Project: Investigate a Dataset

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Introduction

Dataset Description

FREE DATA FROM WORLD BANK VIA GAPMINDER.ORG,

> Gapminder has collected a lot of information about how people live their lives in different countries, tracked across the years, and on a number of different indicators. In the coal_consumption_total.csv dataset, (source: The coal consumption, total dataset in energy/coal/ folder on https://www.gapminder.org/data/) the columns are the countries and value of coal consumption each year from 1965 to 2019
>
> In the oil_consumption_total.csv dataset,(source: The oil consumption, total dataset in energy/oil/ folder onhttps://www.gapminder.org/data/) the columns are the countries and value of oilconsumption each year from 1965 to 2019
>
> and in the consumption_co2_emissions_1000_tonnes.csv, (source: The consumption_co2_emissions_1000_tonnes dataset in environments/emissions/ folder on https://www.gapminder.org/data/) the columns are the countries and value of co2 emissions each year from 1990 to 2017

Question(s) for Analysis

> - what is the general trend in the consumption of coal between 2007 and 2017
> - what is the general trend in the consumption of oil between 2007 and 2017
> - what is the general trend in the emission of co2 between 2007 and 2017
> - What top 10 countries have the highest coal consumption, oil consumption and emission of co2
> - What top 10 countries have the lowest coal consumption, oil consumption and emission of co2

Data Wrangling

import libraries that are needed

In [1]:
```
import pandas as pd
import re

import matplotlib.pyplot as plt
%matplotlib inline
import seaborn as sns
```

Check relationships between consumption of coal, oil and co2 emissions

Import dataset on total cosumption of coals from 1965 to 2019 in all countries

In [2]:
```
coal_data = pd.read_csv('coal_consumption_total.csv')
coal_data.head(1)
```

Out[2]:

	country	1965	1966	1967	1968	1969	1970	1971	1972	1973	...	2010	2011	2012	2013	2014	2015	2016	2017	2018
0	United Arab Emirates	0	0	0	0	0	0	0	0	0	...	658k	445k	1.38M	1.77M	1.97M	1.71M	1.84M	2.13M	2.41M

1 rows × 56 columns

Import dataset on total cosumption of oil from 1965 to 2019 in all countries

In [3]:
```
oil_data = pd.read_csv('oil_consumption_total.csv')
oil_data.head(1)
```

Out[3]:

	country	1965	1966	1967	1968	1969	1970	1971	1972	1973	...	2010	2011	2012	2013	2014	2015	2016	2017	2018
0	United Arab Emirates	69.6k	74.3k	79.8k	89.1k	99k	115k	136k	179k	280k	...	31.3M	33.8M	35.2M	39M	39.3M	42.2M	44.9M	44.2M	46M

1 rows × 56 columns

Import dataset on total co2 emmissions from fossil fuels consumption from 1990 to 2017 in all countries

In [4]:
```
co2_data = pd.read_csv('consumption_co2_emissions_1000_tonnes.csv')
co2_data.head(1)
```

Out[4]:

	country	1990	1991	1992	1993	1994	1995	1996	1997	1998	...	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
0	Albania	5620	4570	2840	2630	2290	2460	2870	2190	2510	...	6130	6370	6140	6350	6060	5870	6300	5660	5500	5650

1 rows × 29 columns

Data cleaning

Limit data to between the years 2007 to 2017

In [5]:
```
cols = ['country'] + [str(x) for x in range(2007,2018)] # create list to get columns from 2009 to 2017,
cols                                                     #with country inclusive
```

Out[5]:
```
['country',
 '2007',
 '2008',
 '2009',
 '2010',
 '2011',
 '2012',
 '2013',
 '2014',
 '2015',
 '2016',
 '2017']
```

To combine the data from the three indicators to a single data

In [6]:
```
def clean_data(data, cols, var):
  '''
  docstring: clean data and rearrange data according to years https://pandas.pydata.org/docs/reference/
api/pandas.melt.html
  input: data  - DataFrame, data to melt
         cols - string, columns to keep
         var - string, name of column values
  output: melted DataFrame
  '''
  data2 = data[cols].copy()
  data2 = pd.melt(data2, id_vars=['country'], var_name= 'year', value_name = var)
  return data2
```

In [7]:
```
# merge coal_data, oil_data and co2_data after they have been melted
data = clean_data(data = coal_data, cols= cols, var = 'coal')\
.merge(clean_data(data = oil_data, cols= cols, var = 'oil'), on = ['country', 'year'])\
.merge(clean_data(data = co2_data, cols= cols, var = 'co2'), on = ['country', 'year'])
```

In [8]:
```
data.head()
```

Out[8]:

	country	year	coal	oil	co2
0	United Arab Emirates	2007	136k	28.7M	203k
1	Argentina	2007	1.23M	24.2M	161k
2	Australia	2007	55.9M	42.1M	358k
3	Austria	2007	3.86M	12.9M	101k
4	Azerbaijan	2007	4930	4.52M	32.2k

To convert the format of the values e.g k is 1000, M is 10^6 and B is 10^9

In [9]:
```
for column in data.columns[2:]:
  data[column] = data[column].replace({'k':'*1e3', 'M':'*1e6', 'B':'*1e9'}, regex = True).map(pd.eval).
astype(int)
data.head()
```

Out[9]:

	country	year	coal	oil	co2
0	United Arab Emirates	2007	136000	28700000	203000
1	Argentina	2007	1230000	24200000	161000
2	Australia	2007	55900000	42100000	358000
3	Austria	2007	3860000	12900000	101000
4	Azerbaijan	2007	4930	4520000	32200

To check for null values

In [10]:
```
data.isna().sum()
```

Out[10]:
```
country    0
year       0
coal       0
oil        0
co2        0
dtype: int64
```

To check for duplicated values

In [11]:
```
data.duplicated().sum()
```

Out[11]: 0

Check datatypes and change year column to datetime datatype

In [12]:
```
data['year'] = pd.to_datetime(data['year'])
```

In [13]:
```
data.dtypes
```

Out[13]:
```
country            object
year       datetime64[ns]
coal                int64
oil                 int64
co2                 int64
dtype: object
```

Check for invalid values, outliers

In [14]:
```
data.describe()
```

Out[14]:

