Assignment 3

May 10, 2020

---

*You are currently looking at **version 1.5** of this notebook. To download notebooks and datafiles, as well as get help on Jupyter notebooks in the Coursera platform, visit the Jupyter Notebook FAQ course resource.*

---

1 Assignment 3 - More Pandas

This assignment requires more individual learning then the last one did - you are encouraged to check out the pandas documentation to find functions or methods you might not have used yet, or ask questions on Stack Overflow and tag them as pandas and python related. And of course, the discussion forums are open for interaction with your peers and the course staff.

1.0.1 Question 1 (20%)

Load the energy data from the file `Energy Indicators.xls`, which is a list of indicators of energy supply and renewable electricity production from the United Nations for the year 2013, and should be put into a DataFrame with the variable name of **energy**.

Keep in mind that this is an Excel file, and not a comma separated values file. Also, make sure to exclude the footer and header information from the datafile. The first two columns are unneccessary, so you should get rid of them, and you should change the column labels so that the columns are:

`['Country', 'Energy Supply', 'Energy Supply per Capita', '% Renewable']`

Convert `Energy Supply` to gigajoules (there are 1,000,000 gigajoules in a petajoule). For all countries which have missing data (e.g. data with "...") make sure this is reflected as `np.NaN` values.

Rename the following list of countries (for use in later questions):

`"Republic of Korea": "South Korea", "United States of America": "United States", "United Kingdom of Great Britain and Northern Ireland": "United Kingdom", "China, Hong Kong Special Administrative Region": "Hong Kong"`

There are also several countries with numbers and/or parenthesis in their name. Be sure to remove these,

e.g.

`'Bolivia (Plurinational State of)'` should be `'Bolivia'`,

`'Switzerland17'` should be `'Switzerland'`.

Next, load the GDP data from the file `world_bank.csv`, which is a csv containing countries' GDP from 1960 to 2015 from World Bank. Call this DataFrame **GDP**.

Make sure to skip the header, and rename the following list of countries:

`"Korea, Rep.": "South Korea", "Iran, Islamic Rep.": "Iran", "Hong Kong SAR, China": "Hong Kong"`

Finally, load the Sciamgo Journal and Country Rank data for Energy Engineering and Power Technology from the file `scimagojr-3.xlsx`, which ranks countries based on their journal contributions in the aforementioned area. Call this DataFrame **ScimEn**.

Join the three datasets: GDP, Energy, and ScimEn into a new dataset (using the intersection of country names). Use only the last 10 years (2006-2015) of GDP data and only the top 15 countries by Scimagojr 'Rank' (Rank 1 through 15).

The index of this DataFrame should be the name of the country, and the columns should be ['Rank', 'Documents', 'Citable documents', 'Citations', 'Self-citations', 'Citations per document', 'H index', 'Energy Supply', 'Energy Supply per Capita', '% Renewable', '2006', '2007', '2008', '2009', '2010', '2011', '2012', '2013', '2014', '2015'].

This function should return a DataFrame with 20 columns and 15 entries.

```
In [32]: import pandas as pd
         import numpy as np

         def edata():
             energy = pd.read_excel('Energy Indicators.xls', header= None, skipfooter= 2)
             energy = (pd.DataFrame(energy).drop([0,1], axis= 1)
                                           .dropna().drop(9)
                                           .rename(columns= {2:'Country',
                                                             3:'Energy Supply',
                                                             4:'Energy Supply per Capita',
                                                             5:'% Renewable'})
                                           .replace(regex= [r'\d', r' \(([^)]+)\)'], value=r'')
                                           .replace(to_replace= {"...": np.nan,
                                                                 "Republic of Korea": "South Kor
                                                                 "United States of America": "Un
                                                                 "United Kingdom of Great Britai
                                                                 "China, Hong Kong Special Admin
                       )
             energy['Energy Supply'] *= 1000000        #Convert petajoules to giga joules

             return(energy)

         def gdp():
             GDP = pd.read_csv('world_bank.csv', header= None, skiprows= 4)
             GDP = (pd.DataFrame(GDP).rename(columns=GDP.iloc[0])
                                     .drop(0)
                                     .replace(to_replace={"Korea, Rep.": "South Korea",
                                                          "Iran, Islamic Rep.": "Iran",
                                                          "Hong Kong SAR, China": "Hong Kong"})
                                     .rename(columns={2006:'2006', 2007:'2007',2008:'2008',2009:
                                                      2010:'2010',2011:'2011',2012:'2012',2013:'
                    )
             return GDP
```

```
def emd():
    ScimEn = pd.read_excel('scimagojr-3.xlsx')
    SciEn = pd.DataFrame(ScimEn)
    return ScimEn

def answer_one():
    energy = edata().dropna()
    GDP = gdp()[['Country Name', '2006', '2007', '2008', '2009', '2010', '2011', '2012'
    ScimEn = emd()[['Rank', 'Country', 'Documents', 'Citable documents', 'Citations', '
    # Merging of all DataFrame df_merge
    df_merge = pd.merge(ScimEn, energy, how='inner', left_on= 'Country', right_on= 'Cou
    df_merge = pd.merge(df_merge, GDP, how='inner', left_on= 'Country', right_on= 'Coun
    df_merge = df_merge.drop('Country Name', axis= 1)
    df_merge = df_merge.set_index('Country')
    return df_merge

answer_one()
```

