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January 21, 2022

1 In Depth A/B Testing - Lab

1.1 Introduction

In this lab, you'll explore a survey from Kaggle regarding budding data scientists. With this, you'll form some initial hypotheses, and test them using the tools you've acquired to date.

1.2 Objectives

You will be able to: * Conduct t-tests and an ANOVA on a real-world dataset and interpret the results

1.3 Load the Dataset and Perform a Brief Exploration

The data is stored in a file called **multipleChoiceResponses_cleaned.csv**. Feel free to check out the original dataset referenced at the bottom of this lab, although this cleaned version will undoubtedly be easier to work with. Additionally, meta-data regarding the questions is stored in a file name **schema.csv**. Load in the data itself as a Pandas DataFrame, and take a moment to briefly get acquainted with it.

> Note: If you can't get the file to load properly, try changing the encoding format as in `encoding='latin1'`

[103]:
```
#Your code here
import pandas as pd
import scipy.stats as stats
import numpy as np
import seaborn as sns
import matplotlib.pyplot as plt

from statsmodels.stats.power import TTestIndPower


import warnings
warnings.filterwarnings("ignore")
```

[52]:
```
df = pd.read_csv("multipleChoiceResponses_cleaned.csv", encoding='latin1')
df.head()
```

[52]:

```
                                         GenderSelect        Country   Age  \
0  Non-binary, genderqueer, or gender non-conforming            NaN   NaN
1                                              Female  United States  30.0
2                                                Male         Canada  28.0
3                                                Male  United States  56.0
4                                                Male         Taiwan  38.0

                                     EmploymentStatus StudentStatus  \
0                                  Employed full-time           NaN
1                Not employed, but looking for work           NaN
2                Not employed, but looking for work           NaN
3  Independent contractor, freelancer, or self-em…           NaN
4                                  Employed full-time           NaN

  LearningDataScience CodeWriter CareerSwitcher  \
0                 NaN        Yes            NaN
1                 NaN        NaN            NaN
2                 NaN        NaN            NaN
3                 NaN        Yes            NaN
4                 NaN        Yes            NaN

            CurrentJobTitleSelect TitleFit  …  JobFactorTitle  \
0            DBA/Database Engineer     Fine  …             NaN
1                              NaN      NaN  …             NaN
2                              NaN      NaN  …  Very Important
3  Operations Research Practitioner   Poorly  …             NaN
4               Computer Scientist     Fine  …             NaN

  JobFactorCompanyFunding JobFactorImpact JobFactorRemote JobFactorIndustry  \
0                     NaN             NaN             NaN               NaN
1                     NaN             NaN             NaN               NaN
2          Very Important  Very Important  Very Important    Very Important
3                     NaN             NaN             NaN               NaN
4                     NaN             NaN             NaN               NaN

  JobFactorLeaderReputation JobFactorDiversity JobFactorPublishingOpportunity  \
0                       NaN                NaN                            NaN
1        Somewhat important                NaN                            NaN
2            Very Important     Very Important                 Very Important
3                       NaN                NaN                            NaN
4                       NaN                NaN                            NaN

  exchangeRate AdjustedCompensation
0          NaN                  NaN
1          NaN                  NaN
2          NaN                  NaN
3          1.0             250000.0
```

```
4          NaN                    NaN

[5 rows x 230 columns]
```

1.4 Wages and Education

You've been asked to determine whether education is impactful to salary. Develop a hypothesis test to compare the salaries of those with Master's degrees to those with Bachelor's degrees. Are the two statistically different according to your results?

> Note: The relevant features are stored in the 'FormalEducation' and 'AdjustedCompensation' features.

You may import the functions stored in the `flatiron_stats.py` file to help perform your hypothesis tests. It contains the stats functions that you previously coded: `welch_t(a,b)`, `welch_df(a, b)`, and `p_value(a, b, two_sided=False)`.

Note that `scipy.stats.ttest_ind(a, b, equal_var=False)` performs a two-sided Welch's t-test and that p-values derived from two-sided tests are two times the p-values derived from one-sided tests. See the documentation for more information.

[55]:
```
condition_M = "Master's degree"
condition_B = "Bachelor's degree"
to_pick = "AdjustedCompensation"
MS = df.loc[df["FormalEducation"] == condition_M][to_pick]
BS = df.loc[df["FormalEducation"] == condition_B][to_pick]
MS.dropna(inplace = True)
BS.dropna(inplace = True)
sns.distplot(MS)
sns.distplot(BS);
```

Some Information about the samples including `mean`, `median`, `standard deviation` and `sample size`:

[58]:
```
# print(f"Comparision of AdjustmentCompensation for {condition_M} and␣
↪{condition_B}")
# print("\n")
print("AdjustmentCompensation for {condition_M}")
print(f"Median:                 {round(MS.median(),2)}")
print(f"Mean:                   {round(MS.mean(),2)}")
print(f"Standard Deviation:     {round(MS.std(),2)}")
print(f"Sample Size:            {len(MS)}")

print("\n")
print(f"AdjustmentCompensation for {condition_B}")
print(f"Median:                 {round(BS.median(),2)}")
print(f"Mean:                   {round(BS.mean(),2)}")
print(f"Standard Deviation:     {round(BS.std(),2)}")
print(f"Sample Size:            {len(BS)}")
```

```
AdjustmentCompensation for {condition_M}
Median:                 53812.17
Mean:                   69139.9
Standard Deviation:     135527.21
Sample Size:            1990


AdjustmentCompensation for Bachelor's degree
Median:                 38399.4
Mean:                   64887.1
Standard Deviation:     306935.87
Sample Size:            1107
```

[74]:

```
results = stats.ttest_ind(MS, BS, equal_var=False)
p_value = 1/2 * results.pvalue
p_value
```

[74]:

```
0.33077639451272445
```

[75]:

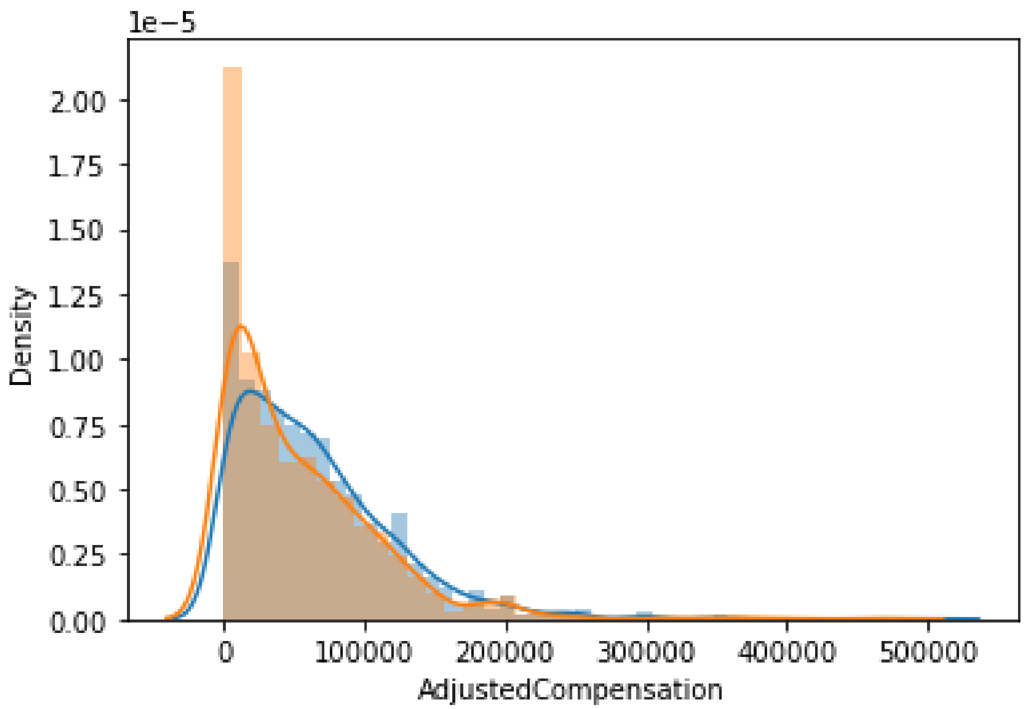
```
#Investigate Percentiles
for q in np.linspace(.8, 1, num=21):
    MSq =  round(MS.quantile(q=q), 2)
    BSq =  round(BS.quantile(q=q), 2)
    print(f'{round(q,2)}th percentile:\tset1: {MSq}\tset2: {BSq}')
```

```
0.8th percentile:       set1: 103000.0  set2: 93233.13
0.81th percentile:      set1: 107009.0  set2: 95572.83
0.82th percentile:      set1: 110000.0  set2: 99276.38
0.83th percentile:      set1: 111503.83 set2: 100000.0
0.84th percentile:      set1: 115240.4  set2: 103040.0
0.85th percentile:      set1: 119582.6  set2: 105935.04
0.86th percentile:      set1: 120000.0  set2: 110000.0
0.87th percentile:      set1: 124719.88 set2: 112000.0
0.88th percentile:      set1: 129421.46 set2: 115000.0
0.89th percentile:      set1: 130000.0  set2: 120000.0
0.9th percentile:       set1: 135000.0  set2: 120346.5
0.91th percentile:      set1: 140000.0  set2: 126460.0
0.92th percentile:      set1: 149640.0  set2: 132615.4
0.93th percentile:      set1: 150000.0  set2: 140000.0
0.94th percentile:      set1: 160000.0  set2: 143408.8
0.95th percentile:      set1: 166778.6  set2: 150000.0
0.96th percentile:      set1: 180000.0  set2: 179849.74
0.97th percentile:      set1: 200000.0  set2: 195000.0
0.98th percentile:      set1: 211100.0  set2: 200000.0
0.99th percentile:      set1: 250000.0  set2: 250000.0
1.0th percentile:       set1: 4498900.0 set2: 9999999.0
```

