covid-19-cases-analysis

October 18, 2023

[1]:
```
import warnings
warnings.simplefilter('ignore')
```

[2]:
```
import requests
cases_request = requests.get('https://coronavirus-tracker-api.herokuapp.com/
 ↪confirmed')
deaths_request = requests.get('https://coronavirus-tracker-api.herokuapp.com/
 ↪deaths')
recovered_request = requests.get('https://coronavirus-tracker-api.herokuapp.com/
 ↪recovered')
cases_json_data = cases_request.json()
deaths_json_data = deaths_request.json()
recovered_json_data = recovered_request.json()
```

[3]:
```
def transform_data(json_data, number_field_name):
    """Function that transforms the full json-data into a list of small␣
 ↪dict-objects.

    Each object states for a single day in a single country.
    """
    complete_list = []
    for country_data in json_data['locations']:
        for history_date, number in country_data['history'].items():
            if history_date == 'latest':
                continue
            day_data = {'country': country_data['country'], 'date_text':␣
 ↪history_date, number_field_name: number}
            complete_list.append(day_data)
    return complete_list

cases_list = transform_data(cases_json_data, 'number_of_cases')
deaths_list = transform_data(deaths_json_data, 'number_of_deaths')
recovered_list = transform_data(recovered_json_data, 'number_of_recovered')
cases_list[:5]
```

[3]:
```
[{'country': 'Afghanistan', 'date_text': '1/22/20', 'number_of_cases': 0},
 {'country': 'Afghanistan', 'date_text': '1/23/20', 'number_of_cases': 0},
```

```
 {'country': 'Afghanistan', 'date_text': '1/24/20', 'number_of_cases': 0},
 {'country': 'Afghanistan', 'date_text': '1/25/20', 'number_of_cases': 0},
 {'country': 'Afghanistan', 'date_text': '1/26/20', 'number_of_cases': 0}]
```

[4]:
```
import pandas as pd
cases_df = pd.DataFrame(cases_list)
deaths_df = pd.DataFrame(deaths_list)
recovered_df = pd.DataFrame(recovered_list)

complete_df = deaths_df.merge(cases_df, on=['country', 'date_text'])
complete_df = complete_df.merge(recovered_df, on=['country', 'date_text'])
complete_df.head()
```

[4]:

	country	date_text	number_of_deaths	number_of_cases	number_of_recovered
0	Afghanistan	1/22/20	0	0	0
1	Afghanistan	1/23/20	0	0	0
2	Afghanistan	1/24/20	0	0	0
3	Afghanistan	1/25/20	0	0	0
4	Afghanistan	1/26/20	0	0	0

[5]:
```
from datetime import date, timedelta, datetime
from matplotlib import pyplot as plt
from datetime import date, datetime

#Set a country and the date of the epidemic's start
country = 'Italy'
start_date = date(2020, 2, 10)

# Filter dataframe by country and dates
country_df = complete_df[complete_df['country'] == country]
country_df['date'] = country_df['date_text'].apply(lambda x: datetime.
 ↪strptime(x, '%m/%d/%y').date())
country_df['days'] = country_df['date'].apply(lambda x: (x - start_date).days)
country_df = country_df[country_df['days'] >= 0]
country_df = country_df.sort_values(by='days')
country_df.head()
```

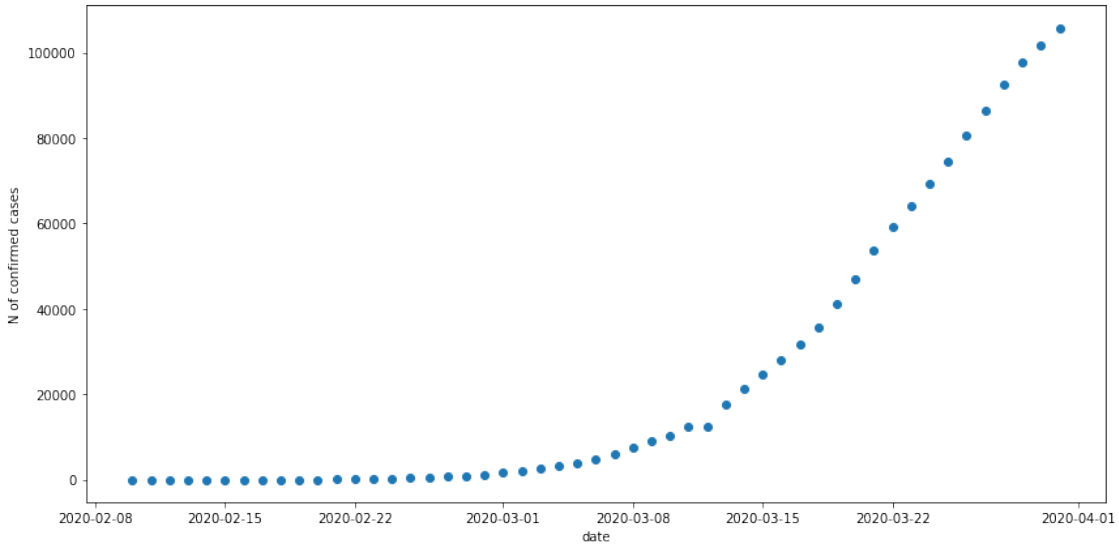
[5]:

	country	date_text	number_of_deaths	number_of_cases	\
2644129	Italy	2/10/20	0	3	
2644130	Italy	2/11/20	0	3	

```
2644131   Italy   2/12/20                0               3
2644132   Italy   2/13/20                0               3
2644133   Italy   2/14/20                0               3
```

	number_of_recovered	date	days
2644129	0	2020-02-10	0
2644130	0	2020-02-11	1
2644131	0	2020-02-12	2
2644132	0	2020-02-13	3
2644133	0	2020-02-14	4

[6]:
```
plt.figure(figsize=(14, 7))
plt.scatter(country_df['date'], country_df['number_of_cases'])
plt.xlabel('date')
plt.ylabel('N of confirmed cases')
plt.show()
```

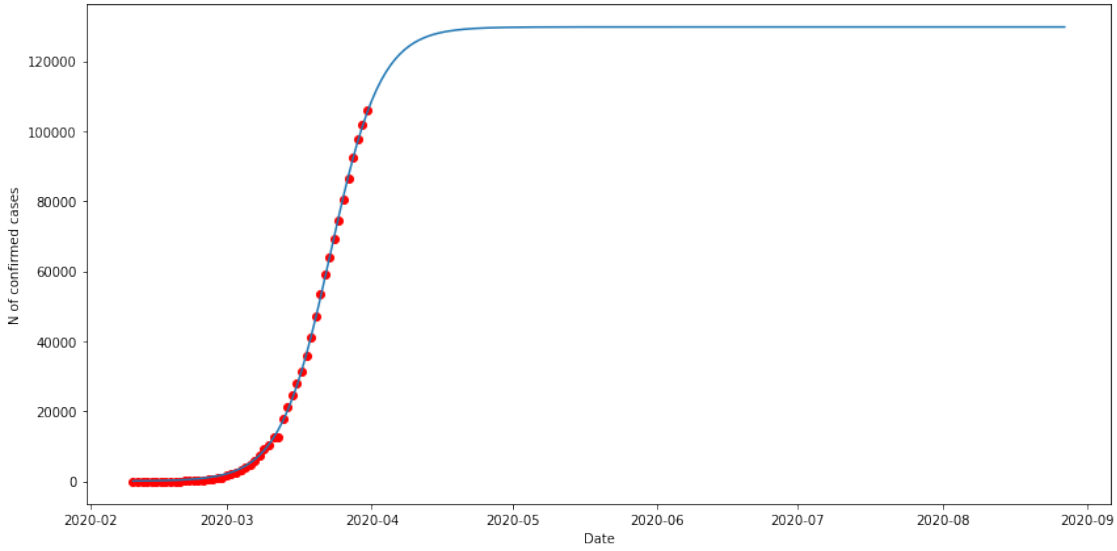


[7]:
```
from scipy.optimize import curve_fit
import numpy as np

def sigmoid(x, m, k, x0):
    """The standard logistic function."""
    return m / (1 + np.exp(-k * (x - x0)))

x_train = country_df['days'].to_numpy()
y_train = country_df['number_of_cases'].to_numpy()

params, __ = curve_fit(sigmoid, x_train, y_train)
```

```
params.tolist()
```

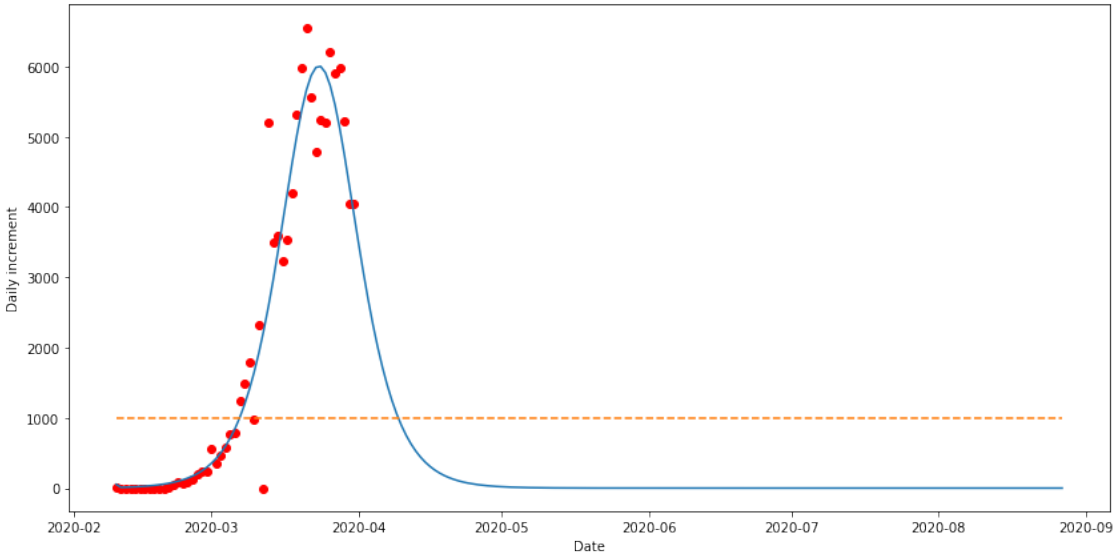
[7]:
```
[129750.53521566899, 0.18535865143548613, 42.13568220173583]
```

[8]:
```
m, k, x0 = params.tolist()
days_to_predict = np.array(list(range(200)))
prediction_dates_list = [start_date + timedelta(days=i) for i in range(200)]
predicted_cases = sigmoid(days_to_predict, m, k, x0)
hictorical_dates = country_df['date']

plt.figure(figsize=(14,7))
plt.scatter(hictorical_dates, country_df['number_of_cases'], color='r')
plt.plot(prediction_dates_list, predicted_cases)
plt.xlabel('Date')
plt.ylabel('N of confirmed cases')
plt.show()
```

