Final_Notebook2_Mapping_for_Metrics

March 15, 2021

1 Interactive maps: change of economic,housing and demographic characteristics between 2014 and 2018

1.1 What's in this notebook?

In this notebook, we explored the options to map the changes of economic, housing and demographic characteristics between 2014 and 2018 in New York Metro Area. We used the dataset that we created from the preliminary analysis of housing, transit density, economic developmment, and demographic characteristics.

1.2 Data Visualization

We created some interactive maps to visualize the changes in various metrics to charterize the housing, economic and demographic change between 2014 and 2018.

2 Importing libraries

[1]:
```
import pandas as pd
import geopandas as gpd
import matplotlib.pyplot as plt
import plotly.express as px
import contextily as ctx
from sodapy import Socrata

import folium
from folium import plugins
from folium.plugins import MarkerCluster

# to explore point patterns
from pointpats import centrography
from matplotlib.patches import Ellipse
import numpy as np
import plotly.express as px
```

```
/opt/conda/lib/python3.8/site-packages/geopandas/_compat.py:106: UserWarning:
The Shapely GEOS version (3.8.1-CAPI-1.13.3) is incompatible with the GEOS
version PyGEOS was compiled with (3.9.0-CAPI-1.16.2). Conversions between both
```

```
will be slow.
  warnings.warn(
```

3 Data exploration

[2]:
```
# importing county border shapefile
countyborder = gpd.read_file('cb_2018_us_county_500k.shp')
countyborder.head()
```

[2]:

	STATEFP	COUNTYFP	COUNTYNS	AFFGEOID	GEOID	NAME	LSAD	ALAND	AWATER	geometry
0	21	007	00516850	0500000US21007	21007	Ballard	06	639387454	69473325	POLYGON ((-89.18137 37.04630, -89.17938 37.053…
1	21	017	00516855	0500000US21017	21017	Bourbon	06	750439351	4829777	POLYGON ((-84.44266 38.28324, -84.44114 38.283…
2	21	031	00516862	0500000US21031	21031	Butler	06	1103571974	13943044	POLYGON ((-86.94486 37.07341, -86.94346 37.074…
3	21	065	00516879	0500000US21065	21065	Estill	06	655509930	6516335	POLYGON ((-84.12662 37.64540, -84.12483 37.646…
4	21	069	00516881	0500000US21069	21069	Fleming	06	902727151	7182793	POLYGON ((-83.98428 38.44549, -83.98246 38.450…

[3]:
```
# import metrics dataset with housing, economic, and demographic characteristic␣
 ↪change between 2014 and 2018
# All data in this data set represent changes of various factors in these three␣
 ↪categories.
metric = pd.read_csv('Combined_Census.csv')
```

[4]:
```
metric.head()
```

[4]:

	AFFGEOID	Geographic Area Name	Out-Migration	Transit Density	Railway Transportation	Total Population	Work From Home	GDP	Number of Jobs	Income Level
0	0500000US34017	Hudson County, New Jersey	2849	0.6851	0.0330	13753	0.0602			
1	0500000US34029	Ocean County, New Jersey	-371	0.0031	-0.0491	10526	0.0507			
2	0500000US09001	Fairfield County, Connecticut	801	0.0432	0.3556	10133	0.3090			
3	0500000US34003	Bergen County, New Jersey	1359	0.1284	0.1696	9543	0.1746			
4	0500000US34039	Union County, New Jersey	1201	0.1541	-0.0957	7830	0.0495			

```
0  0.1475          0.0441        0.6609
1  0.1504          0.0385        0.0795
2  0.1395          0.0571        0.4526
3  0.1450          0.0584        0.6739
4  0.2400          0.0723        1.0136

   Housing affordability % change for owner-occupied units  \
0                                                8.0
1                                                7.0
2                                                6.0
3                                                8.0
4                                                8.0

   Housing affordability % change for rental units  \
0                                              0.0
1                                              5.0
2                                             -1.0
3                                              3.0
4                                              4.0

   Median Number of Owned-Units  Median Rent
0                       -0.0077       0.1178
1                       -0.0089       0.0710
2                       -0.0045       0.0692
3                        0.0135       0.1148
4                        0.0674       0.1094
```