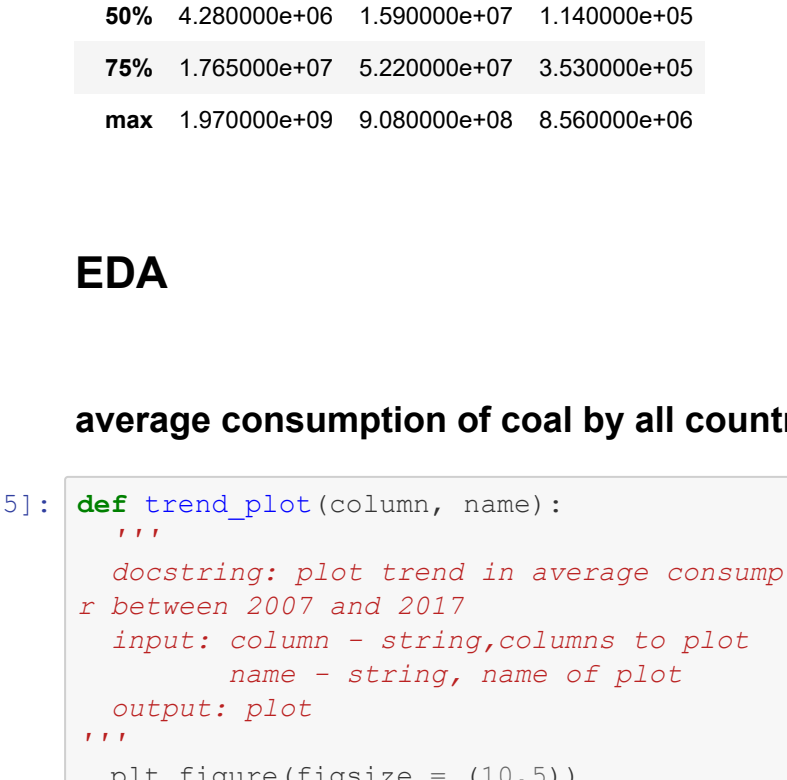
	coal	oil	co2
count	8.030000e+02	8.030000e+02	8.030000e+02
mean	4.993194e+07	5.263674e+07	4.294369e+05
std	2.202716e+08	1.129780e+08	1.133047e+06
min	0.000000e+00	1.330000e+06	7.770000e+03
25%	8.115000e+05	8.100000e+06	5.735000e+04
50%	4.280000e+06	1.590000e+07	1.140000e+05
75%	1.765000e+07	5.220000e+07	3.530000e+05
max	1.970000e+09	9.080000e+08	8.560000e+06

EDA

average consumption of coal by all countries each year between 2007 and 2017

In [15]:
```
def trend_plot(column, name):
  '''
  docstring: plot trend in average consumption of coal, oil and co2 emissions by all countries each yea
r between 2007 and 2017
  input: column - string,columns to plot
         name - string, name of plot
  output: plot
'''
  plt.figure(figsize = (10,5))
  data.groupby('year').mean()[column].plot()
  plt.title(f'Trend in {name} from 2007 to 2017', fontdict ={'fontsize': 14,
  'verticalalignment': 'center_baseline', 'color': 'red'}, pad =15)
  plt.xlabel('years', labelpad= 10, fontdict ={'fontsize': 14,
  'verticalalignment': 'center_baseline', 'color': 'red'});
  plt.ylabel(f'average {name} ', labelpad= 10, fontdict ={'fontsize': 14,
  'verticalalignment': 'center_baseline', 'color': 'red'});
```

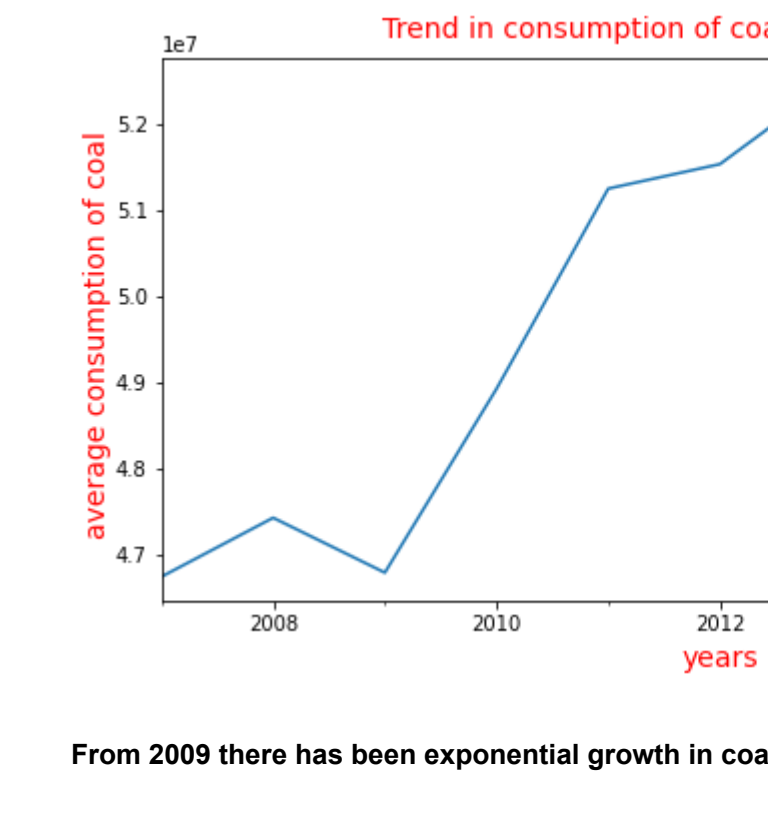
In [16]:
```
trend_plot('coal', 'consumption of coal')
```



From 2009 there has been exponential growth in coal consumption and a decline from 2014

average consumption of oil between 2007 and 2017

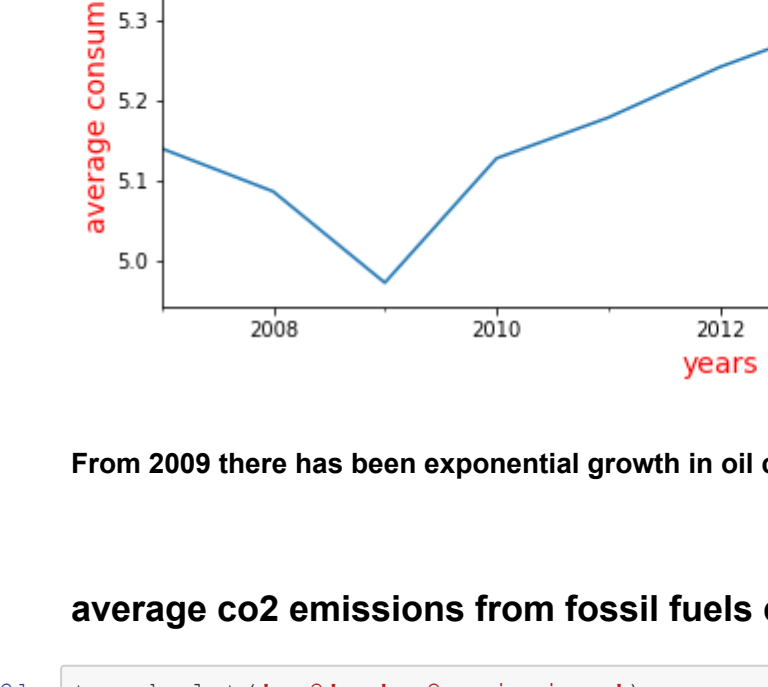
In [17]:
```
trend_plot('oil','consumption of oil')
```