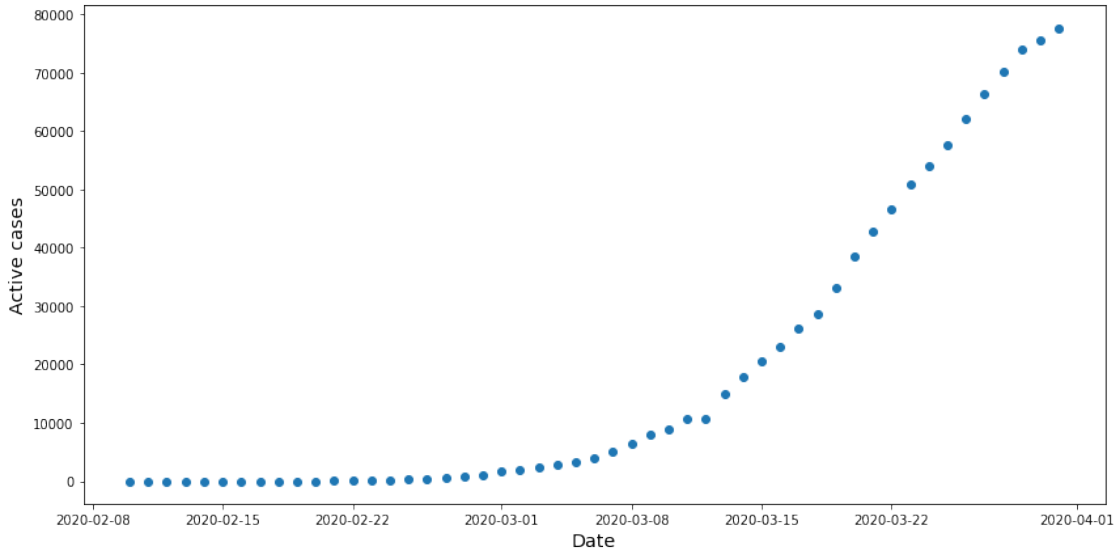


[9]:
```
def get_new_daily_cases(cumulative_cases_list):
    """The function that transforms a list of accumulated daily cases to a list␣
 ↪of new cases."""
    days_number = len(cumulative_cases_list)
    daily_cases = [cumulative_cases_list[i + 1] - cumulative_cases_list[i] for␣
 ↪i in range(days_number - 1)]
    # Add the first day cases number as the first day increment
    daily_cases = [cumulative_cases_list[0]] + daily_cases
    return daily_cases

predicted_cases_list = predicted_cases.tolist()
```

```
predicted_daily_new_cases = get_new_daily_cases(predicted_cases_list)
historical_cases_list = y_train.tolist()
historical_daily_new_cases = get_new_daily_cases(historical_cases_list)

# Plot the real and predicted daily increments
plt.figure(figsize=(14,7))
plt.scatter(hictorical_dates, historical_daily_new_cases, color='r')
plt.plot(prediction_dates_list, predicted_daily_new_cases)
plt.plot(prediction_dates_list, [1000]*len(prediction_dates_list), '--')    #␣
 ↪Trending line
plt.xlabel('Date')
plt.ylabel('Daily increment')
plt.show()
```



[10]:
```
country_df['active_cases'] = (country_df['number_of_cases'] -
                              country_df['number_of_deaths'] -␣
 ↪country_df['number_of_recovered'])

plt.figure(figsize=(14,7))
plt.scatter(country_df['date'], country_df['active_cases'])
plt.xlabel('Date', fontsize='x-large')
plt.ylabel('Active cases', fontsize='x-large')
plt.show()
```



[11]:
```
historical_deaths = country_df['number_of_deaths'].to_numpy()
historical_recoveries = country_df['number_of_recovered'].to_numpy()


def get_prob_vector(m, k, x0):
    """The function that returns the probability vector derived from the␣
 ↪sigmoid function"""
    number_of_days = 90
    return [sigmoid(x, m, k, x0) for x in range(number_of_days)]

def predict_final_state(day, prob_vector, daily_cases=None):
    """Given a day number and the probability vector calculates the number of␣
 ↪persons in the final state.

    It iterates through all previous days. For each previous day it takes the␣
 ↪number of new confirmed cases.
    Then it calculates what fraction of this cohort changed their state to the␣
 ↪final.
    If `daily_cases` is not specified the historical daily new cases are taken.
    """
    if daily_cases is None:
        daily_cases = historical_daily_new_cases
    accumulated_in_state = 0
    for previous_day in range(int(day) + 1):
        new_cases = daily_cases[previous_day]
        days_left = int(day) - previous_day
        if days_left > len(prob_vector) - 1:
            from_that_day = prob_vector[-1] * new_cases
```

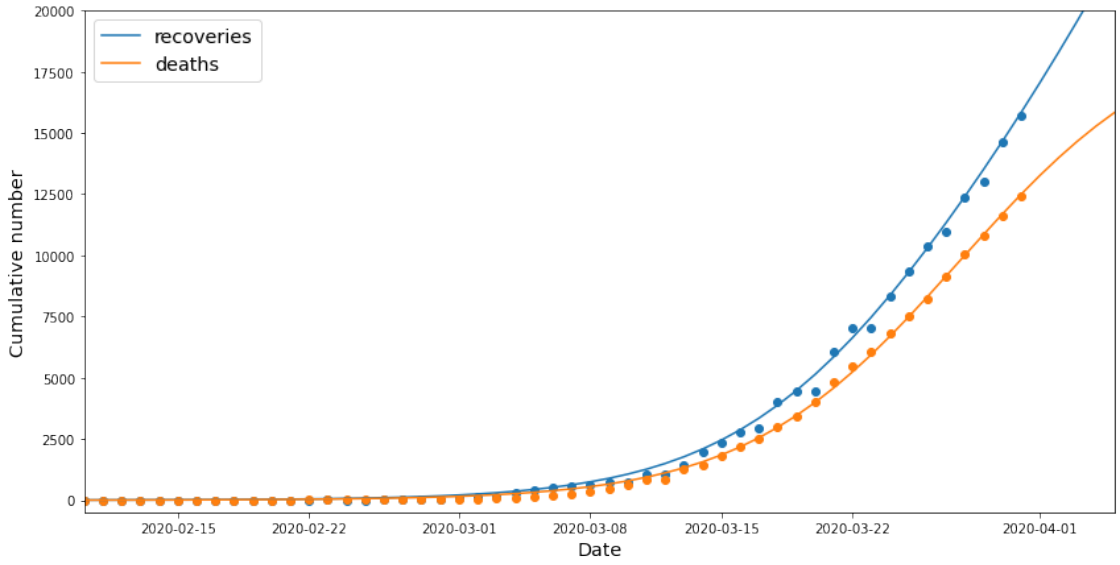
```
        else:
            from_that_day = prob_vector[days_left] * new_cases
        accumulated_in_state += from_that_day
    return accumulated_in_state

def final_state_function(x, m, k, x0, daily_cases=None):
    """The function that given a set of days x and probability parameters
    calculates the number of persons in the final state."""
    prob_vector = get_prob_vector(m, k, x0)
    return np.array([predict_final_state(day, prob_vector,␣
 ↪daily_cases=daily_cases) for day in x])
```

[12]:
```
from numpy import linalg as LA
from scipy.optimize import minimize

def objective_function(params):
    """The objective function that has to be minimized."""
    m_death, k_death, k_recovery, x0_death, x0_recovery = params
    deaths_forecast = final_state_function(x_train, m_death, k_death, x0_death)
    recoveries_forecast = final_state_function(x_train, 1 - m_death,␣
 ↪k_recovery, x0_recovery)
    deaths_errors = historical_deaths - deaths_forecast
    recoveries_errors = historical_recoveries - recoveries_forecast
    return LA.norm(deaths_errors) + LA.norm(recoveries_errors)

bounds = [(0., 0.5), (0., None), (0., None), (0., None), (0., None)]
minimization_result = minimize(objective_function, [0.1, 1., 1., 1., 1.],␣
 ↪bounds=bounds)
m_death, k_death, k_recovery, x0_death, x0_recovery = minimization_result.x
m_death, k_death, k_recovery, x0_death, x0_recovery
```

[12]:
```
(0.1509424424291656,
 0.5946042960578535,
 0.07863373520740886,
 4.031428225557039,
 31.438665048810595)
```

