

Analyze_ab_test_results_notebook

January 29, 2023

1 Analyze A/B Test Results

This project will assure you have mastered the subjects covered in the statistics lessons. We have organized the current notebook into the following sections:

- Section ??
- Section ??
- Section ??
- Section ??
- Section ??
- Section ??

Specific programming tasks are marked with a **ToDo** tag.

Introduction

A/B tests are very commonly performed by data analysts and data scientists. For this project, you will be working to understand the results of an A/B test run by an e-commerce website. Your goal is to work through this notebook to help the company understand if they should: - Implement the new webpage, - Keep the old webpage, or - Perhaps run the experiment longer to make their decision.

Each **ToDo** task below has an associated quiz present in the classroom. Though the classroom quizzes are **not necessary** to complete the project, they help ensure you are on the right track as you work through the project, and you can feel more confident in your final submission meeting the [rubric](#) specification.

Tip: Though it's not a mandate, students can attempt the classroom quizzes to ensure statistical numeric values are calculated correctly in many cases.

Part I - Probability

To get started, let's import our libraries.

```
In [1]: import pandas as pd
import numpy as np
import random
import matplotlib.pyplot as plt
%matplotlib inline
#We are setting the seed to assure you get the same answers on quizzes as we set up
random.seed(42)
```

1.0.1 ToDo 1.1

Now, read in the `ab_data.csv` data. Store it in `df`. Below is the description of the data, there are a total of 5 columns:

Data columns	Purpose	Valid values
<code>user_id</code>	Unique ID	Int64 values
<code>timestamp</code>	Time stamp when the user visited the webpage	-
<code>group</code>	In the current A/B experiment, the users are categorized into two broad groups. The control group users are expected to be served with old_page; and treatment group users are matched with the new_page. However, some inaccurate rows are present in the initial data, such as a control group user is matched with a new_page.	['control', 'treatment']
<code>landing_page</code>	It denotes whether the user visited the old or new webpage.	['old_page', 'new_page']
<code>converted</code>	It denotes whether the user decided to pay for the company's product. Here, 1 means yes, the user bought the product.	[0, 1]

Use your dataframe to answer the questions in Quiz 1 of the classroom.

Tip: Please save your work regularly.

a. Read in the dataset from the `ab_data.csv` file and take a look at the top few rows here:

```
In [2]: #read in dataset
df = pd.read_csv('./ab_data.csv')
df.head()

Out[2]:
```

	user_id	timestamp	group	landing_page	converted
0	851104	2017-01-21 22:11:48.556739	control	old_page	0
1	804228	2017-01-12 08:01:45.159739	control	old_page	0
2	661590	2017-01-11 16:55:06.154213	treatment	new_page	0
3	853541	2017-01-08 18:28:03.143765	treatment	new_page	0
4	864975	2017-01-21 01:52:26.210827	control	old_page	1

b. Use the cell below to find the number of rows in the dataset.

```
In [3]: df.shape

Out[3]: (294478, 5)
```

c. The number of unique users in the dataset.

```
In [4]: df.user_id.nunique()

Out[4]: 290584
```

d. The proportion of users converted.

```
In [5]: df.converted.mean()

Out[5]: 0.11965919355605512
```

e. The number of times when the "group" is treatment but "landing_page" is not a new_page.

f. Do any of the rows have missing values?

```
In [6]: df.query(("group=='treatment' and landing_page != 'new_page'")).count()+df.query(("group!

Out[6]:
```

	user_id	timestamp	group	landing_page	converted
	3893	3893	3893	3893	3893

```
dtype: int64

In [7]: df[df.isnull().any(axis=1)]

Out[7]: Empty DataFrame
Columns: [user_id, timestamp, group, landing_page, converted]
Index: []
```

```
In [ ]:
```

1.0.2 ToDo 1.2

In a particular row, the **group** and **landing_page** columns should have either of the following acceptable values:

user_id	timestamp	group	landing_page	converted
XXXX	XXXX	control	old_page	X
XXXX	XXXX	treatment	new_page	X

It means, the control group users should match with old_page; and treatment group users should be matched with the new_page.

However, for the rows where treatment does not match with new_page or control does not match with old_page, we cannot be sure if such rows truly received the new or old webpage.