From 2009 there has been exponential growth in oil consumption

average co2 emissions from fossil fuels consumption between 2007 and 2017

In [18]:
```
trend_plot('co2', 'co2 emissions')
```



From 2009 there has been exponential growth in co2 emission

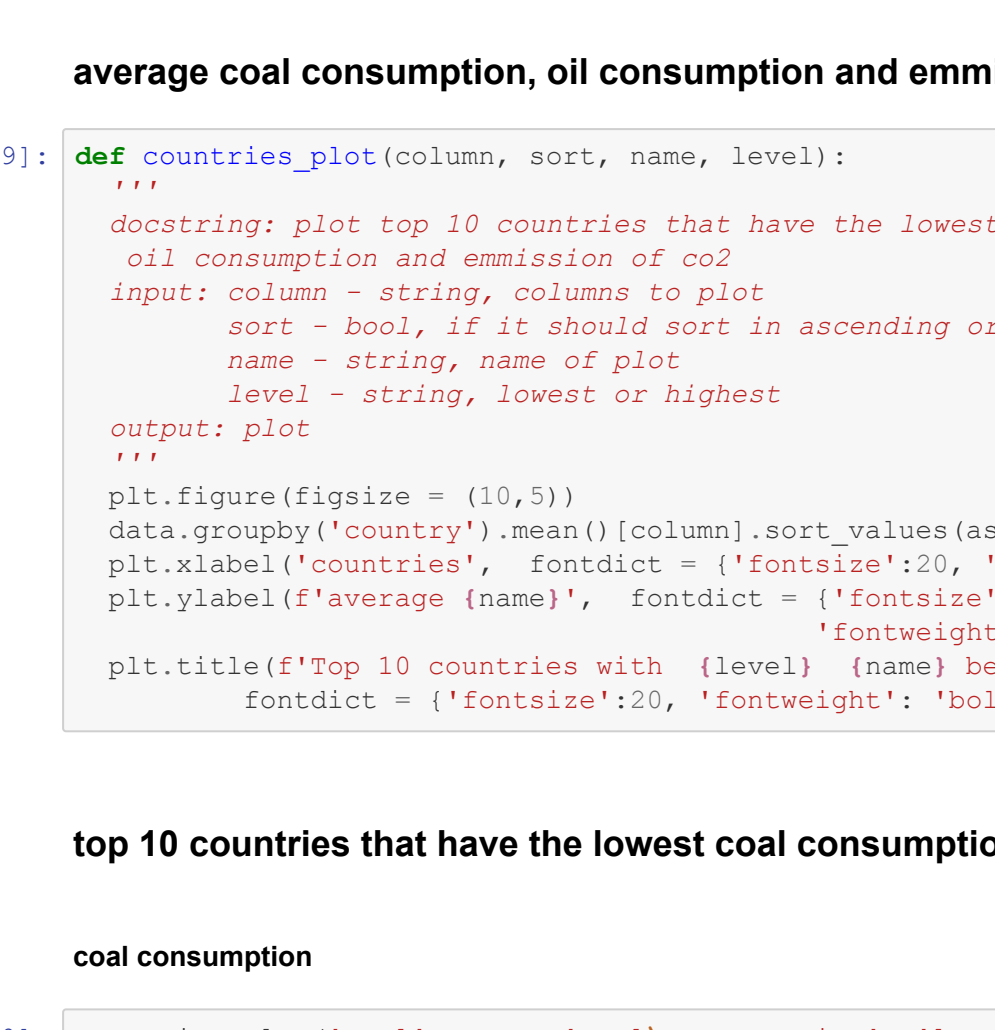
average coal consumption, oil consumption and emmission of co2 per country

In [19]:
```
def countries_plot(column, sort, name, level):
  '''
  docstring: plot top 10 countries that have the lowest and highest coal consumption,
   oil consumption and emmission of co2
  input: column - string, columns to plot
         sort - bool, if it should sort in ascending order
         name - string, name of plot
         level - string, lowest or highest
  output: plot
  '''
  plt.figure(figsize = (10,5))
  data.groupby('country').mean()[column].sort_values(ascending = sort).head(10).plot(kind ='bar')
  plt.xlabel('countries',  fontdict = {'fontsize':20, 'fontweight': 'bold', 'color':'red'})
  plt.ylabel(f'average {name}',  fontdict = {'fontsize':20,\
                                 'fontweight': 'bold', 'color':'red'}, labelpad = 15)
  plt.title(f'Top 10 countries with  {level}  {name} between 2007 to 2017',\
         fontdict = {'fontsize':20, 'fontweight': 'bold', 'color':'blue'}, pad = 15);
```

top 10 countries that have the lowest coal consumption, oil consumption and emmission of co2

coal consumption

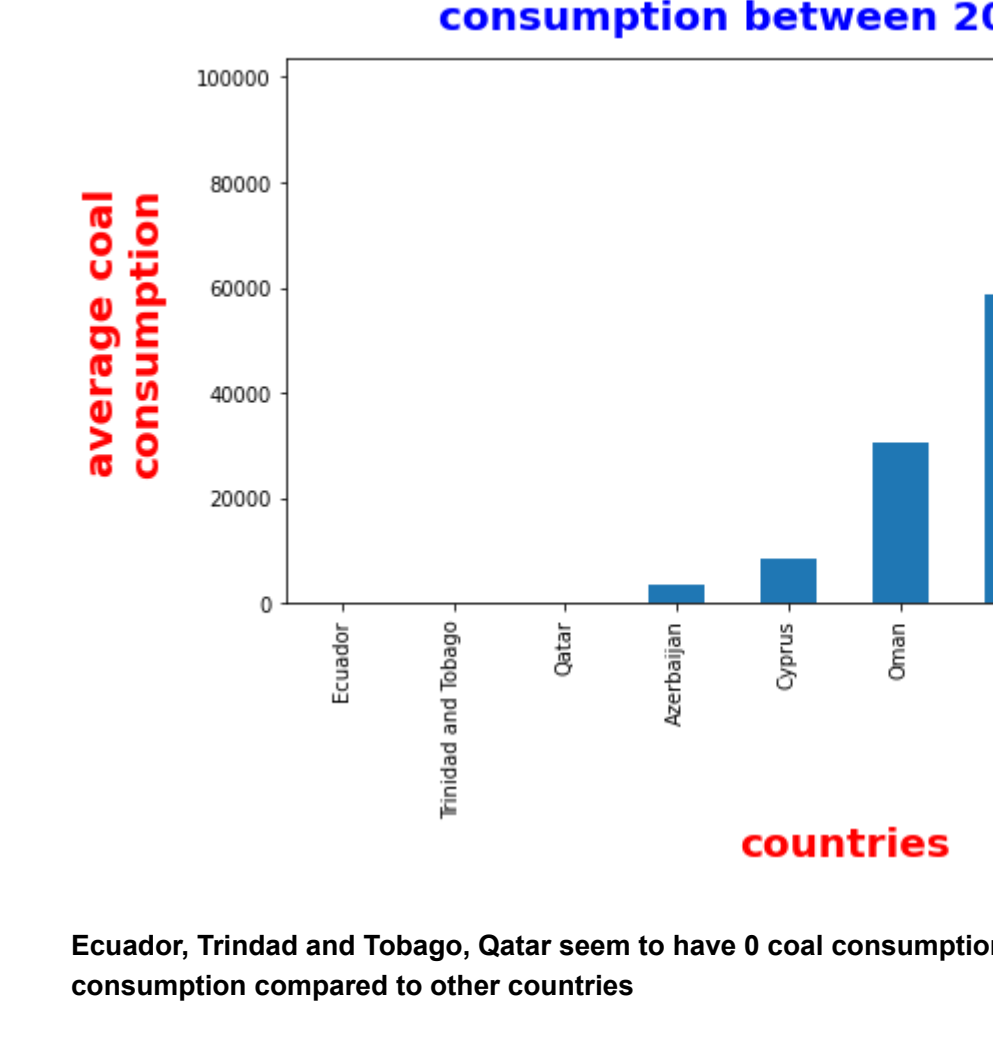
In [20]:
```
countries_plot('coal', True, 'coal\nconsumption', 'lowest')
```



