A/B Test - Translation

A France-based users company have a much higher conversion rate in Franch then in any other Frenchspeaking country. The solution was to have one translation written by a local, aiming to improve the conversion rate However, based on the test the localized translation was doing worse!

The structure of this notebook is as follows:

1. Load Dataset
2. Exploratory Data Analysis
3. Two-sample Z-test on entire dataset
4. Conversion rate by variables
5. Conversion rate by country

In [176]:
```
import  warnings
#warnings.simplefilter('ignore')

import numpy as np
import pandas as pd
import seaborn as sns
import matplotlib.pyplot as plt
from scipy.stats import ttest_ind

%matplotlib inline
```

Load Dataset

In [177]:
```
test = pd.read_csv('test_table.csv', parse_dates=['date'])
test.head()
```

Out[177]:

	user_id	date	source	device	browser_language	ads_channel	browser	conversion	test
0	315281	2015-12-03	Direct	Web	FR	NaN	IE	1	0
1	497851	2015-12-04	Ads	Web	FR	Google	IE	0	1
2	848402	2015-12-04	Ads	Web	FR	Facebook	Chrome	0	0
3	290051	2015-12-03	Ads	Mobile	Other	Facebook	Android_App	0	1
4	548435	2015-11-30	Ads	Web	FR	Google	FireFox	0	1

In [179]:
```
user = pd.read_csv('user_table.csv')
user.head()
```

Out[179]:

	user_id	sex	age	country
0	765821	M	20	Democratic Republic of the Congo
1	343561	F	27	Luxembourg
2	118744	M	23	Canada
3	987753	F	27	Switzerland
4	554597	F	20	France

In [180]:
```
# Merge two tables
data = pd.merge(left=test, right=user, how='left', on='user_id')
data.head()
```

Out[180]:

	user_id	date	source	device	browser_language	ads_channel	browser	conversion	test	sex	age	c
0	315281	2015-12-03	Direct	Web	FR	NaN	IE	1	0	M	32.0	Fran
1	497851	2015-12-04	Ads	Web	FR	Google	IE	0	1	M	21.0	Dem Repu the (
2	848402	2015-12-04	Ads	Web	FR	Facebook	Chrome	0	0	M	34.0	Fran
3	290051	2015-12-03	Ads	Mobile	Other	Facebook	Android_App	0	1	F	22.0	Dem Repu the (
4	548435	2015-11-30	Ads	Web	FR	Google	FireFox	0	1	M	19.0	Dem Repu the (

Exploratory Data Analysis

In [181]:
```
test.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 453321 entries, 0 to 453320
Data columns (total 9 columns):
user_id             453321 non-null int64
date                453321 non-null datetime64[ns]
source              453321 non-null object
device              453321 non-null object
browser_language    453321 non-null object
ads_channel         181877 non-null object
browser             453321 non-null object
conversion          453321 non-null int64
test                453321 non-null int64
dtypes: datetime64[ns](1), int64(3), object(5)
memory usage: 31.1+ MB
```

In [182]:
```
test.describe()
```

Out[182]:

	user_id	conversion	test
count	453321.000000	453321.000000	453321.000000
mean	499937.514728	0.049579	0.476446
std	288665.193436	0.217073	0.499445
min	1.000000	0.000000	0.000000
25%	249816.000000	0.000000	0.000000
50%	500019.000000	0.000000	0.000000
75%	749522.000000	0.000000	1.000000
max	1000000.000000	1.000000	1.000000

In [183]:
```
user.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 452867 entries, 0 to 452866
Data columns (total 4 columns):
user_id    452867 non-null int64
sex        452867 non-null object
age        452867 non-null int64
country    452867 non-null object
dtypes: int64(2), object(2)
memory usage: 13.8+ MB
```

In [184]:
```
user.describe()
```

Out[184]:

