DSE_200X_FinalProject_COVI19 outbreak predictions using linear regression model_Ong June Young

April 9, 2020

[1]:
```
# import necessary libraries
import json, urllib.request
import csv, requests
import branca, folium, pycountry
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import pycountry_convert as pc
from datetime import datetime
from folium.features import Choropleth
from IPython.display import display
from sklearn.model_selection import train_test_split
from sklearn.linear_model import LinearRegression

%matplotlib inline
```

Load the shape of world map, the source of data can be found below:- Source of JSON file: https://github.com/python-visualization/folium/tree/master/examples/data

Load the time series for COVID-19 cases, the source of data can be found below:- Time series data set: https://github.com/CSSEGISandData/COVID-19/tree/master/csse_covid_19_data/csse_covid_19_time_series

[2]:
```
# JSON file to plot a world map
json_url = 'https://raw.githubusercontent.com/python-visualization/folium/
 ↪master/examples/data/world-countries.json'

# Link to download datasets for confirmed cases, death cases and recovered␣
 ↪cases.
url = "https://raw.githubusercontent.com/CSSEGISandData/COVID-19/master/
 ↪csse_covid_19_data/csse_covid_19_time_series/"


with urllib.request.urlopen(json_url) as parse_url:
    geo_json = json.loads(parse_url.read().decode())
```

```
confirmed_cases = pd.read_csv("{}/{}".format(url,␣
↪'time_series_covid19_confirmed_global.csv'),
                              error_bad_lines=False)
death_reported = pd.read_csv("{}/{}".format(url,␣
↪'time_series_covid19_deaths_global.csv'),
                              error_bad_lines=False)
recovered_cases = pd.read_csv("{}/{}".format(url,␣
↪'time_series_covid19_recovered_global.csv'),
                              error_bad_lines=False)
```

Checking the 1st 4 columns ('Province/State', 'Country/Region', 'Lat', 'Long') and the last columns (i.e. the latest date posted) whether it is empty. The output below shown all these 5 columns "False" as there are not empty cells.

[3]:
```
confirmed_cases.isnull().any()
#death_reported.isnull().any()
#recovered_cases.isnull().any()
```

[3]:
```
Province/State     True
Country/Region    False
Lat               False
Long              False
1/22/20           False
                  …
4/4/20            False
4/5/20            False
4/6/20            False
4/7/20            False
4/8/20            False
Length: 82, dtype: bool
```

[4]:
```
confirmed_cases.columns
#death_reported.columns
#recovered_cases.columns
```

[4]:
```
Index(['Province/State', 'Country/Region', 'Lat', 'Long', '1/22/20', '1/23/20',
       '1/24/20', '1/25/20', '1/26/20', '1/27/20', '1/28/20', '1/29/20',
       '1/30/20', '1/31/20', '2/1/20', '2/2/20', '2/3/20', '2/4/20', '2/5/20',
       '2/6/20', '2/7/20', '2/8/20', '2/9/20', '2/10/20', '2/11/20', '2/12/20',
       '2/13/20', '2/14/20', '2/15/20', '2/16/20', '2/17/20', '2/18/20',
       '2/19/20', '2/20/20', '2/21/20', '2/22/20', '2/23/20', '2/24/20',
       '2/25/20', '2/26/20', '2/27/20', '2/28/20', '2/29/20', '3/1/20',
       '3/2/20', '3/3/20', '3/4/20', '3/5/20', '3/6/20', '3/7/20', '3/8/20',
       '3/9/20', '3/10/20', '3/11/20', '3/12/20', '3/13/20', '3/14/20',
       '3/15/20', '3/16/20', '3/17/20', '3/18/20', '3/19/20', '3/20/20',
       '3/21/20', '3/22/20', '3/23/20', '3/24/20', '3/25/20', '3/26/20',
```

```
       '3/27/20', '3/28/20', '3/29/20', '3/30/20', '3/31/20', '4/1/20',
       '4/2/20', '4/3/20', '4/4/20', '4/5/20', '4/6/20', '4/7/20', '4/8/20'],
      dtype='object')
```

Because we need only the latest updates of the total cases, slicing the data is necessary. We need to perform data cleaning and left only the first 4 columns and last column of datasets. Please see below.

[5]:
```
features = [confirmed_cases.columns[i] for i in (0,1,2,3,-1)]
features
```

[5]:
```
['Province/State', 'Country/Region', 'Lat', 'Long', '4/8/20']
```

[6]:
```
latest_confirmed_cases = confirmed_cases[confirmed_cases[features[-1]] != 0].
 ↪copy()
latest_confirmed_cases = latest_confirmed_cases[features]
latest_confirmed_cases['LogValue'] = np.
 ↪log(latest_confirmed_cases[features[-1]])
latest_confirmed_cases.nlargest(10, [features[-1]])
```

[6]:

	Province/State	Country/Region	Lat	Long	4/8/20	LogValue
225	NaN	US	37.0902	-95.7129	429052	12.969333
201	NaN	Spain	40.0000	-4.0000	148220	11.906453
137	NaN	Italy	43.0000	12.0000	139422	11.845261
120	NaN	Germany	51.0000	9.0000	113296	11.637759
116	NaN	France	46.2276	2.2137	112950	11.634701
62	Hubei	China	30.9756	112.2707	67803	11.124362
133	NaN	Iran	32.0000	53.0000	64586	11.075753
223	NaN	United Kingdom	55.3781	-3.4360	60733	11.014242
213	NaN	Turkey	38.9637	35.2433	38226	10.551271
23	NaN	Belgium	50.8333	4.0000	23403	10.060619

[7]:
```
latest_confirmed_cases.describe()
```

[7]:

	Lat	Long	4/8/20	LogValue
count	261.000000	261.000000	261.000000	261.000000
mean	21.502764	22.237237	5789.670498	5.422398
std	24.803658	71.031114	31583.100626	2.527674
min	-51.796300	-135.000000	1.000000	0.000000
25%	7.540000	-23.041800	32.000000	3.465736
50%	23.685000	20.902977	251.000000	5.525453
75%	41.204400	81.000000	1202.000000	7.091742
max	71.706900	178.065000	429052.000000	12.969333