Ecuador, Trindad and Tobago, Qatar seem to have 0 coal consumption and the other countries in the plot have lesser coal consumption compared to other countries

Oil consumption

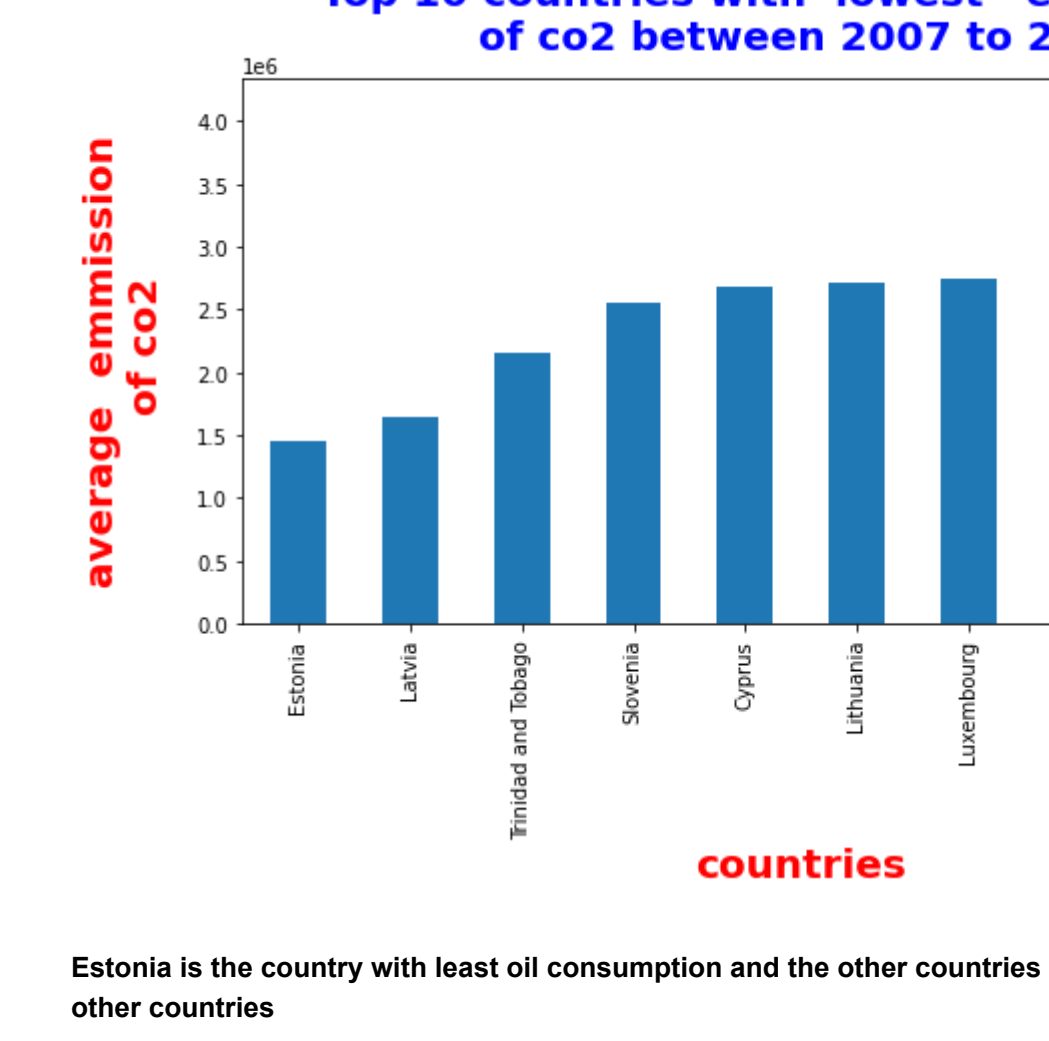
In [21]:
```
countries_plot('oil', True, ' emmission \n of co2', 'lowest')
```



Estonia is the country with least oil consumption and the other countries in the plot have lesser oil consumption compared to other countries