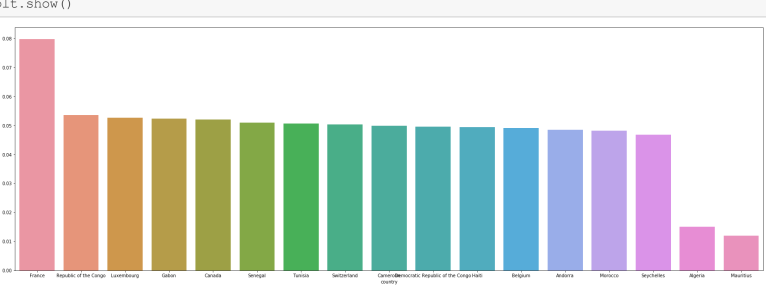
	user_id	age
count	452867.000000	452867.000000
mean	499944.805166	27.130740
std	288676.264784	6.776678
min	1.000000	18.000000
25%	249819.000000	22.000000
50%	500019.000000	26.000000
75%	749543.000000	31.000000
max	1000000.000000	70.000000

In [185]:
```
data.info()
```

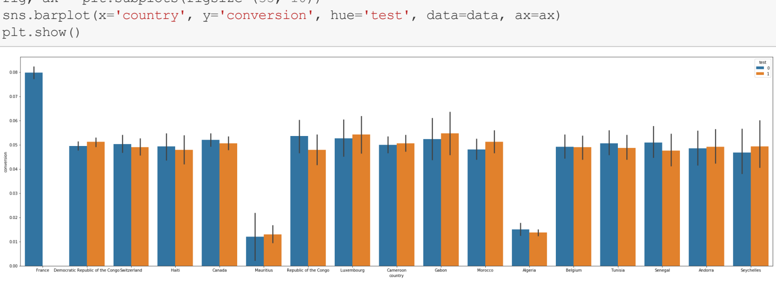
```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 453321 entries, 0 to 453320
Data columns (total 12 columns):
user_id             453321 non-null int64
date                453321 non-null datetime64[ns]
source              453321 non-null object
device              453321 non-null object
browser_language    453321 non-null object
ads_channel         181877 non-null object
browser             453321 non-null object
conversion          453321 non-null int64
test                453321 non-null int64
sex                 452867 non-null object
age                 452867 non-null float64
country             452867 non-null object
dtypes: datetime64[ns](1), float64(1), int64(3), object(7)
memory usage: 45.0+ MB
```

In [186]:
```
# First check that france converts much better than the rest of LatAm countries
groupby_country = data[data['test'] == 0][['conversion', 'country']].groupby('country').mean()
groupby_country = groupby_country.reset_index()
groupby_country = groupby_country.sort_values('conversion', ascending=False)

# Visualization
fig, ax = plt.subplots(figsize=(30,10))
sns.barplot(x='country', y='conversion', data=groupby_country, ax=ax)
plt.show()
```



In [187]:
```
# Visualization
fig, ax = plt.subplots(figsize=(35, 10))
sns.barplot(x='country', y='conversion', hue='test', data=data, ax=ax)
plt.show()
```



Eventually, let's remove France and samples that have missing country values from the dataset because:

Nothing has changed for France Number of missing values is small, so they won't affect statistical tests much

In [188]:
```
data = data[(data.country != 'France') & (data.country != 'missing')]
data.shape
```

Out[188]: (401539, 12)

Two-sample Z-test on entire dataset

When testing whether the conversion rate is statistically different between the experiment and the control groups, we usually apply a two-sample proportion test. Options include Chi-square test, Z-test, etc. When the sample size is large, these tests lead to the same statistical result, i.e. P-value. I chose to use Z-test here because our sample size is sufficiently large.

The team's assumption is:

H0: Conversion rate_experiment group = Conversion rate_control group

H1: Conversion rate_experiment group < Conversion rate_control group

First, let's subset the data into an experiment group and a control group

In [189]:
```
experiment_group = data[(data.test == 1)]
control_group = data[(data.test == 0)]
```

We can see from below that initial comparison of the conversion rates between the experiment and the control groups indicates that the non-localized translation was doing better.

In [190]:
```
control_group.conversion.mean()
```

Out[190]: 0.04833042316066309

In [191]:
```
experiment_group.conversion.mean()
```

Out[191]: 0.043424713982118966

In [192]:
```
import statsmodels.api as sm
def two_sample_z_test(df, alternative='two-sided'):
    """
    This function returns the P-value from a two-sample Z-test
    """
    test_df = df[df.test == 1]
    control_df = df[df.test == 0]

    test_convert = test_df.conversion.sum()
    control_convert = control_df.conversion.sum()

    test_n = len(test_df.conversion)
    control_n = len(control_df.conversion)
    z, p_value = sm.stats.proportions_ztest([test_convert, control_convert],
                                            [test_n, control_n],
                                           alternative=alternative)
    return(z, p_value)

z, pvalue = two_sample_z_test(data, alternative='smaller')
print('Z-score is: {}'.format(z))
print('P-value is: {}'.format(pvalue))
```

```
Z-score is: -7.422021422012666
P-value is: 5.767307540762427e-14
```

From the test result we see that what the team observed was true, the conversion rate of the test group is indeed less than that of the control group.

