

Capstone_Project_Notebook

February 17, 2020

1 Opening a Fitness Center in New York City

1.0.1 - Does it make sense?

A capstone project notebook for the IBM course “Applied Data Science Capstone” on coursera.org by Markus Jäckle

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Rating- and Likes correlation!

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Preliminary Summary

Setup

```
[3]: #installs:  
!conda install -c conda-forge beautifulsoup4 --yes --quiet  
!conda install -c conda-forge geopy --yes --quiet  
!conda install -c conda-forge folium --yes --quiet  
!conda install -c conda-forge phantomjs --yes --quiet  
!conda install -c plotly plotly --yes --quiet  
!conda install -c plotly plotly-orca --yes --quiet  
!conda install -c conda-forge psutil --yes --quiet  
!conda install -c conda-forge requests --yes --quiet  
!conda install -c conda-forge selenium --yes --quiet  
!conda install -c conda-forge shapely --yes --quiet
```

```
Collecting package metadata (current_repodata.json): ...working... done
Solving environment: ...working... done

# All requested packages already installed.

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# All requested packages already installed.

Collecting package metadata (current_repodata.json): ...working... done
Solving environment: ...working... done
```

```
# All requested packages already installed.
```

```
[16]: #imports:  
from bs4 import BeautifulSoup as bsoup  
import folium  
from folium import plugins as fp  
from geopy.geocoders import Nominatim  
from IPython.display import display  
from IPython.display import HTML  
from IPython.display import Image  
import json  
import matplotlib.pyplot as plt  
import numpy as np  
import pandas as pd  
from pandas.io.json import json_normalize  
import plotly  
import pickle  
import re  
import requests  
import seaborn as sns  
import selenium  
import selenium.webdriver  
from shapely.geometry import shape, Point  
from sklearn.cluster import KMeans  
from sklearn.linear_model import LinearRegression  
from sklearn.preprocessing import StandardScaler  
from time import sleep as pause  
import types  
print("Import complete.")
```

Import complete.

```
[18]: driver = selenium.webdriver.PhantomJS()  
driver.set_window_size(800, 600)  
#driver.get('mapname.html')  
#driver.save_screenshot('screenshot.png')  
https://stackoverflow.com/questions/40208051/  
→selenium-using-python-geckodriver-executable-needs-to-be-in-path  
https://github.com/mozilla/geckodriver/releases
```

```
[2]: # Cell containg the Foursquare Credentials and Version  
CLIENT_ID = '#' # your Foursquare ID  
CLIENT_SECRET = '#' # your Foursquare Secret  
VERSION = '20200214' # Foursquare API version
```

```
[27]: pi = 3.14159265359
```

Population Density per Borough

The five boroughs of New York City and their population density:

```
[28]: URL = 'https://en.wikipedia.org/wiki/New_York_City#Boroughs'
URL_HTML = requests.get(URL)
URL_HTML_SOUP = bsoup(URL_HTML.text, 'html.parser')
NYC_TABLE = URL_HTML_SOUP.find_all('table')[4]
NYC_TABLE_PANDAS = pd.DataFrame(pd.read_html(NYC_TABLE.prettify(), flavor='bs4')[0])
NYC_TABLE_PANDAS.columns = ['Borough', 'County', 'Population', 'GDP', 'GDP per capita', 'Area (sq.m.)', 'Area (sq.km.)', 'Density (p.p.sq.mi.)', 'Density (p.p.sq.km.)']
NYC_TABLE_PANDAS.drop([5,6,7], inplace=True)
NYC_TABLE_PANDAS.drop(columns=['County', 'Population', 'GDP', 'GDP per capita', 'Area (sq.km.)', 'Density (p.p.sq.km.)'], inplace=True)
NYC_TABLE_PANDAS.columns = ['Borough', 'Area', 'Population Density']
NYC_TABLE_PANDAS = NYC_TABLE_PANDAS.astype({"Population Density": int})
NYC_TABLE_PANDAS
```

```
[28]:      Borough    Area  Population Density
0        The Bronx   42.10       34653
1        Brooklyn   70.82       37137
2      Manhattan   22.83       72033
3         Queens   108.53      21460
4  Staten Island   58.37       8112
```

```
[29]: NYC_TABLE_PANDAS.sort_values(by='Borough', axis=0, inplace=True)
NYC_TABLE_PANDAS
```

```
[29]:      Borough    Area  Population Density
1        Brooklyn   70.82       37137
2      Manhattan   22.83       72033
3         Queens   108.53      21460
4  Staten Island   58.37       8112
0        The Bronx   42.10       34653
```

Querying the coordinates of New York City (for centering of the map) and of its boroughs, for requesting the fitness center venues via Foursquare.

```
[30]: address = 'New York City, NY'

geolocator = Nominatim(user_agent="New York City explored")
location = geolocator.geocode(address)
NYC_latitude = location.latitude
NYC_longitude = location.longitude
```

```
[31]: NYC_TABLE_PANDAS['Latitude'] = 0
NYC_TABLE_PANDAS['Longitude'] = 0

for i, row in NYC_TABLE_PANDAS.iterrows():
    address = row['Borough'] + ', New York City, NY'
    location = geolocator.geocode(address)
    NYC_TABLE_PANDAS.loc[i, 'Latitude'] = location.latitude
    NYC_TABLE_PANDAS.loc[i, 'Longitude'] = location.longitude

NYC_TABLE_PANDAS.reset_index(inplace=True)
NYC_TABLE_PANDAS.drop(columns='index', inplace=True)

NYC_TABLE_PANDAS
```

	Borough	Area	Population	Density	Latitude	Longitude
0	Brooklyn	70.82		37137	40.650104	-73.949582
1	Manhattan	22.83		72033	40.789624	-73.959894
2	Queens	108.53		21460	40.749824	-73.797634
3	Staten Island	58.37		8112	40.583456	-74.149605
4	The Bronx	42.10		34653	40.846651	-73.878594

In order to get an understanding of where the different boroughs are, an interactive map of New York city is generated.

```
[32]: world_geo = r'Choropleth/boroughs.json'
world_map = folium.Map(location=[NYC_latitude, NYC_longitude], zoom_start=11)

#The following code has been mainly taken from:
#https://nbviewer.jupyter.org/github/jtbaker/folium/blob/geojsonmarker/examples/
#GeoJsonMarkersandToolips.ipynb

folium.Choropleth(
    geo_data=world_geo,
    fill_color='grey',
    fill_opacity=0.3,
    line_opacity=0.2,
    legend_name='Population density of NYC boroughs'
).add_to(world_map)

folium.GeoJson(data=world_geo,
               name='NYC Boroughs', smooth_factor=1,
               style_function=lambda x: {'color':'black', 'colorOpacity':0.
               →5, 'fillColor':'transparent', 'weight':0.2},
               tooltip=folium.GeoJsonTooltip(fields=['BoroName'],
                                             labels=False,
                                             sticky=False),
```

```

        highlight_function=lambda x: {'weight':2,'fillColor':
    ↵ '#6495ED','fillOpacity': 0.5}
    ).add_to(world_map)

#display(world_map)

world_map_png_1 = world_map._to_png()

Image(world_map_png_1)

```

[32] :



Please hover over the different boroughs to get their names.

Next, we will create a choropleth map of the population densities of the different boroughs.

To display information in form of a tooltip upon hovering above a certain borough, the desired data needs to be injected into the cached `boroughs.json` file, since the `GeoJsonTooltip` option of `folium` only allows for the displaying of information about the hovered borough, if that information is contained within the accessed `geojson` data file.

In this case, this means that we inject the information about the respective population densities into the `world_geo_data` object, which contains our `geojson` file:

```

[33]: Borough_PopDens_Dict = {}

for i, row in NYC_TABLE_PANDAS.iterrows():
    Borough_PopDens_Dict[row[0]] = row[2]

```

```

with open('Choropleth/boroughs.json') as world_geo_file:
    world_geo_data = json.load(world_geo_file)

for element in world_geo_data['features']:
    element['properties']['PopDens'] = "Population Density: " + str(Borough_PopDens_Dict[element['properties']['BoroName']])

```

Now, the choropleth map can actually be created:

```

[35]: world_geo = r'Choropleth/boroughs.json'
world_map = folium.Map(location=[NYC_latitude, NYC_longitude], zoom_start=11, min_zoom=11, max_zoom=11, zoom_control=False)

folium.Choropleth(
    geo_data=world_geo_data,
    data=NYC_TABLE_PANDAS,
    columns=['Borough', 'Population Density'],
    key_on='feature.properties.BoroName',
    fill_color='PuBu',
    fill_opacity=0.7,
    line_opacity=0.2,
    legend_name='Population Density of NYC boroughs in people per square mile'
).add_to(world_map)

#folium.vector_layers.Rectangle(bounds=[[41.075, -74.411], [40.985, -73.2]], color='white', opacity=0.5, fill=True, fill_color='white', fill_opacity=0.8).
#add_to(world_map)

folium.GeoJson(data=world_geo_data,
               name='NYC_Boroughs', smooth_factor=1,
               style_function=lambda x: {'color':'black', 'colorOpacity':0.5, 'fillColor':'transparent', 'weight':0.2},
               tooltip=folium.GeoJsonTooltip(fields=['BoroName', 'PopDens'],
                                             labels=False,
                                             sticky=False),
               highlight_function=lambda x: {'weight':2, 'fillColor': '#6495ED', 'fillOpacity': 0.5}
).add_to(world_map)

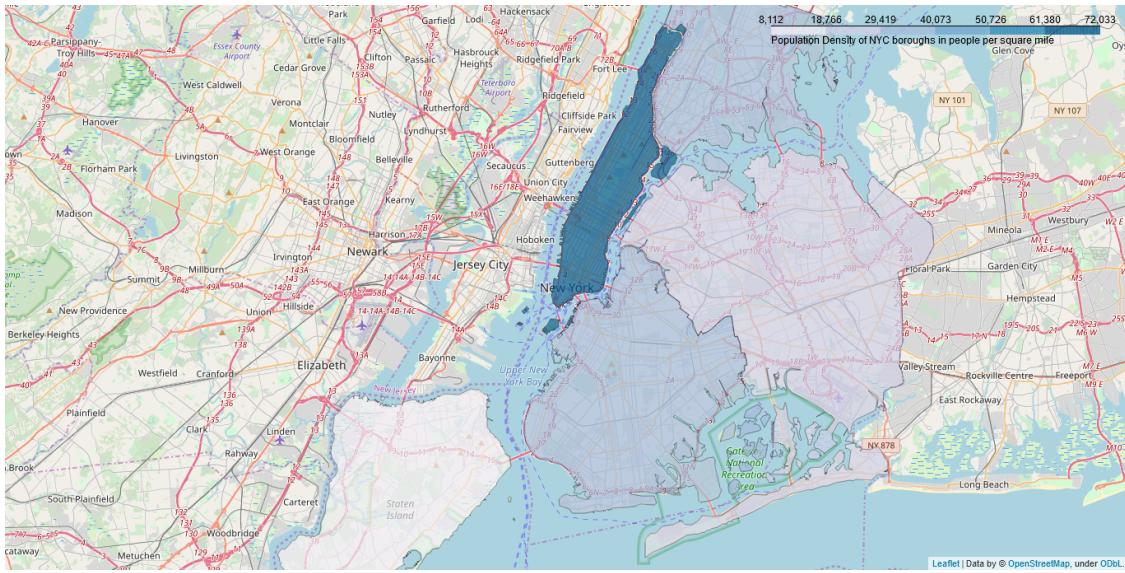
#display(world_map)

world_map_png_2 = world_map._to_png()

Image(world_map_png_2)

```

[35] :



Data Preparation and Cleaning

Now, we will query the top 100 fitness locations for each borough:

```
[36]: radius = 6000
LIMIT = 100
q_category = '52f2ab2ebcbc57f1066b8b48,4bf58dd8d48988d176941735,590a0744340a5803fd8508c3'
```

```
[310]: q_results = pd.DataFrame(columns=['Name', 'Category', 'Latitude', 'Longitude', 'ID'])

for i, row in NYC_TABLE_PANDAS.iterrows():

    q_borough = row[0]
    q_lat = row[3]
    q_long = row[4]

    q_url = 'https://api.foursquare.com/v2/venues/explore?
→client_id={}&client_secret={}&v={}&ll={},{}&categoryIds={}&radius={}
→format(CLIENT_ID, CLIENT_SECRET, VERSION, q_lat, q_long, q_category, radius,
→LIMIT)

    #q_requests_results = requests.get(q_url).json()

    with open('Boroughs/' + q_borough + '.json', 'w') as file_out:
        file_out.write(str(q_requests_results))

    q_temp = json_normalize(q_requests_results['response']['groups'][0]['items'])
```

```

q_temp = q_temp.loc[:,['venue.name','venue.categories','venue.location.
→lat','venue.location.lng','venue.id']]

for i, row in q_temp.iterrows():
    q_temp.loc[i,'venue.categories'] = row['venue.categories'][0]['name']

q_temp = q_temp.rename(columns={'venue.name':'Name', 'venue.categories':
→'Category', 'venue.location.lat':'Latitude', 'venue.location.lng':'Longitude', ↳
→'venue.id':'ID'})

q_results = q_results.append(q_temp, sort=False)

print('Borough: ' + q_borough)
print('The query contained ' + str(len(q_temp)) + ' venues.')

q_results = q_results.reindex(['Name', 'Category', 'Latitude', 'Longitude', ↳
→'ID'], axis=1)

q_results.to_csv('Boroughs/q_results.csv', index = None, header=True)

```

Borough: Brooklyn
The query contained 100 venues.
Borough: Manhattan
The query contained 100 venues.
Borough: Queens
The query contained 80 venues.
Borough: Staten Island
The query contained 47 venues.
Borough: The Bronx
The query contained 85 venues.