co2 emmissions

In [22]:
```
countries_plot('co2', True, 'emmission of co2', 'lowest')
```

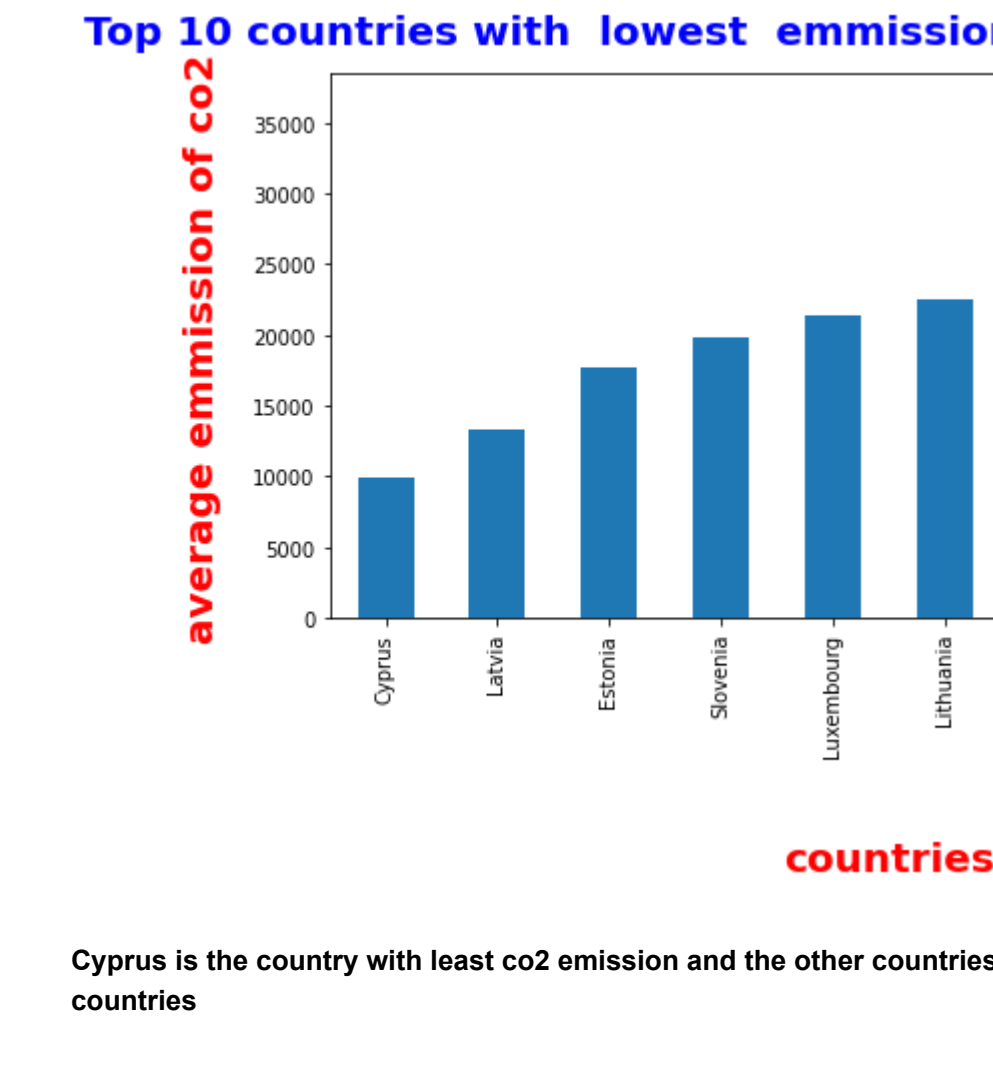


Cyprus is the country with least co2 emission and the other countries in the plot have lesser co2 emission compared to other countries

top 10 countries that have the highest coal consumption, oil consumption and emmission of co2

coal consumption

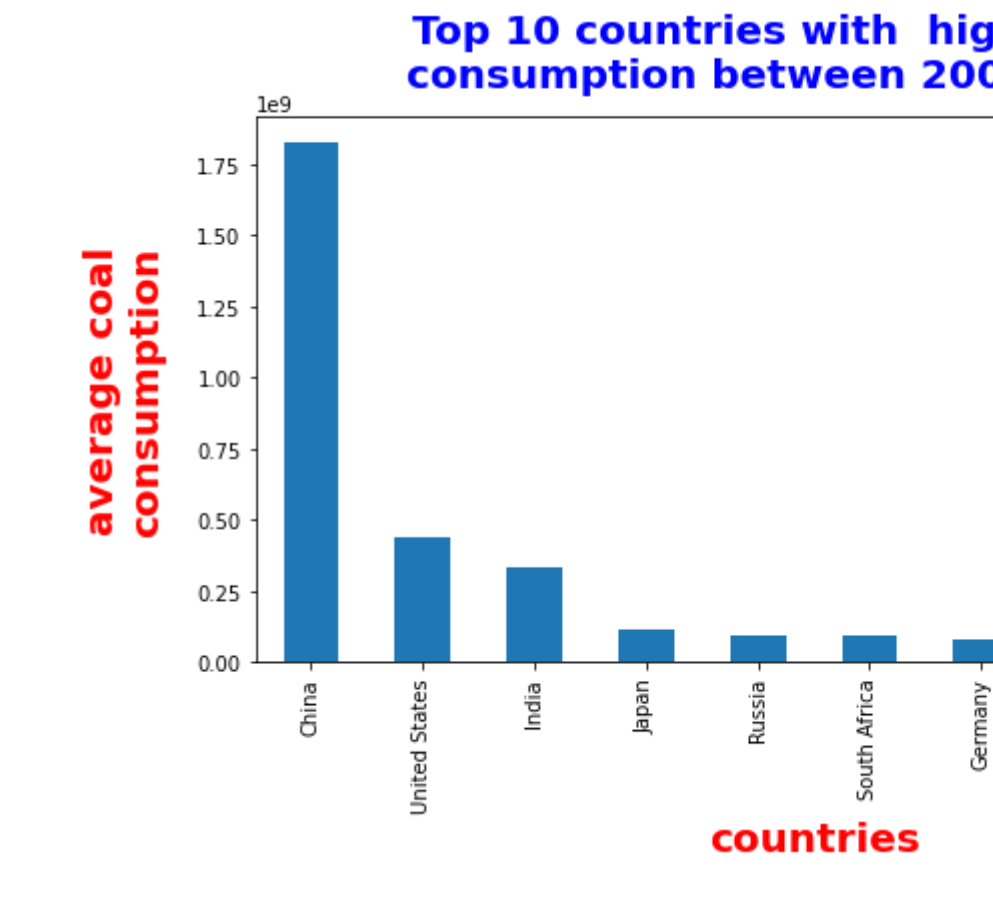
In [23]:
```
countries_plot('coal', False, 'coal\nconsumption', 'highest')
```



United States, china have the highest consumption.

Oil consumption

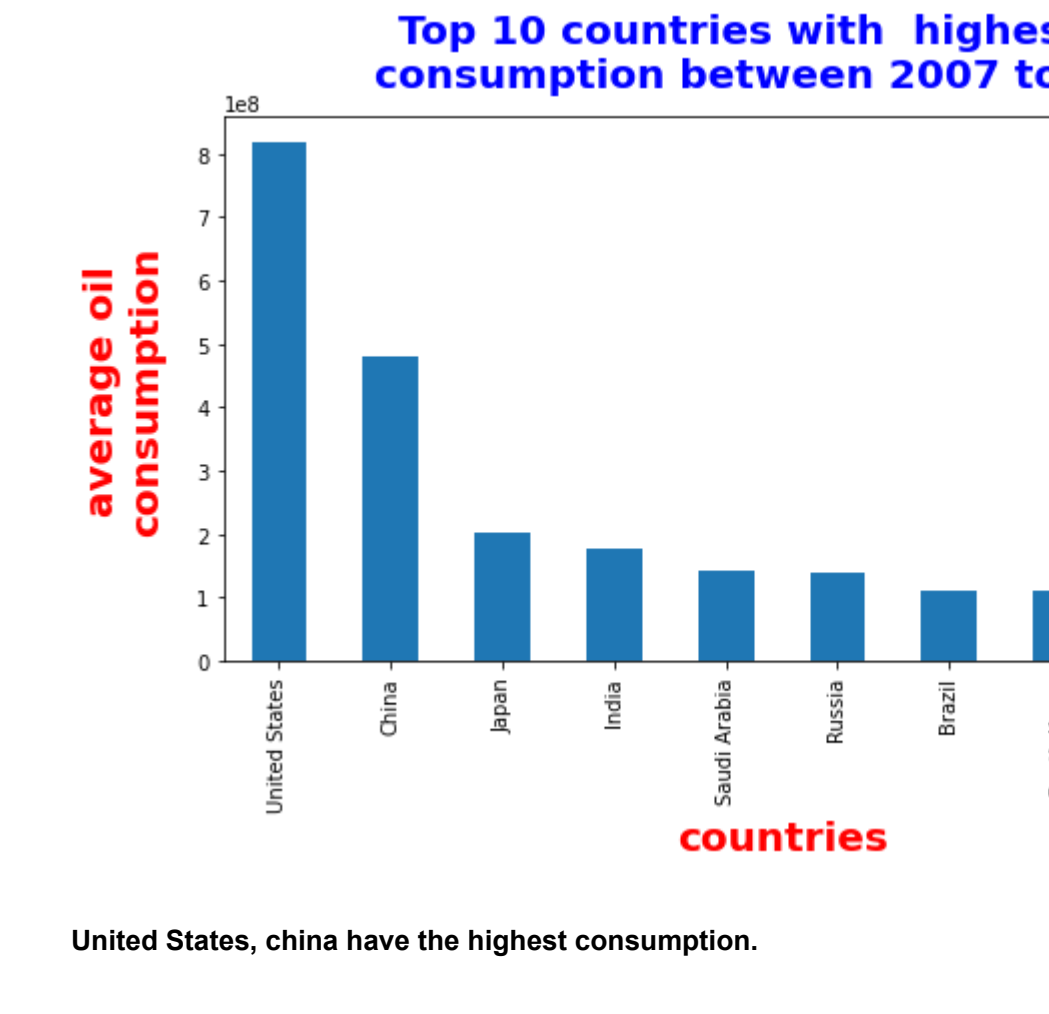
In [24]:
```
countries_plot('oil', False, 'oil\nconsumption', 'highest')
```