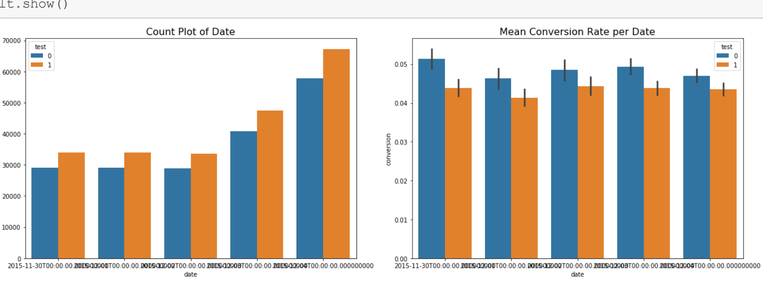
Conversion rate by variable

Is there any confounding variable?

A confounding variable is an outside influence that changes the effect of an independent variable on the dependent variable

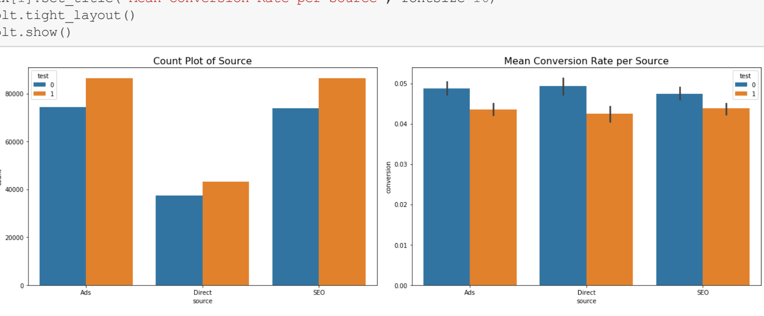
In [203]:
```
# Visualization of different dates
fig, ax = plt.subplots(nrows=1, ncols=2, figsize=(18, 6))
sns.countplot(x='date', hue='test', data=data, ax=ax[0])
ax[0].set_title('Count Plot of Date', fontsize=16)

sns.barplot(x='date', y='conversion', hue='test', data=data, ax=ax[1])
ax[1].set_title('Mean Conversion Rate per Date', fontsize=16)
plt.tight_layout()
plt.show()
```



In [204]:
```
# Visualization of different source
fig, ax = plt.subplots(nrows=1, ncols=2, figsize=(18, 6))
sns.countplot(x='source', hue='test', data=data, ax=ax[0])
ax[0].set_title('Count Plot of Source', fontsize=16)

sns.barplot(x='source', y='conversion', hue='test', data=data, ax=ax[1])
ax[1].set_title('Mean Conversion Rate per Source', fontsize=16)
plt.tight_layout()
plt.show()
```

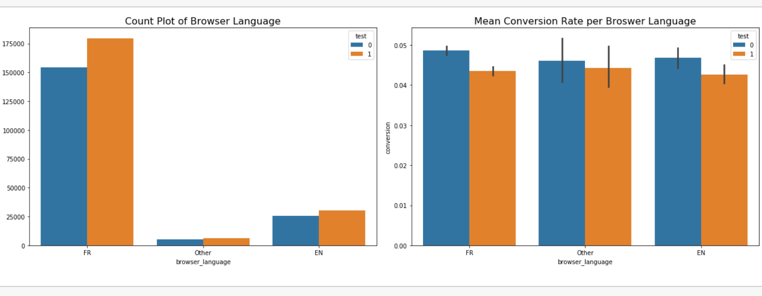


In [205]:
```
# Visualization of different devices
fig, ax = plt.subplots(nrows=1, ncols=2, figsize=(18, 6))
sns.countplot(x='device', hue='test', data=data, ax=ax[0])
ax[0].set_title('Count Plot of Device', fontsize=16)

sns.barplot(x='device', y='conversion', hue='test', data=data, ax=ax[1])
ax[1].set_title('Mean Conversion Rate per Device', fontsize=16)
plt.tight_layout()
plt.show()
```