Use **Quiz 2** in the classroom to figure out how should we handle the rows where the group and landing_page columns don't match?

a. Now use the answer to the quiz to create a new dataset that meets the specifications from the quiz. Store your new dataframe in **df2**.

```
In [8]: # Remove the inaccurate rows, and store the result in a new dataframe df2
df2=df.query("group!='treatment' or landing_page =='new_page'")
df2.shape
```

```
Out[8]: (292513, 5)
```

```
In [9]: df2=df2.query("group=='treatment' or landing_page !='new_page'")
df2.shape
```

```
Out[9]: (290585, 5)
```

```
In [10]: # Double Check all of the incorrect rows were removed from df2 -
# Output of the statement below should be 0
df2[((df2['group'] == 'treatment') == (df2['landing_page'] == 'new_page')) == False].shape
```

```
Out[10]: 0
```

1.0.3 ToDo 1.3

Use **df2** and the cells below to answer questions for **Quiz 3** in the classroom.

a. How many unique **user_ids** are in **df2**?

```
In [11]: df2.user_id.nunique()
```

```
Out[11]: 290584
```

b. There is one **user_id** repeated in **df2**. What is it?

```
In [12]: df2[df2.user_id.duplicated()]
```

```
Out[12]:
```

	user_id	timestamp	group	landing_page	converted
2893	773192	2017-01-14 02:55:59.590927	treatment	new_page	0

c. Display the rows for the duplicate **user_id**?

```
In [13]: df2.query("user_id=='773192'")
```

```
Out[13]:
```

	user_id	timestamp	group	landing_page	converted
1899	773192	2017-01-09 05:37:58.781806	treatment	new_page	0
2893	773192	2017-01-14 02:55:59.590927	treatment	new_page	0

d. Remove **one** of the rows with a duplicate **user_id**, from the **df2** dataframe.

```
In [14]: # Remove one of the rows with a duplicate user_id..
# Hint: The dataframe.drop_duplicates() may not work in this case because the rows with
df2.drop(index = 2893, inplace = True)
# Check again if the row with a duplicate user_id is deleted or not
df2.query("user_id=='773192'")
```

```
Out[14]:
```

	user_id	timestamp	group	landing_page	converted
1899	773192	2017-01-09 05:37:58.781806	treatment	new_page	0

1.0.4 ToDo 1.4

Use **df2** in the cells below to answer the quiz questions related to **Quiz 4** in the classroom.

a. What is the probability of an individual converting regardless of the page they receive?

Tip: The probability you'll compute represents the overall "converted" success rate in the population and you may call it $p_{population}$.

```
In [15]: df2.converted.mean()
```

```
Out[15]: 0.11959708724499628
```

b. Given that an individual was in the control group, what is the probability they converted?

```
In [16]: df2.query("group=='control']").converted.mean()
```

```
Out[16]: 0.1203863045004612
```

c. Given that an individual was in the treatment group, what is the probability they converted?

```
In [17]: df2.query("group=='treatment']").converted.mean()
```

```
Out[17]: 0.11880806551510564
```

Tip: The probabilities you've computed in the points (b). and (c). above can also be treated as conversion rate. Calculate the actual difference (**obs_diff**) between the conversion rates for the two groups. You will need that later.

```
In [18]: # Calculate the actual difference (obs_diff) between the conversion rates for the two g
obs_diff = df2.query("group=='treatment']").converted.mean()-df2.query("group=='control'
obs_diff
```

```
Out[18]: -0.0015782389853555567
```

d. What is the probability that an individual received the new page?

```
In [19]: (df2["landing_page"]=="new_page").mean()
```

```
Out[19]: 0.50006194422266881
```

e. Consider your results from parts (a) through (d) above, and explain below whether the new treatment group users lead to more conversions.

Your answer goes here. as we see the probability they converted in the control group is more than treatment group by a very small value % 0.16 so we do not expect to reject H_0 as we treatment 50% of all dataset

Part II - A/B Test

Since a timestamp is associated with each event, you could run a hypothesis test continuously as long as you observe the events.

However, then the hard questions would be: - Do you stop as soon as one page is considered significantly better than another or does it need to happen consistently for a certain amount of time?

- How long do you run to render a decision that neither page is better than another?

These questions are the difficult parts associated with A/B tests in general.

1.0.5 ToDo 2.1

For now, consider you need to make the decision just based on all the data provided.

Recall that you just calculated that the "converted" probability (or rate) for the old page is *slightly* higher than that of the new page (ToDo 1.4.c).