Remember, the above presented counted venues per borough are only counted, as retrieved from the query. These counts have to be verified, and corrected, if necessary.

[38]: q_results

	Name	Category	Latitude	\
0	Blink Fitness	Gym	40.651901	
1	Crunch Flatbush	Gym / Fitness Center	40.645798	
2	Tabata Ultimate Fitness	Gym	40.678852	
3	Blink Fitness	Gym	40.669828	
4	iLoveKickboxing	Gym	40.666018	
..
407	Harlem CrossFit	Gym	40.817194	
408	Hayden On Hudson Gym	Gym	40.889593	
409	The Grinnell Gym	Gym	40.834771	

```

410                               P90x Bootcamp          Gym  40.816337
411  CrossFit Harlem - Afrobrutality Sports      Gym  40.817750

    Longitude                  ID
0   -73.958828  51f9c38a498e0a7711ce2e28
1   -73.958149  58f51678826444025008d538
2   -73.957216  5895dbd93bd4ab768a282289
3   -73.931352  538ce459498ebe718bcc4339
4   -73.989289  583d359d46563a02bea58238
...
407  -73.935138  4f71aa93e4b00bcde29e9632
408  -73.917446  4ce716cd0f196dcb7fe43bae
409  -73.945975  518c3c36498ed8cb9750053c
410  -73.935574  4eae730177c8cdc66db9bede
411  -73.937753  51e47b61498e3113f272d510

[412 rows x 5 columns]

```

The following box contains the import of the above-created pandas dataframes. It does not have to executed.

```
[37]: ###q_results = pd.read_csv('Boroughs/q_results.csv')
```

Now, we check how many entries our dataframe consists of:

```
[39]: print(len(q_results))
```

412

Are they unique?

```
[40]: print(len(set(q_results['ID'])))
```

410

This means, that two entries have the same ID, and are thus duplicates of each other.

Let's remove these:

```
[41]: q_results.drop_duplicates(subset='ID',inplace=True)
print(len(q_results))
print(len(set(q_results['ID'])))
```

410

410

Let's visualize the results:

```
[42]: world_geo = r'Choropleth/boroughs.json'
world_map = folium.Map(location=[NYC_latitude, NYC_longitude], zoom_start=11)
```

```

folium.Choropleth(
    geo_data=world_geo,
    fill_color='grey',
    fill_opacity=0.3,
    line_opacity=0.2,
    legend_name='Population density of NYC boroughs'
).add_to(world_map)

folium.GeoJson(data=world_geo,
                name='NYC Boroughs', smooth_factor=1,
                style_function=lambda x: {'color':'black','colorOpacity':0.
→5,'fillColor':'transparent','weight':0.2},
                tooltip=folium.GeoJsonTooltip(fields=['BoroName'],
                                              labels=False,
                                              sticky=False),
                highlight_function=lambda x: {'weight':2,'fillColor':
→'#6495ED','fillOpacity': 0.5}
            ).add_to(world_map)

for lat, lng, name, category, idnum in zip(q_results['Latitude'], □
→q_results['Longitude'], q_results['Name'], q_results['Category'], □
→q_results['ID']):
    label = '{}, {}, {}'.format(name, category, idnum)
    label = folium.Popup(label, parse_html=True)
    folium.CircleMarker(
        [lat, lng],
        radius=5,
        popup=label,
        color='blue',
        fill=True,
        fill_color='#3186cc',
        fill_opacity=0.7,
        parse_html=False).add_to(world_map)

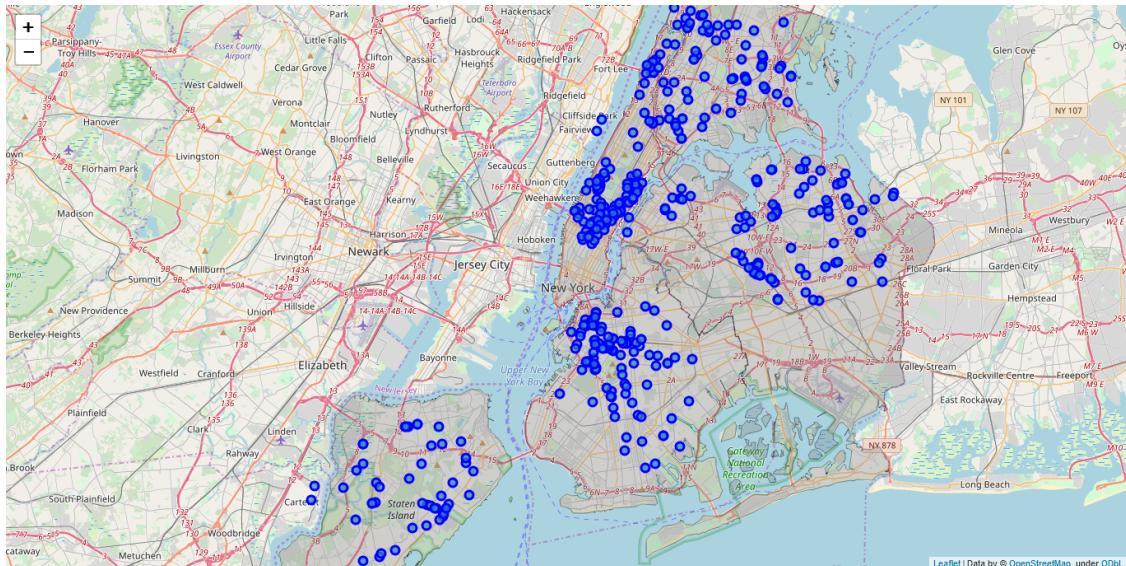
#display(world_map)

world_map_png_3 = world_map._to_png()

Image(world_map_png_3)

```

[42] :



Please note that the venues in the Queens borough, which clearly lie outside the query radius of the queens borough, will be removed from further processing, since they later on falsify the density of venues per square mile, if calculated based on the query radius:

```
[43]: q_results_corque = q_results.copy()

#Since there are only 9 boroughs in Queens,
#which fall under the mentioned category,
#a list of the boroughs, which need to be removed is created manually,
#using the generated map:

queens_venues_remove = [
    '51dcbe2498e05253437a98f', '4a843826f964a520f2fb1fe3', '4bafcc2cf964a5208e213ce3', '51e02b2d2f'

counter_queens_remove = 0
counter = 0

bool_flag = False

for item in queens_venues_remove:

    bool_flag = (q_results_corque.loc[q_results_corque['ID'] == item]['ID'] == item).values[0]

    if bool_flag:
        q_results_corque.drop(q_results_corque.loc[q_results_corque['ID'] == item].index, inplace=True)
```

```

        counter_queens_remove += 1
    else:
        pass
    counter += 1

print(str(counter_queens_remove) + ' venues have been removed from the dataframe.
      →')

```

9 venues have been removed from the dataframe.

[44]:

```

q_results_corque.reset_index(inplace=True)
q_results_corque.drop(columns='index', inplace=True)
print(len(q_results_corque))

```

401

Also, let's associate the different venues with a neighborhood, if within a neighborhood, and if not, let's remove them from the dataframe:

[45]:

```

q_results_b = q_results_corque.copy()
q_results_b['Borough'] = 'Null'
q_results_b = q_results_b.reindex(['Name', 'Category', 'Borough', 'Latitude',
      →'Longitude', 'ID'], axis=1)

```

[46]:

*#Parts of the following code have been taken from:
<http://archived.mhermans.net/geojson-shapely-geocoding.html>*

```

# load GeoJSON file containing sectors
with open ('Choropleth/boroughs.json', 'r') as f:
    boroughs_shapes = json.load(f)

counter_noborough = 0

for i, row in q_results_b.iterrows():

    # construct point based on lat/long returned by geocoder
    # IMPORTANT: THE FORMAT HERE IS Point(LONGITUDE, LATITUDE)
    point = Point(row["Longitude"], row["Latitude"])

    # check each polygon to see if it contains the point

    counter = 0
    check = 0

    for feature in boroughs_shapes['features']:
        polygon = shape(feature['geometry'])
        if polygon.contains(point):
            q_results_b.loc[i, 'Borough'] = feature['properties']['BoroName']

```

```

        check = 1
    elif check == 0 and counter == 4:
        #print('No corresponding borough found for ID ' + row['ID'] + ' !')
        q_results_b.drop([i], inplace=True)
        #print('Venue removed from dataframe.')
        counter_noborough += 1
    counter += 1

print(str(counter_noborough) + ' venues have been removed from the dataframe.')

```

5 venues have been removed from the dataframe.

Since 5 venues have been removed from the dataframe, the dataframe should consist of 401 - 5 venues, let's check that:

[47]: `print(len(q_results_b))`

396

Let's print a map with all venues again:

[48]: `world_geo = r'Choropleth/boroughs.json'`
`world_map = folium.Map(location=[NYC_latitude, NYC_longitude], zoom_start=11)`

```

folium.Choropleth(
    geo_data=world_geo,
    fill_color='grey',
    fill_opacity=0.3,
    line_opacity=0.2,
    legend_name='Population density of NYC boroughs'
).add_to(world_map)

folium.GeoJson(data=world_geo,
               name='NYC_Boroughs', smooth_factor=1,
               style_function=lambda x: {'color':'black','colorOpacity':0.
               ↪5,'fillColor':'transparent','weight':0.2},
               tooltip=folium.GeoJsonTooltip(fields=['BoroName'],
                                             labels=False,
                                             sticky=False),
               highlight_function=lambda x: {'weight':2,'fillColor':
               ↪'#6495ED','fillOpacity': 0.5}
).add_to(world_map)

for lat, lng, name, category, idnum in zip(q_results_b['Latitude'], ↪
    ↪q_results_b['Longitude'], q_results_b['Name'], q_results_b['Category'], ↪
    ↪q_results_b['ID']):
    label = '{}, {}, {}'.format(name, category, idnum)

```

```

label = folium.Popup(label, parse_html=True)
folium.CircleMarker(
    [lat, lng],
    radius=5,
    popup=label,
    color='blue',
    fill=True,
    fill_color='#3186cc',
    fill_opacity=0.7,
    parse_html=False).add_to(world_map)

#display(world_map)

world_map_png_4 = world_map._to_png()

Image(world_map_png_4)

```

[48] :



The dataframe needs to be reindexed, since 5 rows have been removed:

[49]:

```

q_results_b.reset_index(inplace=True)
q_results_b.drop(columns='index', inplace=True)

```

[50]:

```
###q_results_b = pd.read_csv('Boroughs/q_results_b.csv')
```

[51]:

```
venues = q_results_b.copy()
```

Now, let's group the venues by Borough and then count the venues per borough:

```
[52]: venues_count = venues.groupby('Borough').count()
venues_count.
    →drop(columns=['Name', 'Category', 'Latitude', 'Longitude'], inplace=True)
venues_count['Count'] = venues_count['ID']
venues_count.drop(columns='ID', inplace=True)
venues_count
```

```
[52]:      Count
Borough
Brooklyn     100
Manhattan    105
Queens       79
Staten Island 45
The Bronx    67
```

We have removed two duplicates, five venues with no assigned borough, and reassigned certain venues to different boroughs.

After this data cleaning and correction process, contrary to the original counts, where ‘The Bronx’ contained 85 venues, only 67 venues are left. The reason can be found in the shape of Manhattan. Manhattan is a very long-stretched borough, and a long part of it extends into the query radius of ‘The Bronx’ on its borders.

Venue Density per Borough

In the next step, the venues per area per borough are counted.

Please note, since the query consisted of a radius of 6000 meters, the area will be calculated based on a circle with that radius, and not with the official borough area.

!!! Please also note, that, within in the scope of this work, and with a free personal Foursquare account, the number of venues per query was restricted to 100 venues. !!!

```
[53]: radius = 6000

A_q_sqme = 2 * pi * radius**2
A_q_sqkm = A_q_sqme / 1000000

#Query-area in square miles:
A_q_sqmi = A_q_sqkm * 0.386102
```

```
[54]: venues_count['Venue Density'] = 0

for i, row in venues_count.iterrows():
    venues_count.loc[i, 'Venue Density'] = row['Count'] / A_q_sqmi
```

```
[55]: venues_count.reset_index(inplace=True)
venues_count
```

```
[55]:      Borough  Count  Venue Density
0      Brooklyn    100    1.145027
1      Manhattan   105    1.202278
2       Queens     79    0.904571
3  Staten Island   45    0.515262
4   The Bronx     67    0.767168
```

```
[56]: Borough_VenDens_Dict = {}

for i, row in venues_count.iterrows():
    Borough_VenDens_Dict[row[0]] = row[2]

with open('Choropleth/boroughs.json') as world_geo_file:
    world_geo_data = json.load(world_geo_file)

for element in world_geo_data['features']:
    element['properties']['VenDens'] = "Venue Density: " + '{0:.3}'.
    →format(Borough_VenDens_Dict[element['properties']['BoroName']])
```

```
[58]: world_geo = r'Choropleth/boroughs.json'
world_map = folium.Map(location=[NYC_latitude, NYC_longitude], zoom_start=11, ▾
    →min_zoom=11, max_zoom=11, zoom_control=False)

folium.Choropleth(
    geo_data=world_geo_data,
    data=venues_count,
    columns=['Borough', 'Venue Density'],
    key_on='feature.properties.BoroName',
    fill_color='PuBu',
    fill_opacity=0.7,
    line_opacity=0.2,
    legend_name='Venue Density of NYC boroughs in venues per square mile'
).add_to(world_map)

#folium.vector_layers.Rectangle(bounds=[[41.075, -74.411], [40.985, -73.
    →2]], color='white', opacity=0.5, fill=True, fill_color='white', fill_opacity=0.8).
    →add_to(world_map)

folium.GeoJson(data=world_geo_data,
    name='NYC Boroughs', smooth_factor=1,
    style_function=lambda x: {'color':'black', 'colorOpacity':0.
    →5, 'fillColor':'transparent', 'weight':0.2},
    tooltip=folium.GeoJsonTooltip(fields=['BoroName', 'VenDens'],
        labels=False,
        sticky=False),
    highlight_function=lambda x: {'weight':2, 'fillColor':
    →'#6495ED', 'fillOpacity': 0.5}
```

```

    ) . add_to(world_map)

#display(world_map)

world_map_png_5 = world_map._to_png()

Image(world_map_png_5)

```

[58] :



Population- and Venue Density correlation?

While some boroughs suggest a correlation between population density and venue density, which would make sense, some boroughs counter this trend.

Let's try to verify such a correlation, or show for which boroughs it holds true, we normalize our data using feature scaling

$$x_{new} = \frac{x - x_{min}}{x_{max} - x_{min}}$$

and create a regression plot.

```

[59]: popdens_vendens_dataframe = pd.DataFrame()

max_popdens = NYC_TABLE_PANDAS['Population Density'].max()
min_popdens = NYC_TABLE_PANDAS['Population Density'].min()
max_vendens = venues_count['Venue Density'].max()
min_vendens = venues_count['Venue Density'].min()

popdens_vendens_dataframe['Borough'] = NYC_TABLE_PANDAS['Borough']
popdens_vendens_dataframe['Population Density'] = (NYC_TABLE_PANDAS['Population Density'] - min_popdens) / (max_popdens - min_popdens)

```

```
popdens_vendens_dataframe['Venue Density'] = (venues_count['Venue Density'] - min_vendens) / (max_vendens - min_vendens)
```

```
popdens_vendens_dataframe
```

```
[59]:      Borough  Population Density  Venue Density
0        Brooklyn       0.454076      0.916667
1      Manhattan       1.000000      1.000000
2        Queens        0.208820      0.566667
3  Staten Island       0.000000      0.000000
4     The Bronx        0.415216      0.366667
```

```
[60]: linear_regression = LinearRegression()
X = popdens_vendens_dataframe[['Population Density']]
Y = popdens_vendens_dataframe[['Venue Density']]

linear_regression.fit(X,Y)

#adjusted = 1 - (1-linear_regression.score(X,Y))*(len(Y)-1)/(len(Y)-X.shape[1]-1)
#print(adjusted)

plt.figure(figsize=(7,7))

sns.set(font_scale=1.5)
sns.set_style('whitegrid')

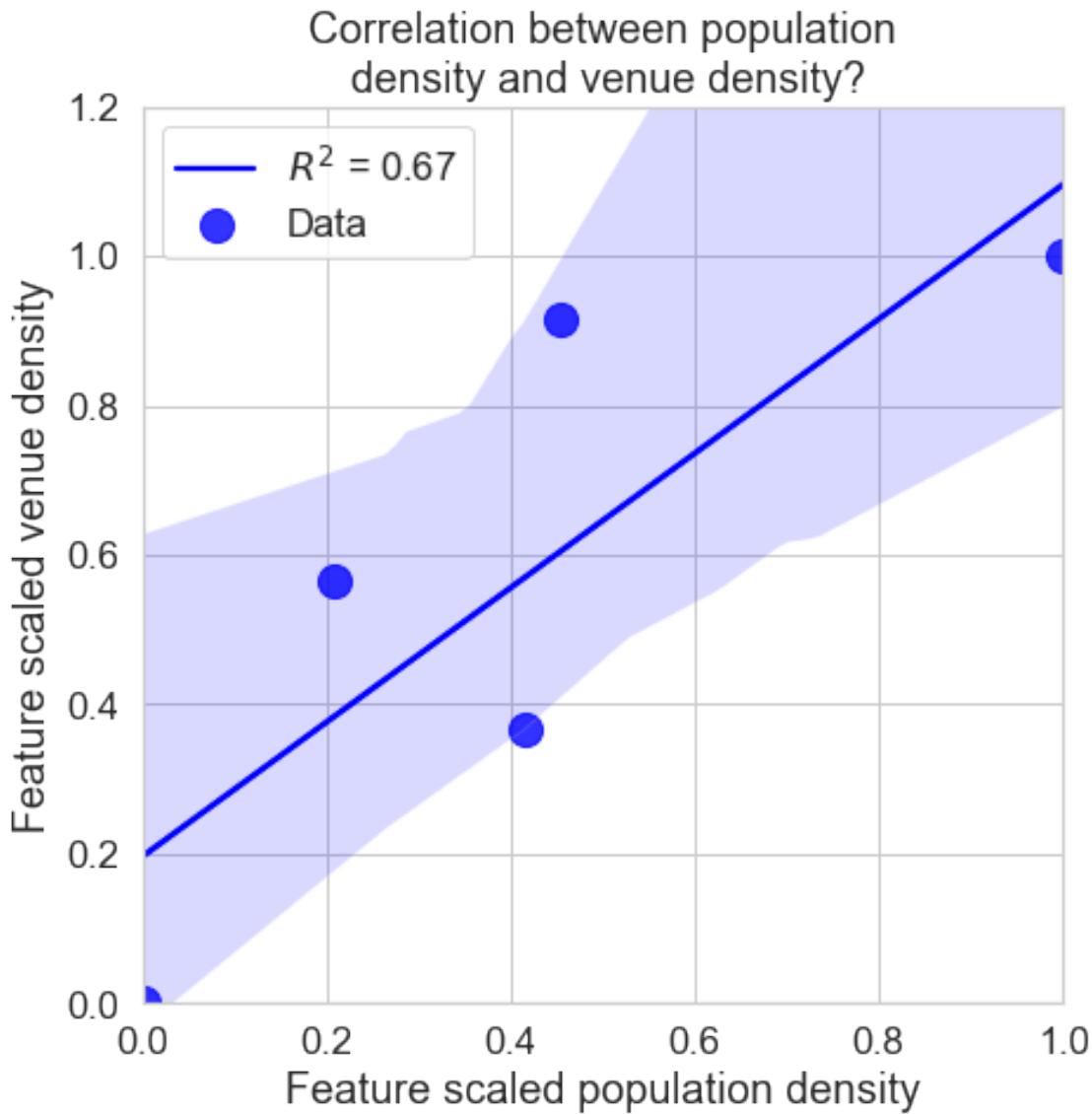
ax = sns.regplot(x='Population Density', y='Venue Density',
                  data=popdens_vendens_dataframe, color='blue', marker='o', scatter_kws={'s':200}, ci=None, label='Data')
ax = sns.regplot(x='Population Density', y='Venue Density',
                  data=popdens_vendens_dataframe, color='blue', marker='o', scatter_kws={'s':200}, scatter=False, label='\$R^2\$ = ' + '{0:.4}'.format(str(linear_regression.score(X,Y)))) 

ax.set(xlabel='Feature scaled population density', ylabel='Feature scaled venue density')
ax.set_title('Correlation between population\n density and venue density?')

plt.xlim((0,1))
plt.ylim((0,1.2))

plt.legend()
```

```
[60]: <matplotlib.legend.Legend at 0x209a85aeb08>
```



As can be seen, some correlation seems to be present, however, not enough data points are measured to verify this trends, also quite some outliers, with factors of ~ 2 (Brooklyn) to ~ 3 (Queens) are present.

Also, the coefficient of determination R^2 seems to small, in order to speak of a direct correlation.

Both, the lack of data points and the small coefficient of determination are reflected in the blue-shaded confidence interval for the regression estimate.

To get a measure for venues per population, generally, it would be enough to divide the total amount of venues by the population. However, due to restrictions of the foursquare api free accounts, such a query is barely possible since the output of a query is restricted to 100 venues.

Therefore, the venues per area will be divided by the population per area, which in our case should give a good estimate of venues per population:

```
[61]: #vpd = venues per population dataframe

vpd = pd.DataFrame()

popdens = NYC_TABLE_PANDAS['Population Density']
vendens = venues_count['Venue Density']

vpd['Borough'] = NYC_TABLE_PANDAS['Borough']
vpd['Venues per Population'] = vendens/popdens

vpd.sort_values(by='Venues per Population', ascending=False, inplace=True)

vpd
```

```
[61]:      Borough  Venues per Population
3  Staten Island          0.000064
2        Queens           0.000042
0     Brooklyn           0.000031
4    The Bronx            0.000022
1   Manhattan            0.000017
```

Thus, according to the queried data, Staten Island has the highest venues per people, even though it has the lowest venue density and population density.

Even though having the highest population density, Manhattan has the lowest venues per population, according to the queried data.

Please note that these results have to be treated with caution, since the query for Brooklyn and Manhattan was capped at 100 venues, possibly, the query would have returned more venues.