Out[32]:

Country	Rank	Documents	Citable documents	Citations	\
China	1	127050	126767	597237	
United States	2	96661	94747	792274	
Japan	3	30504	30287	223024	
United Kingdom	4	20944	20357	206091	
Russian Federation	5	18534	18301	34266	
Canada	6	17899	17620	215003	
Germany	7	17027	16831	140566	
India	8	15005	14841	128763	
France	9	13153	12973	130632	
South Korea	10	11983	11923	114675	
Italy	11	10964	10794	111850	
Spain	12	9428	9330	123336	
Iran	13	8896	8819	57470	
Australia	14	8831	8725	90765	
Brazil	15	8668	8596	60702	

Country	Self-citations	Citations per document	H index	\
China	411683	4.70	138	
United States	265436	8.20	230	
Japan	61554	7.31	134	
United Kingdom	37874	9.84	139	
Russian Federation	12422	1.85	57	
Canada	40930	12.01	149	
Germany	27426	8.26	126	
India	37209	8.58	115	
France	28601	9.93	114	

South Korea	22595		9.57	104
Italy	26661		10.20	106
Spain	23964		13.08	115
Iran	19125		6.46	72
Australia	15606		10.28	107
Brazil	14396		7.00	86

Country	Energy Supply	Energy Supply per Capita	% Renewable	\
China	1.271910e+11	93.0	19.754910	
United States	9.083800e+10	286.0	11.570980	
Japan	1.898400e+10	149.0	10.232820	
United Kingdom	7.920000e+09	124.0	10.600470	
Russian Federation	3.070900e+10	214.0	17.288680	
Canada	1.043100e+10	296.0	61.945430	
Germany	1.326100e+10	165.0	17.901530	
India	3.319500e+10	26.0	14.969080	
France	1.059700e+10	166.0	17.020280	
South Korea	1.100700e+10	221.0	2.279353	
Italy	6.530000e+09	109.0	33.667230	
Spain	4.923000e+09	106.0	37.968590	
Iran	9.172000e+09	119.0	5.707721	
Australia	5.386000e+09	231.0	11.810810	
Brazil	1.214900e+10	59.0	69.648030	

Country	2006	2007	2008	2009	\
China	3.992331e+12	4.559041e+12	4.997775e+12	5.459247e+12	
United States	1.479230e+13	1.505540e+13	1.501149e+13	1.459484e+13	
Japan	5.496542e+12	5.617036e+12	5.558527e+12	5.251308e+12	
United Kingdom	2.419631e+12	2.482203e+12	2.470614e+12	2.367048e+12	
Russian Federation	1.385793e+12	1.504071e+12	1.583004e+12	1.459199e+12	
Canada	1.564469e+12	1.596740e+12	1.612713e+12	1.565145e+12	
Germany	3.332891e+12	3.441561e+12	3.478809e+12	3.283340e+12	
India	1.265894e+12	1.374865e+12	1.428361e+12	1.549483e+12	
France	2.607840e+12	2.669424e+12	2.674637e+12	2.595967e+12	
South Korea	9.410199e+11	9.924316e+11	1.020510e+12	1.027730e+12	
Italy	2.202170e+12	2.234627e+12	2.211154e+12	2.089938e+12	
Spain	1.414823e+12	1.468146e+12	1.484530e+12	1.431475e+12	
Iran	3.895523e+11	4.250646e+11	4.289909e+11	4.389208e+11	
Australia	1.021939e+12	1.060340e+12	1.099644e+12	1.119654e+12	
Brazil	1.845080e+12	1.957118e+12	2.056809e+12	2.054215e+12	