United States, china have the highest consumption.

co2 emmissions

In [25]:
```
countries_plot('co2', False, 'emission of co2', 'highest')
```



United States, china have the highest emission.

Because United States, china, india, Japan have both high consumption and emission.I want to check the relationship of the three indicators in these countries during the decade

In [26]:
```
def count(df, countryname):
  country_data = df.query(countryname)
  country_data =country_data[df.columns[1:].to_list()]
  country_data.index = country_data['year']
  country_data = country_data.drop(['year'], axis = 1)
  return country_data
```

In [27]:
```
def rel_plot(df, country):
  df.plot(subplots = True, figsize = (10,8), title =[f'consumption of coal in {country}',
      f'consumption of oil in {country}',
     f'emmission of co2 in {country}'],)
```

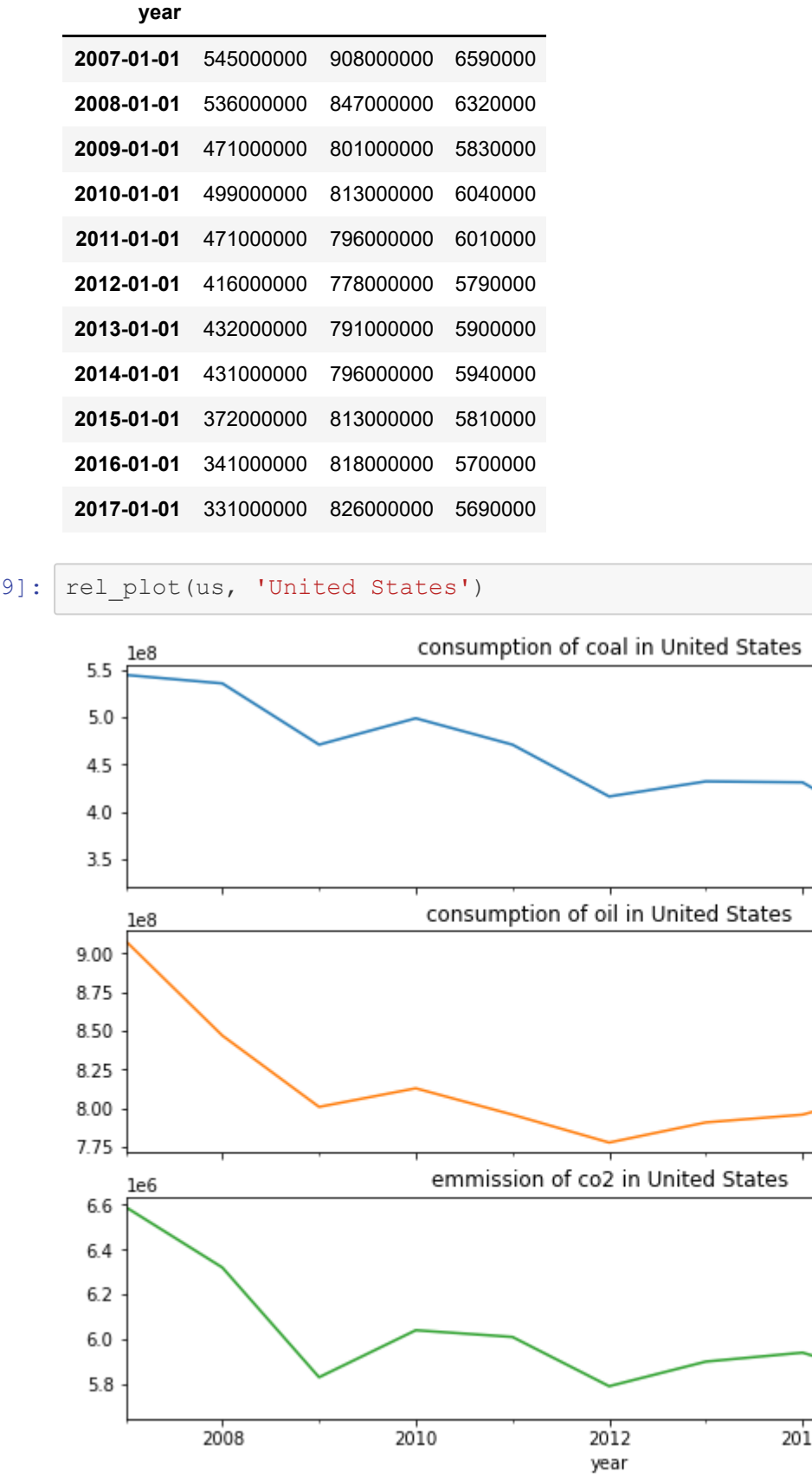
Data on United States

In [28]:
```
us = count(df = data, countryname = "country == 'United States'")
us
```

Out[28]:

year	coal	oil	co2
2007-01-01	545000000	908000000	6590000
2008-01-01	536000000	847000000	6320000
2009-01-01	471000000	801000000	5830000
2010-01-01	499000000	813000000	6040000
2011-01-01	471000000	796000000	6010000
2012-01-01	416000000	778000000	5790000
2013-01-01	432000000	791000000	5900000
2014-01-01	431000000	796000000	5940000
2015-01-01	372000000	813000000	5810000
2016-01-01	341000000	818000000	5700000
2017-01-01	331000000	826000000	5690000

In [29]:
```
rel_plot(us, 'United States')
```



There seems to b e positive correlation between the three indicators in United States

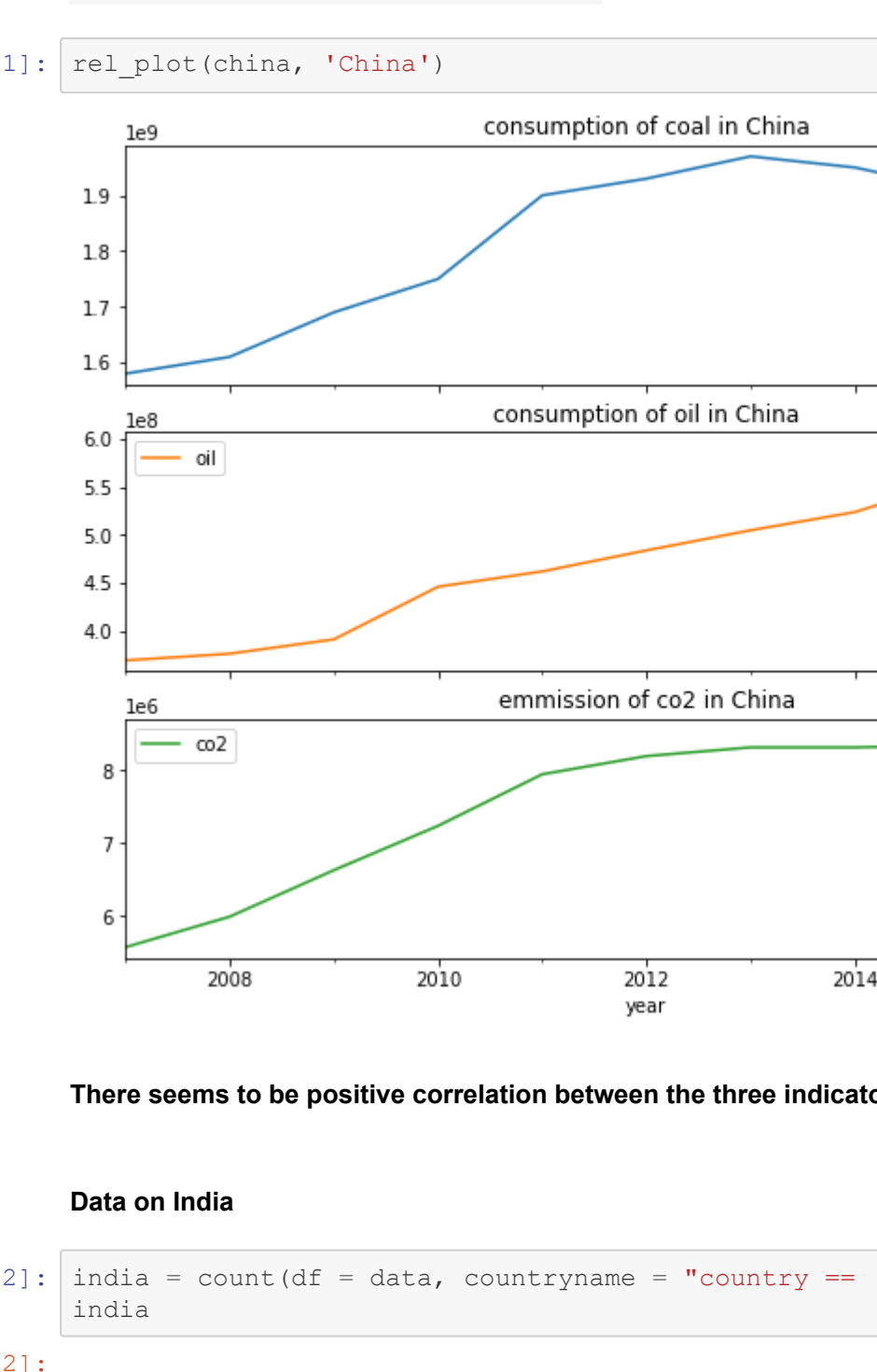
Data on China

In [30]:
```
china = count(df = data, countryname = "country == 'China'")
china
```

Out[30]:

year	coal	oil	co2
2007-01-01	1580000000	369000000	5570000
2008-01-01	1610000000	376000000	5990000
2009-01-01	1690000000	391000000	6630000
2010-01-01	1750000000	446000000	7240000
2011-01-01	1900000000	462000000	7950000
2012-01-01	1930000000	484000000	8199999
2013-01-01	1970000000	505000000	8320000
2014-01-01	1950000000	524000000	8320000
2015-01-01	1910000000	558000000	8350000
2016-01-01	1890000000	571000000	8470000
2017-01-01	1890000000	596000000	8560000