If you want to assume that the old page is better unless the new page proves to be definitely better at a Type I error rate of 5%, what should be your null and alternative hypotheses (H_0 and H_1)?

You can state your hypothesis in terms of words or in terms of p_{old} and p_{new} , which are the "converted" probability (or rate) for the old and new pages respectively.

$$H_0 : p_{new} - p_{old} \leq 0$$

$$H_1 : p_{new} - p_{old} > 0$$

1.0.6 ToDo 2.2 - Null Hypothesis H_0 Testing

Under the null hypothesis H_0 , assume that p_{new} and p_{old} are equal. Furthermore, assume that p_{new} and p_{old} both are equal to the **converted** success rate in the df2 data regardless of the page. So, our assumption is:

$$p_{new} = p_{old} = p_{population}$$

In this section, you will:

- Simulate (bootstrap) sample data set for both groups, and compute the "converted" probability p for those samples.
- Use a sample size for each group equal to the ones in the df2 data.

- Compute the difference in the "converted" probability for the two samples above.
- Perform the sampling distribution for the "difference in the converted probability" between the two simulated-samples over 10,000 iterations; and calculate an estimate.

Use the cells below to provide the necessary parts of this simulation. You can use **Quiz 5** in the classroom to make sure you are on the right track.

a. What is the **conversion rate** for p_{new} under the null hypothesis?

```
In [20]: p_new = df2.converted.mean()
         p_new
```

```
Out[20]: 0.11959708724499628
```

b. What is the **conversion rate** for p_{old} under the null hypothesis?

```
In [21]: p_old = df2.converted.mean()
         p_old
```

```
Out[21]: 0.11959708724499628
```

c. What is n_{new} , the number of individuals in the treatment group? *Hint:* The treatment group users are shown the new page.

```
In [22]: n_new = df2.query("group == 'treatment' ").user_id.count()
         n_new
```

```
Out[22]: 145310
```

d. What is n_{old} , the number of individuals in the control group?

```
In [23]: n_old = df2.query("group == 'control' ").user_id.count()
         n_old
```

```
Out[23]: 145274
```

e. **Simulate Sample for the treatment Group** Simulate n_{new} transactions with a conversion rate of p_{new} under the null hypothesis. *Hint:* Use `numpy.random.choice()` method to randomly generate n_{new} number of values. Store these n_{new} 1's and 0's in the `new_page_converted` numpy array.

```
In [24]: # Simulate a Sample for the treatment Group
         new_page_converted = np.random.choice([0, 1], size=n_new, p=[1-p_new, p_new])
         new_page_converted.mean()
```

```
Out[24]: 0.12032207005711926
```

f. **Simulate Sample for the control Group** Simulate n_{old} transactions with a conversion rate of p_{old} under the null hypothesis. Store these n_{old} 1's and 0's in the `old_page_converted` numpy array.

```
In [25]: # Simulate a Sample for the control Group
old_page_converted = np.random.choice([0, 1], size=n_old, p=[1-p_old, p_old])
old_page_converted.mean()
```

```
Out[25]: 0.1201660310860856
```

g. Find the difference in the "converted" probability ($p'_{new} - p'_{old}$) for your simulated samples from the parts (e) and (f) above.

```
In [26]: new_page_converted.mean() - old_page_converted.mean()
```

```
Out[26]: 0.0001560389710336535
```

h. Sampling distribution Re-create `new_page_converted` and `old_page_converted` and find the ($p'_{new} - p'_{old}$) value 10,000 times using the same simulation process you used in parts (a) through (g) above.

Store all ($p'_{new} - p'_{old}$) values in a NumPy array called `p_diffs`.

```
In [27]: # Sampling distribution
p_diffs = []
for _ in range(10000):
    new_page_converted = np.random.choice([0, 1], size=n_new, p=[1-p_new, p_new])
    old_page_converted = np.random.choice([0, 1], size=n_old, p=[1-p_old, p_old])
    p_diffs.append(new_page_converted.mean() - old_page_converted.mean())
```

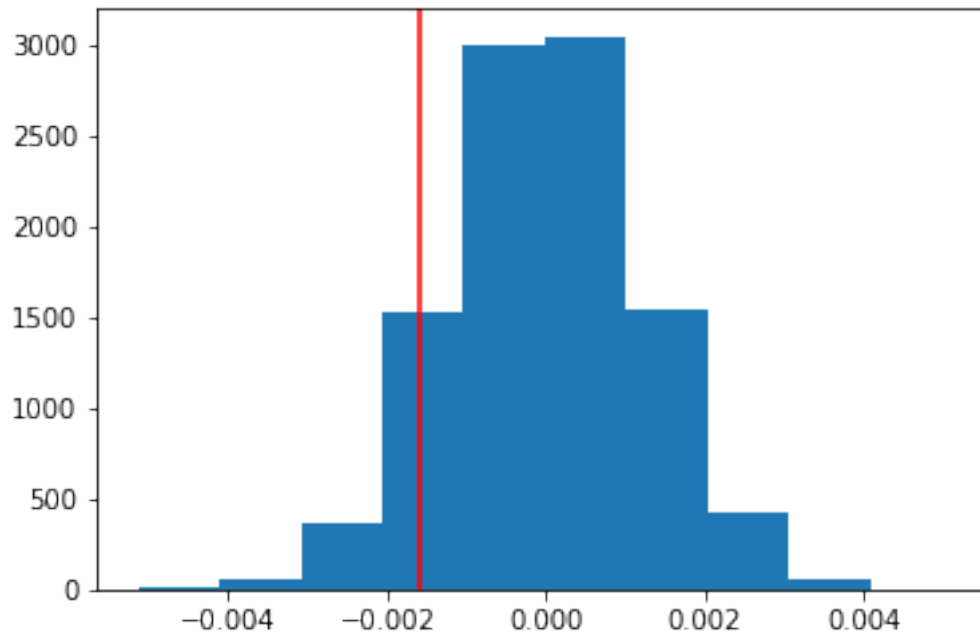
i. Histogram Plot a histogram of the `p_diffs`. Does this plot look like what you expected? Use the matching problem in the classroom to assure you fully understand what was computed here.

Also, use `plt.axvline()` method to mark the actual difference observed in the `df2` data (recall `obs_diff`), in the chart.

Tip: Display title, x-label, and y-label in the chart.

```
In [28]: plt.hist(p_diffs)
plt.axvline(obs_diff, c='red')
```

```
Out[28]: <matplotlib.lines.Line2D at 0x7f93729e8a20>
```

j. What proportion of the **p_diffs** are greater than the actual difference observed in the df2 data?

```
In [29]: (p_diffs>obs_diff).mean()
```

```
Out[29]: 0.90439999999999998
```

```
In [ ]:
```

k. Please explain in words what you have just computed in part j above.

- What is this value called in scientific studies?
- What does this value signify in terms of whether or not there is a difference between the new and old pages? *Hint*: Compare the value above with the "Type I error rate (0.05)".

as

$$H_1 : p_{new} - p_{old} > 0$$

we compute the P-Value as the proportion of the p_diffs are greater than the actual difference observed as to get %90.4 which is very high compared to 0.05 so we fail to reject the null hypothesis H_0

l. Using Built-in Methods for Hypothesis Testing We could also use a built-in to achieve similar results. Though using the built-in might be easier to code, the above portions are a walk-through of the ideas that are critical to correctly thinking about statistical significance.

Fill in the statements below to calculate the: - convert_old: number of conversions with the old_page - convert_new: number of conversions with the new_page - n_old: number of individuals who were shown the old_page - n_new: number of individuals who were shown the new_page

```
In [30]: import statsmodels.api as sm
```

```

# number of conversions with the old_page
convert_old = df2.query("(group == 'control') and (converted == True)").user_id.count()

# number of conversions with the new_page
convert_new = df2.query("(group == 'treatment') and (converted == True)").user_id.count()

# number of individuals who were shown the old_page
n_old = df2.query("group == 'control']").user_id.count()

# number of individuals who received new_page
n_new = df2.query("group == 'treatment']").user_id.count()

convert_old, convert_new, n_old, n_new

```

```

/opt/conda/lib/python3.6/site-packages/statsmodels/compat/pandas.py:56: FutureWarning: The pandas
from pandas.core import datetools

```

Out[30]: (17489, 17264, 145274, 145310)

m. Now use `sm.stats.proportions_ztest()` to compute your test statistic and p-value. [Here](#) is a helpful link on using the built in.

The syntax is:

```
proportions_ztest(count_array, nobs_array, alternative='larger')
```

where, - `count_array` = represents the number of "converted" for each group - `nobs_array` = represents the total number of observations (rows) in each group - `alternative` = choose one of the values from `[two-sided, smaller, larger]` depending upon two-tailed, left-tailed, or right-tailed respectively. **>Hint:** It's a two-tailed if you defined H_1 as $(p_{new} = p_{old})$. It's a left-tailed if you defined H_1 as $(p_{new} < p_{old})$. It's a right-tailed if you defined H_1 as $(p_{new} > p_{old})$.

The built-in function above will return the `z_score`, `p_value`.

Tip: You don't have to dive deeper into z-test for this exercise. **Try having an overview of what does z-score signify in general.**

```

In [31]: import statsmodels.api as sm
# ToDo: Complete the sm.stats.proportions_ztest() method arguments
z_score, p_value = sm.stats.proportions_ztest([convert_new, convert_old], [n_new, n_old], a
print(z_score, p_value)

```

```
-1.31092419842 0.905058312759
```

n. What do the z-score and p-value you computed in the previous question mean for the conversion rates of the old and new pages? Do they agree with the findings in parts **j.** and **k.**?

Tip: Notice whether the p-value is similar to the one computed earlier. Accordingly, can you reject/fail to reject the null hypothesis? It is important to correctly interpret the test statistic and p-value.

p-value = 0.905058312759 is near what we get in part j 0.9025999999999996 which is very high compared to 0.05 so we fail to reject the null hypothesis H_0

Part III - A regression approach

1.0.7 ToDo 3.1

In this final part, you will see that the result you achieved in the A/B test in Part II above can also be achieved by performing regression.

a. Since each row in the df2 data is either a conversion or no conversion, what type of regression should you be performing in this case?

Logistic Regression.

b. The goal is to use **statsmodels** library to fit the regression model you specified in part a. above to see if there is a significant difference in conversion based on the page-type a customer receives. However, you first need to create the following two columns in the df2 dataframe: 1. intercept - It should be 1 in the entire column. 2. ab_page - It's a dummy variable column, having a value 1 when an individual receives the **treatment**, otherwise 0.

```
In [32]: df2['intercept']= 1
```

```
In [33]: df2['ab_page'] = (df2['group'] == 'treatment').astype(int)
df2.head()
```

```
Out[33]:
```

	user_id	timestamp	group	landing_page	converted
0	851104	2017-01-21 22:11:48.556739	control	old_page	0
1	804228	2017-01-12 08:01:45.159739	control	old_page	0
2	661590	2017-01-11 16:55:06.154213	treatment	new_page	0
3	853541	2017-01-08 18:28:03.143765	treatment	new_page	0
4	864975	2017-01-21 01:52:26.210827	control	old_page	1

	intercept	ab_page
0	1	0
1	1	0
2	1	1
3	1	1
4	1	0

c. Use **statsmodels** to instantiate your regression model on the two columns you created in part (b). above, then fit the model to predict whether or not an individual converts.

```
In [34]: logit_mod = sm.Logit(df2['converted'],df2[['intercept', 'ab_page']])
```

d. Provide the summary of your model below, and use it as necessary to answer the following questions.

```
In [35]: #fit the model
results = logit_mod.fit()
```

```
Optimization terminated successfully.
Current function value: 0.366118
Iterations 6
```

```
In [36]: #get summary statistics
results.summary2()
```

```
Out[36]: <class 'statsmodels.iolib.summary2.Summary'>
"""
                                Results: Logit
=====
Model:                        Logit                No. Iterations:    6.0000
Dependent Variable: converted      Pseudo R-squared: 0.000
Date:      2022-10-20 11:12  AIC:                        212780.3502
No. Observations:  290584      BIC:                        212801.5095
Df Model:          1           Log-Likelihood:    -1.0639e+05
Df Residuals:      290582      LL-Null:          -1.0639e+05
Converged:         1.0000      Scale:          1.0000
-----
                                Coef.   Std.Err.    z      P>|z|    [0.025   0.975]
-----
intercept    -1.9888     0.0081   -246.6690  0.0000   -2.0046   -1.9730
ab_page      -0.0150     0.0114   -1.3109   0.1899   -0.0374    0.0074
=====
"""
```

```
In [37]: np.exp(results.params)
```

```
Out[37]: intercept    0.136863
ab_page    0.985123
dtype: float64
```

```
In [38]: 1 / np.exp(results.params)
```

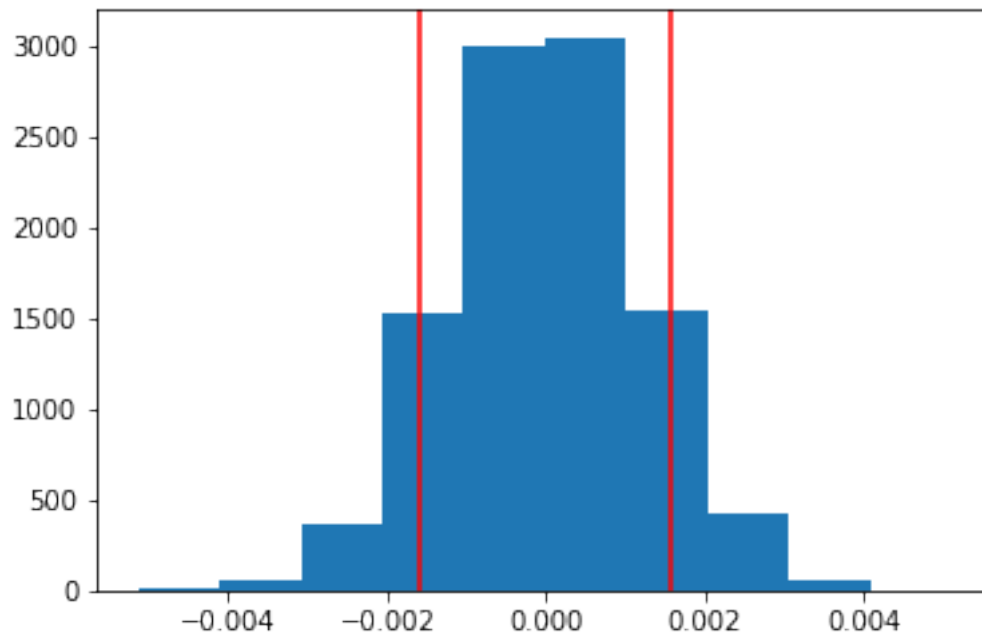
```
Out[38]: intercept    7.306593
ab_page    1.015102
dtype: float64
```

e. What is the p-value associated with **ab_page**? Why does it differ from the value you found in **Part II**?

Hints: - What are the null and alternative hypotheses associated with your regression model, and how do they compare to the null and alternative hypotheses in **Part II**? - You may comment on if these hypothesis (Part II vs. Part III) are one-sided or two-sided. - You may also compare the current p-value with the Type I error rate (0.05).

```
In [39]: plt.hist(p_diffs)
plt.axvline(obs_diff,c='red')
plt.axvline(-obs_diff,c='red')
```

Out[39]: <matplotlib.lines.Line2D at 0x7f936b3e8748>



-the null and alternative hypotheses in **Part II**? was one-sided (right side) ≈ 0.905 so the left area $\approx (1 - 0.905) \approx 0.095$ -but the hypotheses associated with your regression model are **if there is a relationship between ab_page and converted**

$$H_0 : p_{new} - p_{old} = 0$$

$$H_1 : p_{new} - p_{old} \neq 0$$

- which is two-sides so p-value is $(.095 * 2) \approx .19$ (in the table the p-value associated with ab_page is 0.1899) which is very high compared to 0.05 so we fail to reject the null hypothesis H_0

f. Now, you are considering other things that might influence whether or not an individual converts. Discuss why it is a good idea to consider other factors to add into your regression model. Are there any disadvantages to adding additional terms into your regression model?

we need more segmentation to the market may be the age ,gender, the countries influence on sales

g. Adding countries Now along with testing if the conversion rate changes for different pages, also add an effect based on which country a user lives in.

1. You will need to read in the **countries.csv** dataset and merge together your df2 datasets on the appropriate rows. You call the resulting dataframe df_merged. [Here](#) are the docs for joining tables.
2. Does it appear that country had an impact on conversion? To answer this question, consider the three unique values, ['UK', 'US', 'CA'], in the country column. Create dummy variables for these country columns. **>Hint:** Use `pandas.get_dummies()` to create dummy variables. **You will utilize two columns for the three dummy variables.**

Provide the statistical output as well as a written response to answer this question.

```
In [40]: # Read the countries.csv
df_countries = pd.read_csv('./countries.csv')

In [41]: # Join with the df2 dataframe
df_merged = df2.set_index('user_id').join(df_countries.set_index('user_id'))
df_merged.head()
```

```
Out[41]:
```

	timestamp	group	landing_page	converted	\
user_id					
851104	2017-01-21 22:11:48.556739	control	old_page	0	
804228	2017-01-12 08:01:45.159739	control	old_page	0	
661590	2017-01-11 16:55:06.154213	treatment	new_page	0	
853541	2017-01-08 18:28:03.143765	treatment	new_page	0	
864975	2017-01-21 01:52:26.210827	control	old_page	1	

	intercept	ab_page	country
user_id			
851104	1	0	US
804228	1	0	US
661590	1	1	US
853541	1	1	US
864975	1	0	US

```
In [42]: # Create the necessary dummy variables
df_merged[['CA', 'UK', 'US']] = pd.get_dummies(df_merged['country'])
df_merged.head()
```

```
Out[42]:
```

	timestamp	group	landing_page	converted	\
user_id					
851104	2017-01-21 22:11:48.556739	control	old_page	0	
804228	2017-01-12 08:01:45.159739	control	old_page	0	
661590	2017-01-11 16:55:06.154213	treatment	new_page	0	
853541	2017-01-08 18:28:03.143765	treatment	new_page	0	
864975	2017-01-21 01:52:26.210827	control	old_page	1	

	intercept	ab_page	country	CA	UK	US
user_id						
851104	1	0	US	0	0	1
804228	1	0	US	0	0	1
661590	1	1	US	0	0	1
853541	1	1	US	0	0	1
864975	1	0	US	0	0	1

```
In [47]: # Fit your model, and summarize the results
logit_mod = sm.Logit(df_merged['converted'], df_merged[['intercept', 'CA', 'UK']])
#fit the model
results = logit_mod.fit()
```

```
#get summary statistics
results.summary2()
```

Optimization terminated successfully.
Current function value: 0.366116
Iterations 6

```
Out[47]: <class 'statsmodels.iolib.summary2.Summary'>
"""
```

```

Results: Logit
=====
Model:                Logit                No. Iterations:    6.0000
Dependent Variable: converted                Pseudo R-squared: 0.000
Date:                2022-10-20 11:56 AIC:                212780.8333
No. Observations:    290584                BIC:                212812.5723
Df Model:            2                    Log-Likelihood:    -1.0639e+05
Df Residuals:        290581                LL-Null:            -1.0639e+05
Converged:            1.0000                Scale:            1.0000
-----
              Coef.   Std.Err.    z      P>|z|    [0.025   0.975]
-----
intercept    -1.9967    0.0068  -292.3145  0.0000   -2.0101   -1.9833
CA            -0.0408    0.0269   -1.5178  0.1291   -0.0935    0.0119
UK             0.0099    0.0133    0.7458  0.4558   -0.0161    0.0360
=====
"""
```

country is not statistically significant

h. Fit your model and obtain the results Though you have now looked at the individual factors of country and page on conversion, we would now like to look at an interaction between page and country to see if are there significant effects on conversion. **Create the necessary additional columns, and fit the new model.**

Provide the summary results (statistical output), and your conclusions (written response) based on the results.

Tip: Conclusions should include both statistical reasoning, and practical reasoning for the situation.

Hints: - Look at all of p-values in the summary, and compare against the Type I error rate (0.05). - Can you reject/fail to reject the null hypotheses (regression model)? - Comment on the effect of page and country to predict the conversion.

```
In [60]: # Create the necessary dummy variables
df_merged['CA_ab_page'] = df_merged['CA']*df_merged['ab_page']
df_merged['UK_ab_page'] = df_merged['UK']*df_merged['ab_page']
df_merged['US_ab_page'] = df_merged['US']*df_merged['ab_page']
df_merged.head(10)
```

```
Out[60]:
```

	timestamp	group	landing_page	converted	\
user_id					
851104	2017-01-21 22:11:48.556739	control	old_page	0	
804228	2017-01-12 08:01:45.159739	control	old_page	0	
661590	2017-01-11 16:55:06.154213	treatment	new_page	0	
853541	2017-01-08 18:28:03.143765	treatment	new_page	0	
864975	2017-01-21 01:52:26.210827	control	old_page	1	
936923	2017-01-10 15:20:49.083499	control	old_page	0	
679687	2017-01-19 03:26:46.940749	treatment	new_page	1	
719014	2017-01-17 01:48:29.539573	control	old_page	0	
817355	2017-01-04 17:58:08.979471	treatment	new_page	1	
839785	2017-01-15 18:11:06.610965	treatment	new_page	1	