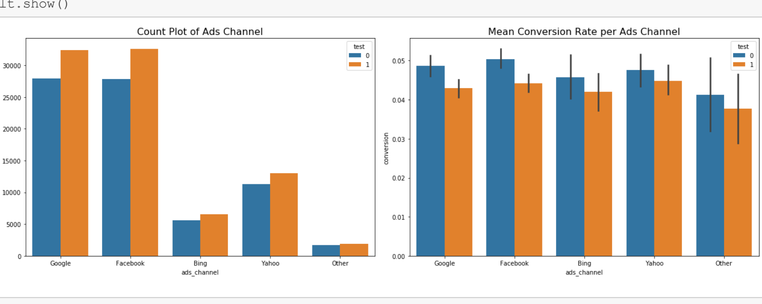
In [206]:
```
# Visualization of different devices
fig, ax = plt.subplots(nrows=1, ncols=2, figsize=(18, 6))
sns.countplot(x='browser_language', hue='test', data=data, ax=ax[0])
ax[0].set_title('Count Plot of Browser Language', fontsize=16)

sns.barplot(x='browser_language', y='conversion', hue='test', data=data, ax=ax[1])
ax[1].set_title('Mean Conversion Rate per Broswer Language', fontsize=16)
plt.tight_layout()
plt.show()
```



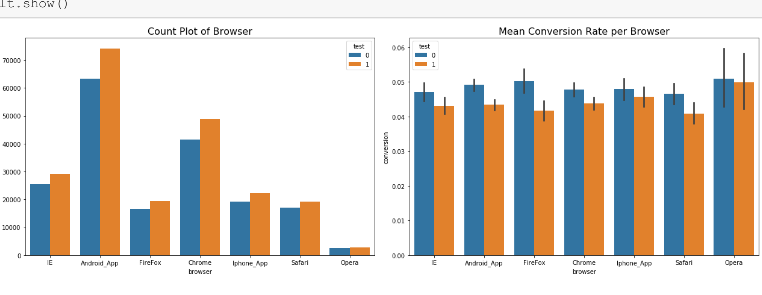
In [207]:
```
# Visualization of different devices
fig, ax = plt.subplots(nrows=1, ncols=2, figsize=(18, 6))
sns.countplot(x='ads_channel', hue='test', data=data, ax=ax[0])
ax[0].set_title('Count Plot of Ads Channel', fontsize=16)

sns.barplot(x='ads_channel', y='conversion', hue='test', data=data, ax=ax[1])
ax[1].set_title('Mean Conversion Rate per Ads Channel', fontsize=16)
plt.tight_layout()
plt.show()
```



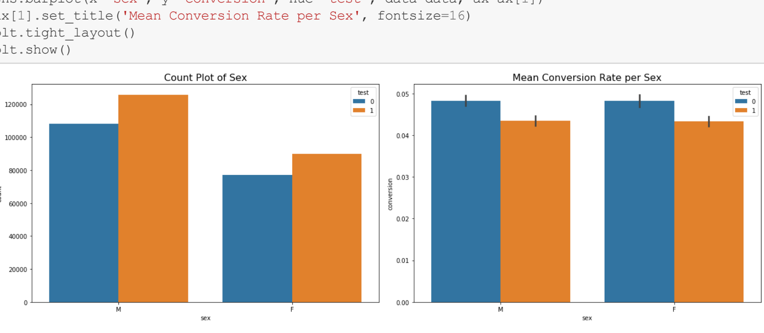
In [208]:
```
# Visualization of different devices
fig, ax = plt.subplots(nrows=1, ncols=2, figsize=(18, 6))
sns.countplot(x='browser', hue='test', data=data, ax=ax[0])
ax[0].set_title('Count Plot of Browser', fontsize=16)

sns.barplot(x='browser', y='conversion', hue='test', data=data, ax=ax[1])
ax[1].set_title('Mean Conversion Rate per Browser', fontsize=16)
plt.tight_layout()
plt.show()
```



