Introduction to Exploratory Data Analysis

STATISTICAL THINKING IN PYTHON (PART 1)

Justin Bois

Teaching Professor 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

2008_swing_states.csv

```
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/)

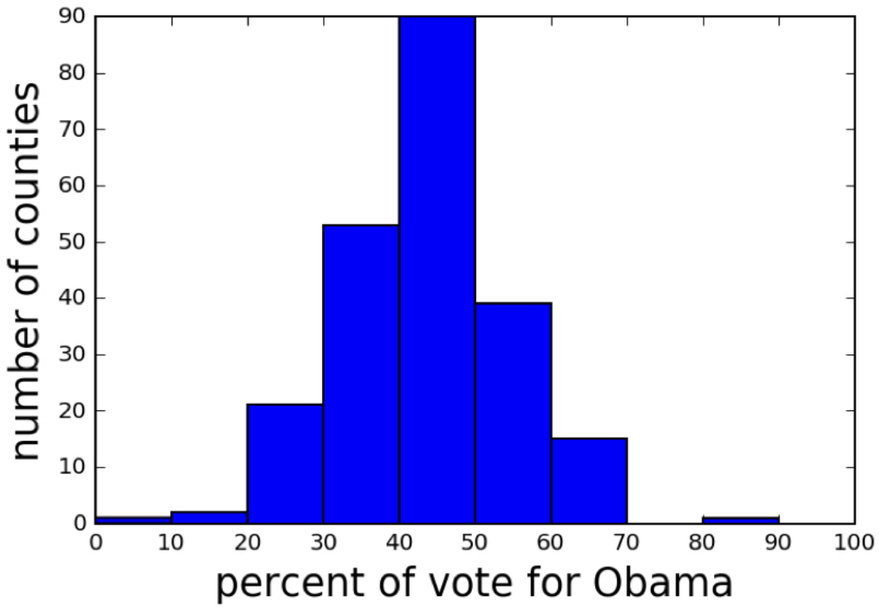
2008 US swing state election results

```
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

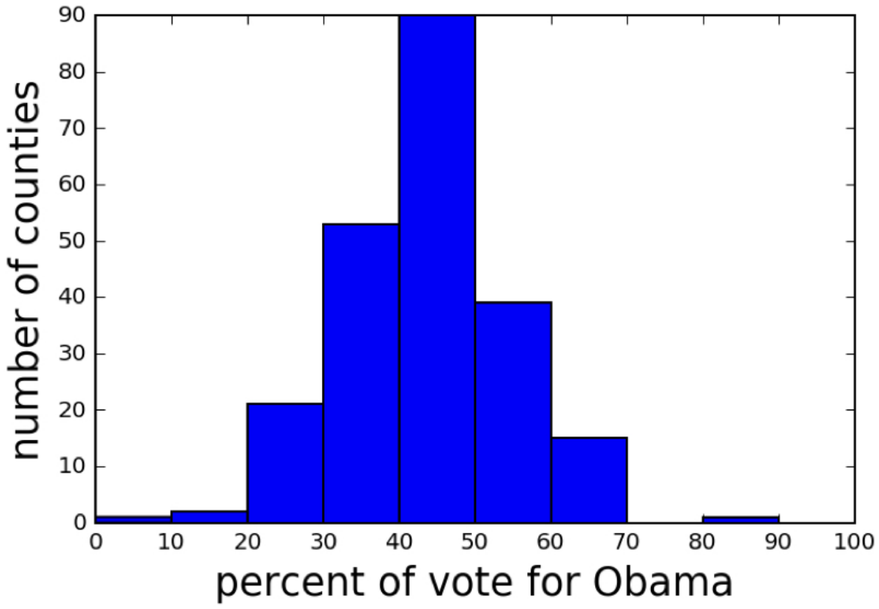
STATISTICAL THINKING IN PYTHON (PART 1)

Justin Bois

Teaching Professor at the California Institute of Technology

2008 US swing state election results

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



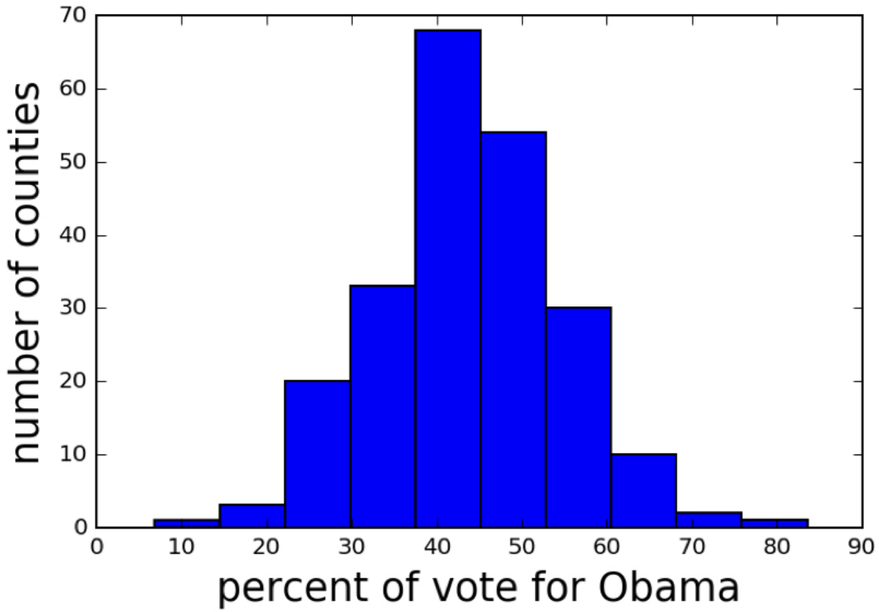
Generating a histogram

```
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

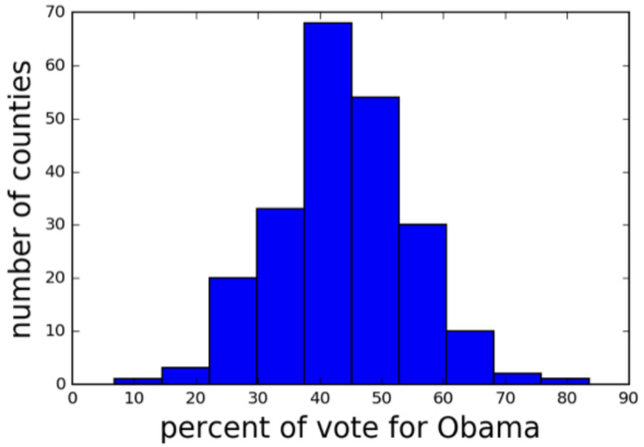
2008 US swing state election results

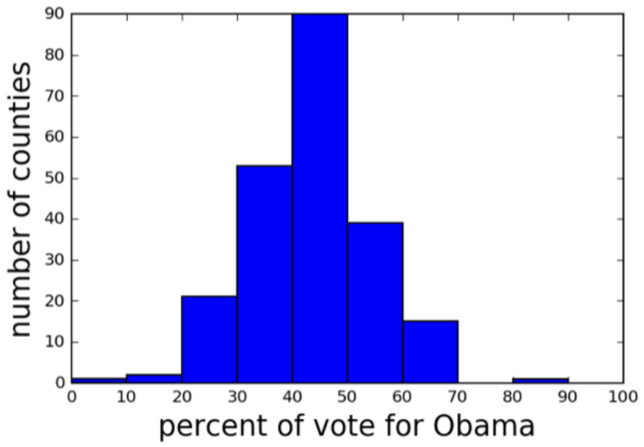
Data retrieved from Data.gov (https://www.data.gov/)



Histograms with different binning

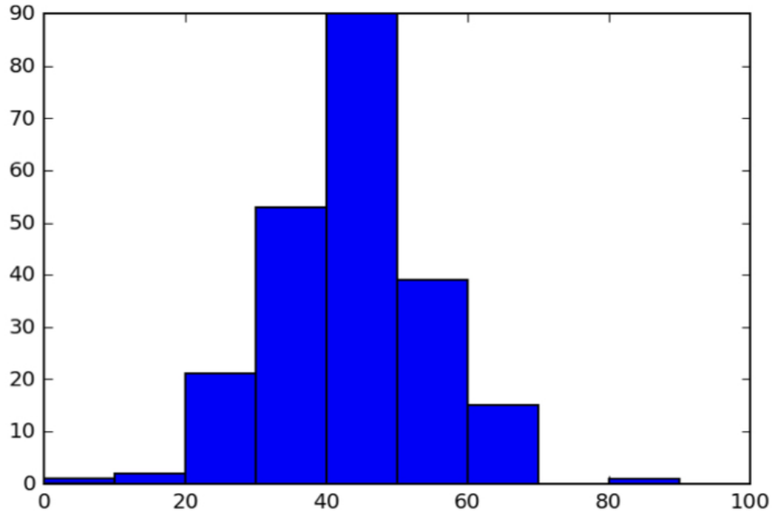
Data retrieved from Data.gov (https://www.data.gov/)





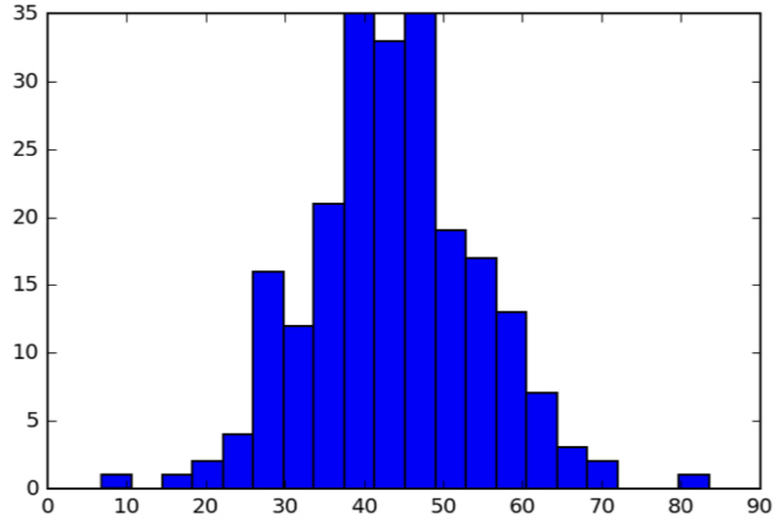
Setting the bins of a histogram

```
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()
```



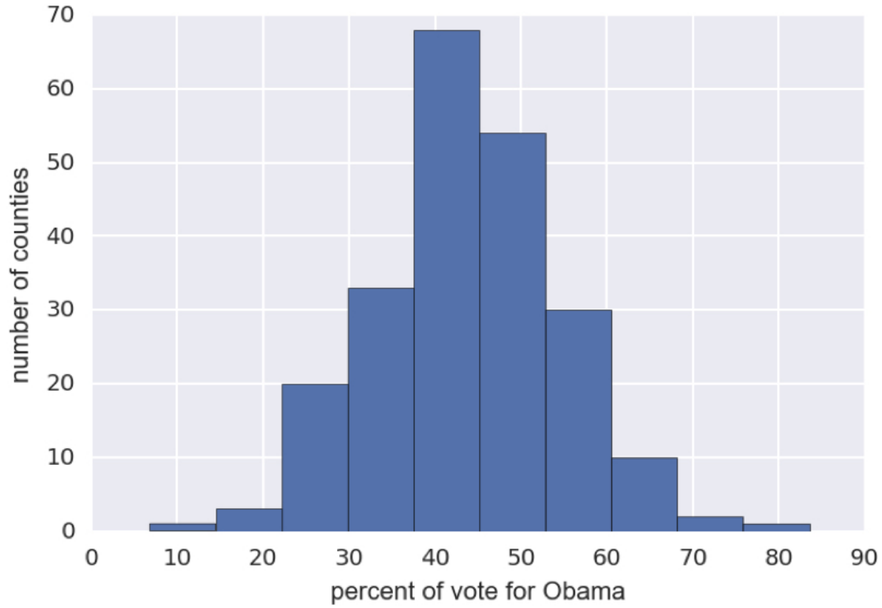
Seaborn

- 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



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

Let's practice!

STATISTICAL THINKING IN PYTHON (PART 1)

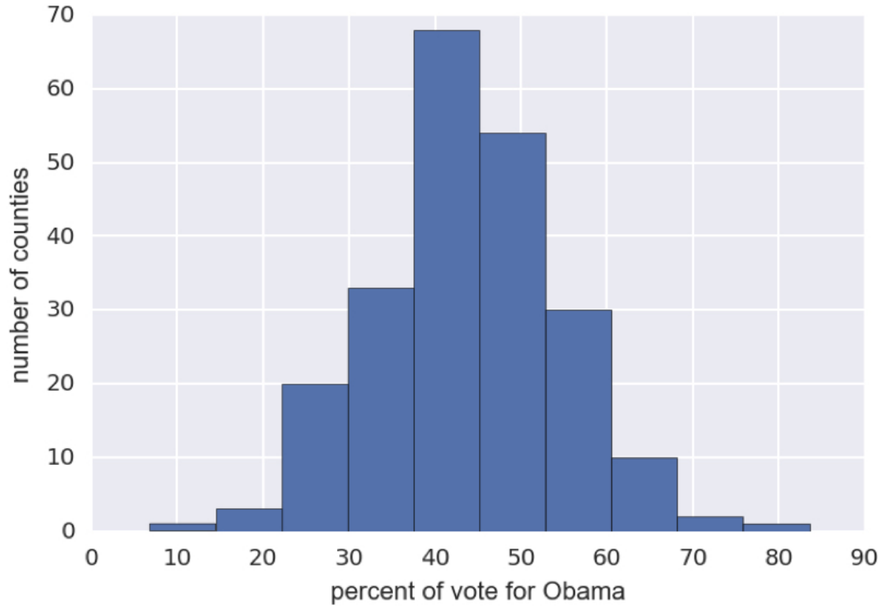
Plot all of your data: Bee swarm plots

STATISTICAL THINKING IN PYTHON (PART 1)

Justin Bois

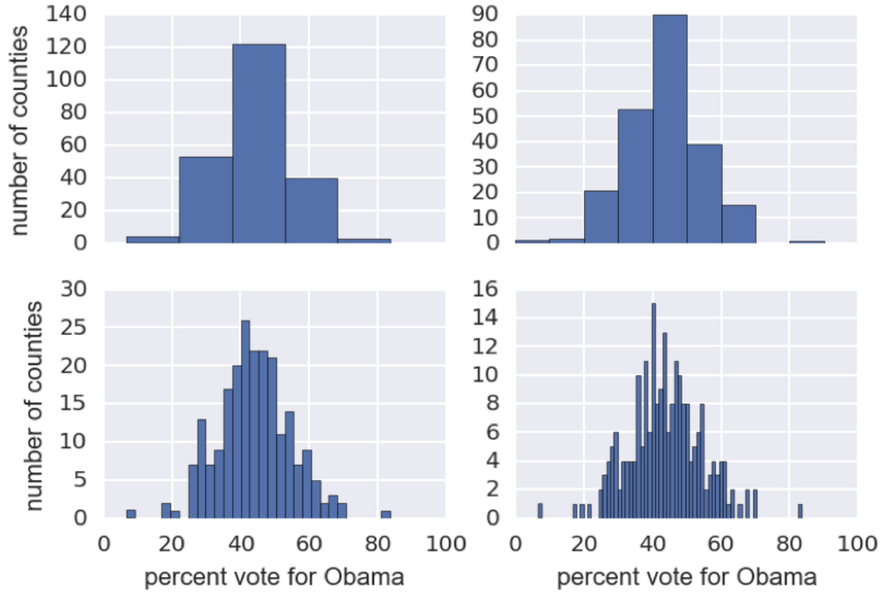
Teaching Professor at the California Institute of Technology

2008 US swing state election results



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

2008 US swing state election results

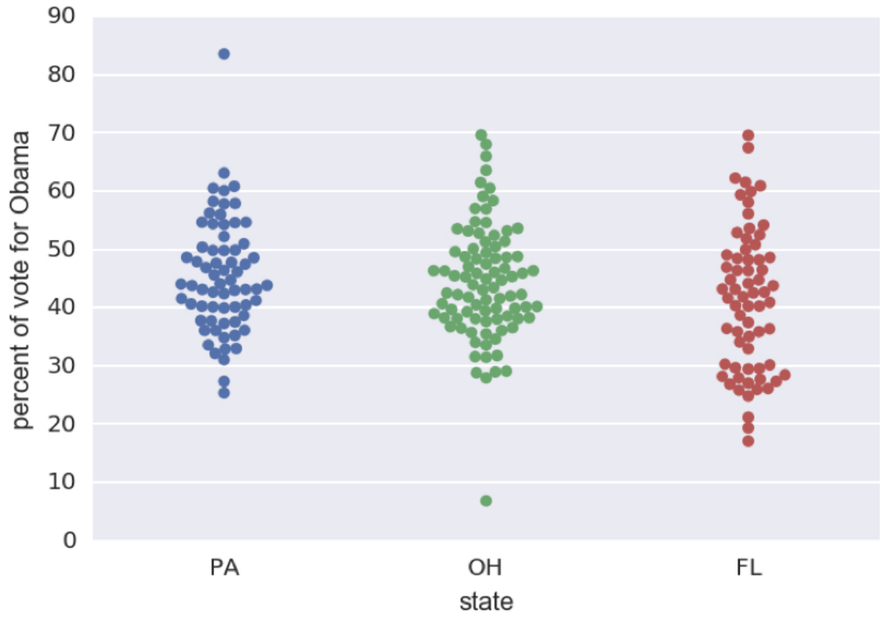


[1] Data retrieved from Data.gov (https://www.data.gov/)

Binning bias

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

Bee swarm plot



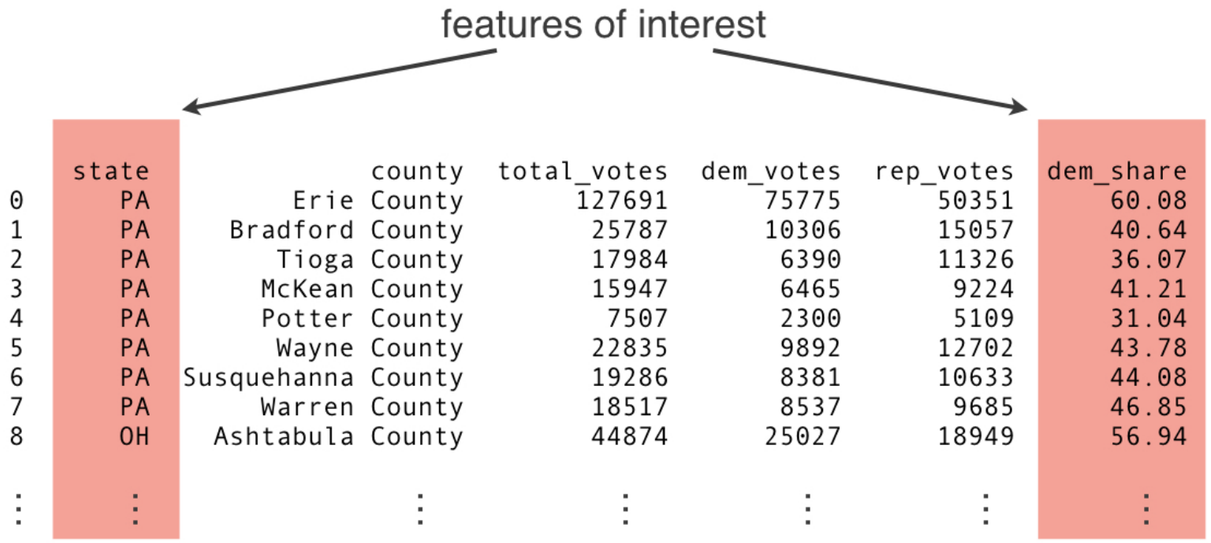
[1] Data retrieved from Data.gov (https://www.data.gov/)

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
⋮	⋮	⋮	⋮	⋮	⋮	⋮

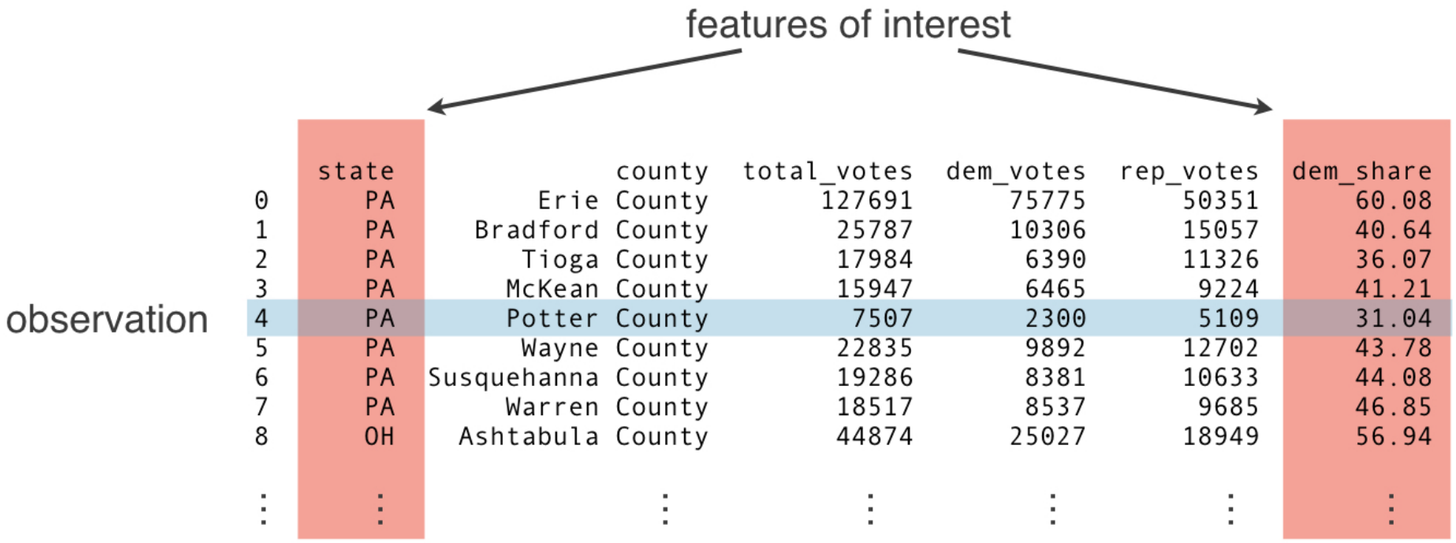
[1] Data retrieved from Data.gov (https://www.data.gov/)

Organization of the data frame



	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
⋮	⋮	⋮	⋮	⋮	⋮	⋮

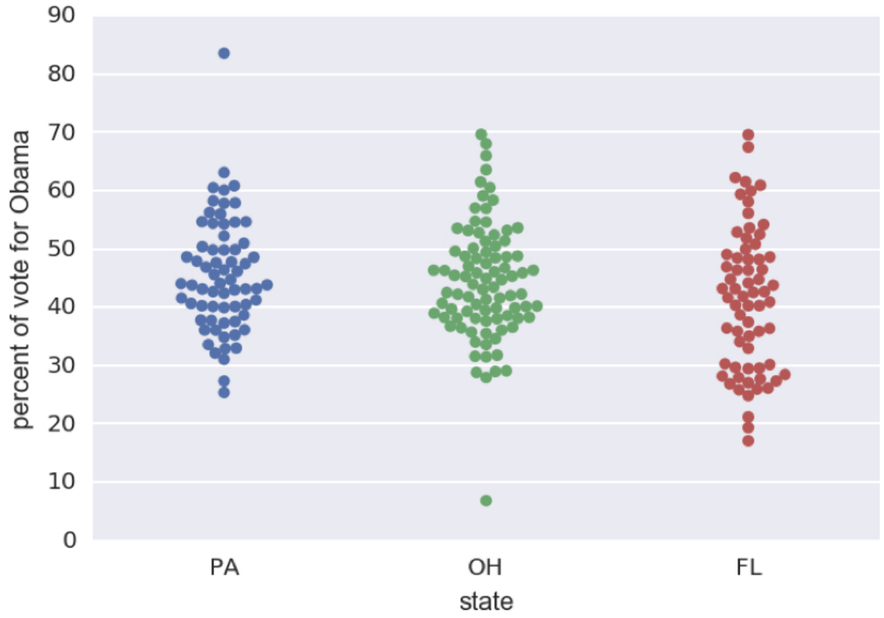
Organization of the data frame