	intercept	ab_page	country	CA	UK	US	CA_ab_page	UK_ab_page	\
user_id									
851104	1	0	US	0	0	1	0	0	
804228	1	0	US	0	0	1	0	0	
661590	1	1	US	0	0	1	0	0	
853541	1	1	US	0	0	1	0	0	
864975	1	0	US	0	0	1	0	0	
936923	1	0	US	0	0	1	0	0	
679687	1	1	CA	1	0	0	1	0	
719014	1	0	US	0	0	1	0	0	
817355	1	1	UK	0	1	0	0	1	
839785	1	1	CA	1	0	0	1	0	

	US_ab_page
user_id	
851104	0
804228	0
661590	1
853541	1
864975	0
936923	0
679687	0
719014	0
817355	0
839785	0

```
In [64]: # Fit your model, and summarize the results
logit_mod = sm.Logit(df_merged['converted'],df_merged[['intercept' , 'CA_ab_page', 'US_ab_
#fit the model
results = logit_mod.fit()
#get summary statistics
results.summary2()
```

Optimization terminated successfully.
Current function value: 0.366109

Iterations 6

```
Out[64]: <class 'statsmodels.iolib.summary2.Summary'>
"""
                        Results: Logit
=====
Model:                  Logit                  No. Iterations:    6.0000
Dependent Variable: converted                Pseudo R-squared: 0.000
Date:                  2022-10-20 12:18 AIC:                  212777.1060
No. Observations:    290584                  BIC:                  212808.8450
Df Model:              2                    Log-Likelihood:    -1.0639e+05
Df Residuals:         290581                LL-Null:           -1.0639e+05
Converged:             1.0000                Scale:            1.0000
-----
                        Coef.   Std.Err.   z      P>|z|   [0.025   0.975]
-----
intercept            -1.9873    0.0072  -275.5728  0.0000   -2.0014   -1.9732
CA_ab_page           -0.0842    0.0378   -2.2251  0.0261   -0.1583   -0.0100
US_ab_page           -0.0197    0.0121   -1.6337  0.1023   -0.0434    0.0039
=====
"""
```

```
In [65]: np.exp(results.params)
```

```
Out[65]: intercept      0.137065
CA_ab_page      0.919292
US_ab_page      0.980455
dtype: float64
```

```
In [66]: 1/np.exp(results.params)
```

```
Out[66]: intercept      7.295829
CA_ab_page      1.087793
US_ab_page      1.019935
dtype: float64
```

statistical reasoning : we get statistically significant with the interaction between page and country at CA_ab_page but we have a very little effect 1.087 practical reasoning: we should not change to the new page as effect is small and at one country even if we change this country server it will cost more in future upgrade

Final Check!

Congratulations! You have reached the end of the A/B Test Results project! You should be very proud of all you have accomplished!

Tip: Once you are satisfied with your work here, check over your notebook to make sure that it satisfies all the specifications mentioned in the rubric. You should also probably remove all of the "Hints" and "Tips" like this one so that the presentation is as polished as possible.

Submission You may either submit your notebook through the "SUBMIT PROJECT" button at the bottom of this workspace, or you may work from your local machine and submit on the last page of this project lesson.

1. Before you submit your project, you need to create a .html or .pdf version of this notebook in the workspace here. To do that, run the code cell below. If it worked correctly, you should get a return code of 0, and you should see the generated .html file in the workspace directory (click on the orange Jupyter icon in the upper left).
2. Alternatively, you can download this report as .html via the **File > Download as** submenu, and then manually upload it into the workspace directory by clicking on the orange Jupyter icon in the upper left, then using the Upload button.
3. Once you've done this, you can submit your project by clicking on the "Submit Project" button in the lower right here. This will create and submit a zip file with this .ipynb doc and the .html or .pdf version you created. Congratulations!

```
In [44]: from subprocess import call
         call(['python', '-m', 'nbconvert', 'Analyze_ab_test_results_notebook.ipynb'])
```

```
Out[44]: 0
```