Country	2010	2011	2012	2013	\
China	6.039659e+12	6.612490e+12	7.124978e+12	7.672448e+12	
United States	1.496437e+13	1.520402e+13	1.554216e+13	1.577367e+13	
Japan	5.498718e+12	5.473738e+12	5.569102e+12	5.644659e+12	

```
United Kingdom      2.403504e+12  2.450911e+12  2.479809e+12  2.533370e+12
Russian Federation  1.524917e+12  1.589943e+12  1.645876e+12  1.666934e+12
Canada              1.613406e+12  1.664087e+12  1.693133e+12  1.730688e+12
Germany             3.417298e+12  3.542371e+12  3.556724e+12  3.567317e+12
India               1.708459e+12  1.821872e+12  1.924235e+12  2.051982e+12
France              2.646995e+12  2.702032e+12  2.706968e+12  2.722567e+12
South Korea         1.094499e+12  1.134796e+12  1.160809e+12  1.194429e+12
Italy               2.125185e+12  2.137439e+12  2.077184e+12  2.040871e+12
Spain               1.431673e+12  1.417355e+12  1.380216e+12  1.357139e+12
Iran                4.677902e+11  4.853309e+11  4.532569e+11  4.445926e+11
Australia           1.142251e+12  1.169431e+12  1.211913e+12  1.241484e+12
Brazil              2.208872e+12  2.295245e+12  2.339209e+12  2.409740e+12

                             2014          2015
Country
China               8.230121e+12  8.797999e+12
United States       1.615662e+13  1.654857e+13
Japan               5.642884e+12  5.669563e+12
United Kingdom      2.605643e+12  2.666333e+12
Russian Federation  1.678709e+12  1.616149e+12
Canada              1.773486e+12  1.792609e+12
Germany             3.624386e+12  3.685556e+12
India               2.200617e+12  2.367206e+12
France              2.729632e+12  2.761185e+12
South Korea         1.234340e+12  1.266580e+12
Italy               2.033868e+12  2.049316e+12
Spain               1.375605e+12  1.419821e+12
Iran                4.639027e+11           NaN
Australia           1.272520e+12  1.301251e+12
Brazil              2.412231e+12  2.319423e+12
```

1.0.2 Question 2 (6.6%)

The previous question joined three datasets then reduced this to just the top 15 entries. When you joined the datasets, but before you reduced this to the top 15 items, how many entries did you lose?

This function should return a single number.

```
In [33]: %%HTML
         <svg width="800" height="300">
           <circle cx="150" cy="180" r="80" fill-opacity="0.2" stroke="black" stroke-width="2" f
           <circle cx="200" cy="100" r="80" fill-opacity="0.2" stroke="black" stroke-width="2" f
           <circle cx="100" cy="100" r="80" fill-opacity="0.2" stroke="black" stroke-width="2" f
           <line x1="150" y1="125" x2="300" y2="150" stroke="black" stroke-width="2" fill="black
           <text  x="300" y="165" font-family="Verdana" font-size="35">Everything but this!</tex
         </svg>
```

```
<IPython.core.display.HTML object>
```

```
In [55]: def answer_two():
             energy = edata().copy()
             GDP = gdp().copy()
             GDP.columns = ['Country' if c=='Country Name' else c for c in GDP.columns]
             ScimEn = emd().copy()
             # Merging of two DataFrame(intersection) at a time
             m1 = pd.merge(energy, ScimEn, left_on= 'Country', right_on= 'Country', how='outer')
             x = pd.merge(GDP, m1, left_on= 'Country', right_on= 'Country', how='outer')

             m2 = pd.merge(energy, ScimEn, left_on= 'Country', right_on= 'Country', how='inner')
             y = pd.merge(GDP, m2, left_on= 'Country', right_on= 'Country', how='inner')
             # No. of data in each sets
             return len(x)-len(y)

         answer_two()

Out[55]: 156
```

1.1 Answer the following questions in the context of only the top 15 countries by Scimagojr Rank (aka the DataFrame returned by `answer_one()`)

1.1.1 Question 3 (6.6%)

What is the average GDP over the last 10 years for each country? (exclude missing values from this calculation.)

This function should return a Series named `avgGDP` with 15 countries and their average GDP sorted in descending order.

```
In [35]: def answer_three():
             Top15 = answer_one()
             avgGDP = Top15.loc[:,'2006':'2015'].apply(np.average, axis="columns")
             avgGDP.sort_values(ascending=False, inplace=True)
             return avgGDP

         answer_three()

Out[35]: Country
         United States         1.536434e+13
         China                 6.348609e+12
         Japan                 5.542208e+12
         Germany               3.493025e+12
         France                2.681725e+12
         United Kingdom        2.487907e+12
         Brazil                2.189794e+12
         Italy                 2.120175e+12
         India                 1.769297e+12
         Canada                1.660647e+12
         Russian Federation    1.565459e+12
         Spain                 1.418078e+12
```

```
Australia            1.164043e+12
South Korea          1.106715e+12
Iran                          NaN
dtype: float64
```

1.1.2 Question 4 (6.6%)

By how much had the GDP changed over the 10 year span for the country with the 6th largest average GDP?

This function should return a single number.

```
In [50]: def answer_four():
             Top15 = answer_one()
             country = answer_three().keys()[5]
             # Changes over 10 years GDP
             ANS = Top15.at[country,'2015'] - Top15.at[country,'2006']
             return ANS

         answer_four()
```

```
Out[50]: 246702696075.3999
```

1.1.3 Question 5 (6.6%)

What is the mean `Energy Supply per Capita`?

This function should return a single number.

```
In [37]: def answer_five():
             Top15 = answer_one()
             M_espc = Top15['Energy Supply per Capita'].mean()
             return float(M_espc)

         answer_five()
```

```
Out[37]: 157.6
```

1.1.4 Question 6 (6.6%)

What country has the maximum % Renewable and what is the percentage?

This function should return a tuple with the name of the country and the percentage.

```
In [38]: def answer_six():
             Top15 = answer_one()
             max = Top15['% Renewable'].max()
             country = Top15[Top15['% Renewable'] == max].index.format()[0]
             ANS = country, float(max)
             return ANS

         answer_six()
```

```
Out[38]: ('Brazil', 69.64803)
```

1.1.5 Question 7 (6.6%)

Create a new column that is the ratio of Self-Citations to Total Citations. What is the maximum value for this new column, and what country has the highest ratio?

This function should return a tuple with the name of the country and the ratio.

```
In [39]: def answer_seven():
             Top15 = answer_one()
             Top15['Ratio Citations'] = Top15['Self-citations']/Top15['Citations']
             max = Top15['Ratio Citations'].max()
             country = Top15[Top15['Ratio Citations'] == max].index.format()[0]
             ANS = country, max
             return ANS

         answer_seven()

Out[39]: ('China', 0.68931261793894216)
```

1.1.6 Question 8 (6.6%)

Create a column that estimates the population using Energy Supply and Energy Supply per capita. What is the third most populous country according to this estimate?

This function should return a single string value.

```
In [40]: def answer_eight():
             Top15 = answer_one()
             pop = Top15.apply(lambda x: x['Energy Supply'] / x['Energy Supply per Capita'], axi
             pop.sort_values(ascending=False, inplace=True)
             #  third most populous country
             Ans = pop.keys()[2]
             return Ans

         answer_eight()

Out[40]: 'United States'
```

1.1.7 Question 9 (6.6%)

Create a column that estimates the number of citable documents per person. What is the correlation between the number of citable documents per capita and the energy supply per capita? Use the `.corr()` method, (Pearson's correlation).

This function should return a single number.