[8]:
```
# create a std distribution scales based on logarithmic values
scales = list(round(latest_confirmed_cases.LogValue.quantile([0,0.25,0.5,0.75,1.
 ↪0])))
```

```
# I increase scale of the range by 1 to ensure that every time the maximum␣
 ↪value is within the range.
scales[-1] = scales [-1] + 1

scales
```

[8]:
```
[0.0, 3.0, 6.0, 7.0, 14.0]
```

After creating the scales, I divided the Dataframe into 4 groups:

The range of min() value to 25th percentile (lower whisker)

The range of 25th percentile to median (lower half of interquartile range)

The range of median to 75th precentile (upper half of interquartile range)

The range of 75th percentile to max() (upper whisker)

[9]:
```
### based on the scales created, four division is created.
grouplist = {}

for i in range(0,len(scales)-1):
    grouplist[i] = latest_confirmed_cases[
                    (latest_confirmed_cases.LogValue.values >= scales[i]) &
                    (latest_confirmed_cases.LogValue.values < scales[i+1])
                ]

# prefix color code for each group
colorCode = ['#ffffb2','#fecc5c','#fd8d3c','#e31a1c']
```

[10]:
```
# creating the logarithmic scale bar as a legend to be added in folium map
scale_legend = branca.colormap.linear.YlOrRd_09.scale(0,␣
 ↪latest_confirmed_cases[features[-1]].max())
scale_legend = scale_legend.to_step(index=scales, method='log')
scale_legend.caption = "Logarithmical scale for COVID-19 confirmed cases"
scale_legend
```

[10]:
```
<branca.colormap.StepColormap at 0x7fb936d41250>
```

[11]:
```
def addBubbleToMap(df, colorCode):

    for i in range(0, len(df)):

        if str(df.iloc[i]['Province/State']) == 'nan':
            state = 'N/A'
        else:
            state = df.iloc[i]['Province/State']
```

```
        html = """
                    <b>Country/Region</b>: {}<br>
                    <b>Province/State</b>: {}<br>
                    <b>Total Cases</b>   : {}<br>
            """.format(df.iloc[i]['Country/Region'], state, df.
 ↪iloc[i][features[-1]])

        folium.CircleMarker(
            location=(df.Lat.iloc[i], df.Long.iloc[i]),
                popup=folium.Popup(max_width=200,
                                   min_width=10,
                                   html=html
                                  ),
                color=colorCode,
                fill=True,
                fill_color=colorCode,
                radius=float(df.LogValue.iloc[i]*1.8),
                ).add_to(m)
```

[12]:
```
# Plotting a interactive map for covid19 confirmed cases
m = folium.Map(location=[15,0], tiles='cartodbdark_matter', zoom_start=1.5)

title_html = """
                <h3 align="center" style="font-size:10px">
                    <b>Interactive Maps for Coronavirus COVID-19 Confirmed␣
 ↪Cases around the World. (Data as at: {})</b>
                </h3>
            """.format(features[-1])

m.get_root().html.add_child(folium.Element(title_html))

Choropleth(
    geo_data=geo_json,
    name='choropleth',
    key_on='feature.propreties.name',
    fill_color='green',
    nan_fill_color='blue',
    fill_opacity=0.7,
    line_opacity=0.2,
).add_to(m)


scale_legend.add_to(m)

for i in range(0, len(grouplist)):
    addBubbleToMap(grouplist[i], colorCode[i])
```

```
m.save('covid19_confirmed_cases_on_map.html')
#display(m)
```

[13]:
```
duplicated_countries = death_reported[death_reported['Country/Region'].
↪duplicated(keep =False)]['Country/Region'].unique()
duplicated_countries
```

[13]:
```
array(['Australia', 'Canada', 'China', 'Denmark', 'France', 'Netherlands',
       'United Kingdom'], dtype=object)
```

[14]:
```
confirmed_cases[confirmed_cases['Country/Region'] == duplicated_countries[2]].
↪head()
```

[14]:

	Province/State	Country/Region	Lat	Long	1/22/20	1/23/20	\
49	Anhui	China	31.8257	117.2264	1	9	
50	Beijing	China	40.1824	116.4142	14	22	
51	Chongqing	China	30.0572	107.8740	6	9	
52	Fujian	China	26.0789	117.9874	1	5	
53	Gansu	China	37.8099	101.0583	0	2	

	1/24/20	1/25/20	1/26/20	1/27/20	…	3/30/20	3/31/20	4/1/20	4/2/20	\
49	15	39	60	70	…	990	990	990	990	
50	36	41	68	80	…	577	580	580	582	
51	27	57	75	110	…	579	579	579	579	
52	10	18	35	59	…	340	343	345	345	
53	2	4	7	14	…	138	138	138	138	

	4/3/20	4/4/20	4/5/20	4/6/20	4/7/20	4/8/20
49	990	990	990	990	990	990
50	584	585	586	587	587	588
51	579	579	579	579	579	579
52	349	350	350	350	351	351
53	138	138	138	139	139	139

[5 rows x 82 columns]

[15]:
```
def rearrangeDataFrame(df, countries):
    for country in countries:
        # summations of selected rows to become one
        sum_df = df[df['Country/Region'] == str(country)].sum()
        sum_df['Province/State'] = country

        # append the row to the main dataFrame
        df = df[df['Country/Region'] != country].append(sum_df, ignore_index =␣
↪True) # append to last rows
```

```
    # Combine Province and Region.  Because the following data needs to use␣
↪Country as representative.
    df['Country'] = df['Province/State']
    df['Country'] = df.Country.fillna(df[df['Province/State'].isna()]['Country/
↪Region'])

    # Move country columns to 1st column
    cols = list(df.columns)
    cols = [cols[-1]] + [cols[-2]]

    return df[cols]
```

Theses four coutnries: **'Denmark'**, **'France'**, **'Netherlands'** and **'United Kingdom'** countains outside-country-territories. Since these territories each has separated coordinates far away from its country. Hence, it is better to treat it as a separate region and not combining them with their respective countries.