In [31]:
```
rel_plot(china, 'China')
```



There seems to be positive correlation between the three indicators in China

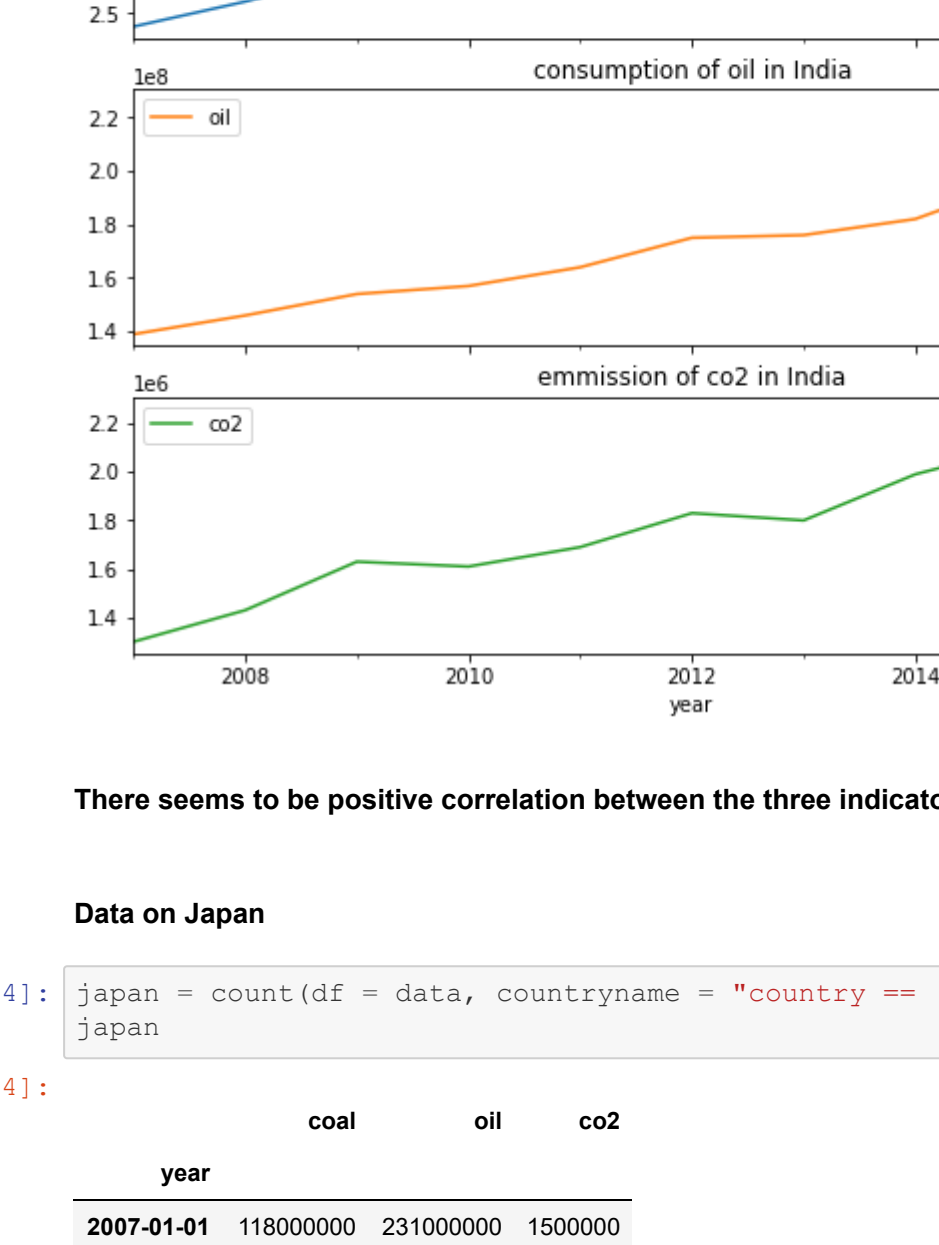
Data on India

In [32]:
```
india = count(df = data, countryname = "country == 'India'")
india
```

Out[32]:

year	coal	oil	co2
2007-01-01	240000000	139000000	1300000
2008-01-01	259000000	146000000	1430000
2009-01-01	281000000	154000000	1630000
2010-01-01	290000000	157000000	1610000
2011-01-01	305000000	164000000	1690000
2012-01-01	330000000	175000000	1830000
2013-01-01	353000000	176000000	1800000
2014-01-01	388000000	182000000	1990000
2015-01-01	395000000	197000000	2110000
2016-01-01	403000000	218000000	2180000
2017-01-01	417000000	226000000	2260000

In [33]:
```
rel_plot(india, 'India')
```



There seems to be positive correlation between the three indicators in India

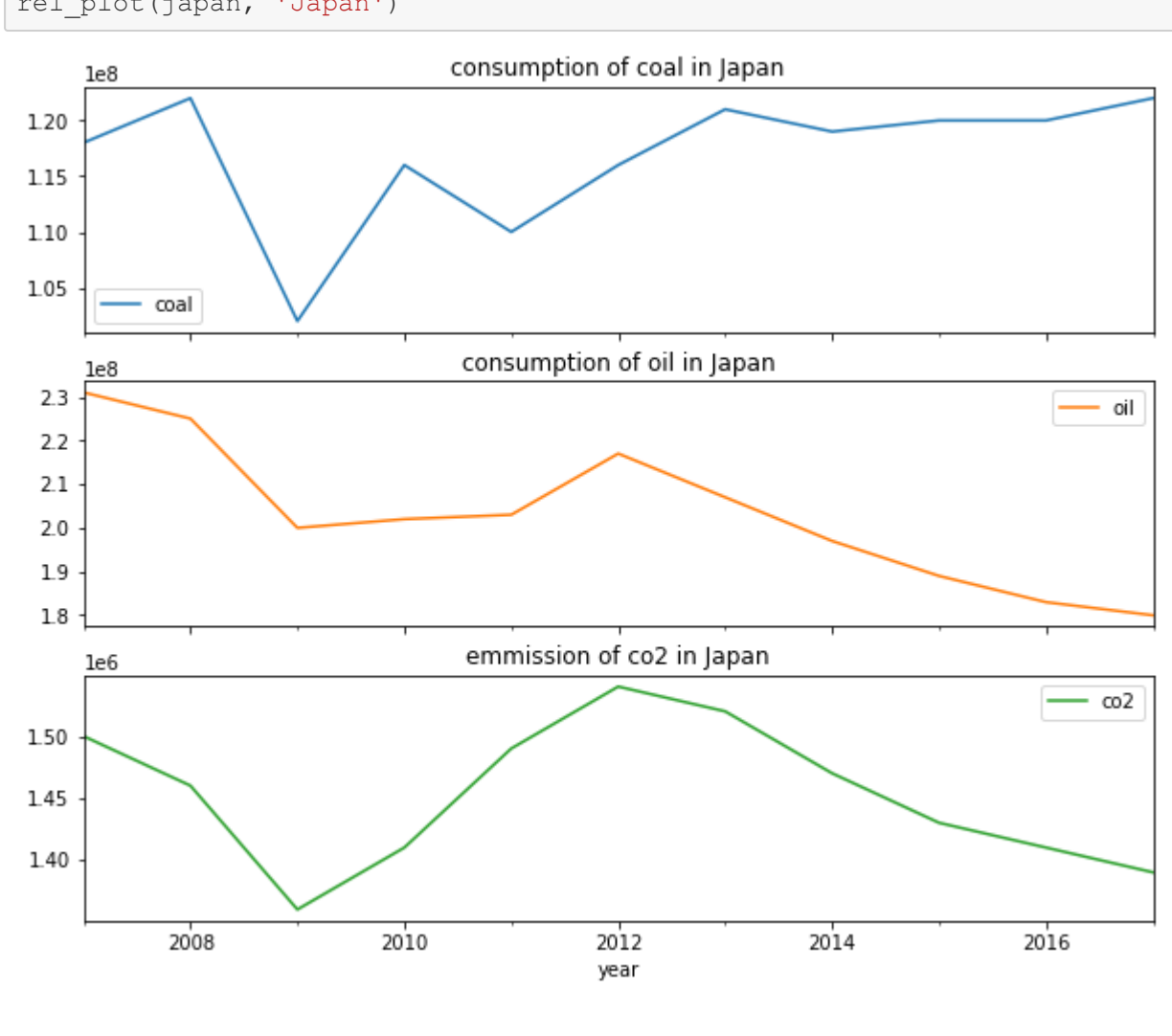
Data on Japan

In [34]:
```
japan = count(df = data, countryname = "country == 'Japan'")
japan
```

Out[34]:

year	coal	oil	co2
2007-01-01	118000000	231000000	1500000
2008-01-01	122000000	225000000	1460000
2009-01-01	102000000	200000000	1360000
2010-01-01	116000000	202000000	1410000
2011-01-01	110000000	203000000	1490000
2012-01-01	116000000	217000000	1540000
2013-01-01	121000000	207000000	1520000
2014-01-01	119000000	197000000	1470000
2015-01-01	120000000	189000000	1430000
2016-01-01	120000000	183000000	1410000
2017-01-01	122000000	180000000	1390000

```
In [35]: rel_plot(japan, 'Japan')
```



There seems to be positive correlation between the three indicators in Japan

Conclusion

From the analysis:

> - Analysis were made on the trend in consumption of coal and oil,co2 emission between 2007 and 2017.
> - Analysis were made to check countries with low and high consumption of coal and oil,co2 emission between 2007 and 2017.
> - It seems the consumption of oil has more effect than coal consumption on co2 emission.
> - More focus should be on United States, china, india, Japan to get more insights on why they have high co2 emission and solve environmental problems.
> - From 2009 there has been exponential growth in consumption of coal and oil,co2 emission.
> - A limitation faced is getting enough data on indicators related to co2 emission.