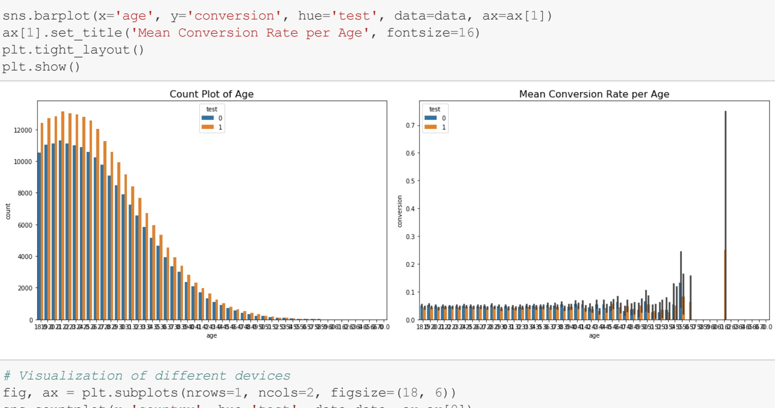
In [209]:
```
# Visualization of different devices
fig, ax = plt.subplots(nrows=1, ncols=2, figsize=(18, 6))
sns.countplot(x='sex', hue='test', data=data, ax=ax[0])
ax[0].set_title('Count Plot of Sex', fontsize=16)

sns.barplot(x='sex', y='conversion', hue='test', data=data, ax=ax[1])
ax[1].set_title('Mean Conversion Rate per Sex', fontsize=16)
plt.tight_layout()
plt.show()
```



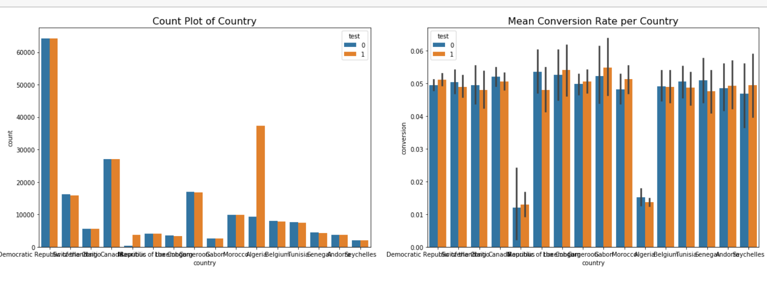
In [210]:
```
# Visualization of different devices
fig, ax = plt.subplots(nrows=1, ncols=2, figsize=(18, 6))
sns.countplot(x='age', hue='test', data=data, ax=ax[0])
ax[0].set_title('Count Plot of Age', fontsize=16)

sns.barplot(x='age', y='conversion', hue='test', data=data, ax=ax[1])
ax[1].set_title('Mean Conversion Rate per Age', fontsize=16)
plt.tight_layout()
plt.show()
```



In [211]:
```
# Visualization of different devices
fig, ax = plt.subplots(nrows=1, ncols=2, figsize=(18, 6))
sns.countplot(x='country', hue='test', data=data, ax=ax[0])
ax[0].set_title('Count Plot of Country', fontsize=16)

sns.barplot(x='country', y='conversion', hue='test', data=data, ax=ax[1])
ax[1].set_title('Mean Conversion Rate per Country', fontsize=16)
plt.tight_layout()
plt.show()
```



We have identified that country may be a confounding factor that influences the coversion rate. In next section, let's dive deeper into this variable.

Conversion rate by country

In this section, let's look at conversion rate by country and check how many countries have a higher conversion rate in the experiment group than the control.

From the table below, we see that several countries have a higher conversion rate in the experiment group.

In [124]:
```
conversion_by_country = data.groupby(['country', 'test']).conversion.mean().reset_index()
conversion_by_country
```

Out[124]:

	country	test	conversion
0	Algeria	0	0.015071
1	Algeria	1	0.013725
2	Andorra	0	0.048493
3	Andorra	1	0.049229
4	Belgium	0	0.049154
5	Belgium	1	0.048988
6	Cameroon	0	0.049914
7	Cameroon	1	0.050604
8	Canada	0	0.052089
9	Canada	1	0.050571
10	Democratic Republic of the Congo	0	0.049495
11	Democratic Republic of the Congo	1	0.051186
12	Gabon	0	0.052256
13	Gabon	1	0.054738
14	Haiti	0	0.049369
15	Haiti	1	0.047901
16	Luxembourg	0	0.052647
17	Luxembourg	1	0.054177
18	Mauritius	0	0.012048
19	Mauritius	1	0.012907
20	Morocco	0	0.048107
21	Morocco	1	0.051295
22	Republic of the Congo	0	0.053554
23	Republic of the Congo	1	0.047947
24	Senegal	0	0.050906
25	Senegal	1	0.047540
26	Seychelles	0	0.046796
27	Seychelles	1	0.049370
28	Spain	0	0.079719
29	Switzerland	0	0.050344
30	Switzerland	1	0.048978
31	Tunisia	0	0.050643
32	Tunisia	1	0.048647