[5]:
```
#look at datatypes
metric.dtypes
```

[5]:
```
AFFGEOID                                                 object
Geographic Area Name                                     object
Out-Migration                                             int64
Transit Density                                         float64
Railway Transportation                                  float64
Total Population                                          int64
Work From Home                                          float64
GDP                                                     float64
Number of Jobs                                          float64
Income Level                                            float64
Housing affordability % change for owner-occupied units  float64
Housing affordability % change for rental units          float64
Median Number of Owned-Units                            float64
Median Rent                                             float64
dtype: object
```

[6]:
```
#add a column "GEOID" from "AFFGEOID"
metric['GEOID'] = metric['AFFGEOID'].str.strip().str[-5:]
metric.head()
```

[6]:

	AFFGEOID	Geographic Area Name	Out-Migration	Transit Density	Railway Transportation	Total Population	Work From Home	GDP	Number of Jobs	Income Level	Housing affordability % change for owner-occupied units	Housing affordability % change for rental units	Median Number of Owned-Units	Median Rent	GEOID
0	0500000US34017	Hudson County, New Jersey	2849	0.6851	0.0330	13753	0.0602	0.1475	0.0441	0.6609	8.0	0.0	-0.0077	0.1178	34017
1	0500000US34029	Ocean County, New Jersey	-371	0.0031	-0.0491	10526	0.0507	0.1504	0.0385	0.0795	7.0	5.0	-0.0089	0.0710	34029
2	0500000US09001	Fairfield County, Connecticut	801	0.0432	0.3556	10133	0.3090	0.1395	0.0571	0.4526	6.0	-1.0	-0.0045	0.0692	09001
3	0500000US34003	Bergen County, New Jersey	1359	0.1284	0.1696	9543	0.1746	0.1450	0.0584	0.6739	8.0	3.0	0.0135	0.1148	34003
4	0500000US34039	Union County, New Jersey	1201	0.1541	-0.0957	7830	0.0495	0.2400	0.0723	1.0136	8.0	4.0	0.0674	0.1094	34039

[7]:
```
#quick look at countyborder dataset
countyborder.head()
```

[7]:

	STATEFP	COUNTYFP	COUNTYNS	AFFGEOID	GEOID	NAME	LSAD	ALAND	\
0	21	007	00516850	0500000US21007	21007	Ballard	06	639387454	
1	21	017	00516855	0500000US21017	21017	Bourbon	06	750439351	
2	21	031	00516862	0500000US21031	21031	Butler	06	1103571974	
3	21	065	00516879	0500000US21065	21065	Estill	06	655509930	
4	21	069	00516881	0500000US21069	21069	Fleming	06	902727151	

	AWATER	geometry
0	69473325	POLYGON ((-89.18137 37.04630, -89.17938 37.053…
1	4829777	POLYGON ((-84.44266 38.28324, -84.44114 38.283…
2	13943044	POLYGON ((-86.94486 37.07341, -86.94346 37.074…
3	6516335	POLYGON ((-84.12662 37.64540, -84.12483 37.646…
4	7182793	POLYGON ((-83.98428 38.44549, -83.98246 38.450…

[8]:
```
#trim the county border dataset to keep the desired columns
columns_to_keep1 = ['GEOID','geometry','STATEFP']
cb= countyborder [columns_to_keep1]
```

[9]:
```
#define different geographic areas with FIPS code from the county border dataset
#Our analysis focuses on the Non-NYC metro area
NYC_5County = ['36005','36047','36061','36081','36085']
NonNYC_Metro =␣
↪['09001','09005','09009','34003','34013','34017','34019','34021','34023',
                ␣
↪'34025','34027','34029','34031','34035','34037','34039','36027','36059',
                '36071','36079','36087','36103','36111','36119','42089','42103']
NonContiguous = ['72','02','15','66','69','78','60']
```

[10]:
```
def regionbyGEOID_NYC(name):
    cb.loc[cb['GEOID'] == name,'Region'] = 'NYC'

def regionbyGEOID_NonNYC_Metro(name):
    cb.loc[cb['GEOID'] == name,'Region'] = 'NonNYC_Metro'

def regionbyGEOID_NonContiguous(name):
    cb.loc[cb['STATEFP'] == name,'Region'] = 'Non_the_contiguous_US'
```

[11]:
```
#create another dataframe of counties in non-NYC metro region
for GEOID in NonNYC_Metro:
    regionbyGEOID_NonNYC_Metro(GEOID)

NonNYC_Metro = cb[cb.Region == 'NonNYC_Metro']
```

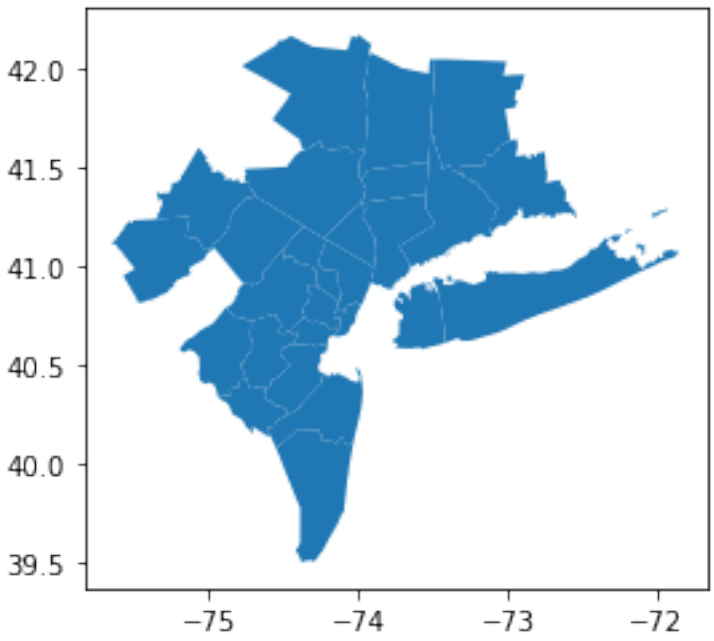
```
/opt/conda/lib/python3.8/site-packages/geopandas/geodataframe.py:1322:
```

```
SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  super(GeoDataFrame, self).__setitem__(key, value)
```

[12]:
```
#plot those counties
NonNYC_Metro.plot()
```

[12]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x7fedde9a6ca0>
```



[13]:
```
NonNYC_Metro.head(5)
```

[13]:

	GEOID	geometry	STATEFP	\
56	09009	MULTIPOLYGON (((-72.76143 41.24233, -72.75973 …	09	
153	34003	POLYGON ((-74.27066 41.02103, -74.25046 41.060…	34	
155	34013	POLYGON ((-74.37623 40.76275, -74.37389 40.762…	34	
156	34023	POLYGON ((-74.63023 40.34313, -74.63047 40.344…	34	
445	34019	POLYGON ((-75.19511 40.57969, -75.19466 40.581…	34	

	Region
56	NonNYC_Metro
153	NonNYC_Metro
155	NonNYC_Metro

```
156  NonNYC_Metro
445  NonNYC_Metro
```

[14]:
```
#create FIPS based on the GEOID in the dataset
NonNYC_Metro['FIPS']=NonNYC_Metro['GEOID']
```

```
/opt/conda/lib/python3.8/site-packages/geopandas/geodataframe.py:1322:
SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  super(GeoDataFrame, self).__setitem__(key, value)
```

[15]:
```
#merge the geodataframe with metric data frame
demo = NonNYC_Metro.merge(metric,on='GEOID',how='left')
```

[16]:
```
# a quick look at the data
demo.head()
```

[16]:

	GEOID	geometry	STATEFP
0	09009	MULTIPOLYGON (((-72.76143 41.24233, -72.75973 …	09
1	34003	POLYGON ((-74.27066 41.02103, -74.25046 41.060…	34
2	34013	POLYGON ((-74.37623 40.76275, -74.37389 40.762…	34
3	34023	POLYGON ((-74.63023 40.34313, -74.63047 40.344…	34
4	34019	POLYGON ((-75.19511 40.57969, -75.19466 40.581…	34

	Region	FIPS	AFFGEOID	Geographic Area Name
0	NonNYC_Metro	09009	0500000US09009	New Haven County, Connecticut
1	NonNYC_Metro	34003	0500000US34003	Bergen County, New Jersey
2	NonNYC_Metro	34013	0500000US34013	Essex County, New Jersey
3	NonNYC_Metro	34023	0500000US34023	Middlesex County, New Jersey
4	NonNYC_Metro	34019	0500000US34019	Hunterdon County, New Jersey

	Out-Migration	Transit Density	Railway Transportation	Total Population
0	506	0.0161	0.0893	-3809
1	1359	0.1284	0.1696	9543
2	2411	0.3058	0.1165	3939
3	255	0.0318	-0.0478	2652
4	-52	0.0091	0.3594	-1695

	Work From Home	GDP	Number of Jobs	Income Level
0	0.1997	0.1238	0.0684	0.3806
1	0.1746	0.1450	0.0584	0.6739
2	0.1739	0.1722	0.0460	0.3081
3	0.1152	0.2122	0.0645	0.2652

```
4          0.0523  0.1274          0.0427        0.3661

   Housing affordability % change for owner-occupied units  \
0                                                      6.0
1                                                      8.0
2                                                      7.0
3                                                      8.0
4                                                      7.0

   Housing affordability % change for rental units  \
0                                              5.0
1                                              3.0
2                                              1.0
3                                              0.0
4                                             -2.0

   Median Number of Owned-Units  Median Rent
0                       -0.0138       0.1056
1                        0.0135       0.1148
2                        0.0034       0.1027
3                       -0.0074       0.0580
4                        0.0021       0.0851
```

[17]:
```
#creaet a new column"FIPS" from "GEOID" for later analysis
demo['FIPS']=demo['GEOID']
demo.head()
```

[17]:
```
   GEOID                                           geometry STATEFP  \
0  09009  MULTIPOLYGON (((-72.76143 41.24233, -72.75973 …       09
1  34003  POLYGON ((-74.27066 41.02103, -74.25046 41.060…       34
2  34013  POLYGON ((-74.37623 40.76275, -74.37389 40.762…       34
3  34023  POLYGON ((-74.63023 40.34313, -74.63047 40.344…       34
4  34019  POLYGON ((-75.19511 40.57969, -75.19466 40.581…       34

         Region   FIPS        AFFGEOID           Geographic Area Name  \
0  NonNYC_Metro  09009  0500000US09009  New Haven County, Connecticut
1  NonNYC_Metro  34003  0500000US34003      Bergen County, New Jersey
2  NonNYC_Metro  34013  0500000US34013       Essex County, New Jersey
3  NonNYC_Metro  34023  0500000US34023   Middlesex County, New Jersey
4  NonNYC_Metro  34019  0500000US34019   Hunterdon County, New Jersey

   Out-Migration  Transit Density  Railway Transportation  Total Population  \
0            506           0.0161                  0.0893             -3809
1           1359           0.1284                  0.1696              9543
2           2411           0.3058                  0.1165              3939
3            255           0.0318                 -0.0478              2652
4            -52           0.0091                  0.3594             -1695
```

```
   Work From Home     GDP  Number of Jobs  Income Level  \
0          0.1997  0.1238          0.0684        0.3806
1          0.1746  0.1450          0.0584        0.6739
2          0.1739  0.1722          0.0460        0.3081
3          0.1152  0.2122          0.0645        0.2652
4          0.0523  0.1274          0.0427        0.3661

   Housing affordability % change for owner-occupied units  \
0                                                  6.0
1                                                  8.0
2                                                  7.0
3                                                  8.0
4                                                  7.0

   Housing affordability % change for rental units  \
0                                              5.0
1                                              3.0
2                                              1.0
3                                              0.0
4                                             -2.0

   Median Number of Owned-Units  Median Rent
0                       -0.0138       0.1056
1                        0.0135       0.1148
2                        0.0034       0.1027
3                       -0.0074       0.0580
4                        0.0021       0.0851
```

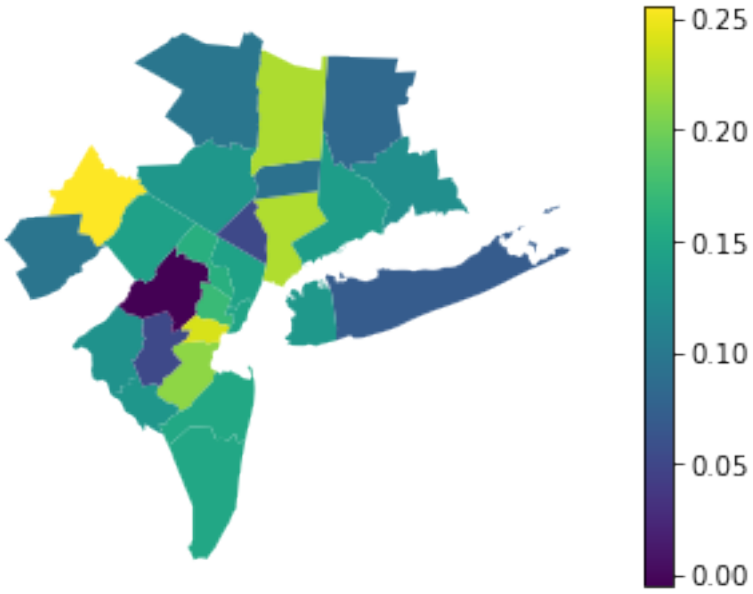
4 Create interactive to visualize the changes

[18]:
```
#create a map with GDP change between 2014 and 2018
def metrics(factor= 'GDP'):

    # plot it
    fig,ax = plt.subplots()

    # map
    demo.plot(ax=ax,
              column=factor,
              legend=True)

    ax.axis('off')
metrics()
```



[19]:
```
#import ipywidgets to create interactive maps
import ipywidgets as widgets
from ipywidgets import interact, interact_manual
```

[20]:
```
#create a new datafram with columns to map, and make a list
df = pd.DataFrame(demo, columns =
[
 'Railway Transportation',
 'Total Population',
 'Work From Home',
 'GDP',
 'Number of Jobs',
 'Income Level',
 'Housing affordability % change for owner-occupied units',
 'Housing affordability % change for rental units',
 'Median Number of Owned-Units',
 'Median Rent'])
factors = df.columns.values.tolist()
factors
```

[20]:
```
['Railway Transportation',
 'Total Population',
 'Work From Home',
 'GDP',
 'Number of Jobs',
 'Income Level',
 'Housing affordability % change for owner-occupied units',
```

```
 'Housing affordability % change for rental units',
 'Median Number of Owned-Units',
 'Median Rent']
```

[21]:
```
#add those columns to indicators
indicators = [
 'Railway Transportation',
 'Total Population',
 'Work From Home',
 'GDP',
 'Number of Jobs',
 'Income Level',
 'Housing affordability % change for owner-occupied units',
 'Housing affordability % change for rental units',
 'Median Number of Owned-Units',
 'Median Rent']
```

4.1 Ipywidgets and choropleth map

[22]:
```
#create interactive maps
@interact

def metrics(factor = factors):

    # plot it
    fig,ax = plt.subplots(figsize=(15,10))

    # map
    demo.plot(ax=ax,
              column=factor,
              legend=True,
             )

    ax.axis('off')
for indicator in indicators:
    metrics
```

```
interactive(children=(Dropdown(description='factor', options=('Railway␣
 ↪Transportation', 'Total Population', 'W…
```

4.2 Folium map

[26]:
```
#Create a base map
m = folium.Map(location=[40.730610,-73.935242],
           tiles='OpenStreetMap',
          zoom_start=8.5
          )
```

[27]:
```
# create a for loop
for indicator in indicators:
#create folium map for the indicators
    folium.Choropleth(geo_data=NonNYC_Metro,
                  data=demo,
                  name=indicator,
                  columns=['FIPS',indicator],
                  key_on="feature.properties.FIPS",
                  fill_color='BuGn',
                  fill_opacity=0.8,
                  line_opacity=0.2,
                  legend=False,
                       highlight=True
                 ).add_to(m)
#add layers
folium.LayerControl().add_to(m)
m
```

[27]:
```
<folium.folium.Map at 0x7fedde9ab250>
```

[25]:
```
m.save('metrics.html')
```

There are advantages and disadvantages to each of these mapping methods. For the first method, there is little interactive components, but visually it's clean and nice to look at. With the folium map, there are a lot of interactions, but due to the limited time, we did not find a way to only show the legend based on the layer, which made it looks "crowded". We hope to investigate more options for mapping and to improve the folium map in the future.