[76]:
```python
outlier_threshold = 5e5

condition_M = "Master's degree"
condition_B = "Bachelor's degree"
to_pick = "AdjustedCompensation"
modified_MS = df.loc[(df["FormalEducation"] == condition_M) &
            (df["AdjustedCompensation"] <= outlier_threshold)][to_pick]
modified_BS = df.loc[(df["FormalEducation"] == condition_B) &
            (df["AdjustedCompensation"] <= outlier_threshold)][to_pick]
modified_MS.dropna(inplace = True)
modified_BS.dropna(inplace = True)
```

[77]:
```python
sns.distplot(modified_MS)
sns.distplot(modified_BS);
```



[78]:
```python
print(f"AdjustmentCompensation for {condition_M} after setting out Outlier␣
 ↪Threshold")
print(f"Median:                 {round(modified_MS.median(),2)}")
print(f"Mean:                   {round(modified_MS.mean(),2)}")
print(f"Standard Deviation:     {round(modified_MS.std(),2)}")
print(f"Sample Size:            {len(modified_MS)}")

print("\n")
```

```
print(f"AdjustmentCompensation for {condition_B} after setting out Outlier␣
 ↪Threshold")
print(f"Median:                 {round(modified_BS.median(),2)}")
print(f"Mean:                   {round(modified_BS.mean(),2)}")
print(f"Standard Deviation:     {round(modified_BS.std(),2)}")
print(f"Sample Size:            {len(modified_BS)}")
```

```
AdjustmentCompensation for Master's degree after setting out Outlier Threshold
Median:               53539.72
Mean:                 63976.63
Standard Deviation:   55340.99
Sample Size:          1985


AdjustmentCompensation for Bachelor's degree after setting out Outlier Threshold
Median:               38292.15
Mean:                 53744.35
Standard Deviation:   55285.48
Sample Size:          1103
```

[79]:
```
results = stats.ttest_ind(modified_MS, modified_BS, equal_var=False)
results
# p_value = 1/2 * results.pvalue
# p_value
```

