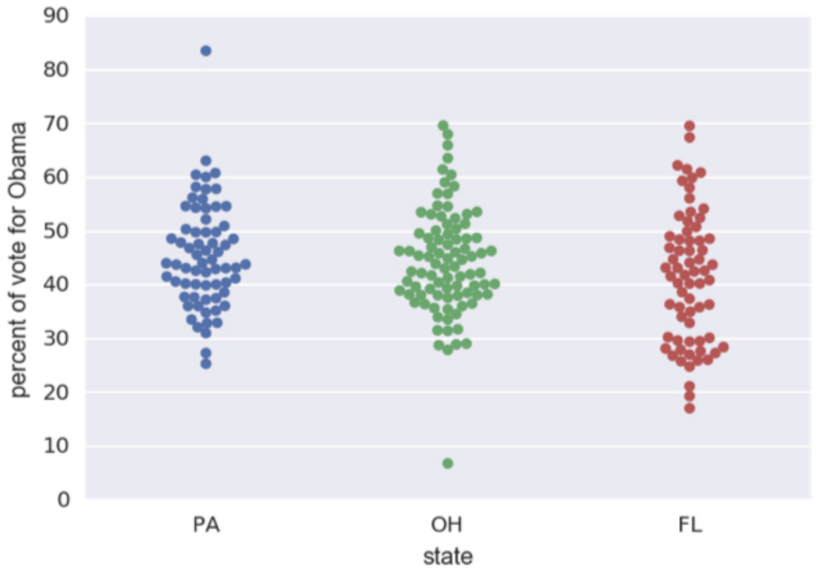
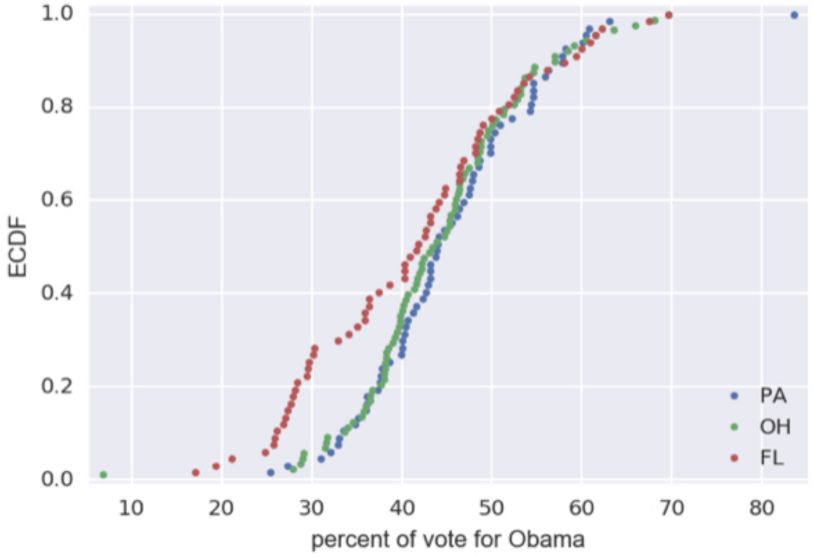


number of counties
70
60
50
40
30
20
10
0
0
10
20
30
40
50
60
70
80
90
percent of vote for Obama



percent of vote for Obama
90
80
70
60
50
40
30
20
10
0
PA
OH
FL
state



ECDF
1.0
0.8
0.6
0.4
0.2
0.0
10
20
30
40
50
60
70
80
percent of vote for Obama
PA
OH
FL

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Coming up...

- Thinking probabilistically
- Discrete and continuous distributions
- The power of hacker statistics using `np.random`

Let's practice!

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