[16]:
```
new_confirmed_cases = rearrangeDataFrame(confirmed_cases.copy(),␣
↪duplicated_countries[0:3])
new_death_reported = rearrangeDataFrame(death_reported.copy(),␣
↪duplicated_countries[0:3])
new_recovered_cases = rearrangeDataFrame(recovered_cases.copy(),␣
↪duplicated_countries[0:3])

new_confirmed_cases[new_confirmed_cases.Country.str.contains('Australia')]
```

[16]:

	Country	4/8/20
207	Australia	6010

[17]:
```
# Check if number of row of countries is the same
print("Total rows in confirmed cases: {}".format(new_confirmed_cases.shape[0]))
print("Total rows in death cases:     {}".format(new_death_reported.shape[0]))
print("Total rows in recovered cases: {}".format(new_recovered_cases.shape[0]))
```

```
Total rows in confirmed cases: 210
Total rows in death cases:     210
Total rows in recovered cases: 210
```

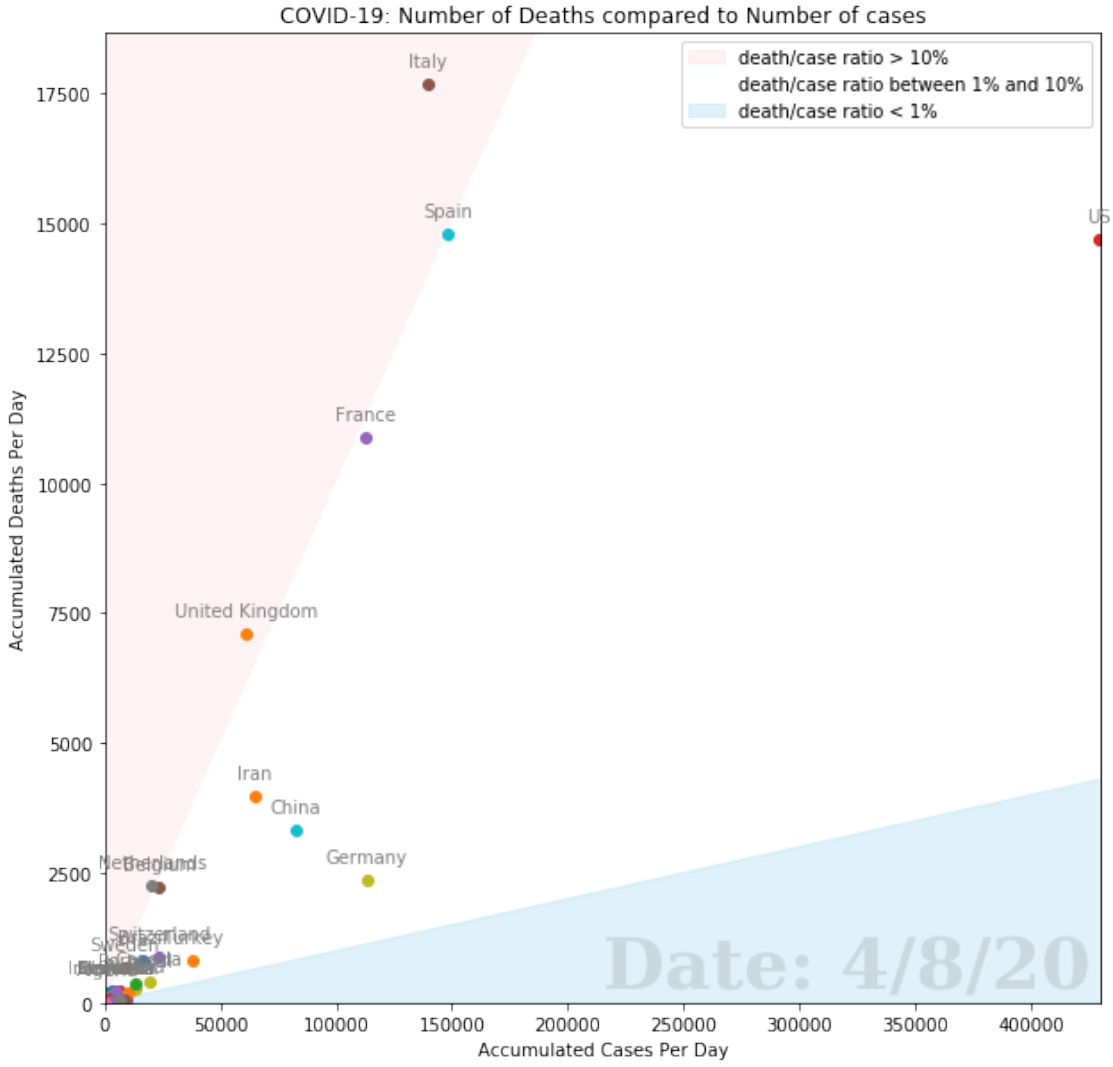
[18]:
```
# create a lit of countries
countries = [x for x in new_confirmed_cases.Country]

# create a list of columns
cols = list(new_confirmed_cases.columns)

new_confirmed_cases.nlargest(10, features[-1])
#new_death_reported.nlargest(10, features[-1])
#new_recovered_cases.nlargest(10, features[-1])
```

[18]:

	Country	4/8/20
173	US	429052
149	Spain	148220
85	Italy	139422
68	Germany	113296
64	France	112950
209	China	82809
81	Iran	64586
171	United Kingdom	60733
161	Turkey	38226
15	Belgium	23403

[19]:
```
# Plotting scatter graph in comparison with death cases and confirmed cases
fig = plt.figure()
ax = fig.add_subplot(111)

col = cols[-1]

# Initialize styles
style = dict(size=10, color='gray')

# set x-axis and y-axis
x_lim = int(new_confirmed_cases[cols[-1]].max() + 1e3)
y_lim = int(new_death_reported[cols[-1]].max() + 1e3)
plt.axis([0,x_lim,0,y_lim])

# range to plot fill area
xrange = [10*x for x in range(0, x_lim)]
yrange = [y for y in range(0, x_lim)]
xrange2 = [100*x for x in range(0, x_lim)]

# resize graph
plt.gcf().set_size_inches(10,10, forward=False)

# label the figure
plt.title('COVID-19: Number of Deaths compared to Number of cases')

# Label the axes
plt.xlabel('Accumulated Cases Per Day')
plt.ylabel('Accumulated Deaths Per Day')

# plot fill area
area1 = plt.fill_between(xrange, y_lim, color="crimson", alpha=0.05) # plot␣
 ↪crimson area where death/case ratio is > 10%
area2 = plt.fill_between(xrange, yrange, color="white", alpha=1) # plot area␣
 ↪where death/case ratio is < 10%
```

```
area3 = plt.fill_between(xrange2, yrange, color="skyblue", alpha=0.25) # plot␣
 ↪skyblue area where death/case ratio is < 1%

plt.legend([area1,area2,area3],
           ["death/case ratio > 10%", "death/case ratio between 1% and 10%",␣
 ↪"death/case ratio < 1%"],
           loc='best', bbox_to_anchor=(1, 1)
          )

for country in countries:
    x = new_confirmed_cases[col][new_confirmed_cases.Country == country].
 ↪values[0]
    y = new_death_reported[col][new_death_reported.Country == country].values[0]

    ax.scatter(x, y, label=country)
    if (x > 1e3) and (y > 200):
        ax.annotate(country,
                    xy = (float(x),float(y)),
                    textcoords = "offset points", # how to position the text
                    xytext = (0,10), # distance from text to points (x,y)
                    ha = 'center',
                    **style
                   )

ax.text((x_lim/2), 1,
    "Date: {}".format(col),
    horizontalalignment= 'left',
    verticalalignment='bottom',
    fontsize = 40,
    fontweight = 'bold',
    family="serif",
    alpha = 0.1
)

plt.savefig('ScatterPlot.png')
plt.show()
```



Load hospital beds indicator from OECD DATA Citation: OECD (2020), Hospital beds (indicator). doi: 10.1787/0191328e-en (Accessed on 03 April 2020) Source of data for hospital beds for OECD DATA: https://data.oecd.org/healtheqt/hospital-beds.htm

[20]:
```
#Main Pull
payload = {'contentType': 'csv','detail': 'code', 'separator': 'comma',␣
 ↪'csv-lang':'en'}
r = requests.get('https://stats.oecd.org/sdmx-json/data/DP_LIVE/.HOSPITALBED.../
 ↪OECD', params=payload)
r.url
```

[20]:
```
'https://stats.oecd.org/sdmx-json/data/DP_LIVE/.HOSPITALBED…/OECD?contentType=
csv&detail=code&separator=comma&csv-lang=en'
```

[21]:
```
r.text.splitlines()[0]
```

[21]:
```
'ï»¿"LOCATION","INDICATOR","SUBJECT","MEASURE","FREQUENCY","TIME","Value","Flag
Codes"'
```

Note that there is an alien wording on the front of **"LOCATION"**. The columns will be modified later.

[22]:
```
#writing the main pull
output_reader = csv.reader(r.text.splitlines())
with open('pdb_data_no_dups.csv', 'w') as csvfile:
    csv_writer = csv.writer(csvfile)
    for row in output_reader:
        csv_writer.writerow(row)
```

[23]:
```
# reading the csv file that just pulled and
beds = pd.read_csv("pdb_data_no_dups.csv")
beds.columns =␣
 ↪['LOCATION','INDICATOR','SUBJECT','MEASURE','FREQUENCY','TIME','Value','Flag␣
 ↪Codes']

#the latest year recorded for bed indicator
# beds.TIME.max()

beds.head()
```

[23]:

	LOCATION	INDICATOR	SUBJECT	MEASURE	FREQUENCY	TIME	Value	Flag Codes
0	AUS	HOSPITALBED	TOT	1000HAB	A	1960	9.65	NaN
1	AUS	HOSPITALBED	TOT	1000HAB	A	1961	9.48	NaN
2	AUS	HOSPITALBED	TOT	1000HAB	A	1962	9.38	NaN
3	AUS	HOSPITALBED	TOT	1000HAB	A	1963	9.36	NaN
4	AUS	HOSPITALBED	TOT	1000HAB	A	1964	9.23	NaN

[24]:
```
# reconfirm the datas
print("Total rows in confirmed cases: {}".format(new_confirmed_cases.shape[0]))
print("Total rows in death cases:     {}".format(new_death_reported.shape[0]))
print("Total rows in recovered cases: {}".format(new_recovered_cases.shape[0]))
```

```
Total rows in confirmed cases: 210
Total rows in death cases:     210
Total rows in recovered cases: 210
```

[25]:
```
new_confirmed_cases[new_confirmed_cases.Country.str.contains('China')]
```

[25]:

	Country	4/8/20
209	China	82809

[26]:
```
# merging confirmed cases table, death cases table and recovered cases table
merge_cases = new_confirmed_cases[['Country', cols[-1]]].
 ↪merge(new_death_reported[['Country', cols[-1]]], on='Country', how='inner')
merge_cases = merge_cases.merge(new_recovered_cases[['Country', cols[-1]]],␣
 ↪on='Country', how='inner')
print(" Columns before rename: {}".format(merge_cases.columns))

# rename columns to become meaningful field
merge_cases.columns = ['Country','confirmed','deaths','recovered']
print(" Columns after rename: {}".format(merge_cases.columns))
```

```
 Columns before rename: Index(['Country', '4/8/20_x', '4/8/20_y', '4/8/20'],
dtype='object')
 Columns after rename: Index(['Country', 'confirmed', 'deaths', 'recovered'],
dtype='object')
```

[27]:
```
# recovery rate
merge_cases['active'] = merge_cases.confirmed - merge_cases.deaths -␣
 ↪merge_cases.recovered
merge_cases['recovery_rate'] = merge_cases.recovered / merge_cases.confirmed *␣
 ↪100
merge_cases.head()
```

[27]:

	Country	confirmed	deaths	recovered	active	recovery_rate
0	Afghanistan	444	14	29	401	6.531532
1	Albania	400	22	154	224	38.500000
2	Algeria	1572	205	237	1130	15.076336
3	Andorra	564	23	52	489	9.219858
4	Angola	19	2	2	15	10.526316

Total countries become lesser by 1 after **2010**.
This implies that one country has stopped updated its data from **2011** onwards

[28]:
```
# Assign all the country code into a list
locations = list(beds.LOCATION.unique())

# Assign the subjects of bed usage into a list
subjects = list(beds.SUBJECT.unique())

beds = beds[beds.TIME >= 2010]  # We can change the year here to verify if the␣
 ↪country code has been reduced
number_of_countries_recorded_in_bed_datasets = len(beds.LOCATION.unique())
#number_of_countries_recorded_in_bed_datasets
```

[29]:
```
def filterForLatestNumOfBed(df, locations=locations, subjects=subjects):
    for location in locations:
        #print(country)
```

```
        for subject in subjects:
            #print(subject)
            new_df = df[df.LOCATION.str.contains(location) & df.SUBJECT.str.
↪contains(subject)]
            index = list(new_df[new_df.TIME != new_df.TIME.max()].index)
            df = df.drop(index)
            #print(index)

    return df
```

[30]:
```
beds_2010_later = filterForLatestNumOfBed(beds[beds.TIME >= 2010].copy())

# Total beds per 1000 inhabitants by country code
beds_data = beds_2010_later.Value.groupby(beds.LOCATION).sum().sort_index
beds_data
```

[30]:
```
<bound method Series.sort_index of LOCATION
AUS     4.26
AUT    13.43
BEL    11.98
BRA     2.30
CAN     4.79
CHE     9.02
CHL     4.20
CHN     4.34
COL     1.71
CRI     1.13
CZE    11.68
DEU    15.30
DNK     5.39
ESP     5.76
EST     8.67
FIN     6.47
FRA     9.91
GBR     5.03
GRC     8.55
HUN    12.16
IDN     1.04
IND     0.53
IRL     6.07
ISL     5.65
ISR     5.58
ITA     5.89
JPN    23.46
KOR    20.72
LTU    13.02
LUX     8.95
```

```
LVA    10.12
MEX     2.79
NLD     7.15
NOR     7.87
NZL     5.50
POL    12.12
PRT     7.28
RUS     8.05
SVK    11.54
SVN     9.36
SWE     4.69
TUR     5.64
USA     5.42
ZAF     2.32
Name: Value, dtype: float64>
```

[31]:
```
countries_with_recorded_beds = [pycountry.countries.get(alpha_3=loc).name for␣
↪loc in locations]
countries_with_recorded_beds
```

[31]:
```
['Australia',
 'Austria',
 'Belgium',
 'Canada',
 'Czechia',
 'Denmark',
 'Finland',
 'France',
 'Germany',
 'Greece',
 'Hungary',
 'Iceland',
 'Ireland',
 'Italy',
 'Japan',
 'Korea, Republic of',
 'Luxembourg',
 'Mexico',
 'Netherlands',
 'New Zealand',
 'Norway',
 'Poland',
 'Portugal',
 'Slovakia',
 'Spain',
 'Sweden',
 'Switzerland',
```

```
 'Turkey',
 'United Kingdom',
 'United States',
 'Brazil',
 'Chile',
 'China',
 'Estonia',
 'India',
 'Indonesia',
 'Israel',
 'Russian Federation',
 'Slovenia',
 'South Africa',
 'Colombia',
 'Latvia',
 'Lithuania',
 'Costa Rica']
```

Unfortunately, in merge_cases table there's two country which is using different name from bed datas, which is:

'US' –> United States

'Russia' –> Russian Federation

Plse uncomment this to see that the list of country in merge_cases for comparison

[32]:
```
#merge_cases.Country.unique()
```

[33]:
```
df= merge_cases.copy()

# Change the naming for Russian Federation and United States to access␣
 ↪merge_cases
for x in range(0, len(countries_with_recorded_beds)):
    if countries_with_recorded_beds[x] == 'Russian Federation':
        countries_with_recorded_beds[x] = 'Russia'
    elif countries_with_recorded_beds[x] == 'United States':
        countries_with_recorded_beds[x] = 'US'
    else:
        continue

# Identifying the indices to slice out the unecessary data.
# From here we will only focus on the countries which has records for number of␣
 ↪beds
indices = [df[df.Country == country].index[0] for country in df.Country if␣
 ↪country in countries_with_recorded_beds]
cases_with_recorded_beds = df.iloc[indices]
```

[34]:
```
# It shows that we have almost all the countries in our list except for one:␣
 ↪Replic of Korea
print("# of Countries with recorded beds data in OCED: {}".
 ↪format(number_of_countries_recorded_in_bed_datasets))
print("# of Countries after sliced out from COVID-19 data: {}".
 ↪format(cases_with_recorded_beds.shape[0]))
```

```
# of Countries with recorded beds data in OCED: 44
# of Countries after sliced out from COVID-19 data: 43
```