(Optional: Use the built-in function `plot9()` to visualize the relationship between Energy Supply per Capita vs. Citable docs per Capita)

```
In [41]: def answer_nine():
             Top15 = answer_one()
             Top15['PopEst'] = Top15.apply(lambda x: x['Energy Supply'] / x['Energy Supply per C
             Top15['Citable docs per Capita'] = Top15.apply(lambda x: x['Citable documents'] / x
```

```
            Top15 = Top15.corr(method='pearson')
            # Correlation value b/w citable documents per capita and the energy supply per capi
            Corr = Top15.loc['Energy Supply per Capita', 'Citable docs per Capita']
            return Corr

        answer_nine()
```

```
Out[41]: 0.79400104354429435
```

```
In [42]: def plot9():
            import matplotlib as plt
            %matplotlib inline

            Top15 = answer_one()
            Top15['PopEst'] = Top15['Energy Supply'] / Top15['Energy Supply per Capita']
            Top15['Citable docs per Capita'] = Top15['Citable documents'] / Top15['PopEst']
            Top15.plot(x='Citable docs per Capita', y='Energy Supply per Capita', kind='scatter
```

```
In [52]: #plot9()
```

1.1.8 Question 10 (6.6%)

Create a new column with a 1 if the country's % Renewable value is at or above the median for all countries in the top 15, and a 0 if the country's % Renewable value is below the median.

This function should return a series named `HighRenew` whose index is the country name sorted in ascending order of rank.

```
In [53]: def answer_ten():
            Top15 = answer_one()
            Top15['HighRenew'] = np.nan
            median = Top15['% Renewable'].median()
            for i in range(0,len(Top15)):
                if Top15.iloc[i]['% Renewable'] >= median:
                    Top15.at[Top15.iloc[i].name, 'HighRenew'] = 1
                else:
                    Top15.at[Top15.iloc[i].name, 'HighRenew'] = 0

            # Get the HighRenem Series
            High = Top15['HighRenew'].astype(np.int64)
            High = High.sort_values(inplace= False)
            return High

        answer_ten()
```

```
Out[53]: Country
         United States         0
         Japan                 0
         United Kingdom        0
         India                 0
```

```
South Korea           0
Iran                  0
Australia             0
China                 1
Russian Federation    1
Canada                1
Germany               1
France                1
Italy                 1
Spain                 1
Brazil                1
Name: HighRenew, dtype: int64
```

1.1.9 Question 11 (6.6%)

Use the following dictionary to group the Countries by Continent, then create a dateframe that displays the sample size (the number of countries in each continent bin), and the sum, mean, and std deviation for the estimated population of each country.

```
ContinentDict  = {'China':'Asia',
                  'United States':'North America',
                  'Japan':'Asia',
                  'United Kingdom':'Europe',
                  'Russian Federation':'Europe',
                  'Canada':'North America',
                  'Germany':'Europe',
                  'India':'Asia',
                  'France':'Europe',
                  'South Korea':'Asia',
                  'Italy':'Europe',
                  'Spain':'Europe',
                  'Iran':'Asia',
                  'Australia':'Australia',
                  'Brazil':'South America'}
```

This function should return a DataFrame with index named Continent `['Asia', 'Australia', 'Europe', 'North America', 'South America']` *and columns* `['size', 'sum', 'mean', 'std']`

```
In [45]: ContinentDict  = {'China':'Asia',

                           'United States':'North America',

                           'Japan':'Asia',

                           'United Kingdom':'Europe',

                           'Russian Federation':'Europe',
```

```
                          'Canada':'North America',

                          'Germany':'Europe',

                          'India':'Asia',

                          'France':'Europe',

                          'South Korea':'Asia',

                          'Italy':'Europe',

                          'Spain':'Europe',

                          'Iran':'Asia',

                          'Australia':'Australia',

                          'Brazil':'South America'}


        def answer_eleven():
            Top15 = answer_one()
            Top15['PopEst'] = Top15['Energy Supply'] / Top15['Energy Supply per Capita']
            for i in range(0,len(Top15)):
                country = Top15.iloc[i].name
                Top15.at[Top15.iloc[i].name, 'Continent'] = ContinentDict[country]

            Top15 = Top15.reset_index(level=0).set_index(['Continent','Country'])
            # Here is the size, sum, mean, and std of Population column w.r.t Continent
            Top15 = Top15.groupby(level=0)['PopEst'].agg([np.size, np.sum, np.mean, np.std])
            return Top15

        answer_eleven()
```

Out[45]:

Continent	size	sum	mean	std
Asia	5.0	2.898666e+09	5.797333e+08	6.790979e+08
Australia	1.0	2.331602e+07	2.331602e+07	NaN
Europe	6.0	4.579297e+08	7.632161e+07	3.464767e+07
North America	2.0	3.528552e+08	1.764276e+08	1.996696e+08
South America	1.0	2.059153e+08	2.059153e+08	NaN

1.1.10 Question 12 (6.6%)

Cut % Renewable into 5 bins. Group Top15 by the Continent, as well as these new % Renewable bins. How many countries are in each of these groups?