[13]:
```
deaths_forecast = final_state_function(days_to_predict, m_death, k_death,␣
 ↪x0_death,
                                       predicted_daily_new_cases)
recoveries_forecast = final_state_function(days_to_predict, 1 - m_death,␣
 ↪k_recovery, x0_recovery,
                                           predicted_daily_new_cases)

plt.figure(figsize=(14,7))
plt.scatter(hictorical_dates, historical_recoveries)
plt.scatter(hictorical_dates, historical_deaths)
```

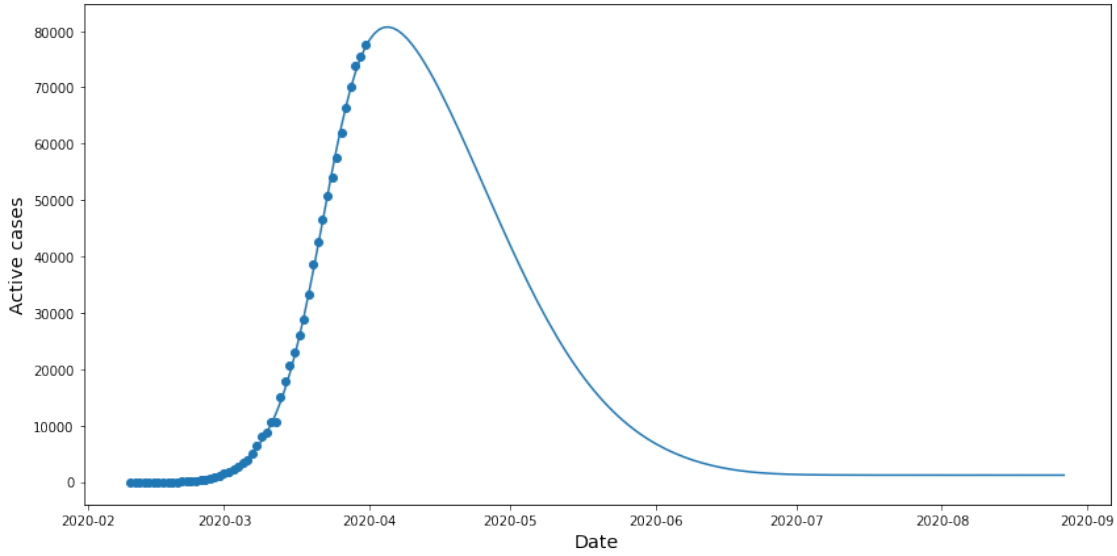
```
plt.plot(prediction_dates_list, recoveries_forecast, label='recoveries')
plt.plot(prediction_dates_list, deaths_forecast, label='deaths')
plt.legend(fontsize='x-large')
plt.xlim(date(2020, 2, 10), date(2020, 4, 5))
plt.ylim(-500, 20000)
plt.xlabel('Date', fontsize='x-large')
plt.ylabel('Cumulative number', fontsize='x-large')
plt.show()
```



[14]:
```
int(np.max(deaths_forecast))
```

[14]: 19584

[15]:
```
active_cases_forecast = np.array(predicted_cases_list) - deaths_forecast -␣
↪recoveries_forecast
plt.figure(figsize=(14,7))
plt.plot(prediction_dates_list, active_cases_forecast)
plt.scatter(country_df['date'], country_df['active_cases'])
plt.xlabel('Date', fontsize='x-large')
plt.ylabel('Active cases', fontsize='x-large')
plt.show()
```



[16]:
```
maximum_active_cases = max(active_cases_forecast)
date_index_for_maximum = active_cases_forecast.tolist().
 ↪index(maximum_active_cases)
date_of_peak = prediction_dates_list[date_index_for_maximum]
date_of_peak
```

[16]:
```
datetime.date(2020, 4, 5)
```

1 conclusion

In conclusion, the COVID-19 pandemic has been a profound global challenge, and the analysis presented here underscores the importance of a multifaceted response. By learning from our experiences and implementing evidence-based strategies, we can better prepare for future health crises and work together to safeguard the well-being of our communities and the world at large.

[ ]: