project2

February 10, 2025

PROJECT 2: VISUALIZATION OF WORLD GDP AND CARBON - DIOXIDE EMISSION

[9]:

```python
import pandas as pd
import numpy as np
import random
import matplotlib.pyplot as plt
import matplotlib.cbook
import zipfile
import bz2
import warnings
```

[10]:

```python
#warnings.filterwarnings("ignore",category=matplotlib.cbook.mplDeprecation)
#Let us read the dataset
data = pd.read_csv('Indicators.bz2')

#data = pd.read_csv('data/Indicators.bz2', compression = 'bz2')
print("data.shape: ", data.shape)

#This is a really large dataset, at least in terms of the number of rows.
print("Sample Data: \n",data.head())
print("Columns: \n",data.columns)

#How many UNIQUE country names are there ?
countries = data['CountryName'].unique().tolist()
print("Number of countries: ",len(countries))

#Are there same number of country codes ?
#How many unique country codes are there?
#It should be the same as number of unique countries.
countryCodes = data['CountryCode'].unique().tolist()
print("Number of country codes: ",len(countryCodes))

#Are there many indicators or few ?
#How many unique indicators are there?
indicators = data['IndicatorName'].unique().tolist()
print("Number of indicators: ",len(indicators))

#How many years of data do we have ?
```

```python
years = data['Year'].unique().tolist()
print("Number of years: ",len(years))

#What's the range of years?
print(min(years)," to ",max(years))
hist_indicator = 'CO2 emissions \(metric'
hist_country = 'USA'
mask1 = data['IndicatorName'].str.contains(hist_indicator)
mask2 = data['CountryCode'].str.contains(hist_country)
stage = data[mask1 & mask2]

# stage dataset contain indicators matching the USA for country code & CO2
#emissions over time.
print (stage.shape)
stage.head()
```

```
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<>:33: SyntaxWarning: invalid escape sequence '\('
C:\Users\ADMIN\AppData\Local\Temp\ipykernel_7444\3798847121.py:33:
SyntaxWarning: invalid escape sequence '\('
  hist_indicator = 'CO2 emissions \(metric'

data.shape:  (5656458, 6)
Sample Data:
   CountryName CountryCode                                      IndicatorName  \
0   Arab World         ARB  Adolescent fertility rate (births per 1,000 wo…
1   Arab World         ARB  Age dependency ratio (% of working-age populat…
2   Arab World         ARB  Age dependency ratio, old (% of working-age po…
3   Arab World         ARB  Age dependency ratio, young (% of working-age …
4   Arab World         ARB        Arms exports (SIPRI trend indicator values)

    IndicatorCode  Year         Value
0     SP.ADO.TFRT  1960  1.335609e+02
1     SP.POP.DPND  1960  8.779760e+01
2  SP.POP.DPND.OL  1960  6.634579e+00
3  SP.POP.DPND.YG  1960  8.102333e+01
4  MS.MIL.XPRT.KD  1960  3.000000e+06
Columns:
 Index(['CountryName', 'CountryCode', 'IndicatorName', 'IndicatorCode', 'Year',
       'Value'],
      dtype='object')
Number of countries:  247
Number of country codes:  247
Number of indicators:  1344
Number of years:  56
1960  to  2015
(52, 6)
```
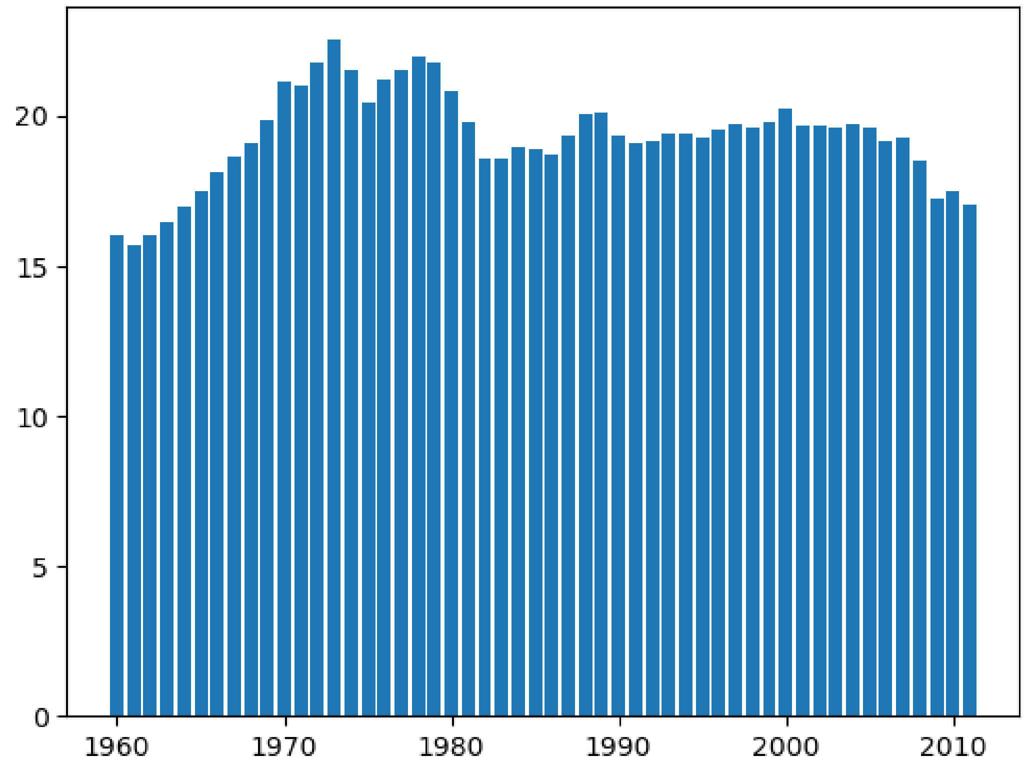

