Workshop - Bootstrap

Today we will

1. Show the average unique number of observations when bootstrapping
2. Estimate the standard deviation on the causal effect from a **RANDOMIZED CONTROL TRIAL**

Bootstrap Samples

In one code cell:

- import `numpy` and `numpy.random`
- set the seed to 490
- create *a range* from 0 to 10,000
  - *hint: start with a smaller size to set up the framework*
- create an empty list
- in a 1,000 iteration for loop
  - *hint: start with a smaller size to set up the framework*
  - randomly sample your range your range with replacement with a size equal to the length of your range using `npr.choice()`
  - append your empty list with the length of the the number of unique values from the sampling with replacement
- output the average number of unique values over all bootstrapped samples

In [1]:
```
import numpy as np
import numpy.random as npr
npr.seed(490)

x = np.arange(0, 10000)

n_unique = []
for i in range(1000):
    smpl = npr.choice(x, len(x)) # replace = True is default
```

```
    n_unique.append(len(np.unique(smpl)))

np.mean(n_unique)/len(x)
```

Out[1]: 0.6321646

Is this closer to 1/2, 2/3, or 3/4?

2/3

Randomize Control Trial

In economics, we call experiments with randomly assigned treatment and control groups ***randomized control trials***. In data science, they are called ***A-B testing***.

In this application, we will be using a data set from kaggle. We will be using an LPM to estimate the effect of being in a treament group on clicking *something*. The data is from Audacity, however, there is no information about the experiment specifically. We do not know if this is showing different versions of a website, different versions of an advertisement, or something else entirely.

In [2]:
```
import pandas as pd
from tqdm import tqdm

import statsmodels.api as sm
from sklearn.linear_model import LinearRegression

import matplotlib.pyplot as plt
```

Load in the audacity data as `ab` with `index_col = timestamp`. Print the head.

In [3]:
```
ab = pd.read_csv('homepage_actions.csv', index_col = 'timestamp')
ab.head()
```

Out[3]:

	id	group	action
timestamp			

	id	group	action
timestamp			
2016-09-24 17:42:27.839496	804196	experiment	view
2016-09-24 19:19:03.542569	434745	experiment	view
2016-09-24 19:36:00.944135	507599	experiment	view
2016-09-24 19:59:02.646620	671993	control	view
2016-09-24 20:26:14.466886	536734	experiment	view

Determine the unique values of `group` and `action`

In [4]:
```
print(ab['group'].unique())
print(ab['action'].unique())
```

```
['experiment' 'control']
['view' 'click']
```

Create a dummy variable `treatment` for those in the treatment group. Create a dummy variable `click` for those that clicked.

In [5]:
```
ab['treatment'] = (ab.group == 'experiment')*1
ab['click']     = (ab.action == 'click')*1
```

Create an object `x` that is the model matrix composed of a constant and the `treatment` variable. Create an object `y` that is the `click` variable.

In [6]:
```
x = sm.add_constant(ab.treatment)
y = ab.click
```

In one line, fit a statsmodel OLS and print the summary. Note the estimate and standard error on the `treatment` variable.

In [7]:
```
sm.OLS(y, x).fit().summary2()
```

Out[7]:

Model:	OLS	Adj. R-squared:	0.000
Dependent Variable:	click	AIC:	8991.4917
Date:	2021-03-10 12:26	BIC:	9005.5126
No. Observations:	8188	Log-Likelihood:	-4493.7

Df Model:	1	F-statistic:	3.738
Df Residuals:	8186	Prob (F-statistic):	0.0532
R-squared:	0.000	Scale:	0.17552

	Coef.	Std.Err.	t	P>|t|	[0.025	0.975]
const	0.2186	0.0064	34.0676	0.0000	0.2060	0.2312
treatment	0.0179	0.0093	1.9335	0.0532	-0.0002	0.0361

Omnibus:	1459.439	Durbin-Watson:	2.566
Prob(Omnibus):	0.000	Jarque-Bera (JB):	2342.875
Skew:	1.301	Prob(JB):	0.000
Kurtosis:	2.696	Condition No.:	3

Here we will perform the bootstrap in one code cell.

- set the `npr` seed to 490
- define `n` equal to the number of rows of `ab`
- create an empty list `beta`
- set up a for loop over 2,000 iterations using tqdm
  - use `npr.choice()` to obtain the bootstrap index
  - fit a `LinearRegression()`
    - *hint:* `X` *needs to be a DataFrame, not a Series. Select the* `treatment` *variable using* `ab[['treatment']].iloc[indx]`. `y` *needs to be a Series. Select with only single square brackets.*
  - append the `fit.coef_` to beta
    - *Note: the intercept, which we do not need, is contained seperately in* `fit.intercept_`.