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)

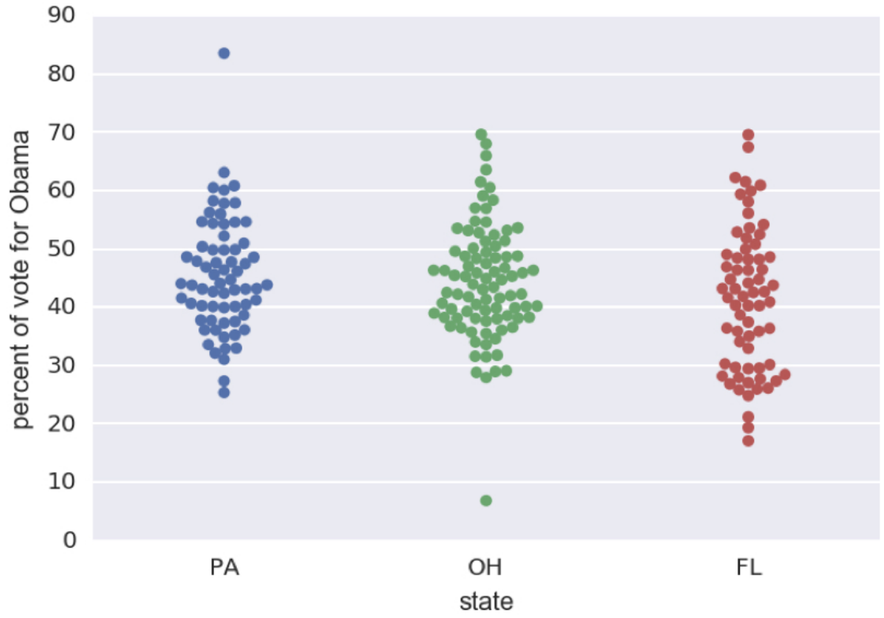
Plot all of your data: ECDFs

STATISTICAL THINKING IN PYTHON (PART 1)

Justin Bois

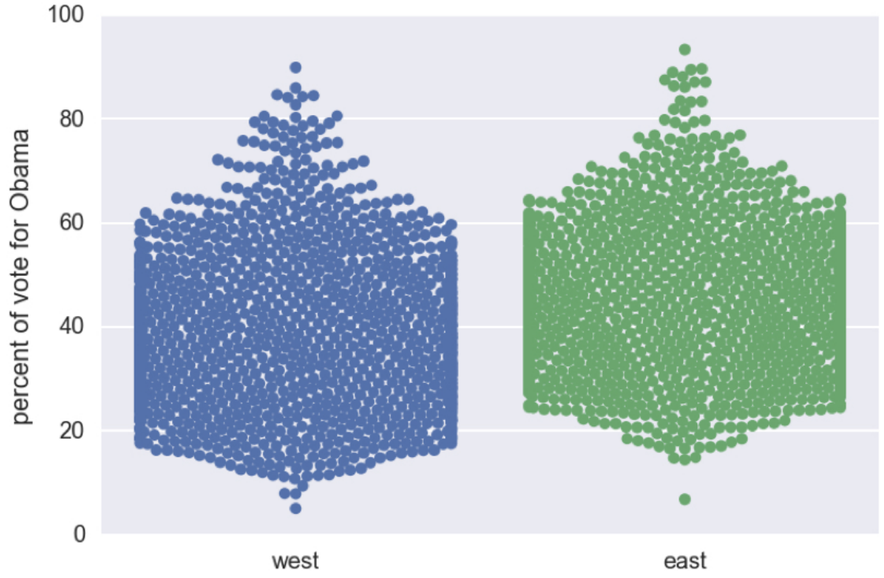
Teaching Professor at the California Institute of Technology

2008 US swing state election results



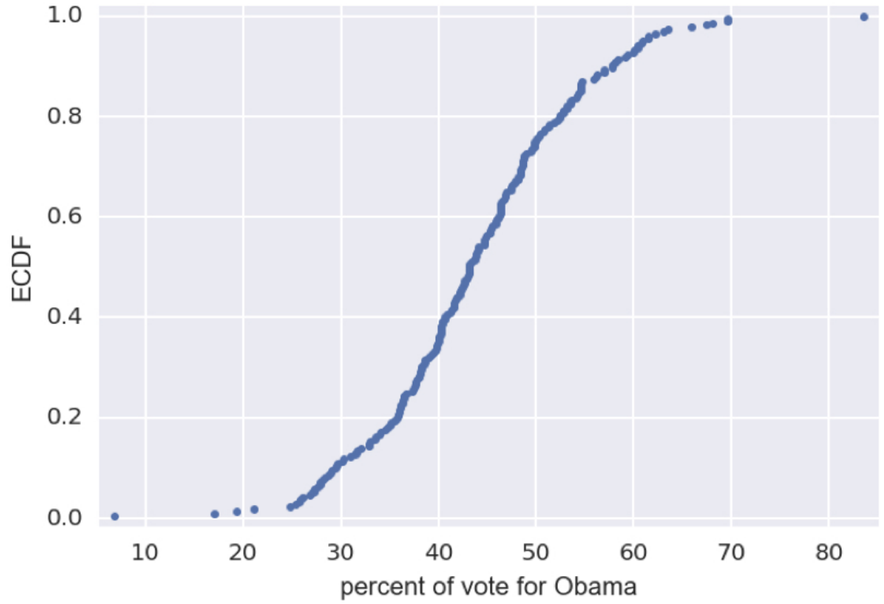
[1] Data retrieved from Data.gov (https://www.data.gov/)

2008 US election results: East and West



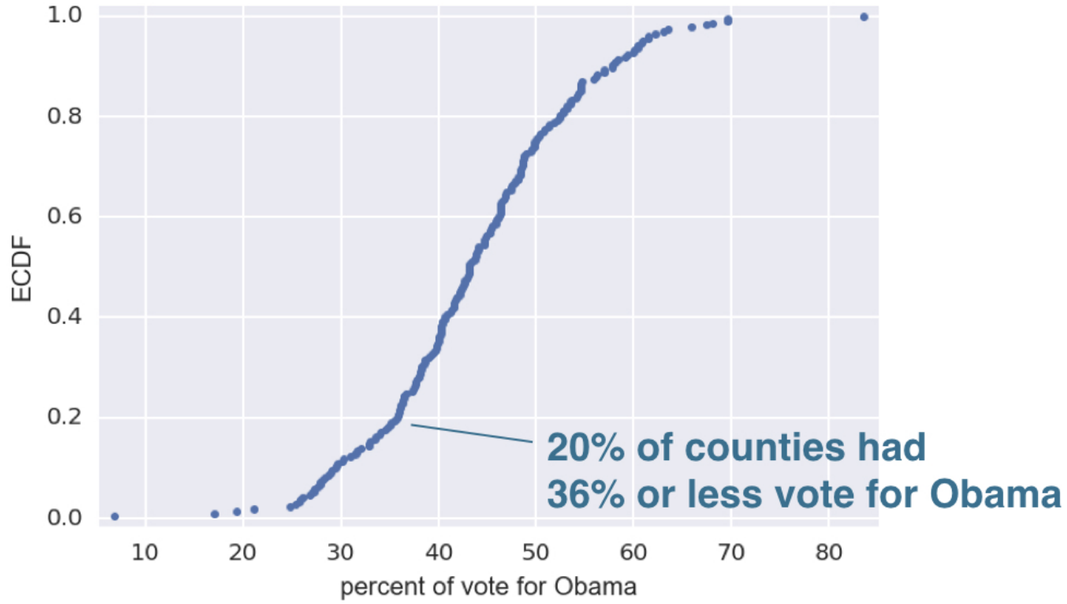
[1] Data retrieved from Data.gov (https://www.data.gov/)

Empirical cumulative distribution function (ECDF)



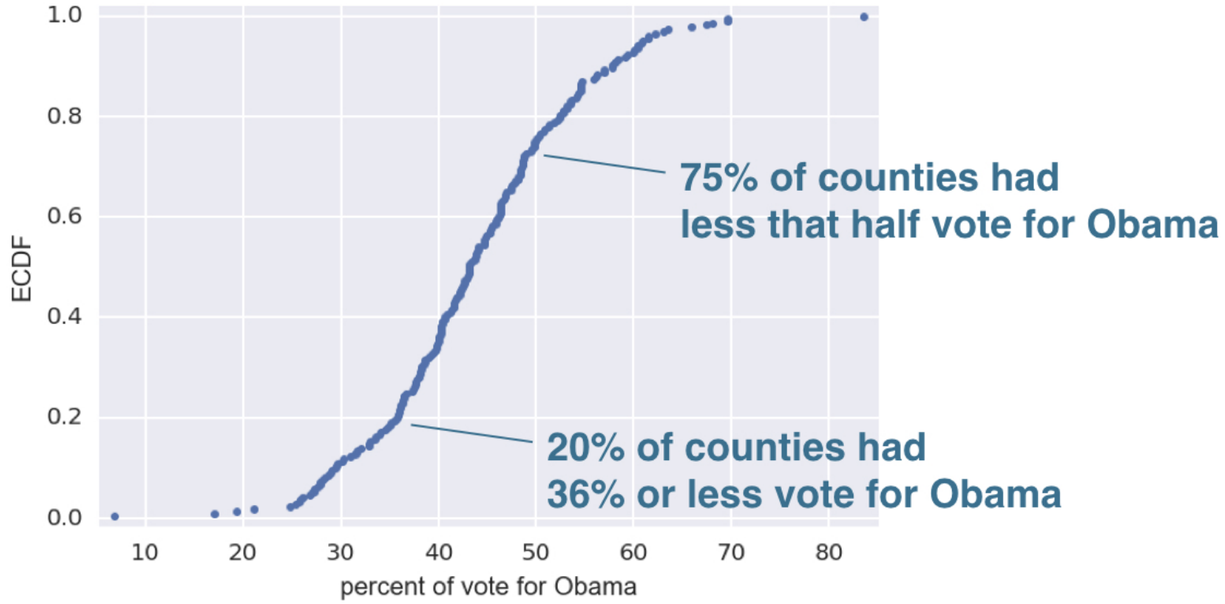
[1] Data retrieved from Data.gov (https://www.data.gov/)

Empirical cumulative distribution function (ECDF)



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

Empirical cumulative distribution function (ECDF)

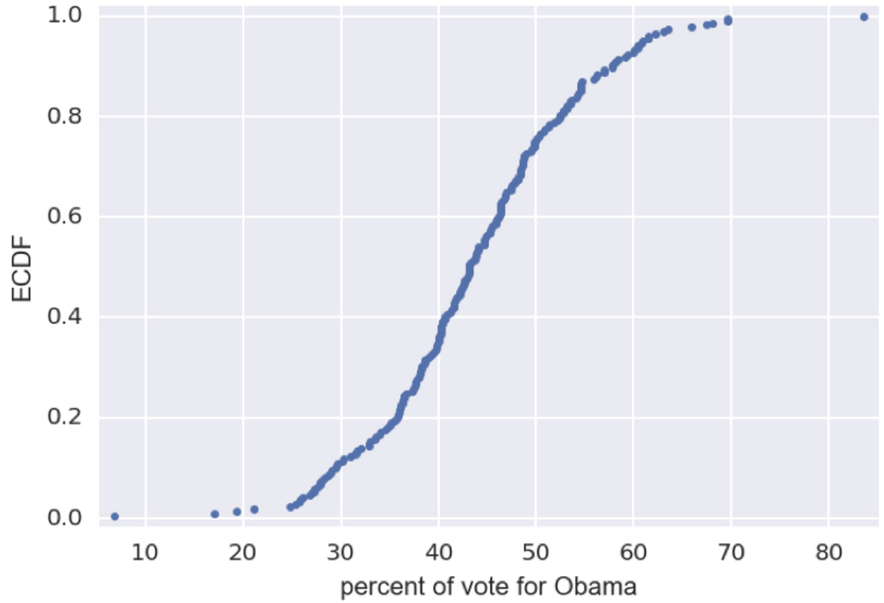


[1] Data retrieved from Data.gov (https://www.data.gov/)

Making an ECDF

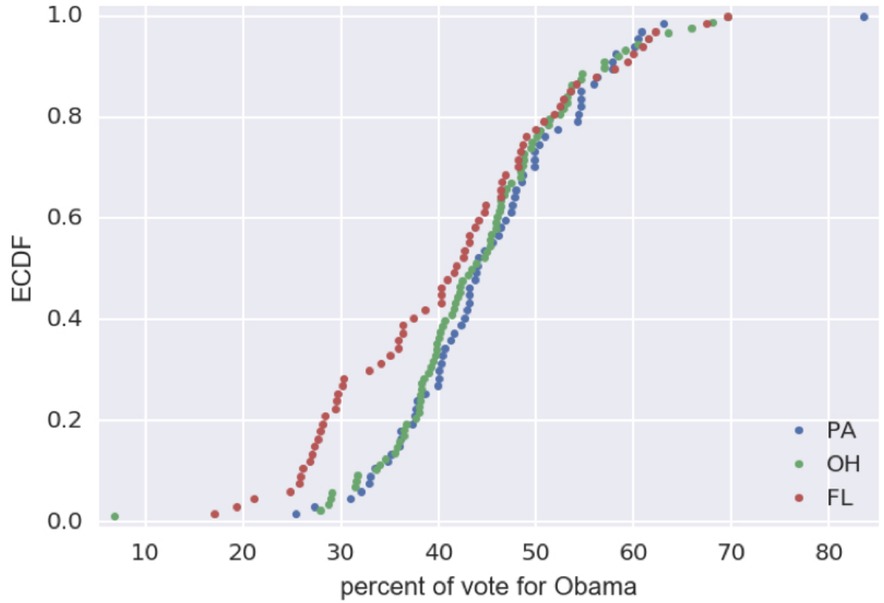
```
import numpy as np
x = np.sort(df_swing['dem_share'])
y = np.arange(1, len(x)+1) / len(x)
_ = plt.plot(x, y, marker='.', linestyle='none')
_ = plt.xlabel('percent of vote for Obama')
_ = plt.ylabel('ECDF')
plt.margins(0.02) # Keeps data off plot edges
plt.show()
```

2008 US swing state election ECDF



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

2008 US swing state election ECDFs



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

Let's practice!

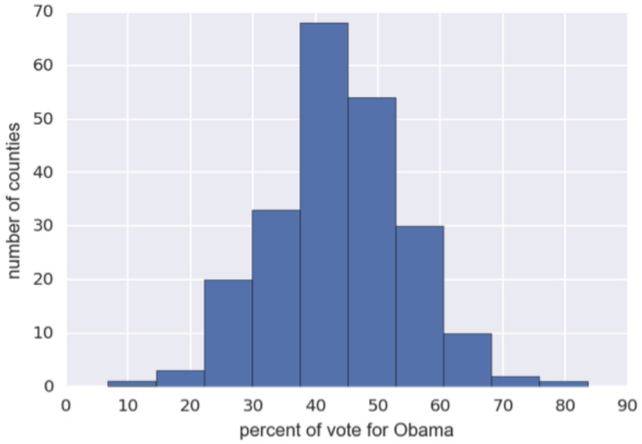
STATISTICAL THINKING IN PYTHON (PART 1)

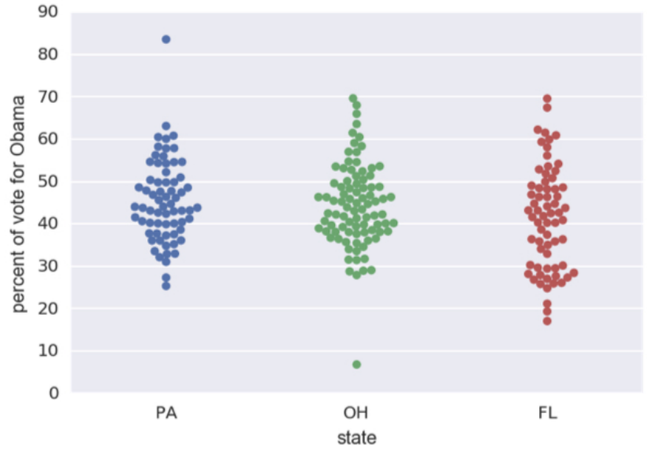
Onward toward the whole story!

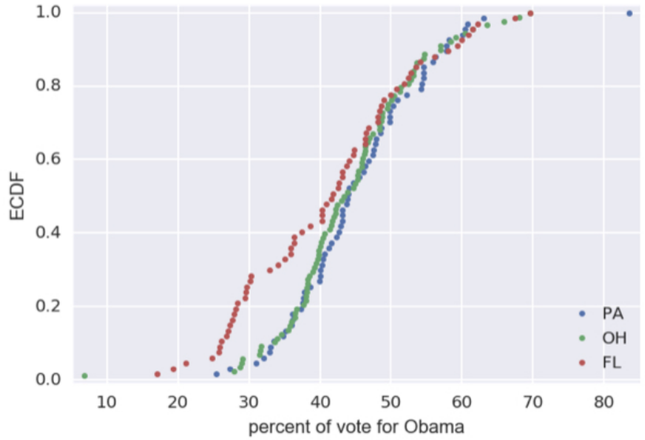
STATISTICAL THINKING IN PYTHON (PART 1)

Justin Bois

Teaching Professor at the California Institute of Technology


number of counties
percent of vote for Obama


percent of vote for Obama
PA
OH
FL
state


ECDF
PA
OH
FL
percent of vote for Obama

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

Coming up...

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

Let's practice!

STATISTICAL THINKING IN PYTHON (PART 1)