In [125]:
```
data.groupby(['country', 'test']).conversion.count()
```

Out[125]:
```
country                           test
Algeria                           0        9356
                                  1       37377
Andorra                           0        3650
                                  1        3697
Belgium                           0        8036
                                  1        7859
Cameroon                          0       16869
                                  1       16797
Canada                            0       27088
                                  1       26972
Democratic Republic of the Congo  0       64209
                                  1       64275
Gabon                             0        2660
                                  1        2649
Haiti                             0        5550
                                  1        5574
Luxembourg                        0        3419
                                  1        3304
Mauritius                         0         415
                                  1        3719
Morocco                           0        9853
                                  1        9884
Republic of the Congo             0        4108
                                  1        4067
Senegal                           0        4361
                                  1        4207
Seychelles                        0        1966
                                  1        1985
Spain                             0       51782
Switzerland                       0       16149
                                  1       15905
Tunisia                           0        7622
                                  1        7503
Name: conversion, dtype: int64
```

In [127]:
```
data.groupby(['country', 'test']).conversion.sum()
```

Out[127]:
```
country                           test
Algeria                           0        141
                                  1        513
Andorra                           0        177
                                  1        182
Belgium                           0        395
                                  1        385
Cameroon                          0        842
                                  1        850
Canada                            0       1411
                                  1       1364
Democratic Republic of the Congo  0       3178
                                  1       3290
Gabon                             0        139
                                  1        145
Haiti                             0        274
                                  1        267
Luxembourg                        0        180
                                  1        179
Mauritius                         0          5
                                  1         48
Morocco                           0        474
                                  1        507
Republic of the Congo             0        220
                                  1        195
Senegal                           0        222
                                  1        200
Seychelles                        0         92
                                  1         98
Spain                             0       4128
Switzerland                       0        813
                                  1        779
Tunisia                           0        386
                                  1        365
Name: conversion, dtype: int64
```

Overall, we found that 27% of countries have higher conversion rates in the experiment group than the control group. But are these differences statistically significant?

In [134]:
```
tol = 0
for i in range(1, len(conversion_by_country.conversion),2):
        if conversion_by_country.conversion[i] > conversion_by_country.conversion[i - 1]:
            tol += 1
print('Proportion of countries that have a higher conversion rate in the experiment group: {}'.\
      format(tol/len(conversion_by_country.conversion)))
```

```
Proportion of countries that have a higher conversion rate in the experiment group: 0.2727272727
272727
```

Next, let's use a Z-test to check whether the difference of conversion rates are statistically significant. We have the following hypotheses:

H0: Conversion rate experiment group = Conversion rate control group

H1: Conversion rate experiment group} < Conversion rate control group

When performing a two-sided Z-test for each country where, we found that all p-values are above the 0.05 significance level, therefore, we cannot reject the null hypothesis mentioned above.

In [173]:
```
country_df = data.groupby(['country'])
pvalue_df = country_df.apply(lambda x: two_sample_z_test(x, 'smaller')[1]).reset_index()
pvalue_df.columns = [u'country', 'pvalue']
pvalue_df
```

Out[173]:

	country	pvalue
0	Algeria	0.160878
1	Andorra	0.558159
2	Belgium	0.480755
3	Cameroon	0.614029
4	Canada	0.211862
5	Democratic Republic of the Congo	0.917228
6	Gabon	0.656102
7	Haiti	0.359424
8	Luxembourg	0.609844
9	Mauritius	0.558611
10	Morocco	0.848577
11	Republic of the Congo	0.124099
12	Senegal	0.235832
13	Seychelles	0.647363
14	Switzerland	0.286863
15	Tunisia	0.286068

Conclusion: Localized translation didn't worsen the conversion rate.

Ariel Negrin