In [8]:
```
npr.seed(490)

n = ab.shape[0]

beta = []
```

```
for i in tqdm(range(2000)):
    indx = npr.choice(range(n), n)
    fit = LinearRegression().fit(ab[['treatment']].iloc[indx], y = ab['click'].iloc[indx])
    # fit.intercept_
    beta.append(fit.coef_)
```

```
100%|██████████| 2000/2000 [00:16<00:00, 121.27it/s]
```

Using one `print()` statment, print the average `beta` with 3 decimal places and the standard deviation of `beta` with 4 decimal places.

In [9]:
```
print((np.mean(beta), np.std(beta)))
```

```
(0.017742494201839362, 0.009154431907603055)
```

Up next, we will produce a histogram. However, we need to perform some preprocessing.

Print the top five observations of `beta` using a slice. Note the format.

In [11]:
```
beta[:5]
```

Out[11]:
```
[array([0.02343743]),
 array([0.02741371]),
 array([0.00896696]),
 array([0.02451603]),
 array([0.0079953])]
```

To convert to a list we can work with

- use `np.concatenate()` on `beta`
- chain the `.flat` attribute
- wrap the whole thing with `list()`
- overwrite `beta`

In [12]:
```
beta = list(np.concatenate(beta).flat)
```

Finally, use `matplotlib` to create a histogram of `beta`.

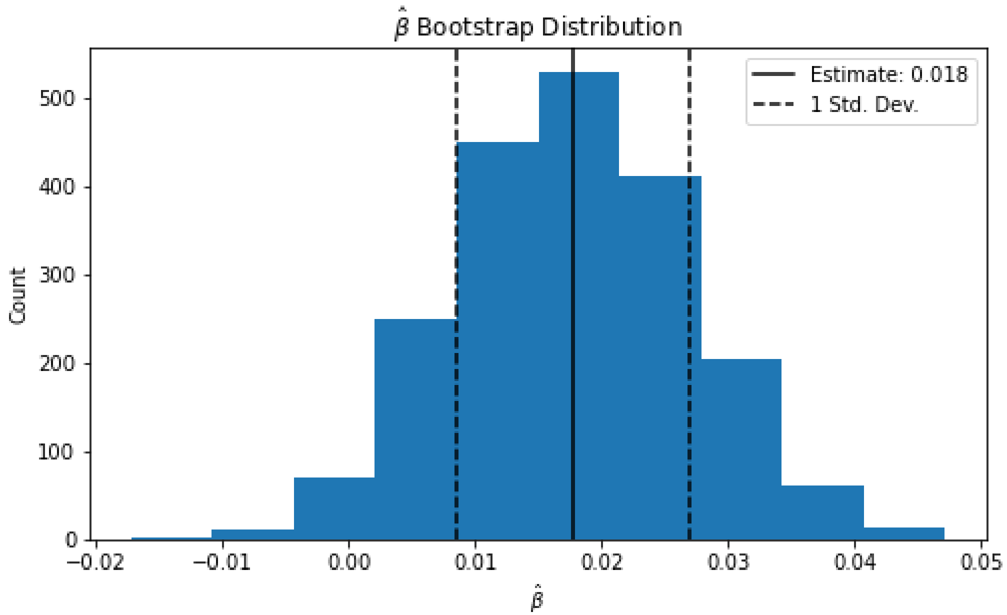
In [13]:
```
plt.figure(figsize = (8, 4.5))

plt.hist(beta)
```

```python
plt.axvline(x = np.mean(beta), ymin = 0, ymax = 525, color = 'black',
            label = 'Estimate: {0:.3f}'.format(np.mean(beta)))
plt.axvline(x = np.mean(beta) - np.std(beta), ymin = 0, ymax = 525, color = 'black', linestyle = 'dashed',
            label = '1 Std. Dev.')
plt.axvline(x = np.mean(beta) + np.std(beta), ymin = 0, ymax = 525, color = 'black', linestyle = 'dashed')

plt.title('$\\hat{\\beta}$ Bootstrap Distribution')
plt.ylabel('Count')
plt.xlabel('$\\hat{\\beta}$')
plt.legend()

plt.show()
```



In [ ]: