In [136…
```python
# import libraries
import matplotlib.pyplot as plt
import os, requests
import numpy as np
import pandas as pd
import csv
import seaborn as sb
import matplotlib as pt
import scipy.optimize
import warnings
warnings.filterwarnings('ignore')
%matplotlib inline
```

Load Dataset

In [137…
```python
# add file location
os.chdir('C:\\Users\\francon\\Downloads\\data')
```

In [138…
```python
#Load necessary  files into data frames
coviddf = pd.read_csv("covid_data.csv", error_bad_lines=False, warn_bad_lines=False, encoding='latin-1',delimiter = ",")
```

In [139…
```python
coviddf.head(1)
```

Out[139…

	location	date	new_cases	new_deaths	population	aged_65_older_percent	gdp_per_capita	hospital_beds_per_thousand
0	Afghanistan	2019-12-31	0	0	38928341.0	2.581	1803.987	0.5

Data Cleaning

In [140…
```python
# check data types
coviddf.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 23082 entries, 0 to 23081
Data columns (total 8 columns):
 #   Column                     Non-Null Count  Dtype
---  ------                     --------------  -----
 0   location                   23082 non-null  object
 1   date                       23082 non-null  object
 2   new_cases                  23082 non-null  int64
 3   new_deaths                 23082 non-null  int64
 4   population                 23018 non-null  float64
 5   aged_65_older_percent      20643 non-null  float64
 6   gdp_per_capita             20711 non-null  float64
 7   hospital_beds_per_thousand 19144 non-null  float64
dtypes: float64(4), int64(2), object(2)
memory usage: 1.4+ MB
```

In [141…
```python
coviddf.describe()
```

Out[141…

	new_cases	new_deaths	population	aged_65_older_percent	gdp_per_capita	hospital_beds_per_thousand
count	23082.000000	23082.000000	2.301800e+04	20643.000000	20711.000000	19144.000000
mean	624.769257	35.629062	1.037003e+08	9.758570	22708.384791	3.204687
std	5517.309068	330.986941	6.716897e+08	6.445662	21187.826121	2.593700
min	-2461.000000	-1918.000000	8.090000e+02	1.144000	661.240000	0.100000
25%	0.000000	0.000000	2.083380e+06	3.853000	6426.674000	1.400000
50%	3.000000	0.000000	9.449321e+06	7.646000	15524.995000	2.600000
75%	55.000000	1.000000	3.346920e+07	15.322000	35220.084000	4.210000
max	133510.000000	10520.000000	7.794799e+09	27.049000	116935.600000	13.800000

We can analyze some values with this table. It seems that there are some observations that could be wrong.

- There are negative variables for new_cases and new_deaths but if we analyze these variables in the real life they can not be negative
- I will ignore negative values of these variables

In [142…
```python
# ignore negative numbers of new cases and new deaths
coviddf[coviddf.select_dtypes(include=[np.number]).ge(0).all(1)].describe()
```

Out[142…

	new_cases	new_deaths	population	aged_65_older_percent	gdp_per_capita	hospital_beds_per_thousand
count	18315.000000	18315.000000	1.831500e+04	18315.000000	18315.000000	18315.000000
mean	784.880207	44.881518	1.269424e+08	10.156367	23336.632846	3.126497
std	6183.781361	370.721681	7.510070e+08	6.461980	21236.226370	2.455429
min	0.000000	0.000000	9.792800e+04	1.144000	661.240000	0.100000
25%	0.000000	0.000000	4.105268e+06	4.469000	7485.013000	1.380000
50%	6.000000	0.000000	1.070898e+07	8.153000	16277.671000	2.600000
75%	98.000000	2.000000	4.373376e+07	15.413000	35220.084000	4.210000
max	133510.000000	10520.000000	7.794799e+09	27.049000	116935.600000	13.050000

Solution

9) Second Dataset, Covid19 cases. This dataset contains daily covidl9 cases for all countries in the world. Each row represents a calendar day. The rows also contain some simple information about the countries, like population, percentage of the population over 65, GDP and hospital beds per thousand inhabitants. Please use this dataset to answer the following questions.

When did the difference in the total number of confirmed cases between Italy and Germany become more than 10 000?

In [143…
```python
# copy specific information we need of Germany and Italy
germanydf=coviddf[coviddf['location']== 'Germany'][["date","new_cases"]]
italydf=coviddf[coviddf['location']== 'Italy'][["date","new_cases"]]
```

In [144…
```python
# change the name of new cases per country
germanydf.rename(columns={'new_cases':'new_cases_germany'}, inplace=True)
italydf.rename(columns={'new_cases':'new_cases_italy'}, inplace=True)
```

In [145…
```python
# merge the information using date
countrinfodf = pd.merge(germanydf, italydf,on='date')
```

In [146…
```python
# calculate the cumulative cases per country
countrinfodf['new_cases_germany_cum'] = countrinfodf['new_cases_germany'].cumsum()
countrinfodf['new_cases_italy_cum'] = countrinfodf['new_cases_italy'].cumsum()
```

In [147…
```python
# calculate the difference between variables before
countrinfodf["difference_cases_cum"]= countrinfodf["new_cases_italy_cum"]-countrinfodf["new_cases_germany_cum"]
```

In [148…
```python
# get the date when the difference between cases were more than 10K
countrinfodf[countrinfodf['difference_cases_cum']>= 10000].head(1)
```

Out[148…

	date	new_cases_germany	new_cases_italy	new_cases_germany_cum	new_cases_italy_cum	difference_cases_cum
72	2020-03-12	271	2313	1567	12462	10895

R9. The difference in the total number of confirmed cases between Italy and Germany became more than 10 000 at 2020-03-12

10) Look at the cumulative number of confirmed cases in Italy between 2020-02-28 and 2020-03-20. Fit an exponential function (y = Ae^(Bx)) to this set to express cumulative cases as a function of days passed, by minimizing squared loss. What is the difference between the exponential curve and the total number of real cases on 2020-03-20?

In [149…
```python
# get the necessary information about cumulative cases and dates
italycasesdf = countrinfodf[(countrinfodf["date"] >= "2020-02-28")&(countrinfodf["date"] <= "2020-03-20")][["date","new_cases_italy_cum"]]
```

In [150…
```python
italycasesdf.head()
```

Out[150…

	date	new_cases_italy_cum
59	2020-02-28	650
60	2020-02-29	888
61	2020-03-01	1128
62	2020-03-02	1689
63	2020-03-03	2036

$$f = a \cdot e^{b \cdot x}$$

Fit Exponential curve
To fit the cumulative cases in function of days passed using exponential formula to achieve the task, it is necessesary following the next steps:

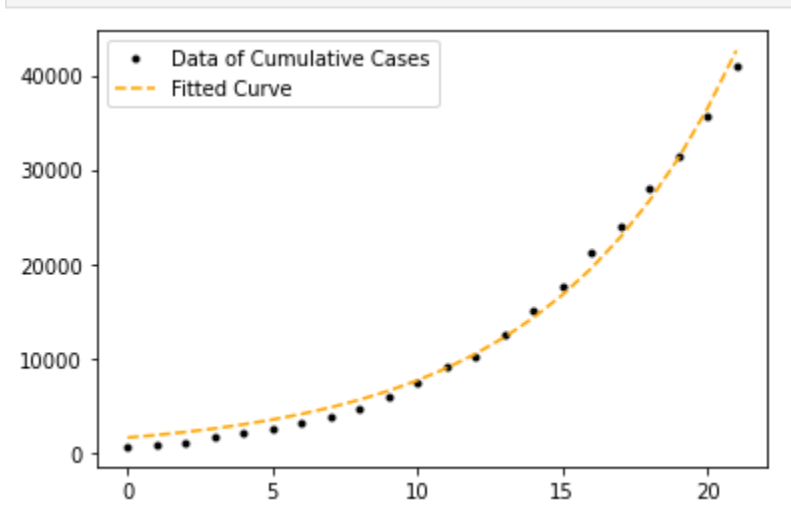
- **define the independent and dependent variables, in this case x and y would be the total of days and the cumulative cases respectably**
- **implement a function that represents exponential formula**
- **apply curvefit function from scipy to fit data, this function uses leastsq**

In [151…
```python
# Implement the fitting
# define the exponential function
def exp_func(x, a, b):
  return a * np.exp(b * x)
# define variables
y_data = italycasesdf["new_cases_italy_cum"]
x_data = np.arange(0, len(y_data))

# use curvefit
popt,cov = scipy.optimize.curve_fit(exp_func, x_data, y_data)
a,b = popt

#calculate new values
x_new_value = np.arange(min(x_data), max(x_data)+1)
y_new_value = exp_func(x_new_value, a, b)

plt.figure()
plt.plot(x_data, y_data, '.', label="Data of Cumulative Cases",color="black")
plt.plot(x_new_value, y_new_value, '--', label="Fitted Curve",color="orange")
plt.legend()
plt.show()
```

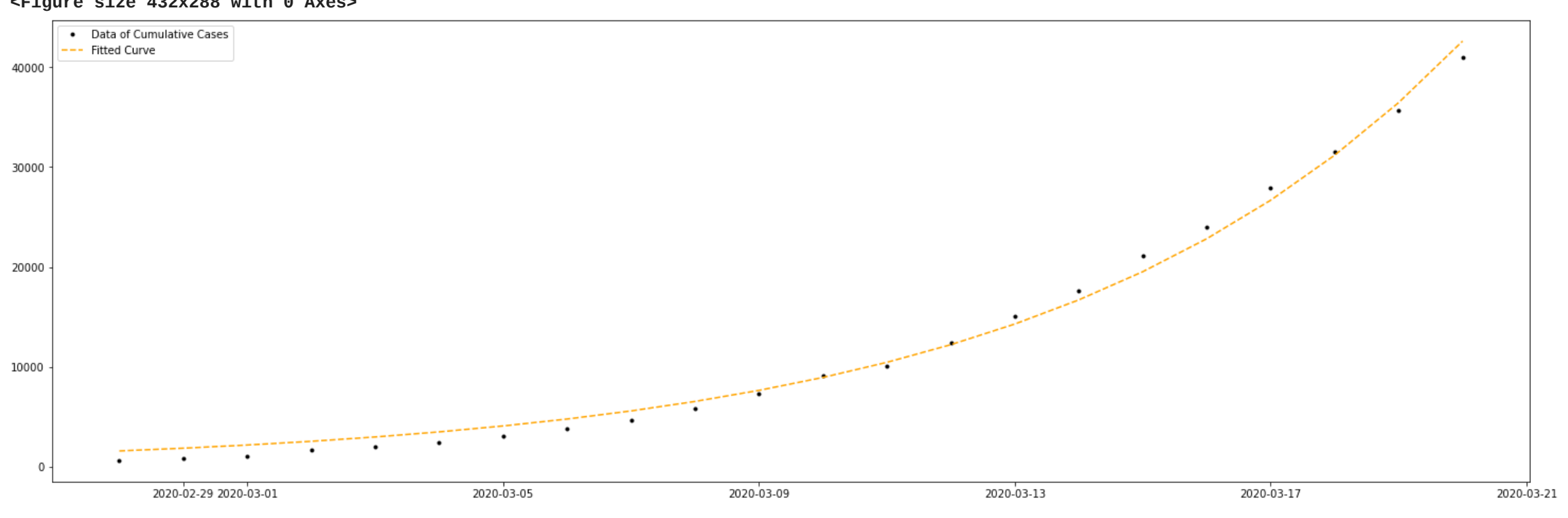


In [152…
```python
# add the fitted data
italycasesdf[['new_cases_cum_fitted']] = y_new_value
```

In [153…
```python
italycasesdf['date'] = pd.to_datetime(italycasesdf['date'])
```

In [154…
```python
# plot the fitted curve and the real data
plt.figure()
plt.figure(figsize=(25,8))
plt.plot(italycasesdf['date'], italycasesdf['new_cases_italy_cum'], '.', label="Data of Cumulative Cases",color="black")
plt.plot(italycasesdf['date'], italycasesdf['new_cases_cum_fitted'], '--', label="Fitted Curve",color="orange")
plt.legend()
plt.show()
```

```
<Figure size 432x288 with 0 Axes>
```



In [155…
```python
# calculate the difference between fitted data and real data
italycasesdf[italycasesdf["date"] == "2020-03-20"]
```

Out[155…

	date	new_cases_italy_cum	new_cases_cum_fitted
80	2020-03-20	41035	42608.506785

In [156…
```python
# calculate the difference at that day
diff =italycasesdf.loc[italycasesdf.date=="2020-03-20", 'new_cases_cum_fitted'].values[0] - italycasesdf.loc[italycasesdf.date=="2020-03-20", 'new_
print("The difference between the exponential curve and the total number of real cases on 2020-03-20 is",round(diff,2))
```

```
The difference between the exponential curve and the total number of real cases on 2020-03-20 is 1573.51
```

11) Which country has the 3rd highest death rate? Death rate: total number of death per million inhabitants

In [157…
```python
# get the information per country to calculate the death rate
deathratedf=coviddf.groupby(['location'],as_index=False).agg({'new_deaths': np.sum, 'population': np.max})
```

In [158…
```python
# get the information
deathratedf["death_rate"]= (deathratedf["new_deaths"]/deathratedf["population"])*1000000
```

In [159…
```python
deathratedf.nlargest(3,['death_rate'])
```

Out[159…

	location	new_deaths	population	death_rate
163	San Marino	42	33938.0	1237.550828
18	Belgium	9619	11589616.0	829.967102
3	Andorra	51	77265.0	660.066007

R11 It shows Andorra has the 3rd highest death rate

12) What is the F1 score of the following statement: Countries, where more than 20% of the population is over 65 years old, have death rates over 50 per million inhabitants. Ignore countries, where any of the necessary information is missing!

In [160…
```python
countdeathrate=coviddf[coviddf["aged_65_older_percent"]>20]
```

In [161…
```python
# get the information of percentage with people over 65 years old per country
countdeathrate=countdeathrate.groupby(['location'],as_index=False).agg({'aged_65_older_percent': np.max})
```

In [162…
```python
countdeathrate
```

Out[162…

	location	aged_65_older_percent
0	Bulgaria	20.801
1	Finland	21.228
2	Germany	21.453
3	Greece	20.396
4	Italy	23.021
5	Japan	27.049
6	Portugal	21.502

In [163…
```python
countdeathrate = pd.merge(countdeathrate, deathratedf,on='location')
countdeathrate
```

Out[163…

	location	aged_65_older_percent	new_deaths	population	death_rate
0	Bulgaria	20.801	167	6948445.0	24.034154
1	Finland	21.228	324	5540718.0	58.476176
2	Germany	21.453	8729	83783945.0	104.184638
3	Greece	20.396	183	10423056.0	17.557231
4	Italy	23.021	34043	60461828.0	563.049467
5	Japan	27.049	919	126476458.0	7.266174
6	Portugal	21.502	1492	10196707.0	146.321749

13) What is the probability that a country has GDP over $10 000, if we know that they have at least 5 hospital beds per 1000 inhabitants.

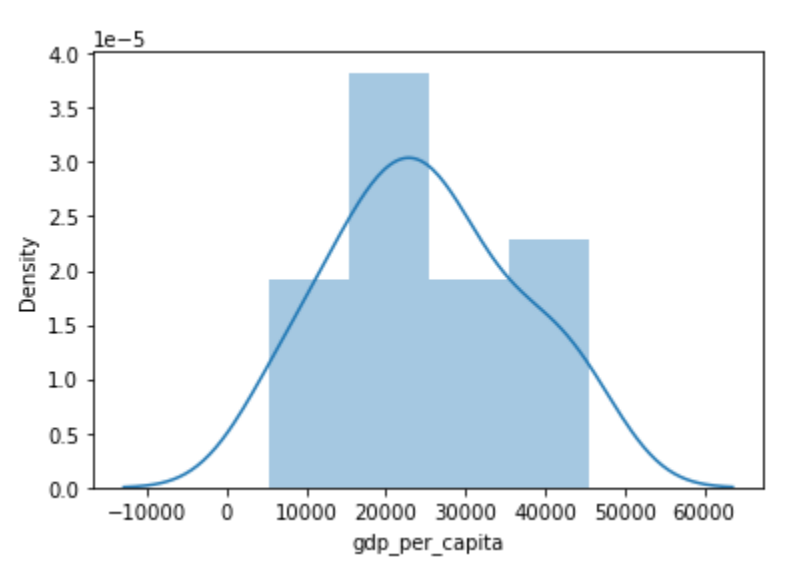
In [89]:
```python
# filter the countries where they have at least 5 hospital per 1000 inhb
gdp=coviddf[coviddf["hospital_beds_per_thousand"]>=5]
```

In [92]:
```python
# get the information per country
gdp=gdp.groupby(['location'],as_index=False).agg({'gdp_per_capita': np.max, 'hospital_beds_per_thousand': np.max})
```

In [100…
```python
# delete nan values
gdp=gdp.dropna()
```

In [103…
```python
# this graphic shows the distribution of data
sb.distplot(gdp["gdp_per_capita"])
```

Out[103…
```
<AxesSubplot:xlabel='gdp_per_capita', ylabel='Density'>
```



In [105…
```python
# get the mean and std
gdp["gdp_per_capita"].describe()
```

Out[105…
```
count       26.000000
mean     24875.705538
std      11583.134812
min       5189.972000
25%      17025.542750
50%      24410.771000
75%      31993.217500
max      45436.686000
Name: gdp_per_capita, dtype: float64
```

In [110…
```python
24875.70-(11583.13*2)
```

Out[110…
```
1709.4400000000023
```

we need to calculate P(X>10000)

In [120…
```python
x = 10000
```

In [121…
```python
# get z score value
z_value = (x-gdp["gdp_per_capita"].mean())/gdp["gdp_per_capita"].std()
```

In [122…
```python
# obtain the probability of z score
scipy.stats.norm.cdf(z_value)
```

Out[122…
```
0.09952627149745163
```

In [128…
```python
# get the probability of p(x>100000)
print("The probability that a country has GDP over $10 000  is ",round((1-scipy.stats.norm.cdf(z_value))*100,3))
```

```
The probability that a country has GDP over $10 000  is  90.047
```

R13.The probability that a country has GDP over $10 000 is 90.047