This function should return a ***Series*** *with a MultiIndex of* `Continent`*, then the bins for* `% Renewable`*.*

Do not include groups with no countries.

```
In [46]: def answer_twelve():
             Top15 = answer_one()
             Top15['PopEst'] = Top15['Energy Supply'] / Top15['Energy Supply per Capita']
             for i in range(0,len(Top15)):
                 country = Top15.iloc[i].name
                 Top15.at[Top15.iloc[i].name, 'Continent'] = ContinentDict[country]

             Top15 = Top15.reset_index(level=0).set_index(['Continent','Country'])
             # Cut % Renewable
             Top15 = pd.cut(Top15['% Renewable'], 5)

             Top15 = Top15.reset_index().set_index(['Continent','% Renewable'])
             # Here is the size of each Continent group
             Top15 = Top15.groupby(level=['Continent','% Renewable']).size()
             return Top15

         answer_twelve()

Out[46]: Continent      % Renewable
         Asia           (2.212, 15.753]     4
                        (15.753, 29.227]    1
         Australia      (2.212, 15.753]     1
         Europe         (2.212, 15.753]     1
                        (15.753, 29.227]    3
                        (29.227, 42.701]    2
         North America  (2.212, 15.753]     1
                        (56.174, 69.648]    1
         South America  (56.174, 69.648]    1
         dtype: int64
```

1.1.11 Question 13 (6.6%)

Convert the Population Estimate series to a string with thousands separator (using commas). Do not round the results.

e.g. 317615384.61538464 -> 317,615,384.61538464

This function should return a Series `PopEst` whose index is the country name and whose values are the population estimate string.

```
In [47]: def answer_thirteen():
             Top15 = answer_one()
             Top15['PopEst'] = Top15['Energy Supply'] / Top15['Energy Supply per Capita']
             Top15 = Top15['PopEst']
             Top15 = Top15.map('{:,}'.format)
             return Top15

         answer_thirteen()
```

```
Out[47]: Country
         China                  1,367,645,161.2903225
         United States           317,615,384.61538464
         Japan                   127,409,395.97315437
         United Kingdom          63,870,967.741935484
         Russian Federation             143,500,000.0
         Canada                   35,239,864.86486486
         Germany                  80,369,696.96969697
         India                  1,276,730,769.2307692
         France                   63,837,349.39759036
         South Korea             49,805,429.864253394
         Italy                   59,908,256.880733944
         Spain                     46,443,396.2264151
         Iran                     77,075,630.25210084
         Australia               23,316,017.316017315
         Brazil                  205,915,254.23728815
         Name: PopEst, dtype: object
```

1.1.12 Optional

Use the built in function `plot_optional()` to see an example visualization.

```
In [48]: def plot_optional():
             import matplotlib as plt
             %matplotlib inline
             Top15 = answer_one()
             ax = Top15.plot(x='Rank', y='% Renewable', kind='scatter',
                             c=['#e41a1c','#377eb8','#e41a1c','#4daf4a','#4daf4a','#377eb8','#4d
                                '#4daf4a','#e41a1c','#4daf4a','#4daf4a','#e41a1c','#dede00','#ff
                             xticks=range(1,16), s=6*Top15['2014']/10**10, alpha=.75, figsize=[1

             for i, txt in enumerate(Top15.index):
                 ax.annotate(txt, [Top15['Rank'][i], Top15['% Renewable'][i]], ha='center')

             print("This is an example of a visualization that can be created to help understand
         This is a bubble chart showing % Renewable vs. Rank. The size of the bubble corresponds
         2014 GDP, and the color corresponds to the continent.")

In [51]: #plot_optional() # Be sure to comment out plot_optional() before submitting the assignm

In [ ]:
```