Now, the ratings and likes of each venue will be queried:

```
[62]: # To prevent false spam-positives, we will introduce a wait time of 1 second in ↴to the loop:

attributes_dict = {}
likes_dict = {}
popular_dict = {}
price_dict = {}
rating_dict = {}
ratingSignals_dict = {}

for i, row in venues.iterrows():
    vID = row["ID"]
```

```

vIDurl = 'https://api.foursquare.com/v2/venues/{}'.format(vID, CLIENT_ID, CLIENT_SECRET, VERSION)
#client_id={}&client_secret={}&v={}'.format(vID, CLIENT_ID, CLIENT_SECRET, VERSION)

#To prevent unintended code execution, I have commented the next line out.
#vIDq = requests.get(vIDurl).json()
vIDn = json_normalize(vIDq)
try:
    attributes_dict[vID] = vIDn.loc[0, 'response.venue.attributes.groups']
except KeyError:
    print('No attributes present.')
try:
    likes_dict[vID] = vIDn.loc[0, 'response.venue.likes.count']
except KeyError:
    print('No likes count present.')
try:
    popular_dict[vID] = vIDn.loc[0, 'response.venue.popular.timeframes']
except KeyError:
    print('No popular timeframes present.')
try:
    price_dict[vID] = vIDn.loc[0, 'response.venue.price']
except KeyError:
    print('No pricing tiers present.')
try:
    rating_dict[vID] = vIDn.loc[0, 'response.venue.rating']
except KeyError:
    print('No ratings present.')
try:
    ratingSignals_dict[vID] = vIDn.loc[0, 'response.venue.ratingSignals']
except KeyError:
    print('No rating signals count present.')
# Pause of 2 seconds between two requests/queries.
pause(2)

```

NameError	Traceback (most recent call last)
<ipython-input-62-5d584869649d> in <module>	
10 for i, row in venues.iterrows():	
11 vID = row["ID"]	
---> 12 vIDurl = 'https://api.foursquare.com/v2/venues/{}'.format(vID, CLIENT_ID, CLIENT_SECRET, VERSION)	
13 #To prevent unintended code execution, I have commented the next line out.	
14 #vIDq = requests.get(vIDurl).json()	

```
NameError: name 'CLIENT_ID' is not defined
```

```
[463]: # Save
###np.save('Venues/attributes_dict.npy', attributes_dict)
###np.save('Venues/likes_dict.npy', likes_dict)
###np.save('Venues/popular_dict.npy', popular_dict)
###np.save('Venues/price_dict.npy', price_dict)
###np.save('Venues/rating_dict.npy', rating_dict)
###np.save('Venues/ratingSignals_dict.npy', ratingSignals_dict)
```



```
[63]: # Load
attributes_dict = np.load('Venues/attributes_dict.npy',allow_pickle='TRUE').
    →item()
likes_dict = np.load('Venues/likes_dict.npy',allow_pickle='TRUE').item()
popular_dict = np.load('Venues/popular_dict.npy',allow_pickle='TRUE').item()
price_dict = np.load('Venues/price_dict.npy',allow_pickle='TRUE').item()
rating_dict = np.load('Venues/rating_dict.npy',allow_pickle='TRUE').item()
ratingSignals_dict = np.load('Venues/ratingSignals_dict.
    →npy',allow_pickle='TRUE').item()
```



```
[64]: print('The number of venues is : ' + str(len(venues)))
print('The number of venues with attributes is : ' + str(len(attributes_dict)))
print('The number of venues with likes is : ' + str(len(likes_dict)))
print('The number of venues with popular hours is : ' + str(len(popular_dict)))
print('The number of venues with price tiers is : ' + str(len(price_dict)))
print('The number of venues with ratings is : ' + str(len(rating_dict)))
print('The number of venues with rating signals is : ' +
    →str(len(ratingSignals_dict)))
```

```
The number of venues is : 396
The number of venues with attributes is : 396
The number of venues with likes is : 396
The number of venues with popular hours is : 235
The number of venues with price tiers is : 0
The number of venues with ratings is : 221
The number of venues with rating signals is : 221
```

Rating- and Likes correlation?

At first glance it would seem that the number of likes is a very good descriptor for the popularity of a location, especially since all locations have likes, however this might not be the case.

Theoretically, a good descriptor should include the ratio between likes and dislikes.

It would be of benefit if we could use the number of likes, since they are

available for all locations, but first let's check if there is a correlation between likes and ratings, for the 221 locations that have both.

If there is a correlation, then we can use number of likes as an indicator for popularity, otherwise we need to use the ratings.

```
[65]: #vwr = venues_with_ratings
vwr = []

venue = ''
for venue in rating_dict:
    vwr.append(venue)

#lwr = likes_with_rating_dict
lwr = {}

venue = ''
for venue in likes_dict:
    if venue in vwr:
        lwr[venue] = likes_dict[venue]
    else:
        pass
```

```
[66]: print('The number of venues in the ratings dictionary is: ' +_
          →str(len(rating_dict)))
print('The number of venues in the likes with rating dictionary is: ' +_
          →str(len(lwr)))
```

The number of venues in the ratings dictionary is: 221

The number of venues in the likes with rating dictionary is: 221

Let's create a dataframe from both dictionaries:

```
[67]: rating_df = pd.DataFrame.from_dict(rating_dict, orient='index').reset_index()
rating_df.columns=['ID', 'Rating']
ratingSignals_df = pd.DataFrame.from_dict(ratingSignals_dict, orient='index').
    →reset_index()
ratingSignals_df.columns=['ID', 'Rating Signals']
lwr_0_1 = pd.DataFrame.from_dict(lwr, orient='index').reset_index()
lwr_0_1.columns=['ID', 'Likes']
```

```
[68]: rating_likes = rating_df.merge(ratingSignals_df, on='ID').merge(lwr_0_1, on='ID')
```

Now, let's check for a correlation:

```
[69]: # fs = feature scaled normalization
rating_likes_fs = pd.DataFrame()

max_rating = rating_likes['Rating'].max()
```

```

min_rating = rating_likes['Rating'].min()
max_likes = rating_likes['Likes'].max()
min_likes = rating_likes['Likes'].min()

rating_likes_fs['ID'] = rating_likes['ID']
rating_likes_fs['Rating'] = (rating_likes['Rating']-min_rating)/
    →(max_rating-min_rating)
rating_likes_fs['Likes'] = (rating_likes['Likes']-min_likes)/
    →(max_likes-min_likes)

```

```

[70]: linear_regression = LinearRegression()
X = rating_likes_fs[['Rating']]
Y = rating_likes_fs[['Likes']]

linear_regression.fit(X,Y)

#adjusted = 1 - (1-linear_regression.score(X,Y))*(len(Y)-1)/(len(Y)-X.shape[1]-1)
#print(adjusted)

plt.figure(figsize=(7,7))

sns.set(font_scale=1.5)
sns.set_style('whitegrid')

ax = sns.regplot(x='Rating', y='Likes', data=rating_likes_fs, color='blue', □
    →marker='o', scatter_kws={'s': 200}, ci=None, label='Data')
ax = sns.regplot(x='Rating', y='Likes', data=rating_likes_fs, color='blue', □
    →marker='o', scatter_kws={'s': 200}, scatter=False, label='$R^2$ = ' + '{0:.4}'.
    →format(str(linear_regression.score(X,Y)))) 

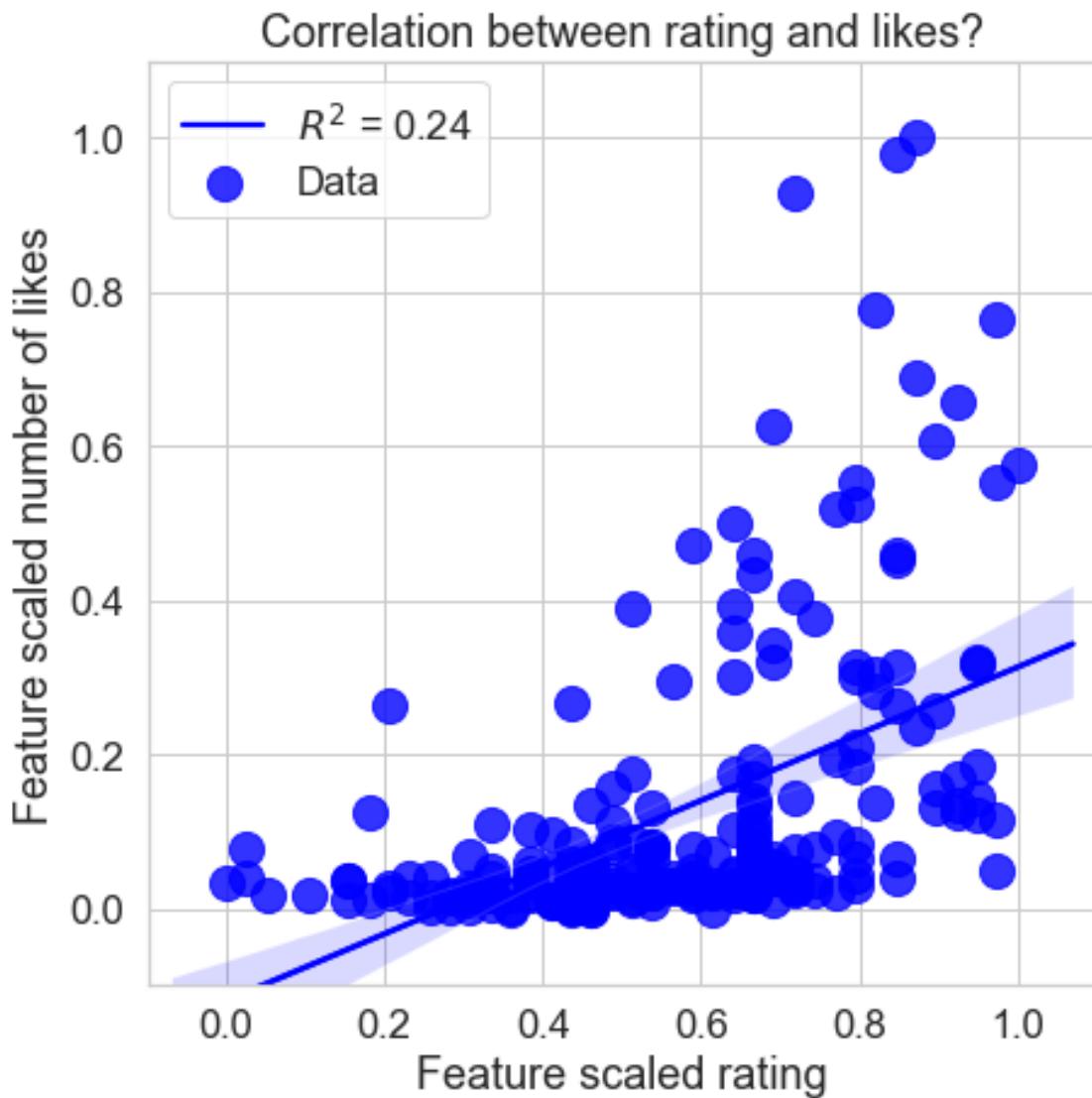
ax.set(xlabel='Feature scaled rating', ylabel='Feature scaled number of likes')
ax.set_title('Correlation between rating and likes?')

plt.xlim((-0.1,1.1))
plt.ylim((-0.1,1.1))

plt.legend()

```

[70]: <matplotlib.legend.Legend at 0x209a90163c8>



Rating- and Likes correlation!

The plot indicates, that there is no correlation between the two properties.

However, a like is an expression of a good rating.

Thus, it would make sense that the number of ratings times the rating divided by 10 correlates with the number of likes, thus let's implement the number of rating signals via:

$$x = \text{ratingSignals}_{\text{weighed}} = \text{ratingSignals} * \frac{\text{rating}}{10}$$

$$y = \text{likes}$$

```
[71]: for i, row in rating_likes.iterrows():
    rating_likes.loc[i, 'Rating Signals weighed'] = row['Rating Signals'] * ↴
    ↪row['Rating'] / 10

rating_likes = rating_likes.reindex(['ID', 'Rating', 'Rating Signals', 'RatingSignals weighed', 'Likes'], axis=1)

rating_likes
```

	ID	Rating	Rating Signals	Rating Signals weighed
0	51f9c38a498e0a7711ce2e28	8.6	95	81.70
1	58f51678826444025008d538	8.5	18	15.30
2	5895dbd93bd4ab768a282289	8.7	13	11.31
3	538ce459498ebe718bcc4339	8.2	67	54.94
4	583d359d46563a02bea58238	8.9	75	66.75
..
216	4c2156c97e85c9282f66ba21	6.8	14	9.52
217	4cf19de26195721e9bc442c1	6.2	9	5.58
218	4c518ceb9426c9283e19f373	6.0	13	7.80
219	4a981282f964a520612a20e3	6.4	189	120.96
220	4bf4778b2d6295212e206058	5.6	32	17.92

	Likes
0	76
1	14
2	12
3	53
4	16
..	...
216	8
217	5
218	7
219	103
220	13

[221 rows x 5 columns]

It can be clearly seen that in most cases, there is a correlation. Let's verify this:

```
[72]: # fs = feature scaled normalization
rating_likes_fs = pd.DataFrame()

max_rating = rating_likes['Rating Signals weighed'].max()
min_rating = rating_likes['Rating Signals weighed'].min()
max_likes = rating_likes['Likes'].max()
min_likes = rating_likes['Likes'].min()
```

```

rating_likes_fs['ID'] = rating_likes['ID']
rating_likes_fs['Rating Signals weighed'] = (rating_likes['Rating Signals'-
→weighed']-min_rating)/(max_rating-min_rating)
rating_likes_fs['Likes'] = (rating_likes['Likes']-min_likes)/
→(max_likes-min_likes)

```

```

[73]: linear_regression = LinearRegression()
X = rating_likes_fs[['Rating Signals weighed']]
Y = rating_likes_fs[['Likes']]

linear_regression.fit(X,Y)

#adjusted = 1 - (1-linear_regression.score(X,Y))*(len(Y)-1)/(len(Y)-X.shape[1]-1)
#print(adjusted)

plt.figure(figsize=(7,7))

sns.set(font_scale=1.5)
sns.set_style('whitegrid')

ax = sns.regplot(x='Rating Signals weighed', y='Likes', data=rating_likes_fs,□
→color='blue', marker='o', scatter_kws={'s': 200}, ci=None, label='Data')
ax = sns.regplot(x='Rating Signals weighed', y='Likes', data=rating_likes_fs,□
→color='blue', marker='o', scatter_kws={'s': 200}, scatter=False, label='\$R^2\$'□
→= ' + \'{0:.4}\'.format(str(linear_regression.score(X,Y))))'

ax.set(xlabel='Feature scaled weighed rating signals', ylabel='Feature scaled'□
→number of likes')
ax.set_title('Correlation between weighed rating signals and likes?')

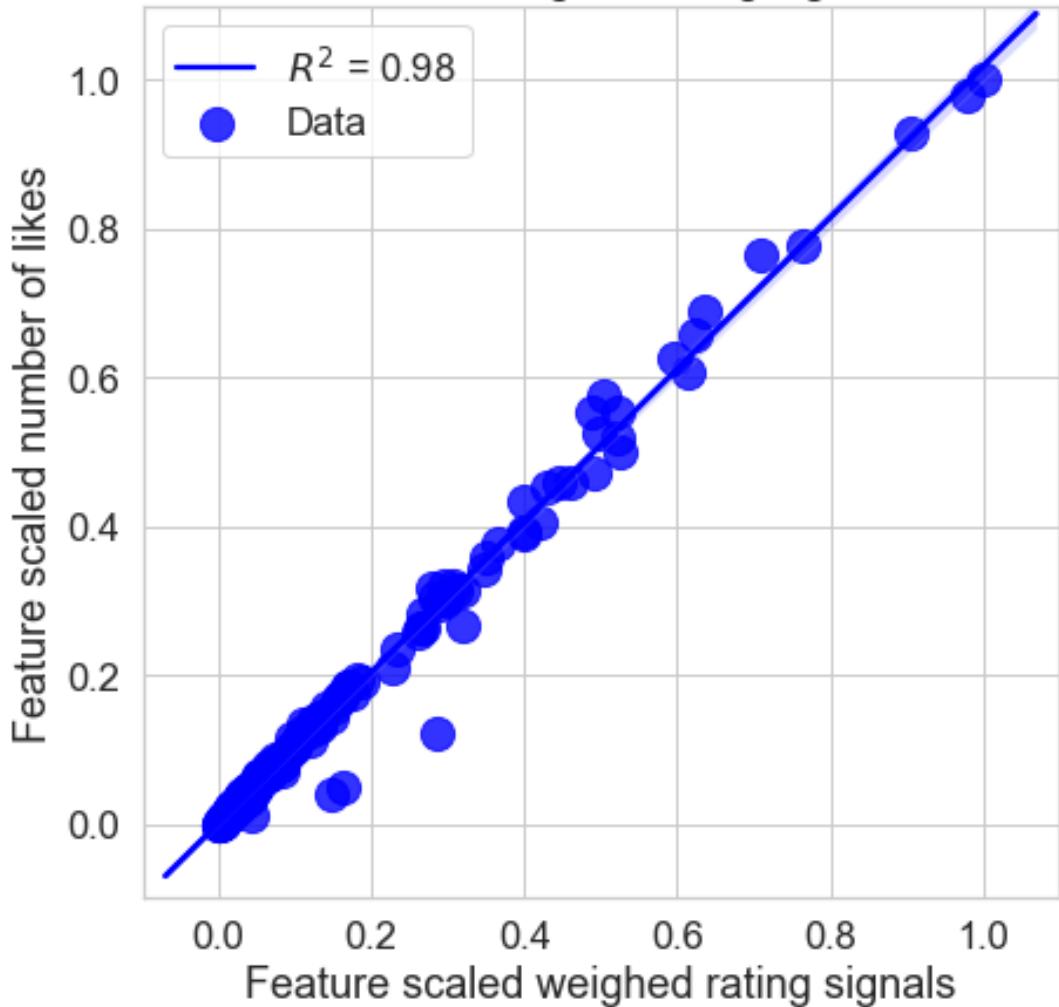
plt.xlim((-0.1,1.1))
plt.ylim((-0.1,1.1))

plt.legend()

```

[73]: <matplotlib.legend.Legend at 0x209a90abe08>

Correlation between weighed rating signals and likes?



Perfect, we found a really good correlation between the weighed rating $rating_{weighed}$ and the number of likes!

This means that we can use the likes as a substitute for the weighed rating, and since all ratings can be weighed, as a substitute for rating measure aswell.

Thus, the number of likes is indeed a descriptor for the popularity of a venue.

Visualized weighed likes per venue

Now, let's visualize color-coded venue locations, based on the number of their weighed likes:

$$likes_{weighed} = \frac{likes}{venues * populationDensity}$$

```
[74]: likes_df = pd.DataFrame.from_dict(likes_dict, orient='index').reset_index()
       likes_df.columns = ['ID', 'Likes']
       venues = venues.merge(likes_df, on='ID')
```

```
[75]: Borough_PopDens_Dict
```

```
[75]: {'Brooklyn': 37137,
       'Manhattan': 72033,
       'Queens': 21460,
       'Staten Island': 8112,
       'The Bronx': 34653}
```

```
[76]: venues_count_reindexed = venues_count.copy().set_index('Borough')
```

```
[77]: Borough_Likes_dict = {'Brooklyn':0,'Manhattan':0,'Queens':0,'Staten Island':
      ↪0,'The Bronx':0}

for i,row in venues.iterrows():
    Borough_Likes_dict[row['Borough']] += row['Likes']

#Likes per venue weighed by population density

BLW = {}

for b in Borough_Likes_dict:
    BLW[b] = Borough_Likes_dict[b] / (venues_count_reindexed.loc[b, 'Count'] * ↪
      Borough_PopDens_Dict[b])

BLW_df = pd.DataFrame.from_dict(BLW, orient='index').reset_index()
BLW_df.columns=['Borough','Weighed Likes']
```

Let's create a choropleth map, based on the weighed likes:

```
[78]: with open('Choropleth/boroughs.json') as world_geo_file:
        world_geo_data = json.load(world_geo_file)

for element in world_geo_data['features']:
    element['properties']['Likes weighed'] = "Weighed Likes: " + '{0:.3E}'.format(BLW[element['properties']['BoroName']])
```

```
[79]: world_map = folium.Map(location=[NYC_latitude, NYC_longitude], zoom_start=11)

folium.Choropleth(
    geo_data=world_geo_data,
    data=BLW_df,
    columns=['Borough', 'Weighed Likes'],
    key_on='feature.properties.BoroName',
```

```

        fill_color='PuBu',
        fill_opacity=0.7,
        line_opacity=0.2,
        legend_name='Venue Density of NYC boroughs in venues per square mile'
    ).add_to(world_map)

folium.GeoJson(data=world_geo_data,
                name='NYC Boroughs', smooth_factor=1,
                style_function=lambda x: {'color':'black','colorOpacity':0.
→5,'fillColor':'transparent','weight':0.2},
                tooltip=folium.GeoJsonTooltip(fields=['BoroName','Likes weighed'],
                                              labels=False,
                                              sticky=False),
                highlight_function=lambda x: {'weight':2,'fillColor':
→'#6495ED','fillOpacity': 0.5}
            ).add_to(world_map)

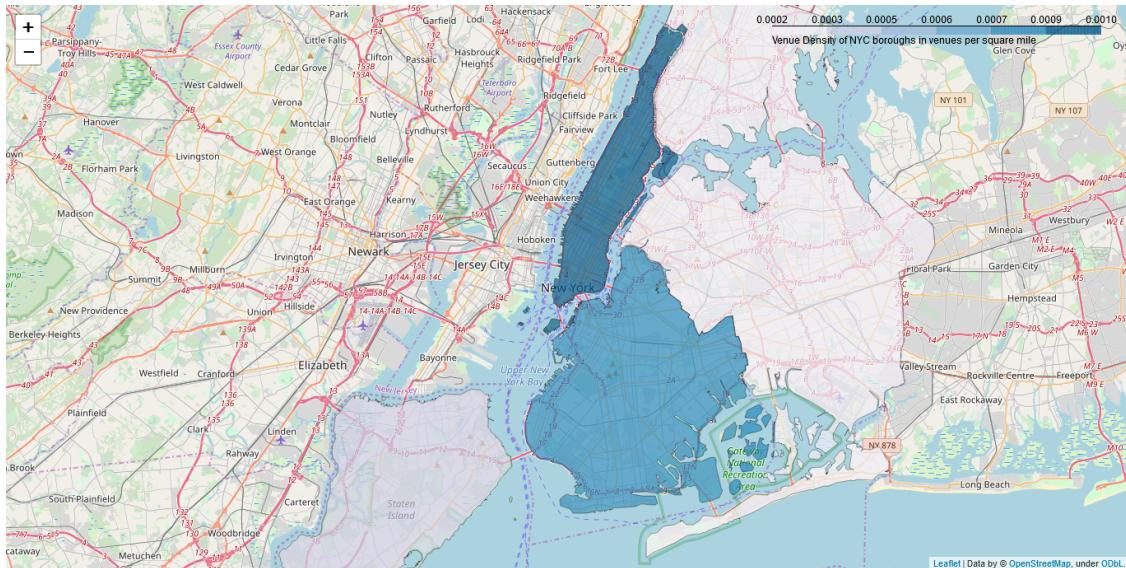
#display(world_map)

world_map_png_6 = world_map._to_png()

Image(world_map_png_6)

```

[79] :



Now, let's color the different venues based on their likes value:

[80]:

```

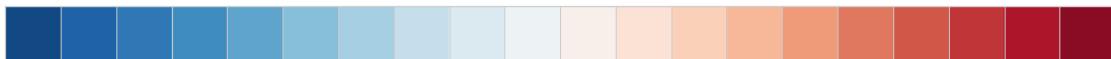
print('The maximum likes were ' + str(venues['Likes'].max()) + ', the minimum
→likes were ' + str(venues['Likes'].min()) + '.')

```

The maximum likes were 393, the minimum likes were 0.

```
[81]: #For a documentation on seaborn color palettes, please visit:  
#https://seaborn.pydata.org/tutorial/color_palettes.html
```

```
likes_range = venues['Likes'].max() + 1 - venues['Likes'].min()  
  
likes_palette = sns.color_palette("RdBu_r", likes_range)  
sns.palplot(sns.color_palette("RdBu_r", likes_range))
```



Please note: The original color palette image has been replaced, since it was far too wide in dimension.

Since folium by default doesn't support color palettes this large, we will use the BeautifyIcon plugin and convert the color palettes generated by seaborn first to the simple rgb format and then to the hex format:

```
[82]: #https://www.codespeedy.com/convert-rgb-to-hex-color-code-in-python/  
def rgb_to_hex(rgb):  
    return '%02x%02x%02x' % rgb  
  
cc = 0  
  
for color in likes_palette:  
    likes_palette[cc] = list(likes_palette[cc])  
    likes_palette[cc][0] = int(likes_palette[cc][0]*255)  
    likes_palette[cc][1] = int(likes_palette[cc][1]*255)  
    likes_palette[cc][2] = int(likes_palette[cc][2]*255)  
    likes_palette[cc] = tuple(likes_palette[cc])  
    likes_palette[cc] = rgb_to_hex(likes_palette[cc])  
    likes_palette[cc] = '#' + str(likes_palette[cc])  
    cc += 1
```

```
[83]: len(likes_palette)
```

```
[83]: 394
```

```
[84]: #For a tutorial on implementing seaborn colorpalettes in folium,  
#please refer to:  
#https://openrouteservice.org/disaster-optimization/  
#https://stackoverflow.com/questions/60131314/folium-draw-star-marker  
#https://python-visualization.github.io/folium/plugins.html#folium.plugins.  
→BeautifyIcon  
#https://github.com/python-visualization/folium/blob/master/folium/plugins/  
→beautify_icon.py
```

```
#https://github.com/marslan390/BeautifyMarker/blob/master/README.md
```

```
[85]: world_map = folium.Map(location=[NYC_latitude, NYC_longitude], zoom_start=11)

folium.Choropleth(
    geo_data=world_geo_data,
    data=BLW_df,
    columns=['Borough', 'Weighed Likes'],
    key_on='feature.properties.BoroName',
    fill_color='PuBu',
    fill_opacity=0.7,
    line_opacity=0.2,
    legend_name='Venue Density of NYC boroughs in venues per square mile'
).add_to(world_map)

folium.GeoJson(data=world_geo_data,
               name='NYC Boroughs', smooth_factor=1,
               style_function=lambda x: {'color':'black', 'colorOpacity':0.
→5, 'fillColor':'transparent', 'weight':0.2},
               tooltip=folium.GeoJsonTooltip(fields=['BoroName', 'Likes weighed'],
                                             labels=False,
                                             sticky=False),
               highlight_function=lambda x: {'weight':2, 'fillColor':
→ '#6495ED', 'fillOpacity': 0.5}
               ).add_to(world_map)

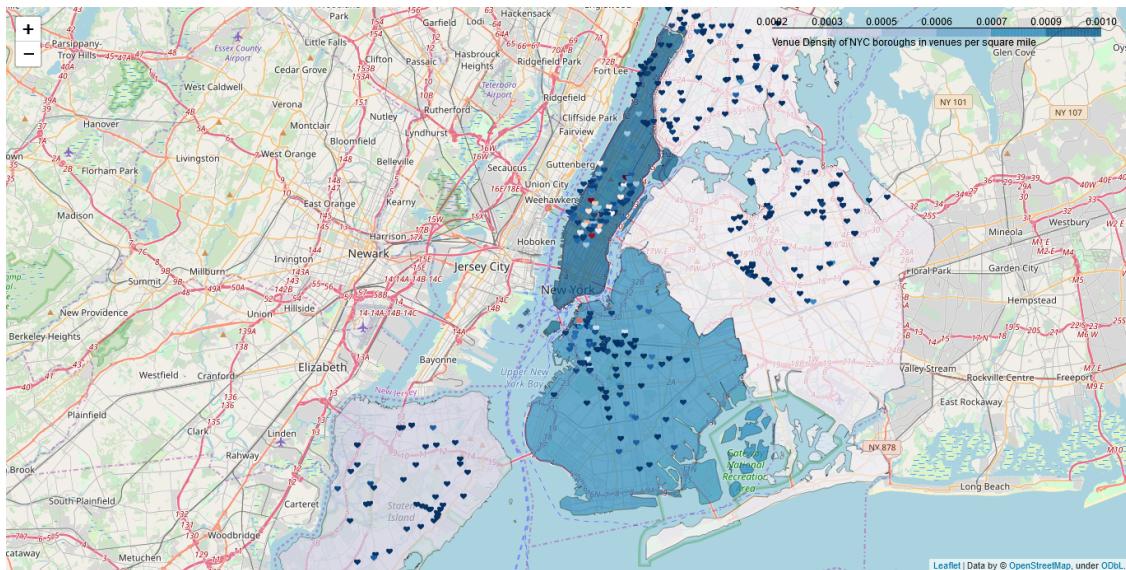
for lat, lng, name, category, likes in zip(venues['Latitude'], □
→venues['Longitude'], venues['Name'], venues['Category'], venues['Likes']):
    label = 'Name: {}, Category: {}, Likes: {}'.format(name, category, likes)
    label = folium.Tooltip(label)
    icon = folium.Icon(color='white', colorOpacity=0.
→5, icon_color='black', icon='heart', prefix='fa', angle=0)
    folium.Marker(
        [lat, lng],
        tooltip=label,
        icon=fp.BeautifyIcon(
            icon='heart',
            #iconShape='circle',
            iconSize=[0,0],
            borderWidth=0,
            text_color=likes_palette[likes],
            #background_color=likes_palette[likes],
            inner_icon_style="font-size:8px;"
        )
    ).add_to(world_map)
```

```
#display(world_map)

world_map_png_7 = world_map._to_png()

Image(world_map_png_7)
```

[85] :



Since the likes of the lower populated boroughs can't be distinguished well enough, let's visualize the likes per normalized population density:

[86] : NYC_TABLE_PANDAS_reindexed = NYC_TABLE_PANDAS.copy().set_index('Borough')

```
venue_weighed_likes_fs = {}

# fs = feature scaled normalization
venue_weighed_likes_fs = pd.DataFrame()

max_vlikes = venues['Likes'].max()
min_vlikes = venues['Likes'].min()

venue_weighed_likes_fs['Likes'] = venues['Likes']
venue_weighed_likes_fs['Borough'] = venues['Borough']
venue_weighed_likes_fs['ID'] = venues['ID']

venue_weighed_likes_fs = venue_weighed_likes_fs.copy()

for i, row in venues.iterrows():
```

```

venue_weighed_likes_fs.loc[i,'vwl'] = venue_weighed_likes_fs.loc[i,'Likes'] /
→ NYC_TABLE_PANDAS_reindexed.loc[venue_weighed_likes_fs.
→loc[i,'Borough'], 'Population Density']

# Now we feature scale the weighed likes:
venue_weighed_likes_fs['vwl'] = (venue_weighed_likes_fs['vwl'] -_
→venue_weighed_likes_fs['vwl'].min())/(venue_weighed_likes_fs['vwl'].
→max()-venue_weighed_likes_fs['vwl'].min())
venue_weighed_likes_fs_color = venue_weighed_likes_fs.copy()
venue_weighed_likes_fs_color['vwl'] = venue_weighed_likes_fs_color['vwl']*1000/2
venue_weighed_likes_fs_color = venue_weighed_likes_fs_color.astype({'vwl':int})
#venue_weighed_likes_fs_color.drop_duplicates(inplace=True)
#venue_weighed_likes_fs_color.sort_values(by='Likes', inplace=True)
venue_weighed_likes_fs_color = venue_weighed_likes_fs_color.set_index('ID')
print(venue_weighed_likes_fs_color['vwl'].max())

```

500

[87]: #For a documentation on seaborn color palettes, please visit:
https://seaborn.pydata.org/tutorial/color_palettes.html

```

likes_range_w = venue_weighed_likes_fs_color['vwl'].max() + 1

likes_palette_w = sns.color_palette("RdBu_r", likes_range_w)
sns.palplot(sns.color_palette("RdBu_r", likes_range_w))

```



Please note: The original color palette image has been replaced, since it was far too wide in dimension.

[88]: <https://www.codespeedy.com/convert-rgb-to-hex-color-code-in-python/>

```

def rgb_to_hex(rgb):
    return '%02x%02x%02x' % rgb

cc = 0

for color in likes_palette_w:
    likes_palette_w[cc] = list(likes_palette_w[cc])
    likes_palette_w[cc][0] = int(likes_palette_w[cc][0]*255)
    likes_palette_w[cc][1] = int(likes_palette_w[cc][1]*255)
    likes_palette_w[cc][2] = int(likes_palette_w[cc][2]*255)
    likes_palette_w[cc] = tuple(likes_palette_w[cc])
    likes_palette_w[cc] = rgb_to_hex(likes_palette_w[cc])

```

```

    likes_palette_w[cc] = '#' + str(likes_palette_w[cc])
    cc += 1

[89]: weighed_color_dict = {}

for i, row in venue_weighted_likes_fs_color.iterrows():
    weighed_color_dict[row['vwl']] = likes_palette_w[row['vwl']]

[90]: world_map = folium.Map(location=[NYC_latitude, NYC_longitude], zoom_start=11)

folium.Choropleth(
    geo_data=world_geo_data,
    data=BLW_df,
    columns=['Borough', 'Weighed Likes'],
    key_on='feature.properties.BoroName',
    fill_color='PuBu',
    fill_opacity=0.7,
    line_opacity=0.2,
    legend_name='Venue Density of NYC boroughs in venues per square mile'
).add_to(world_map)

folium.GeoJson(data=world_geo_data,
               name='NYC Boroughs', smooth_factor=1,
               style_function=lambda x: {'color':'black', 'colorOpacity':0.
→5, 'fillColor':'transparent', 'weight':0.2},
               tooltip=folium.GeoJsonTooltip(fields=['BoroName', 'Likes weighed'],
                                             labels=False,
                                             sticky=False),
               highlight_function=lambda x: {'weight':2, 'fillColor':
→'#6495ED', 'fillOpacity': 0.5}
               ).add_to(world_map)

for lat, lng, name, category, likes, idnum in zip(venues['Latitude'], ↴
→venues['Longitude'], venues['Name'], venues['Category'], venues['Likes'], ↴
→venues['ID']):
    label = 'Name: {}, Category: {}, Likes: {}'.format(name, category, likes)
    label = folium.Tooltip(label)
    icon = folium.Icon(color='white', colorOpacity=0.
→5, icon_color='black', icon='heart', prefix='fa', angle=0)
    folium.Marker(
        [lat, lng],
        tooltip=label,
        icon=fp.BeautifyIcon(
            icon='heart',
            #iconShape='circle',
            iconSize=[0,0],

```

```

        borderwidth=0,
        text_color=weighed_color_dict[venue_weighed_likes_fs_color.
→loc[idnum, 'vwl']],
        #background_color=likes_palette[likes],
        inner_icon_style="font-size:8px;""
    )
).add_to(world_map)

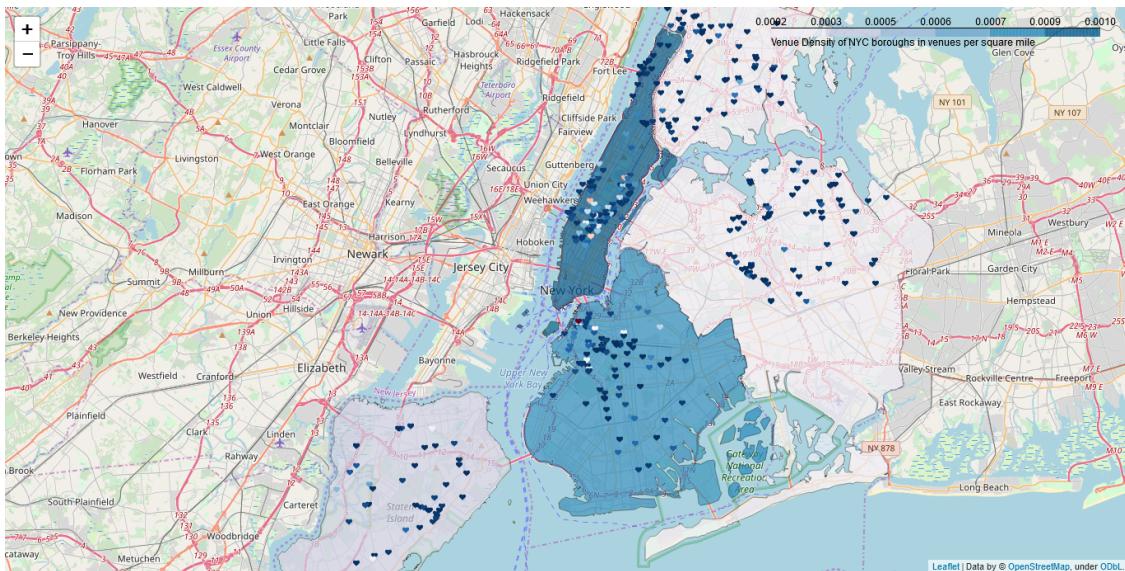
#display(world_map)

world_map_png_8 = world_map._to_png()

Image(world_map_png_8)

```

[90]:



Note that the top location no longer is in Manhattan, but in Brooklyn. Let's look it up:

[91]:

```
print('ID of max value entry: ' + venue_weighed_likes_fs_color['vwl'].idxmax())
venues.loc[venues['ID'] == '49da5ee0f964a5207c5e1fe3']
```

ID of max value entry: 49da5ee0f964a5207c5e1fe3

[91]:

```
Name Category Borough Latitude Longitude \
30 Equinox Brooklyn Heights Gym Brooklyn 40.69253 -73.991587
```

ID	Likes	
30	49da5ee0f964a5207c5e1fe3	305

Let's visualize the weighed likes using a boxplot:

```
[92]: venue_weighed_likes_fs_norm = venue_weighed_likes_fs.copy()  
  
#To mimic the original likes, the venues are multiplied with the original  
#maximum value for the likes, however, of course the values now change,  
#since they are now weighed by the population density:  
venue_weighed_likes_fs_norm['vw1'] = venue_weighed_likes_fs_norm['vw1'] * ↴  
venues['Likes'].max()
```

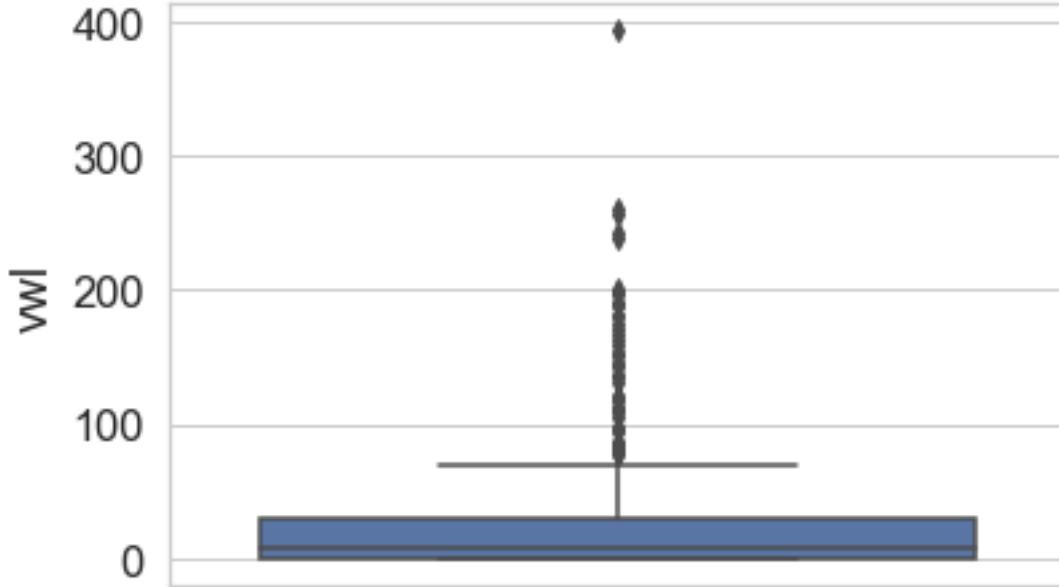
```
[93]: venue_weighed_likes_fs_norm.describe()
```

```
[93]:
```

	Likes	vw1
count	396.000000	396.000000
mean	28.886364	28.628012
std	60.536962	51.575477
min	0.000000	0.000000
25%	0.000000	0.000000
50%	5.000000	7.105904
75%	22.250000	30.224690
max	393.000000	393.000000

```
[94]: sns.boxplot(y=venue_weighed_likes_fs_norm['vw1'], ↴  
data=venue_weighed_likes_fs_norm)
```

```
[94]: <matplotlib.axes._subplots.AxesSubplot at 0x209b0c219c8>
```



As expected, most venues do not get above the upper quartile of 30 weighed likes,

however, some venues get far above that value.

Clustered Fitness Centers

Now, while the above map looks nice, the information contained in it can be better visualized using the `skmeans` clustering method:

```
[95]: venue_weighted_likes_fs_norm_coord = venue_weighted_likes_fs_norm.copy()

for i, row in venue_weighted_likes_fs_norm.iterrows():
    venue_weighted_likes_fs_norm_coord.loc[i, 'Latitude'] = venues.
    →loc[i, 'Latitude']
    venue_weighted_likes_fs_norm_coord.loc[i, 'Longitude'] = venues.
    →loc[i, 'Longitude']
```

Because the weighed likes contain quite some important outliers, we will not use the feature scaling normalization, but rather standardization for scaling:

```
[96]: venue_weighted_likes_skmean =_
    →venue_weighted_likes_fs_norm_coord[['vwl', 'Latitude', 'Longitude']].copy()
vwls = StandardScaler().fit_transform(venue_weighted_likes_skmean)
```

```
[97]: nclusters = 20

kmeans_s = KMeans(n_clusters=nclusters, init="k-means++", n_init=100).fit(vwls)

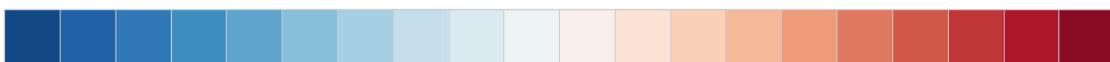
# check cluster labels generated for each row in the dataframe
vwls_labels = kmeans_s.labels_
```

```
[98]: venues.insert(0, 'Cluster label', vwls_labels)
```

```
[99]: #For a documentation on seaborn color palettes, please visit:
#https://seaborn.pydata.org/tutorial/color_palettes.html

vwls_colors_range = nclusters

vwls_colors_palette = sns.color_palette("RdBu_r", vwls_colors_range)
sns.palplot(sns.color_palette("RdBu_r", vwls_colors_range))
```



```
[100]: #https://www.codespeedy.com/convert-rgb-to-hex-color-code-in-python/
def rgb_to_hex(rgb):
    return '%02x%02x%02x' % rgb

cc = 0
```

```

for color in vwls_colors_palette:
    vwls_colors_palette[cc] = list(vwls_colors_palette[cc])
    vwls_colors_palette[cc][0] = int(vwls_colors_palette[cc][0]*255)
    vwls_colors_palette[cc][1] = int(vwls_colors_palette[cc][1]*255)
    vwls_colors_palette[cc][2] = int(vwls_colors_palette[cc][2]*255)
    vwls_colors_palette[cc] = tuple(vwls_colors_palette[cc])
    vwls_colors_palette[cc] = rgb_to_hex(vwls_colors_palette[cc])
    vwls_colors_palette[cc] = '#' + str(vwls_colors_palette[cc])
    cc += 1

```

However, we still have to sort the clusters by the weighed likes, since the skmeans algorithm only groups the clusters by their weighed likes and location, but doesn't sort the labels by the weighted likes:

```

[101]: venues_sort = venue_weighed_likes_skmean.copy()
venues_sort.insert(0, 'Cluster label', vwls_labels)

cluster_likessum_dict = {}
venue_count_per_cluster = {}
cluster_wlikes_dict = {}
row_cluster = ''
row_likes = ''

for i, row in venues_sort.iterrows():
    row_cluster = row['Cluster label']
    row_likes = row['vwl']
    if row_cluster in cluster_likessum_dict:
        venue_count_per_cluster[row_cluster] = \
            venue_count_per_cluster[row_cluster] + 1
        cluster_likessum_dict[row_cluster] = cluster_likessum_dict[row_cluster] + \
            row_likes
    else:
        venue_count_per_cluster[row_cluster] = 1
        cluster_likessum_dict[row_cluster] = row_likes

for cluster, number in cluster_likessum_dict.items():
    cluster_wlikes_dict[cluster] = number / venue_count_per_cluster[cluster]

#print(cluster_likessum_dict)
#print(venue_count_per_cluster)
#print(cluster_wlikes_dict)
#print("The sorted clusters from lowest to highest rated cluster:")
#print(sorted(cluster_wlikes_dict, key=cluster_wlikes_dict.get))

ranked_cluster_list = sorted(cluster_wlikes_dict, key=cluster_wlikes_dict.get)

```

```

ranked_cluster_list = [int(cluster) for cluster in ranked_cluster_list]

ranked_cluster_list

```

[101]: [8, 15, 11, 18, 3, 6, 0, 14, 17, 5, 7, 1, 9, 4, 19, 12, 10, 16, 2, 13]

```

[102]: i = 0

cluster_color_dict_correct = {}

for value in ranked_cluster_list:
    cluster_color_dict_correct[value]=vwls_colors_palette[i]
    i += 1

print(cluster_color_dict_correct)

```

```

{8: '#124984', 15: '#1f62a7', 11: '#2f78b5', 18: '#3f8dc0', 3: '#5ea4cc', 6: '#87beda', 0: '#a6cfe3', 14: '#c4deec', 17: '#dbe9f1', 5: '#edf2f5', 7: '#f8efea', 1: '#fbe2d4', 9: '#fbdb0b9', 4: '#f7b799', 19: '#ef9b7a', 12: '#e0785f', 10: '#d15749', 16: '#c03538', 2: '#ad162a', 13: '#8a0b24'}

```

```

[103]: world_map = folium.Map(location=[NYC_latitude, NYC_longitude], zoom_start=11)

folium.Choropleth(
    geo_data=world_geo_data,
    data=BLW_df,
    columns=['Borough', 'Weighed Likes'],
    key_on='feature.properties.BoroName',
    fill_color='PuBu',
    fill_opacity=0.7,
    line_opacity=0.2,
    legend_name='Venue Density of NYC boroughs in venues per square mile'
).add_to(world_map)

```

```

folium.GeoJson(data=world_geo_data,
                name='NYC Boroughs', smooth_factor=1,
                style_function=lambda x: {'color':'black','colorOpacity':0.
→5,'fillColor':'transparent','weight':0.2},
                tooltip=folium.GeoJsonTooltip(fields=['BoroName','Likes weighed'],
                                              labels=False,
                                              sticky=False),
                highlight_function=lambda x: {'weight':2,'fillColor':
→'#6495ED','fillOpacity': 0.5}
).add_to(world_map)

```

```

for lat, lng, name, category, likes, idnum, cl in zip(venues['Latitude'],  

    ↪venues['Longitude'], venues['Name'], venues['Category'], venues['Likes'],  

    ↪venues['ID'], venues['Cluster label']):  

    label = 'Name: {}, Cluster: {}, Likes: {}'.format(name, cl, likes)  

    label = folium.Tooltip(label)  

    icon = folium.Icon(color='white',colorOpacity=0.  

    ↪5,icon_color='black',icon='heart', prefix='fa', angle=0)  

    folium.Marker(  

        [lat, lng],  

        tooltip=label,  

        icon=fp.BeautifyIcon(  

            icon='heart',  

            #iconShape='circle',  

            iconSize=[0,0],  

            borderWidth=0,  

            text_color=cluster_color_dict_correct[cl],  

            #background_color=likes_palette[likes],  

            inner_icon_style="font-size:8px;"  

        )  

    ).add_to(world_map)

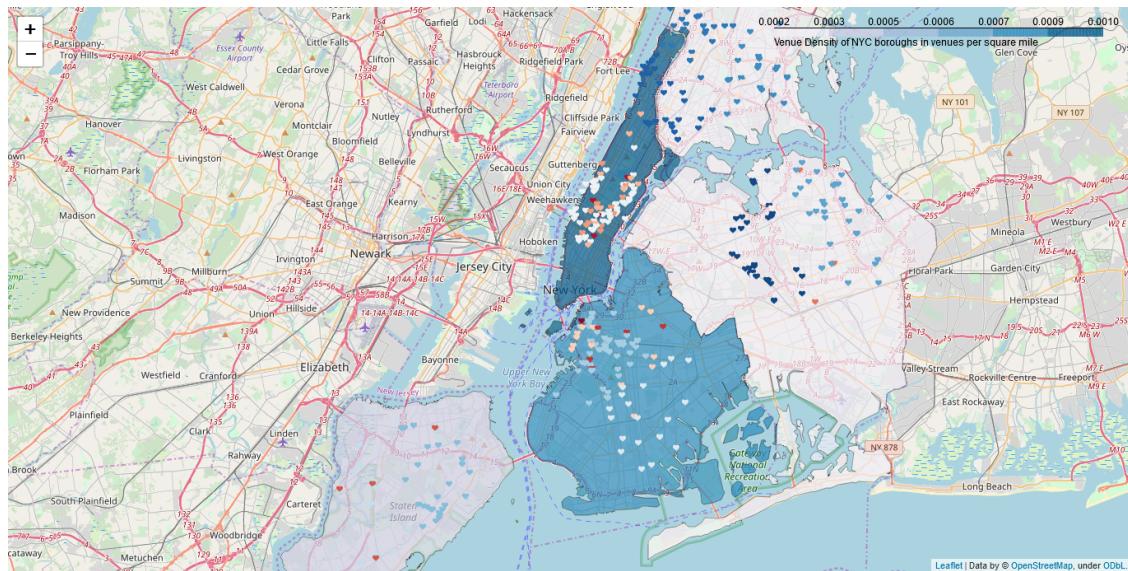
```

```
#display(world_map)
```

```
world_map_png_9 = world_map._to_png()
```

```
Image(world_map_png_9)
```

[103]:



As can be readily seen, Manhattan still has the most fitness centers with a high weighed likes count.

Preliminary Summary

In the following cells, an evaluation of the retrieved data will be performed. Also a first step to identify the optimum location will be performed.

```
[104]: URL = 'https://en.wikipedia.org/wiki/New_York_City#Boroughs'
URL_HTML = requests.get(URL)
URL_HTML_SOUP = bsoup(URL_HTML.text, 'html.parser')
NYC_TABLE_new = URL_HTML_SOUP.find_all('table')[4]
Borough_GDP = pd.DataFrame(pd.read_html(NYC_TABLE_new.prettify(), flavor='bs4')[0])
Borough_GDP.columns = ['Borough', 'County', 'Population', 'GDP', 'GDP per capita', 'Area (sq.m.)', 'Area (sq.km.)', 'Density (p.p.sq.mi.)', 'Density (p.p.sq.km.)']
Borough_GDP.drop([5,6,7], inplace=True)
Borough_GDP.drop(columns=['County', 'Population', 'GDP', 'Area (sq.m.)', 'Area (sq.km.)', 'Density (p.p.sq.mi.)', 'Density (p.p.sq.km.)'], inplace=True)
Borough_GDP.columns = ['Borough', 'GDP per capita']
```

```
[105]: Summary = pd.DataFrame()
Summary['Borough']=NYC_TABLE_PANDAS['Borough'].copy()
Summary['Population Density']=NYC_TABLE_PANDAS['Population Density']
Summary = Summary.merge(venues_count, on='Borough')
Summary.drop('Count', axis=1, inplace=True)
Summary = Summary.merge(BLW_df, on='Borough')
Summary = Summary.merge(Borough_GDP, on='Borough')
Summary = Summary.astype({'Population Density': np.float32, 'Venue Density': np.float32, 'Weighed Likes': np.float32, 'GDP per capita': np.float32})
```

```
[106]: Summary
```

```
[106]:      Borough Population Density  Venue Density  Weighed Likes \
0        Brooklyn       37137.0       1.145027    0.000766
1      Manhattan       72033.0       1.202278    0.000984
2        Queens        21460.0       0.904571    0.000300
3  Staten Island       8112.0       0.515262    0.000427
4      The Bronx        34653.0       0.767168    0.000210

      GDP per capita
0            34600.0
1            360600.0
2            39600.0
3            30300.0
4            29200.0
```

We will normalize all values in this dataframe, give the venue density values a

negative sign, since this value should be minimized, and then sum over all rows:

```
[107]: Summary_norm = Summary.copy()
Summary_norm.drop('Borough',axis=1,inplace=True)

for i,row in Summary_norm.iterrows():
    Summary_norm.loc[i,'Venue Density'] = - Summary_norm.loc[i,'Venue Density']

Summary_norm
```

```
[107]:   Population Density  Venue Density  Weighed Likes  GDP per capita
0           37137.0      -1.145027     0.000766      34600.0
1           72033.0      -1.202278     0.000984      360600.0
2           21460.0      -0.904571     0.000300      39600.0
3            8112.0      -0.515262     0.000427      30300.0
4           34653.0      -0.767168     0.000210      29200.0
```

```
[108]: #PopDensSum = Summary_norm['Population Density'].sum()
#VenDensSum = Summary_norm['Venue Density'].sum()
#WLSum = Summary_norm['Weighed Likes'].sum()
#GDPSum = Summary_norm['GDP per capita'].sum()

PopDensMax = Summary_norm['Population Density'].max()
VenDensMax = Summary_norm['Venue Density'].max()
WLMax = Summary_norm['Weighed Likes'].max()
GDPMax = Summary_norm['GDP per capita'].max()
PopDensMin = Summary_norm['Population Density'].min()
VenDensMin = Summary_norm['Venue Density'].min()
WLMin = Summary_norm['Weighed Likes'].min()
GDPMin = Summary_norm['GDP per capita'].min()
```

```
[109]: Summary_fs = Summary_norm.copy()

for i,row in Summary_fs.iterrows():
    Summary_fs.loc[i,'Population Density'] = (Summary_fs.loc[i,'Population Density'] - PopDensMin) / (PopDensMax - PopDensMin)
    Summary_fs.loc[i,'Venue Density'] = (Summary_fs.loc[i,'Venue Density'] - VenDensMin) / (VenDensMax - VenDensMin)
    Summary_fs.loc[i,'Weighed Likes'] = (Summary_fs.loc[i,'Weighed Likes'] - WLMin) / (WLMax - WLMin)
    Summary_fs.loc[i,'GDP per capita'] = (Summary_fs.loc[i,'GDP per capita'] - GDPMin) / (GDPMax - GDPMin)
```

```
[110]: Brooklyn_score = 0
Manhattan_score = 0
Queens_score = 0
Staten_score = 0
```

```

TheBronx_score = 0

for i, row in Summary_fs.iterrows():
    if i == 0:
        Brooklyn_score = row['Population Density'] + row['Venue Density'] + \
        row['Weighed Likes'] + row['GDP per capita']
    elif i == 1:
        Manhattan_score = row['Population Density'] + row['Venue Density'] + \
        row['Weighed Likes'] + row['GDP per capita']
    elif i == 2:
        Queens_score = row['Population Density'] + row['Venue Density'] + \
        row['Weighed Likes'] + row['GDP per capita']
    elif i == 3:
        Staten_score = row['Population Density'] + row['Venue Density'] + \
        row['Weighed Likes'] + row['GDP per capita']
    elif i == 4:
        TheBronx_score = row['Population Density'] + row['Venue Density'] + \
        row['Weighed Likes'] + row['GDP per capita']
    else:
        pass

print('Results from feature scaling:')
print('Brooklyn: ' + str(Brooklyn_score))
print('Manhattan: ' + str(Manhattan_score))
print('Queens: ' + str(Queens_score))
print('Staten Island: ' + str(Staten_score))
print('The Bronx: ' + str(TheBronx_score))

```

Results from feature scaling:
 Brooklyn: 1.2718301
 Manhattan: 3.0
 Queens: 0.79038596
 Staten Island: 1.2843344
 The Bronx: 1.0485489

```
[111]: Summary_fs = Summary_fs.rename(columns={'Venue Density': 'Inverse Venue' \
    'Density'})  

Summary_fs
```

	Population Density	Inverse Venue Density	Weighed Likes	GDP per capita
0	0.454076	0.083333	0.718126	0.016295
1	1.000000	0.000000	1.000000	1.000000
2	0.208820	0.433333	0.116850	0.031382
3	0.000000	1.000000	0.281015	0.003319
4	0.415216	0.633333	0.000000	0.000000

Based on this scaling, Manhattan still is a very attractive location.

Brooklyn is also very attractive for opening a fitness center, since it has a rather high population density, coupled with the second highest amount of weighed likes, but the second highest venue density and the low GDP per capita might counter this advantage.

According to the scoring, Staten Island might seem to be attractive at first glance, due to its low venue density, however it has the lowest population density and might thus disqualify itself as an attractive location for a large fitness center group.

The Bronx has a rather high population density, and it also has the second lowest venue density, however, people almost don't give any likes, and they also have the lowest GDP per capita.

Queens has the lowest overall score, due to its low population density, and its high venue density, it has the second lowest amount of likes, but the second highest GDP per capita.

Generally, despite the high venue density, Manhattan seems to be the best choice for opening a fitness center.

Let's repeat the analysis one last time, however, this time, the likes count will be viewed as negative, since a high weighed likes count in a way is indicative of a saturated market. Remember that this weighed likes count is normalized per venue and population density:

```
[112]: Summary_norm = Summary.copy()
Summary_norm.drop('Borough',axis=1,inplace=True)

for i,row in Summary_norm.iterrows():
    Summary_norm.loc[i,'Venue Density'] = - Summary_norm.loc[i,'Venue Density']
    Summary_norm.loc[i,'Weighed Likes'] = - Summary_norm.loc[i,'Weighed Likes']

    PopDensMax = Summary_norm['Population Density'].max()
    VenDensMax = Summary_norm['Venue Density'].max()
    WLMax = Summary_norm['Weighed Likes'].max()
    GDPMax = Summary_norm['GDP per capita'].max()
    PopDensMin = Summary_norm['Population Density'].min()
    VenDensMin = Summary_norm['Venue Density'].min()
    WLMin = Summary_norm['Weighed Likes'].min()
    GDPMin = Summary_norm['GDP per capita'].min()

Summary_fs = Summary_norm.copy()

for i,row in Summary_fs.iterrows():
    Summary_fs.loc[i,'Population Density'] = (Summary_fs.loc[i,'Population Density'] - PopDensMin) / (PopDensMax - PopDensMin)
    Summary_fs.loc[i,'Venue Density'] = (Summary_fs.loc[i,'Venue Density'] - VenDensMin) / (VenDensMax - VenDensMin)
```

```

    Summary_fs.loc[i, 'Weighed Likes'] = (Summary_fs.loc[i, 'Weighed Likes'] - WLMIN) / (WLMAX - WLMIN)
    Summary_fs.loc[i, 'GDP per capita'] = (Summary_fs.loc[i, 'GDP per capita'] - GDPMIN) / (GDPMAX - GDPMIN)

    Brooklyn_score = 0
    Manhattan_score = 0
    Queens_score = 0
    Staten_score = 0
    TheBronx_score = 0

for i, row in Summary_fs.iterrows():
    if i == 0:
        Brooklyn_score = row['Population Density'] + row['Venue Density'] + row['Weighed Likes'] + row['GDP per capita']
    elif i == 1:
        Manhattan_score = row['Population Density'] + row['Venue Density'] + row['Weighed Likes'] + row['GDP per capita']
    elif i == 2:
        Queens_score = row['Population Density'] + row['Venue Density'] + row['Weighed Likes'] + row['GDP per capita']
    elif i == 3:
        Staten_score = row['Population Density'] + row['Venue Density'] + row['Weighed Likes'] + row['GDP per capita']
    elif i == 4:
        TheBronx_score = row['Population Density'] + row['Venue Density'] + row['Weighed Likes'] + row['GDP per capita']
    else:
        pass

print('Results from feature scaling:')
print('Brooklyn: ' + str(Brooklyn_score))
print('Manhattan: ' + str(Manhattan_score))
print('Queens: ' + str(Queens_score))
print('Staten Island: ' + str(Staten_score))
print('The Bronx: ' + str(TheBronx_score))

```

Results from feature scaling:
 Brooklyn: 0.8355777
 Manhattan: 2.0
 Queens: 1.5566851
 Staten Island: 1.7223041
 The Bronx: 2.048549

[113]: Summary_fs

	Population Density	Venue Density	Weighed Likes	GDP per capita
0	0.454076	0.083333	0.281874	0.016295
1	1.000000	0.000000	0.000000	1.000000
2	0.208820	0.433333	0.883150	0.031382
3	0.000000	1.000000	0.718985	0.003319
4	0.415216	0.633333	1.000000	0.000000

Even though losing the advantage of its high weighed likes count, Manhattan still get's the second best rating, after The Bronx.

The Bronx takes the first place, however, an investigation into the reasons why customers in The Bronx barely give any likes should be performed, possibly there is a correlation with the GDP per capita, however the data presented above only suggests such a correlation for the extreme cases of Manhattan and The Bronx.

However, an interesting find is, that Staten Island holds its position at the second position. This is rather indicative, of it being an attractive location to invest in.

Overall, while a low weighed likes count can be indicative of a non-saturated market, it can also be a hint, that customers in those areas are either hard to satisfy, or don't care much about rating a location.

Depending on which reasons applies to the Bronx, should also be considered as a location, but since Manhattan and Staten Island hold their respective positions rather well, they should be considered aswell.