Week 6: Descriptive Statistics and Data Visualization

DSUA111: Data Science for Everyone, NYU, Fall 2020

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- This slideshow: https://jjacobs.me/dsua111-sections/week-06 (https://jjacobs.me/dsua111-sections/week-06)
- All materials: https://github.com/jpowerj/dsua111-sections (https://github.com/jpowerj/dsua111-sections)

Overview

1. Quick Pandas Recap
2. Variable Types
3. Frequency/Central Tendency
4. Dispersion and Position

[Visualization: sprinkled throughout]

Pandas Recap

Where we left off...

In [1]:
```
import pandas as pd
gift_df = pd.read_csv("ForeignGifts_Universities.csv")
```

In [2]:
```
try:
    gift_df['amount_cleaned'] = gift_df['Foreign Gift Amount'].str.replace("$","").str.r
eplace(",","").astype(float)
except Exception as e:
    print(e)
```

```
could not convert string to float: '(4970.00)'
```

In [3]:
```
gift_df['amount_cleaned'] = gift_df['Foreign Gift Amount'].str.replace("(","").str.repla
ce(")","").str.replace("$","").str.replace(",","")
```

In [4]:
```
gift_df.head()
```

Out[4]:

	ID	OPEID	Institution Name	City	State	Foreign Gift Received Date	Foreign Gift Amount	Gift Type	Country of Giftor	Giftor Name	amount_cleaned
0	1	107000	Thunderbird School of Global Management	Glendale	AZ	12/12/2012	$1,220,000.00	Contract	MEXICO	Instituto Technologico y de Estudio	1220000.00
1	2	107000	Thunderbird School of Global Management	Glendale	AZ	11/26/2012	$395,790.00	Contract	CHINA	Intel Products (Chengdu) LTD	395790.00
2	3	107000	Thunderbird School of Global Management	Glendale	AZ	11/19/2012	$2,769,651.00	Contract	SAUDI ARABIA	Saudi Basic Industries Corporation	2769651.00
3	4	107000	Thunderbird School of Global Management	Glendale	AZ	7/31/2012	$364,128.00	Contract	KUWAIT	Kuwait National Petroleum CO	364128.00
4	5	108100	Arizona State University	Tempe	AZ	12/29/2017	$180,000.00	Contract	THE NETHERLANDS	Airbus Group SE	180000.00

In [5]:
```
gift_df.dtypes
```

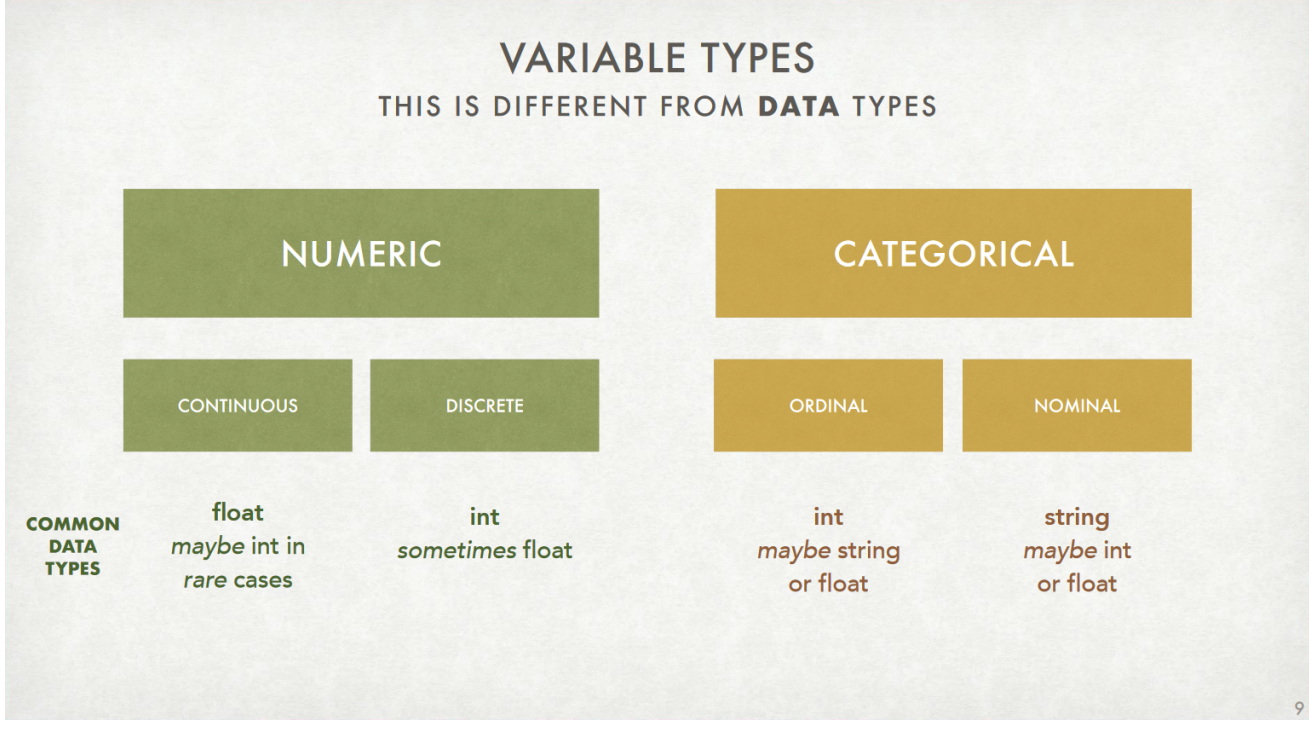
Out[5]:
```
ID                              int64
OPEID                           int64
Institution Name               object
City                           object
State                          object
Foreign Gift Received Date     object
Foreign Gift Amount            object
Gift Type                      object
Country of Giftor              object
Giftor Name                    object
amount_cleaned                 object
dtype: object
```

In [6]:
```
gift_df['amount_cleaned'] = gift_df['amount_cleaned'].astype(float)
```

In [7]:
```
gift_df.dtypes
```

Out[7]:
```
ID                                int64
OPEID                             int64
Institution Name                 object
City                             object
State                            object
Foreign Gift Received Date       object
Foreign Gift Amount              object
Gift Type                        object
Country of Giftor                object
Giftor Name                      object
amount_cleaned                  float64
dtype: object
```

Variable Types



(Lecture 9.1, Slide 9)

Variable Types?

Gift Amount? (the cleaned version)

In [8]:
```
gift_df['amount_cleaned']
```

Out[8]:
```
0         1220000.0
1          395790.0
2         2769651.0
3          364128.0
4          180000.0
             ...
18381      163958.0
18382      163958.0
18383      350000.0
18384    21532410.0
18385      375000.0
Name: amount_cleaned, Length: 18386, dtype: float64
```

`amount_cleaned` is **Numeric**, **Continuous**

(Why not discrete?)

Number of letters in institution name?

In [9]:
```
gift_df['institution_length'] = gift_df['Institution Name'].apply(len)
```

In [10]:
```
gift_df.head()
```

Out[10]:

	ID	OPEID	Institution Name	City	State	Foreign Gift Received Date	Foreign Gift Amount	Gift Type	Country of Giftor	Giftor Name	amount_cleaned	
0	1	107000	Thunderbird School of Global Management	Glendale	AZ	12/12/2012	$1,220,000.00	Contract	MEXICO	Instituto Technologico y de Estudio	1220000.0	
1	2	107000	Thunderbird School of Global Management	Glendale	AZ	11/26/2012	$395,790.00	Contract	CHINA	Intel Products (Chengdu) LTD	395790.0	
2	3	107000	Thunderbird School of Global Management	Glendale	AZ	11/19/2012	$2,769,651.00	Contract	SAUDI ARABIA	Saudi Basic Industries Corporation	2769651.0	
3	4	107000	Thunderbird School of Global Management	Glendale	AZ	7/31/2012	$364,128.00	Contract	KUWAIT	Kuwait National Petroleum CO	364128.0	
4	5	108100	Arizona State University	Tempe	AZ	12/29/2017	$180,000.00	Contract	THE NETHERLANDS	Airbus Group SE	180000.0	

`institution_length` is **Numeric, Discrete**

Name of Institution?