[35]:
```
# identify all the unique countires with recorded beds
countries_with_recorded_beds = list(cases_with_recorded_beds.Country.unique())
location_code = []

for country in countries_with_recorded_beds:
    if country == 'US':
        country = 'United States'
    location_code.append(pc.country_name_to_country_alpha3(country,␣
 ↪cn_name_format="default"))

# Add columns with the country code created
cases_with_recorded_beds['Location'] = location_code

# Add in bed datas
cases_with_recorded_beds['beds'] = [float(beds[beds.LOCATION.str.contains(loc)].
 ↪Value.sum()) for loc in location_code]
cases_with_recorded_beds = cases_with_recorded_beds.sort_values(by=␣
 ↪"confirmed", ascending = False)

# Identify top 10 cases
top_10_cases = cases_with_recorded_beds.head(10)
top_10_location = list(top_10_cases.Location.unique())
cases_with_recorded_beds.nlargest(10, 'confirmed')
```

```
/home/jyong/anaconda3/lib/python3.7/site-packages/ipykernel_launcher.py:11:
SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  # This is added back by InteractiveShellApp.init_path()
/home/jyong/anaconda3/lib/python3.7/site-packages/ipykernel_launcher.py:14:
SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead
```

```
See the caveats in the documentation: https://pandas.pydata.org/pandas-
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
```

[35]:

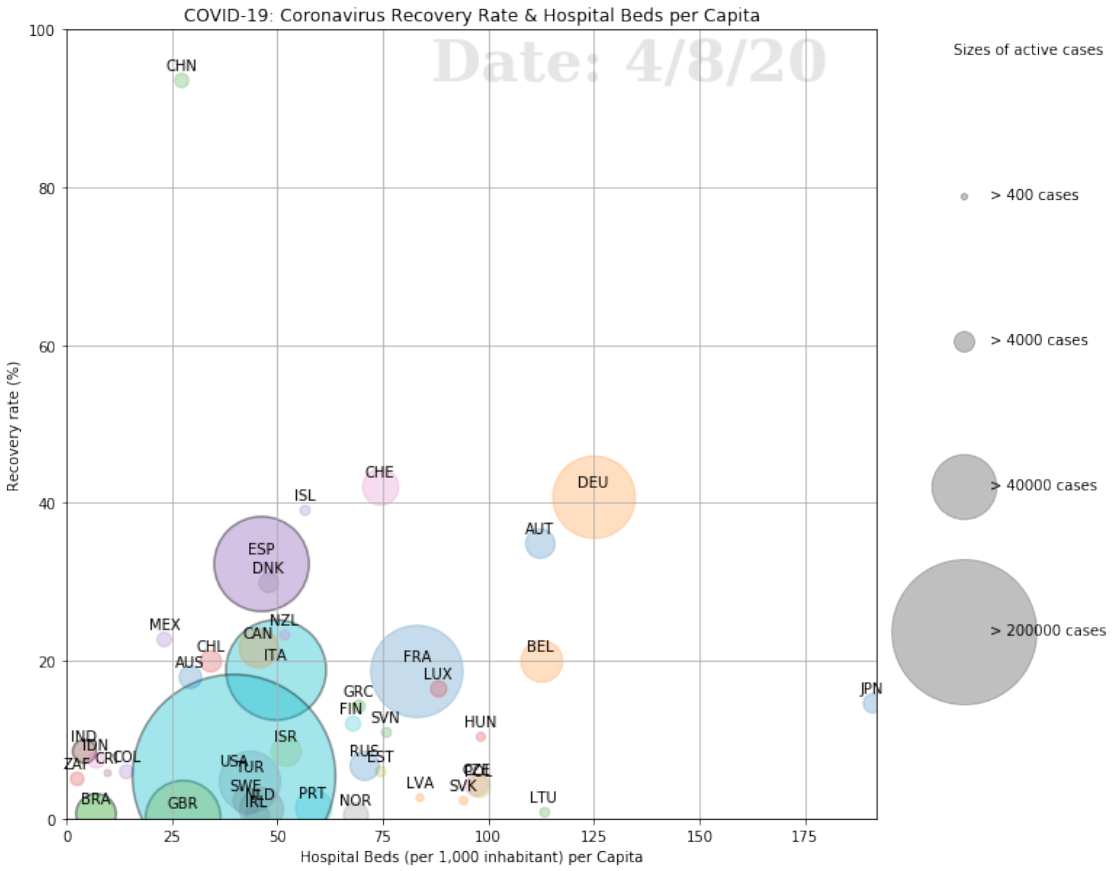
	Country	confirmed	deaths	recovered	active	recovery_rate	\
173	US	429052	14695	23559	390798	5.490943	
149	Spain	148220	14792	48021	85407	32.398462	
85	Italy	139422	17669	26491	95262	19.000588	
68	Germany	113296	2349	46300	64647	40.866403	
64	France	112950	10869	21254	80827	18.817176	
209	China	82809	3337	77567	1905	93.669770	
171	United Kingdom	60733	7097	135	53501	0.222284	
161	Turkey	38226	812	1846	35568	4.829174	
15	Belgium	23403	2240	4681	16482	20.001709	
154	Switzerland	23280	895	9800	12585	42.096220	

	Location	beds
173	USA	39.55
149	ESP	46.21
85	ITA	49.49
68	DEU	124.91
64	FRA	83.06
209	CHN	27.32
171	GBR	27.64
161	TUR	43.40
15	BEL	112.41
154	CHE	74.32