[10]:

```
            CountryName CountryCode                             IndicatorName  \
22232   United States         USA  CO2 emissions (metric tons per capita)
48708   United States         USA  CO2 emissions (metric tons per capita)
77087   United States         USA  CO2 emissions (metric tons per capita)
105704  United States         USA  CO2 emissions (metric tons per capita)
134742  United States         USA  CO2 emissions (metric tons per capita)

          IndicatorCode  Year      Value
22232   EN.ATM.CO2E.PC  1960  15.999779
48708   EN.ATM.CO2E.PC  1961  15.681256
77087   EN.ATM.CO2E.PC  1962  16.013937
105704  EN.ATM.CO2E.PC  1963  16.482762
134742  EN.ATM.CO2E.PC  1964  16.968119
```

[11]:

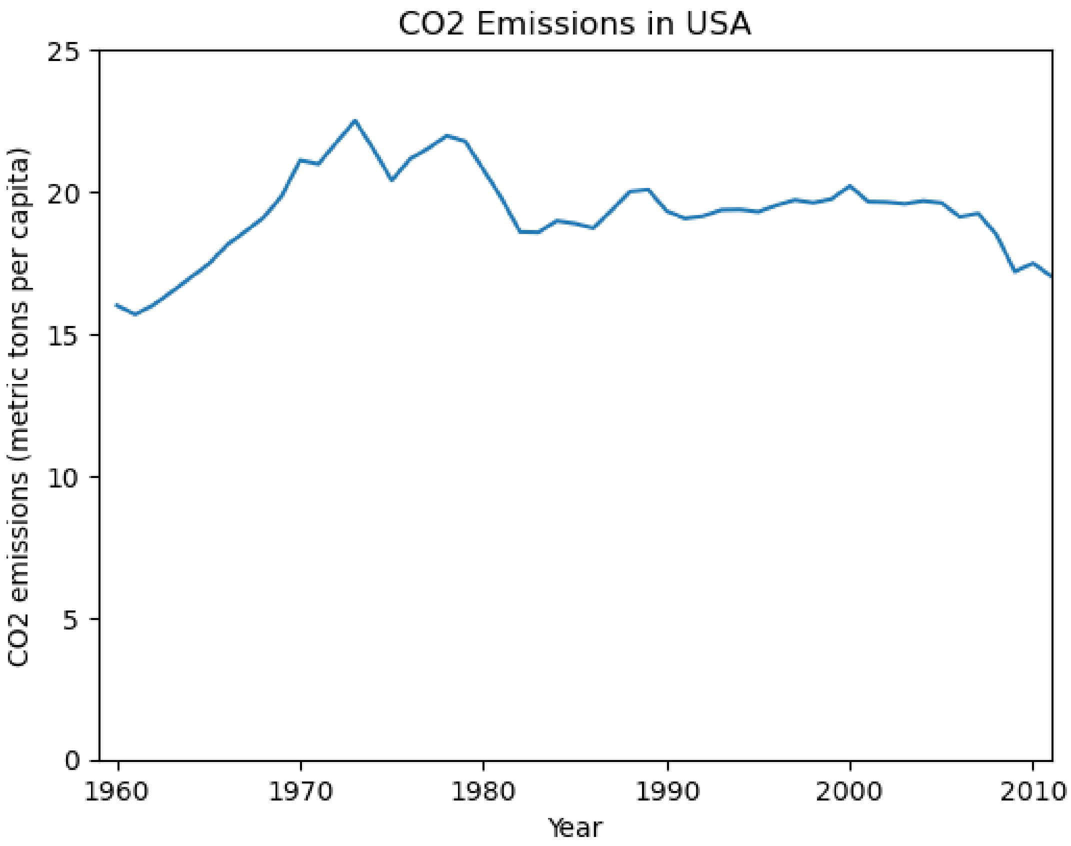
```python
print("Indicator Name: ", stage['IndicatorName'].iloc[0])

#Let us see how emissions have changed over time using MatplotLib
years = stage['Year'].values # get the years
co2 = stage['Value'].values # get the values

# Plot the Histogram
plt.bar(years,co2)
plt.show()
```

```
Indicator Name:  CO2 emissions (metric tons per capita)
```



[13]:

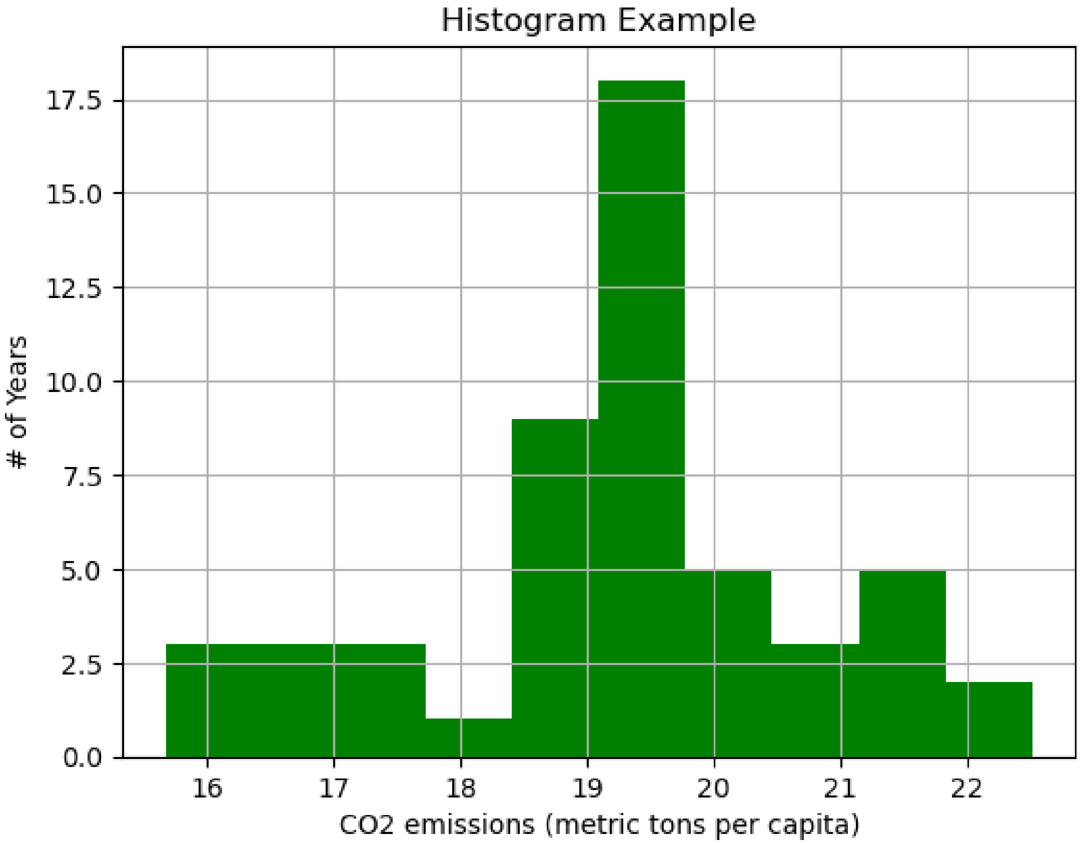
```
#It is seen that emissions per capita have dropped a bit over time,
# but let us make this graph a bit more appealing before we continue to
#explore it.
#Let us create a line plot.
plt.plot(stage['Year'].values, stage['Value'].values)

# Label the axes
plt.xlabel('Year')
plt.ylabel(stage['IndicatorName'].iloc[0])

# Label the figure
plt.title('CO2 Emissions in USA')

# Start the y axis at 0 and x axis from 1959
plt.axis([1959, 2011,0,25])
plt.show()
```



[15]:

```
#Using Histograms to explore the distribution of values
# lower = stage['Value'].mean() - stage['Value'].std()
# upper = stage['Value'].mean() + stage['Value'].std()
# hist_data = [x for x in stage[:10000]['Value'] if x>lower and x<upper ]
# Otherwise, let's look at all the data
hist_data = stage['Value'].values
print(hist_data)
print(len(hist_data))
# Histogram of the data
plt.hist(hist_data, 10, density=False, facecolor='green') # 10 is the number of␣
 ↪bins
plt.xlabel(stage['IndicatorName'].iloc[0])
plt.ylabel('# of Years')
plt.title('Histogram Example')
plt.grid(True)
plt.show()
```

```
[15.99977916 15.68125552 16.0139375  16.48276215 16.96811858 17.45172525
 18.12107301 18.59831788 19.08938916 19.85794566 21.11125227 20.98020348
 21.74864198 22.51058213 21.50293038 20.40222407 21.15761537 21.53248401
 21.97300469 21.78043698 20.78648774 19.76676417 18.59049523 18.57154371
 18.97675027 18.88231274 18.72072272 19.35033442 20.01041341 20.07576978
 19.32336817 19.06223666 19.14555576 19.36346258 19.37655644 19.29565986
 19.52789051 19.71427574 19.6151546  19.74781478 20.20761476 19.65619321
 19.63919577 19.57623905 19.68358135 19.61027504 19.11613882 19.23746045
 18.48923375 17.1923791  17.48479218 17.02021634]
52
```



[17]:
```
#USA has many years where it produced between 19-20 metric tons per capita with␣
 ↪outliers on either side.
#But how do the USA's numbers relate to those of other countries?
# select CO2 emissions for all countries in 2011
hist_indicator = 'CO2 emissions \(metric'
hist_year = 2011
mask1 = data['IndicatorName'].str.contains(hist_indicator)
mask2 = data['Year'].isin([hist_year])
# apply our mask
co2_2011 = data[mask1 & mask2]
co2_2011.head()
```

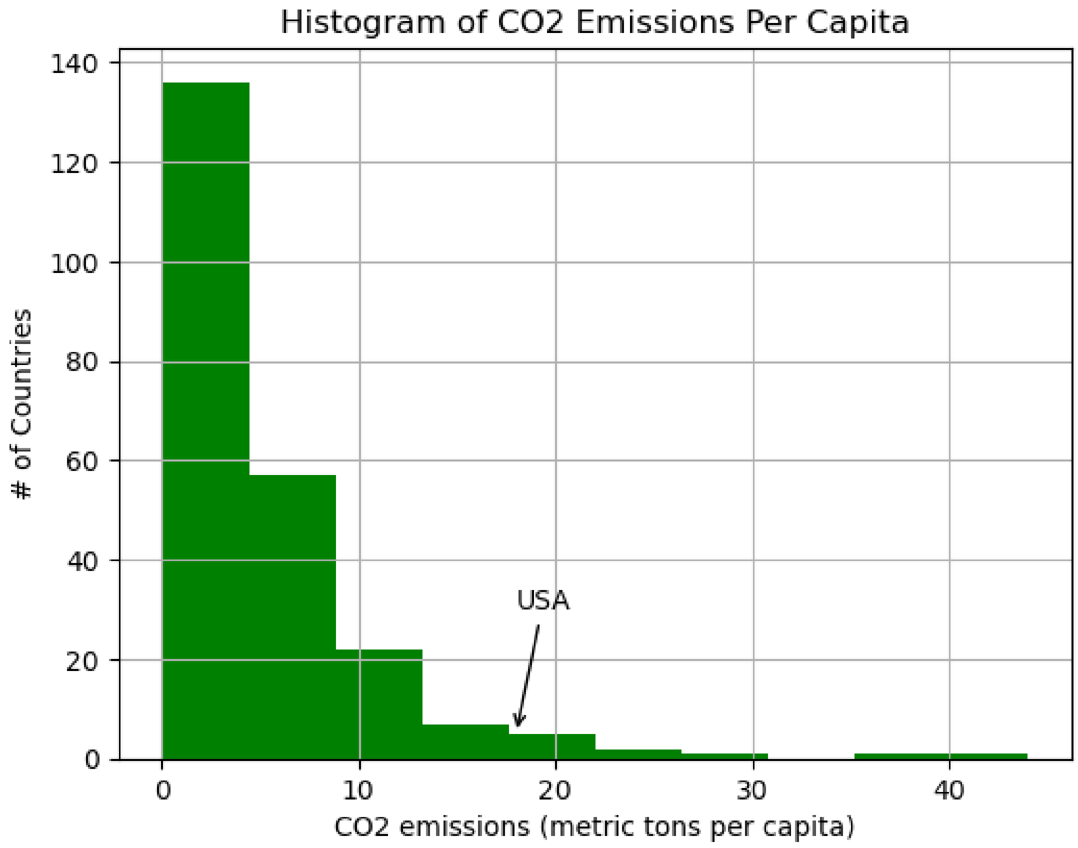
```
<>:4: SyntaxWarning: invalid escape sequence '\('
<>:4: SyntaxWarning: invalid escape sequence '\('
C:\Users\ADMIN\AppData\Local\Temp\ipykernel_7444\3606109019.py:4: SyntaxWarning:
invalid escape sequence '\('
  hist_indicator = 'CO2 emissions \(metric'
```

[17]:
```
                                     CountryName CountryCode  \
5026275                               Arab World         ARB
```

```
5026788                   Caribbean small states         CSS
5027295           Central Europe and the Baltics         CEB
5027870  East Asia & Pacific (all income levels)         EAS
5028456    East Asia & Pacific (developing only)         EAP

                                  IndicatorName   IndicatorCode  Year  \
5026275  CO2 emissions (metric tons per capita)  EN.ATM.CO2E.PC  2011
5026788  CO2 emissions (metric tons per capita)  EN.ATM.CO2E.PC  2011
5027295  CO2 emissions (metric tons per capita)  EN.ATM.CO2E.PC  2011
5027870  CO2 emissions (metric tons per capita)  EN.ATM.CO2E.PC  2011
5028456  CO2 emissions (metric tons per capita)  EN.ATM.CO2E.PC  2011

            Value
5026275  4.724500
5026788  9.692960
5027295  6.911131
5027870  5.859548
5028456  5.302499
```

[23]:

```python
# Let us plot a histogram of the emmissions per capita by country
# subplots returns a touple with the figure, axis attributes.
fig, ax = plt.subplots()
ax.annotate("USA",xy=(18, 5), xycoords='data',xytext=(18, 30),
textcoords='data',
arrowprops=dict(arrowstyle="->",connectionstyle="arc3"))
plt.hist(co2_2011['Value'], 10, density=False, facecolor='green')
plt.xlabel(stage['IndicatorName'].iloc[0])
plt.ylabel('# of Countries')
plt.title('Histogram of CO2 Emissions Per Capita')
plt.grid(True)
plt.show()
```



[26]:
```
#USA, at ~18 CO2 emissions (metric tons per capital) is quite high among all␣
 ↪countries.

#3. Matplotlib: Basic Plotting Part 2
#Relationship between GPD and CO2 Emissions in USA
# Select GDP Per capita emissions for the United States
hist_indicator = 'GDP per capita \(constant 2005'
hist_country = 'USA'
mask1 = data['IndicatorName'].str.contains(hist_indicator)
mask2 = data['CountryCode'].str.contains(hist_country)

# Stage is just those indicators matching the USA for country code and CO2␣
 ↪emissions over time.
gdp_stage = data[mask1 & mask2]

# Plot gdp_stage vs stage
print("GDP: ",gdp_stage.head())
stage.head()
```

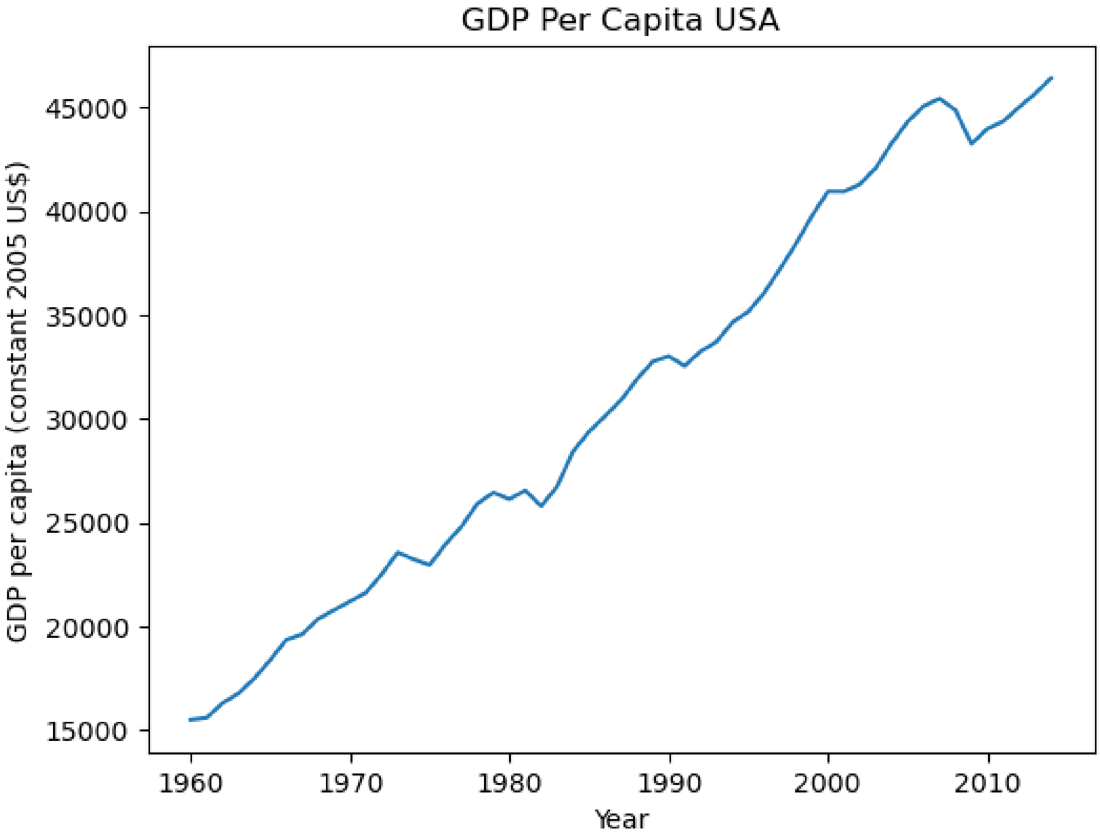
```
# Switch to a line plot
plt.plot(gdp_stage['Year'].values, gdp_stage['Value'].values)
# Label the axes
plt.xlabel('Year')
plt.ylabel(gdp_stage['IndicatorName'].iloc[0])

#Label the figure
plt.title('GDP Per Capita USA')
plt.show()
```

```
<>:6: SyntaxWarning: invalid escape sequence '\('
<>:6: SyntaxWarning: invalid escape sequence '\('
C:\Users\ADMIN\AppData\Local\Temp\ipykernel_7444\514627034.py:6: SyntaxWarning:
invalid escape sequence '\('
  hist_indicator = 'GDP per capita \(constant 2005'
```

```
GDP:            CountryName CountryCode                       IndicatorName  \
22282   United States         USA   GDP per capita (constant 2005 US$)
48759   United States         USA   GDP per capita (constant 2005 US$)
77142   United States         USA   GDP per capita (constant 2005 US$)
105760  United States         USA   GDP per capita (constant 2005 US$)
134798  United States         USA   GDP per capita (constant 2005 US$)

         IndicatorCode  Year         Value
22282   NY.GDP.PCAP.KD  1960  15482.707760
48759   NY.GDP.PCAP.KD  1961  15578.409657
77142   NY.GDP.PCAP.KD  1962  16276.426685
105760  NY.GDP.PCAP.KD  1963  16749.789436
134798  NY.GDP.PCAP.KD  1964  17476.822248
```



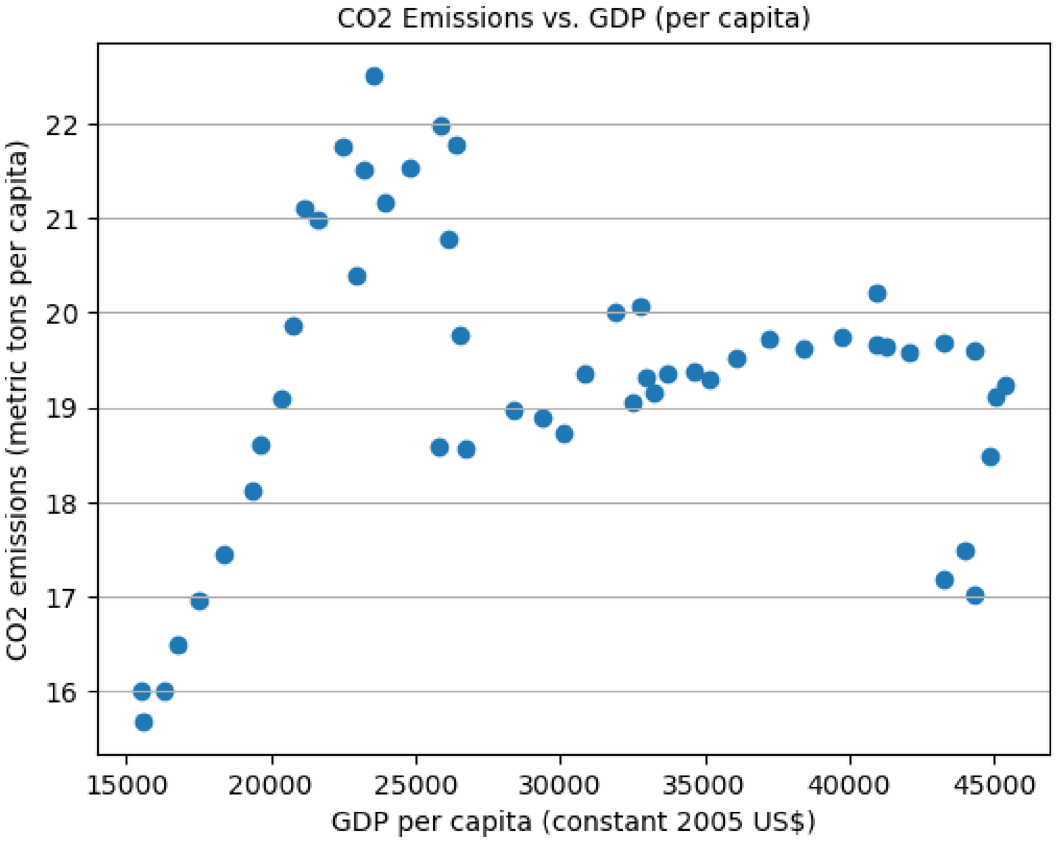
[27]:

```
#Although we have seen a decline in the CO2 emissions per capita,
# it does not seem to translate to a decline in GDP per capita
#ScatterPlot for comparing GDP against CO2 emissions (per capita)
#First, we will need to make sure we are looking at the same time frames.
print("GDP Min Year = ", gdp_stage['Year'].min(), "max: ",
gdp_stage['Year'].max())
print("CO2 Min Year = ", stage['Year'].min(), "max: ", stage['Year'].max())

#We have 3 extra years of GDP data, so let's trim those off so the scatterplot
# has equal length arrays to compare (this is actually required by scatterplot)
gdp_stage_trunc = gdp_stage[gdp_stage['Year'] < 2012]
print(len(gdp_stage_trunc))
print(len(stage))
import matplotlib.pyplot as plt
fig, axis = plt.subplots()
axis.yaxis.grid(True)
axis.set_title('CO2 Emissions vs. GDP (per capita)',fontsize=10)
axis.set_xlabel(gdp_stage_trunc['IndicatorName'].iloc[0],fontsize=10)
axis.set_ylabel(stage['IndicatorName'].iloc[0],fontsize=10)
X = gdp_stage_trunc['Value']
```

```
Y = stage['Value']
axis.scatter(X, Y)
plt.show()
```

```
GDP Min Year =  1960 max:  2014
CO2 Min Year =  1960 max:  2011
52
52
```



[28]:

```
#This does not look like a strong relationship. We can test this by looking at␣
  ↪correlation.
print(np.corrcoef(gdp_stage_trunc['Value'],stage['Value']))
#A correlation of 0.07 is very weak.
```

```
[[1.         0.07676005]
 [0.07676005 1.        ]]
```

Dataset Overview

Total Records: 5,656,458 Countries Covered: 247 Indicators Tracked: 1,344 Years Covered: 1960 to 2015

Main Indicators:

CO Emissions: (metric tons per person) GDP per Capita: (constant 2005 US dollars)

Key Observations The dataset includes 52 data points for GDP and CO emissions.

Correlation between GDP and CO emissions:

[[1. 0.07676005] [0.07676005 1.]] This shows a weak link between economic growth and carbon emissions.

Summary

The USA had steady GDP growth from 1960 to 2014. CO emissions data is available till 2011, showing different trends in various regions. Rich countries had higher CO emissions, while developing countries had lower emissions. Some regions, like East Asia & Pacific and the Arab World, saw increasing emissions over time.

Conclusion

This report gives a simple view of GDP and CO emissions trends. The weak connection between them suggests that factors like energy use, technology, and policies also affect emissions. A deeper study can focus on country-wise trends and ways to control carbon output while growing the economy.

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[ ]:
```