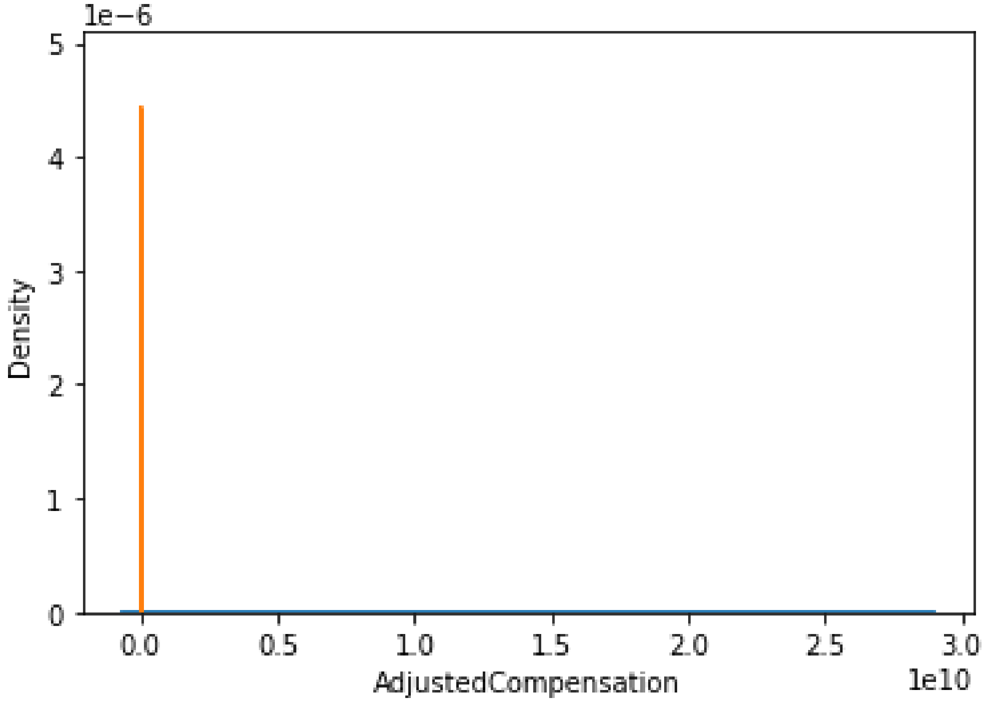
[79]:
```
Ttest_indResult(statistic=4.926460514781741, pvalue=8.974916653864261e-07)
```

[80]:
```
#Your code here
import flatiron_stats as fs
```

1.5 Wages and Education II

Now perform a similar statistical test comparing the AdjustedCompensation of those with Bachelor's degrees and those with Doctorates. If you haven't already, be sure to explore the distribution of the AdjustedCompensation feature for any anomalies.

[86]:
```
condition_D = "Doctoral degree"
condition_B = "Bachelor's degree"
to_pick = "AdjustedCompensation"
D = df.loc[df["FormalEducation"] == condition_D][to_pick]
BS = df.loc[df["FormalEducation"] == condition_B][to_pick]
D.dropna(inplace = True)
BS.dropna(inplace = True)
sns.distplot(D)
sns.distplot(BS);
```



[87]:
```
# print(f"Comparision of AdjustmentCompensation for {condition_M} and␣
↪{condition_B}")
# print("\n")
print("AdjustmentCompensation for {condition_D}")
print(f"Median:                  {round(D.median(),2)}")
print(f"Mean:                    {round(D.mean(),2)}")
print(f"Standard Deviation:      {round(D.std(),2)}")
print(f"Sample Size:             {len(D)}")

print("\n")
print(f"AdjustmentCompensation for {condition_B}")
print(f"Median:                  {round(BS.median(),2)}")
print(f"Mean:                    {round(BS.mean(),2)}")
print(f"Standard Deviation:      {round(BS.std(),2)}")
print(f"Sample Size:             {len(BS)}")
```

```
AdjustmentCompensation for {condition_D}
Median:                 74131.92
Mean:                   29566175.76
Standard Deviation:     909998082.33
Sample Size:            967


AdjustmentCompensation for Bachelor's degree
```

```
Median:                 38399.4
Mean:                   64887.1
Standard Deviation:     306935.87
Sample Size:            1107
```

[88]:
```
results = stats.ttest_ind(D, BS, equal_var=False)
p_value = 1/2 * results.pvalue
p_value
```

[88]: 0.15682381994720257

[89]:
```
#Investigate Percentiles
for q in np.linspace(.8, 1, num=21):
    Dq =  round(D.quantile(q=q), 2)
    BSq =  round(BS.quantile(q=q), 2)
    print(f'{round(q,2)}th percentile:\tset1: {Dq}\tset2: {BSq}')
```

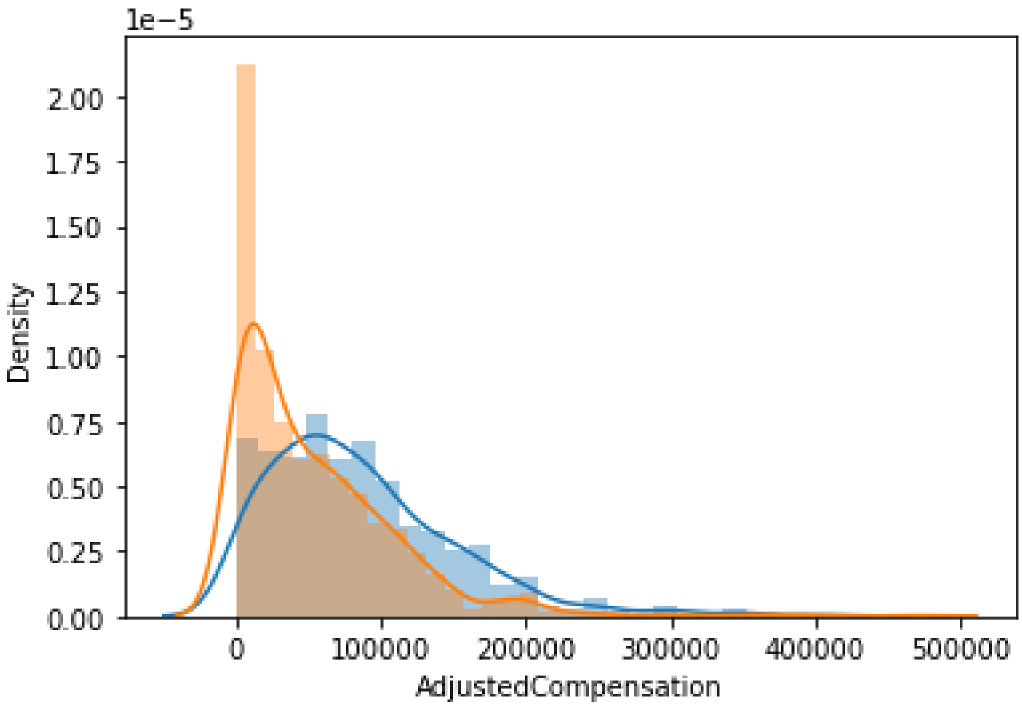
```
0.8th percentile:       set1: 135000.0  set2: 93233.13
0.81th percentile:      set1: 140000.0  set2: 95572.83
0.82th percentile:      set1: 140000.0  set2: 99276.38
0.83th percentile:      set1: 146796.17 set2: 100000.0
0.84th percentile:      set1: 150000.0  set2: 103040.0
0.85th percentile:      set1: 150000.0  set2: 105935.04
0.86th percentile:      set1: 155000.0  set2: 110000.0
0.87th percentile:      set1: 160000.0  set2: 112000.0
0.88th percentile:      set1: 160000.0  set2: 115000.0
0.89th percentile:      set1: 166480.0  set2: 120000.0
0.9th percentile:       set1: 172057.78 set2: 120346.5
0.91th percentile:      set1: 175000.0  set2: 126460.0
0.92th percentile:      set1: 181555.2  set2: 132615.4
0.93th percentile:      set1: 191900.0  set2: 140000.0
0.94th percentile:      set1: 200000.0  set2: 143408.8
0.95th percentile:      set1: 200000.0  set2: 150000.0
0.96th percentile:      set1: 220999.61 set2: 179849.74
0.97th percentile:      set1: 240879.14 set2: 195000.0
0.98th percentile:      set1: 277349.78 set2: 200000.0
0.99th percentile:      set1: 336800.0  set2: 250000.0
1.0th percentile:       set1: 28297400000.0     set2: 9999999.0
```

[90]:
```
outlier_threshold = 5e5

condition_D = "Doctoral degree"
condition_B = "Bachelor's degree"
to_pick = "AdjustedCompensation"
modified_D = df.loc[(df["FormalEducation"] == condition_D) &
            (df["AdjustedCompensation"] <= outlier_threshold)][to_pick]
modified_BS = df.loc[(df["FormalEducation"] == condition_B) &
```

```
            (df["AdjustedCompensation"] <= outlier_threshold)][to_pick]
modified_D.dropna(inplace = True)
modified_BS.dropna(inplace = True)
```

[91]:
```
sns.distplot(modified_D)
sns.distplot(modified_BS);
```



[92]:
```
print(f"AdjustmentCompensation for {condition_D} after setting out Outlier␣
 ↪Threshold")
print(f"Median:                 {round(modified_D.median(),2)}")
print(f"Mean:                   {round(modified_D.mean(),2)}")
print(f"Standard Deviation:     {round(modified_D.std(),2)}")
print(f"Sample Size:            {len(modified_D)}")

print("\n")
print(f"AdjustmentCompensation for {condition_B} after setting out Outlier␣
 ↪Threshold")
print(f"Median:                 {round(modified_BS.median(),2)}")
print(f"Mean:                   {round(modified_BS.mean(),2)}")
print(f"Standard Deviation:     {round(modified_BS.std(),2)}")
print(f"Sample Size:            {len(modified_BS)}")
```

```
AdjustmentCompensation for Doctoral degree after setting out Outlier Threshold
Median:                 73152.77
```

```
Mean:                    86194.98
Standard Deviation:      65298.89
Sample Size:             964


AdjustmentCompensation for Bachelor's degree after setting out Outlier Threshold
Median:                  38292.15
Mean:                    53744.35
Standard Deviation:      55285.48
Sample Size:             1103
```

[93]:
```
results = stats.ttest_ind(modified_D, modified_BS, equal_var=False)
results
# p_value = 1/2 * results.pvalue
# p_value
```

[93]:
```
Ttest_indResult(statistic=12.098472655425814, pvalue=1.6387413004630542e-32)
```

1.6 Wages and Education III

Remember the multiple comparisons problem; rather than continuing on like this, perform an ANOVA test between the various 'FormalEducation' categories and their relation to 'AdjustedCompensation'.

[108]:
```
#Your code here
import statsmodels.api as sm
from statsmodels.formula.api import ols


F = "FormalEducation"
A = "AdjustedCompensation"
formula = 'AdjustedCompensation ~ C(FormalEducation)'
lm = ols(formula, df).fit()
table = sm.stats.anova_lm(lm, typ=2)
print(table)
```

```
                          sum_sq      df         F    PR(>F)
C(FormalEducation)  6.540294e+17     6.0  0.590714  0.738044
Residual            7.999414e+20  4335.0       NaN       NaN
```

[109]:
```
F = "FormalEducation"
A = "AdjustedCompensation"
temp = df[df["AdjustedCompensation"]<=5*10**5]
formula = 'AdjustedCompensation ~ C(FormalEducation)'
lm = ols(formula, temp).fit()
table = sm.stats.anova_lm(lm, typ=2)
print(table)
```

```
                         sum_sq      df          F        PR(>F)
C(FormalEducation)  5.841881e+11     6.0  29.224224  1.727132e-34
Residual            1.439270e+13  4320.0        NaN           NaN
```

1.7 Additional Resources

Here's the original source where the data was taken from:
Kaggle Machine Learning & Data Science Survey 2017

1.8 Summary

In this lab, you practiced conducting actual hypothesis tests on actual data. From this, you saw how dependent results can be on the initial problem formulation, including preprocessing!