[50]:
```
fig = plt.figure()

# Initialize styles
style = dict(size='medium', color='black')

# set x-axis and y-axis
x_lim = int(cases_with_recorded_beds.beds.max() + 2)
y_lim = int(100)
plt.axis([0,x_lim,0,y_lim])

# resize graph
plt.gcf().set_size_inches(10,10, forward=False)

# label the figure
plt.title('COVID-19: Coronavirus Recovery Rate & Hospital Beds per Capita')

# Label the axes
plt.xlabel('Hospital Beds (per 1,000 inhabitant) per Capita')
plt.ylabel('Recovery rate (%)')
```

```
plt.grid(True,axis='both')

# Plotting multiple bubbles
for location in location_code:
    isLocation = cases_with_recorded_beds.Location.str.contains(location)
    x = cases_with_recorded_beds[isLocation].beds.values[0]
    y = cases_with_recorded_beds[isLocation].recovery_rate.values[0]
    size = cases_with_recorded_beds[isLocation].active.values[0]

    # Highlight the number of beds that is less than active cases
    if x*1000 < size:
        plt.scatter(x, y, s=size*0.05, alpha=0.4, linewidths=1.5, edgecolor␣
 ↪='black')
    else:
        plt.scatter(x, y, s=size*0.05, alpha=0.25)

# Label country code on bubbles
for row in range(0, cases_with_recorded_beds.shape[0]):
    plt.annotate(cases_with_recorded_beds.Location.iloc[row],
                 xy = (cases_with_recorded_beds.beds.
 ↪iloc[row],cases_with_recorded_beds.recovery_rate.iloc[row]),
                 textcoords = "offset points", # how to position the text
                 xytext = (0,10), # distance from text to points (x,y)
                 horizontalalignment= 'center',
                 verticalalignment='center',
                 **style
                 )

# Display text of data as dated.
plt.text(x_lim*0.45, y_lim-1,
    "Date: {}".format(col),
    horizontalalignment= 'left',
    verticalalignment='top',
    fontsize = 40,
    fontweight = 'bold',
    family="serif",
    alpha = 0.1
)

# Create legend for bubble plot
for area in [4e2, 4e3, 4e4, 2e5]:
    plt.scatter([],
                [],
                c ='k', alpha=0.25,
                s=area*0.05,
                label="> {} cases".format(int(area))
```

```
                )

plt.legend(scatterpoints=1, frameon=False, labelspacing=9, loc="best",␣
 ↪title="Sizes of active cases", bbox_to_anchor=(1.3, 1))

plt.savefig('BubblePlot.png')
plt.show()
```



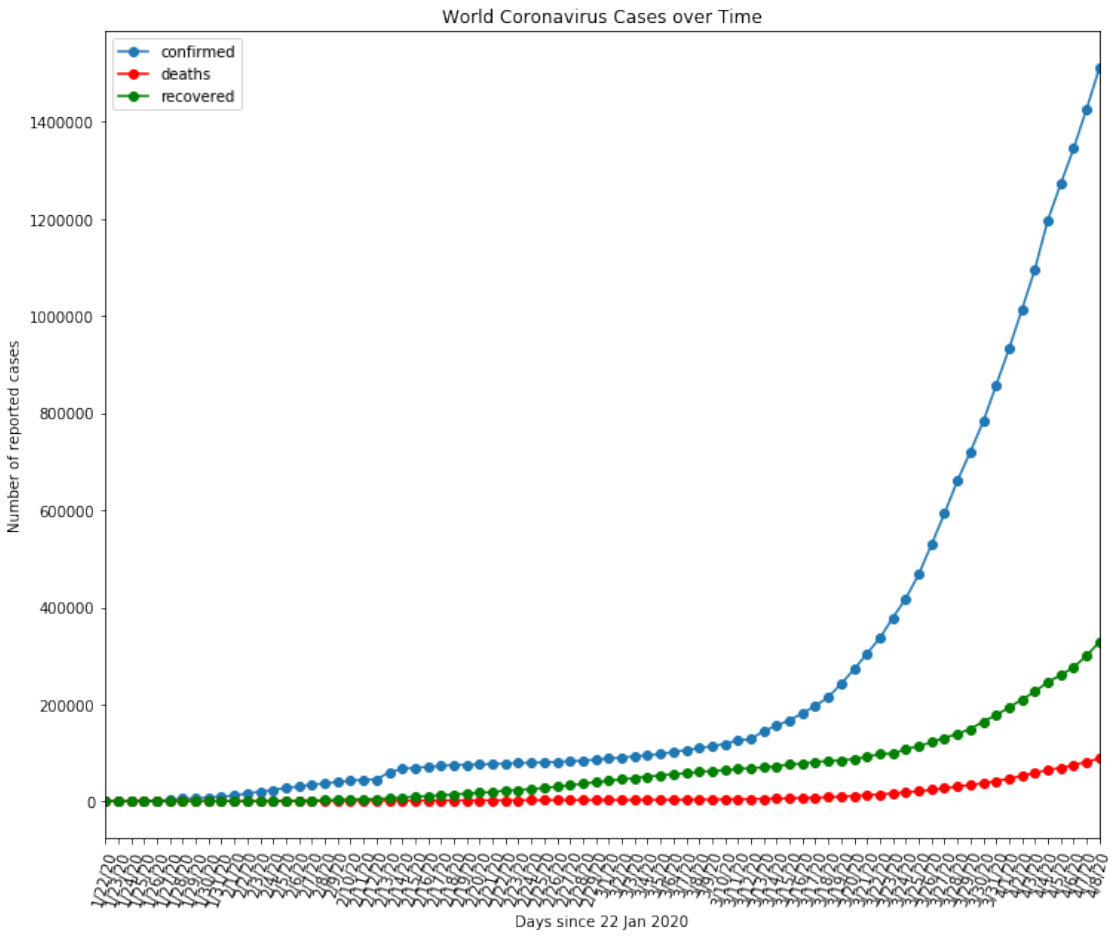
[37]:
```
cols = confirmed_cases.columns
```

[38]:
```
# slicing the data and retain the daily record
confirmed_cases_over_time = confirmed_cases.loc[:,cols[4]:cols[-1]]
death_reported_over_time = death_reported.loc[:,cols[4]:cols[-1]]
recoveries_over_time = recovered_cases.loc[:,cols[4]:cols[-1]]
days = confirmed_cases_over_time.keys()
```

[39]:
```
# obtain the total cases for daily basis
sum_of_confirmed_over_time = confirmed_cases_over_time.sum()
sum_of_deaths_over_time = death_reported_over_time.sum()
```

```
sum_of_recoveries_over_time = recoveries_over_time.sum()
days_since_1_22 = np.array([i for i in range(len(days))]).reshape(-1, 1)
```

[40]:
```
plt.figure(figsize=(12,10))
plt.plot(sum_of_confirmed_over_time, marker='o')
plt.plot(sum_of_deaths_over_time, marker='o', color='r')
plt.plot(sum_of_recoveries_over_time, marker='o', color='g')
plt.title('World Coronavirus Cases over Time')
plt.legend(['confirmed','deaths', 'recovered'])
plt.xticks(rotation=75)
plt.xlim(0,days[-1])

# Label the axes
plt.xlabel('Days since 22 Jan 2020')
plt.ylabel('Number of reported cases')

plt.savefig('WorldCoronavirusCasesOverTime.png')
plt.show()
```



The linear regression formula are expected as:

$$y = a + b * x$$

where:

a is the value of constant

b is the value of days

By converting the exponential function into a linear function, we will get:

$$log(x(t)) = log(x_0) + log(b) * t$$

where:

$$x_0 = e^a$$

the **linear regression's a** is the **log of initial value** the **linear regression's b** is the **log of growth factor**

By applying inverse log to the equation, we will have the actual formula for the coronavirus pandemic

$$x(t) = e^a * b^t$$

[49]:
```
def linearRegressionModel(x_data, y_data):
    X_train, X_test, y_train, y_test = train_test_split(x_data, y_data,␣
 ↪random_state = 0)
    X_train = pd.DataFrame(X_train)
    X_test = pd.DataFrame(X_test)

    #implement linear regression
    model = LinearRegression()
    reg = model.fit(X_train,y_train)

    #make predictions and find the rmse
    preds = model.predict(X_test)
    #print(preds)
    rms=np.sqrt(np.mean(np.power((np.array(y_test)-np.array(preds)),2)))


    return reg, rms, preds
```

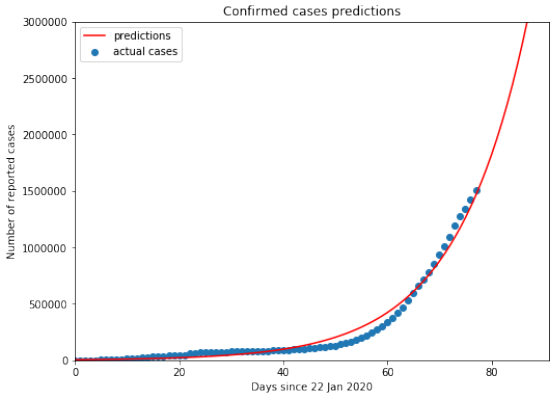
[42]:
```
confirmed_reg, confirmed_rms, confirmed_preds =␣
 ↪linearRegressionModel(days_since_1_22, np.log(sum_of_confirmed_over_time))
deaths_reg, deaths_rms, deaths_preds = linearRegressionModel(days_since_1_22,␣
 ↪np.log(sum_of_deaths_over_time))
recovery_reg, recovery_rms, recovery_preds =␣
 ↪linearRegressionModel(days_since_1_22, np.log(sum_of_recoveries_over_time))
```

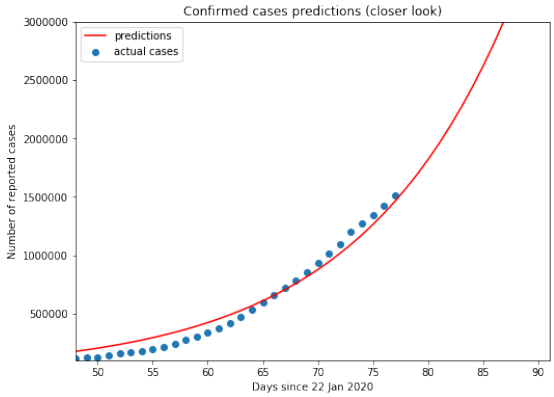
[43]:
```
print("RMS determined for confirmed cases: {}".format(confirmed_rms))
print("RMS determined for death reported: {}".format(deaths_rms))
print("RMS determined for recovery cases: {}".format(recovery_rms)) # this is␣
 ↪invalid for recovery cases
```

```
RMS determined for confirmed cases: 0.6590924307563436
RMS determined for death reported: 0.5698045326068973
RMS determined for recovery cases: 1.0645497056887319
```

[44]:
```
extra_day_for_predictions = 14
future_forecast = np.array([i for i in␣
 ↪range(len(days_since_1_22)+extra_day_for_predictions)]).reshape(-1, 1)
```

[45]:
```
fig, axs = plt.subplots(1, 2)
plt.gcf().set_size_inches(18,6, forward=False)
axs[0].plot(future_forecast, np.exp(confirmed_reg.coef_)**future_forecast * np.
 ↪exp(confirmed_reg.intercept_), color ="red")
axs[0].scatter(days_since_1_22, sum_of_confirmed_over_time)
axs[0].axis([0,future_forecast[-1],0,30e5])
axs[0].set_title('Confirmed cases predictions')
# Label the axes
axs[0].set_xlabel('Days since 22 Jan 2020')
axs[0].set_ylabel('Number of reported cases')
axs[0].legend(['predictions', 'actual cases'])

#plot another graph for closer look
axs[1].plot(future_forecast, np.exp(confirmed_reg.coef_)**future_forecast * np.
 ↪exp(confirmed_reg.intercept_), color ="red")
axs[1].scatter(days_since_1_22, sum_of_confirmed_over_time)
axs[1].axis([future_forecast[-44],future_forecast[-1],1e5,30e5])
axs[1].set_title('Confirmed cases predictions (closer look)')
# Label the axes
axs[1].set_xlabel('Days since 22 Jan 2020')
axs[1].set_ylabel('Number of reported cases')
axs[1].legend(['predictions', 'actual cases'])

plt.savefig('LinearRegressionPredictionPlot.png')
plt.show()
```


Confirmed cases predictions
predictions
actual cases
Number of reported cases
Days since 22 Jan 2020
3000000
2500000
2000000
1500000
1000000
500000
0
0
20
40
60
80


Confirmed cases predictions (closer look)
predictions
actual cases
Number of reported cases
Days since 22 Jan 2020
3000000
2500000
2000000
1500000
1000000
500000
50
55
60
65
70
75
80
85
90