In [11]:
```
gift_df['Institution Name']
```

Out[11]:
```
0                  Thunderbird School of Global Management
1                  Thunderbird School of Global Management
2                  Thunderbird School of Global Management
3                  Thunderbird School of Global Management
4                               Arizona State University
                                ...
18381    Keck Graduate Institute of Applied Life Sciences
18382    Keck Graduate Institute of Applied Life Sciences
18383    Keck Graduate Institute of Applied Life Sciences
18384                  Hult International Business School
18385         California Institute of Advanced Management
Name: Institution Name, Length: 18386, dtype: object
```

`Institution Name` is **Categorical**, **Nominal**

Rank of the gift? (1=largest, 2=second-largest, ...)

In [12]:
```
gift_df['gift_rank'] = gift_df['amount_cleaned'].rank(method='min', ascending=False).astype(int)
```

In [13]:
```
gift_df.head()
```

Out[13]:

	ID	OPEID	Institution Name	City	State	Foreign Gift Received Date	Foreign Gift Amount	Gift Type	Country of Giftor	Giftor Name	amount_cleaned	
0	1	107000	Thunderbird School of Global Management	Glendale	AZ	12/12/2012	$1,220,000.00	Contract	MEXICO	Instituto Technologico y de Estudio	1220000.0	
1	2	107000	Thunderbird School of Global Management	Glendale	AZ	11/26/2012	$395,790.00	Contract	CHINA	Intel Products (Chengdu) LTD	395790.0	
2	3	107000	Thunderbird School of Global Management	Glendale	AZ	11/19/2012	$2,769,651.00	Contract	SAUDI ARABIA	Saudi Basic Industries Corporation	2769651.0	
3	4	107000	Thunderbird School of Global Management	Glendale	AZ	7/31/2012	$364,128.00	Contract	KUWAIT	Kuwait National Petroleum CO	364128.0	
4	5	108100	Arizona State University	Tempe	AZ	12/29/2017	$180,000.00	Contract	THE NETHERLANDS	Airbus Group SE	180000.0	

In [14]:
```
gift_df.sort_values(by='gift_rank').head(5)
```

Out[14]:

	ID	OPEID	Institution Name	City	State	Foreign Gift Received Date	Foreign Gift Amount	Gift Type	Country of Giftor	Giftor Name	amount_cleaned
16386	16387	324200	Carnegie Mellon University	Pittsburgh	PA	1/1/2015	$77,391,377.00	Contract	QATAR	Qatar Foundation for Education	77391377.0
16343	16344	324200	Carnegie Mellon University	Pittsburgh	PA	2/16/2016	$75,000,000.00	Contract	BERMUDA	NaN	75000000.0
16345	16346	324200	Carnegie Mellon University	Pittsburgh	PA	2/16/2016	$75,000,000.00	Contract	BERMUDA	NaN	75000000.0
16346	16347	324200	Carnegie Mellon University	Pittsburgh	PA	2/16/2016	$75,000,000.00	Contract	BERMUDA	NaN	75000000.0
16347	16348	324200	Carnegie Mellon University	Pittsburgh	PA	2/16/2016	$75,000,000.00	Contract	BERMUDA	NaN	75000000.0

`gift_rank` is **Categorical, Ordinal**

Measures of Frequency

In [15]:
```
gift_df['Institution Name'].value_counts().head(10)
```

Out[15]:
```
University of California, Los Angeles          3206
California Institute of Technology             3127
Johns Hopkins University                       1157
Columbia University in the City of New York     791
Ohio State University (The)                     681
University of Michigan - Ann Arbor              630
Stanford University                             518
Harvard University                              513
Babson College                                  378
Saint John's University                         332
Name: Institution Name, dtype: int64
```

In [16]:
```
gift_df['Institution Name'].value_counts(normalize=True).head(10)
```

Out[16]:
```
University of California, Los Angeles          0.174372
California Institute of Technology             0.170075
Johns Hopkins University                       0.062928
Columbia University in the City of New York    0.043022
Ohio State University (The)                    0.037039
University of Michigan - Ann Arbor             0.034265
Stanford University                            0.028174
Harvard University                             0.027902
Babson College                                 0.020559
Saint John's University                        0.018057
Name: Institution Name, dtype: float64
```

In [17]:
```
gift_df['Country of Giftor'].value_counts().head(10)
```

Out[17]:
```
ENGLAND          2490
CANADA           1885
JAPAN            1540
CHINA            1297
FRANCE           1130
SWITZERLAND      1124
GERMANY          1025
HONG KONG         675
SAUDI ARABIA      627
SOUTH KOREA       441
Name: Country of Giftor, dtype: int64
```

In [18]:
```
gift_df['Country of Giftor'].value_counts(normalize=True).head(10)
```

Out[18]:
```
ENGLAND          0.135429
CANADA           0.102524
JAPAN            0.083759
CHINA            0.070543
FRANCE           0.061460
SWITZERLAND      0.061133
GERMANY          0.055749
HONG KONG        0.036713
SAUDI ARABIA     0.034102
SOUTH KOREA      0.023986
Name: Country of Giftor, dtype: float64
```

Measures of Central Tendency

In [19]:
```
gift_df['amount_cleaned'].describe()
```

Out[19]:
```
count    1.838600e+04
mean     5.014007e+05
std      2.760354e+06
min      0.000000e+00
25%      2.419250e+03
50%      6.000000e+04
75%      3.171265e+05
max      7.739138e+07
Name: amount_cleaned, dtype: float64
```

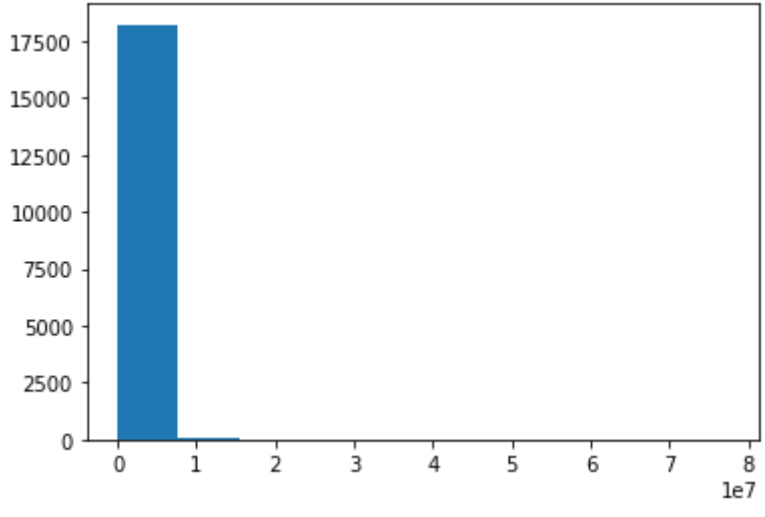
https://www.google.com/search?client=firefox-b-1-d&q=pandas+describe+format (https://www.google.com/search?client=firefox-b-1-d&q=pandas+describe+format)

https://stackoverflow.com/questions/40347689/dataframe-describe-suppress-scientific-notation (https://stackoverflow.com/questions/40347689/dataframe-describe-suppress-scientific-notation)

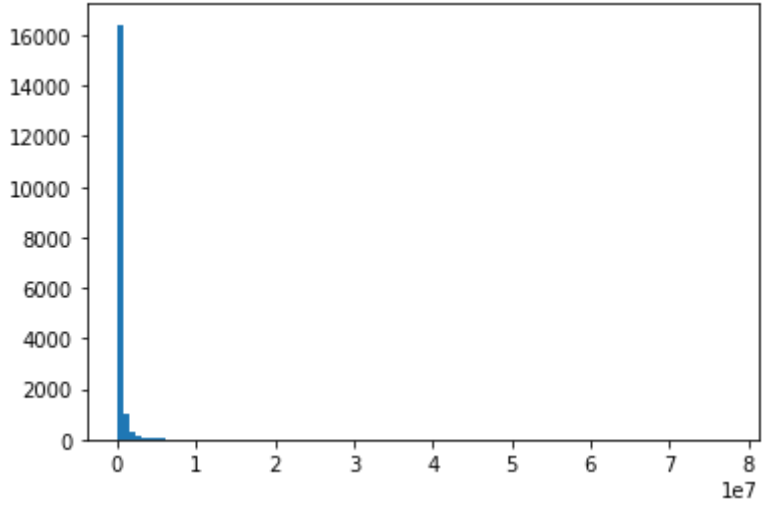
In [20]:
```
gift_df['amount_cleaned'].describe().apply(lambda x: format(x, 'f'))
```

Out[20]:
```
count       18386.000000
mean       501400.674535
std       2760353.536498
min             0.000000
25%          2419.250000
50%         60000.000000
75%        317126.500000
max      77391377.000000
Name: amount_cleaned, dtype: object
```

In [21]:
```
import matplotlib.pyplot as plt
plt.hist(gift_df['amount_cleaned'])
plt.show()
```



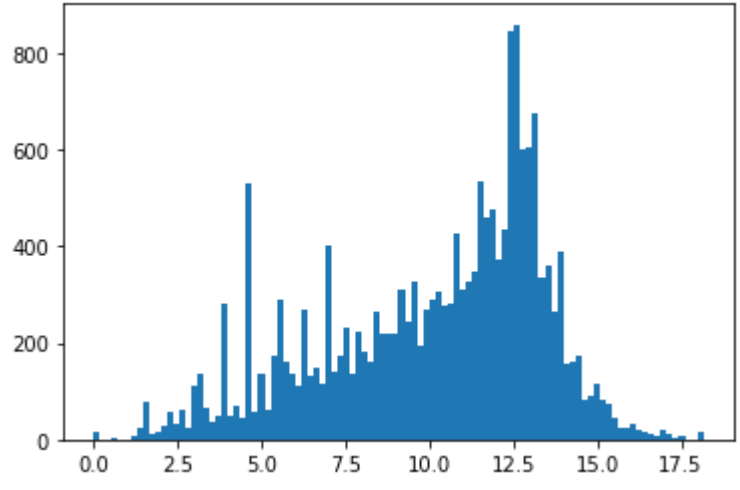
In [22]:
```
plt.hist(gift_df['amount_cleaned'], bins=100)
plt.show()
```



In [23]:
```
import numpy as np
gift_df['log_amount'] = gift_df['amount_cleaned'].apply(np.log)
```

In [24]:
```
gift_df[gift_df['log_amount'] == -np.inf] = np.nan
```

In [25]:
```
plt.hist(gift_df['log_amount'], bins=100)
plt.show()
```



In [26]:
```
np.exp(13.125)
```

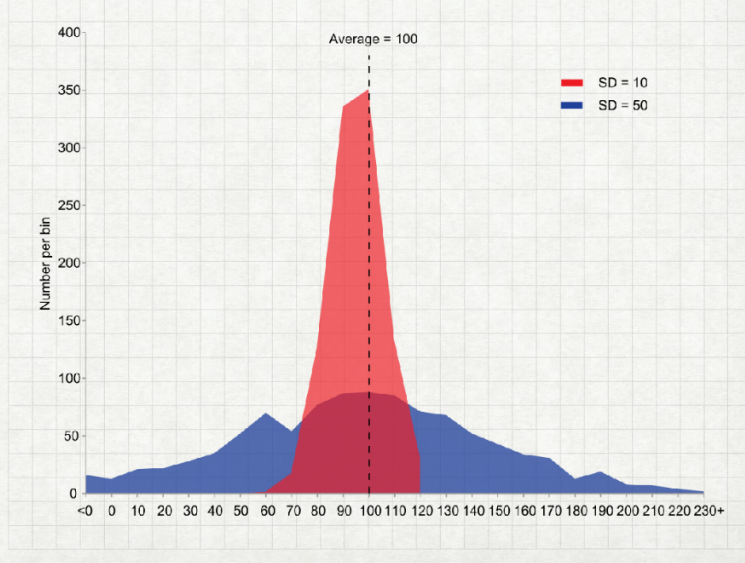
Out[26]:
```
501320.0507709557
```

But... BEWARE!

DESCRIPTIVE STATISTICS

RISKS

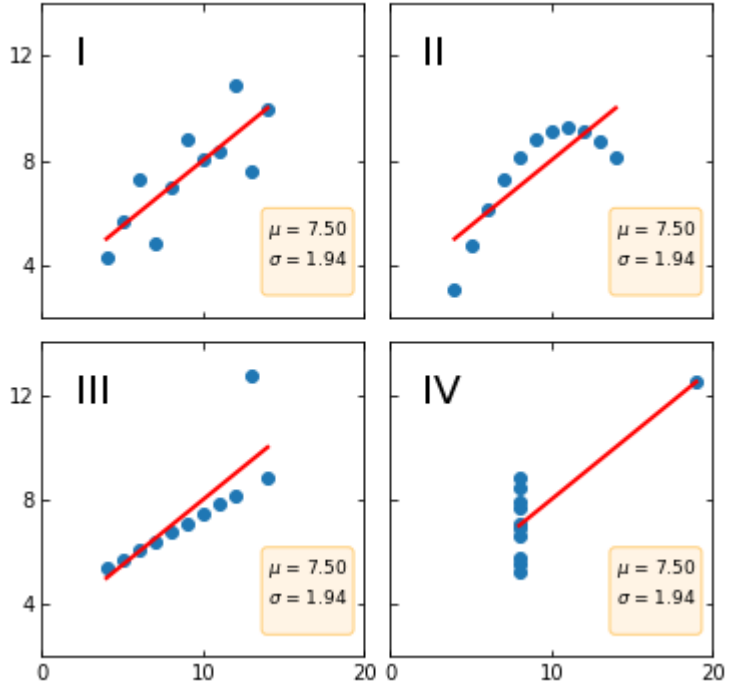
- Summarizing a variable is very useful!
  - We can quickly identify trends, make comparisons, and better understand the **distribution** of values
- But there's a tradeoff: Any time we simplify, we **lose information**
  - If not handled carefully, descriptive statistics can be misleading (at best)
  - Or actually obscure important information
- Example, the mean in the graph to the right is the same for both the blue and red variables, but the **distributions** (the patterns the values the variables take on) are very different
  - Simply presenting the mean might falsely lead us to assume the two variables are the same
  - This could have serious implications if we wish to learn from our research!



(Lecture 9.1. Slide 6)

and... BEWARE!

In [27]:
```
import anscombe
anscombe.plot_anscombe()
```



("Anscombe's Quartet": https://en.wikipedia.org/wiki/Anscombe%27s_quartet (https://en.wikipedia.org/wiki/Anscombe%27s_quartet))

Measures of Dispersion

In [28]:
```
gift_df['amount_cleaned'].var()
```

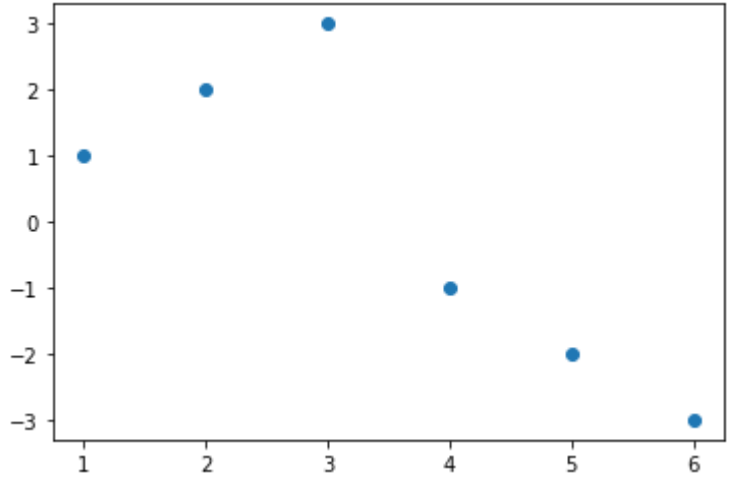
Out[28]:
```
7622759151302.67
```

Variance in words: the average squared distance from the mean

But... why do we square it?

In [29]:
```
my_df = pd.DataFrame({'x':[1,2,3,4,5,6],'y':[1,2,3,-1,-2,-3]})
```

In [30]:
```
plt.scatter(my_df['x'], my_df['y']); plt.show()
```



In [31]:
```
y_mean = my_df['y'].mean(); y_mean
```

Out[31]:
```
0.0
```

In [32]:
```
my_df['y'].std()
```

Out[32]:
```
2.3664319132398464
```

In [33]:
```
(my_df['y'] - y_mean).mean()
```

Out[33]:
```
0.0
```

And why *both* standard deviation and variance?

- Simple answer: standard deviation is in the same units as the variable.
- Standard deviation of gift amount is approx. $2.76 million
- Variance of gift amount is approx. 7.6 trillion .....?

In [34]:

```
%%HTML
<video width="80%" controls>
      <source src="ice_cream_glove.mp4" type="video/mp4">
</video>
```