Notebook4_NYMA housing affordability and value

February 22, 2021

1 Notebook 4

Project:" Intra-Regional Migration and Transportation in New York Metro Area"

Due to the large data our team is working with, there are a total of four notebooks submitted for this midterm (two from each team member)

I also outlined the notebook into the Table of Content

2 Research Questions

- **Q1: On the county level, did housing costs (median housing value for owner occupied units and median rent for rental units) change between 2014 and 2018? If so, what county experience increase in housing price? And what county experience decrease in housing price?**

  - **Expected Exploration:**

    * We expect to explore and analyze the housing value data in New York Metro Region on the county level in 2014 and 2018. We expect to compare the housing value between the two years on the county level to find out changes in housing value. We hope to capture the geographic shift of housing value if there was any change.

    * We expect to create maps and charts to visually represent our findings of housing value comparison in 2014 and 2018.

- **Q2: On the county level, did housing affordability change bewteen 2014 and 2018? If so, what county experience increase in housing afforability? And what county experience decrease in housing affordability?**

  - **Expected Exploration:**
    * We expect to capture changes of housing affordability in the New York Metro Area on the county level between 2014 and 2018 by exploring and analyzing the housing affordability data.
    * We expect to create maps and charts to visually represent our findings of housing affordability comparison in 2014 and 2018.

- **Purpose of this notebook:** I conducted data exploration and analysis of the New York Metro Area housing affordability and value data in 2014 and 2018. I used the ACS 5-year data from 2010 to 2014, and from 2014 to 2018. I created bar graphs with plotly.express to compare housing values and affordability in counties across NYMA between 2014 and 2018.

3 Data sources

1. 2010-2014 5-Years ACS: https://www.census.gov/acs/www/data/data-tables-and-tools/data-profiles/2014/
2. 2014-2018 5-Years ACS: https://www.census.gov/acs/www/data/data-tables-and-tools/data-profiles/2018/

4 Importing libraries

```python
[1]: #import libraries
     import pandas as pd
     import geopandas as gpd
     import matplotlib.pyplot as plt
     import plotly.express as px
```

5 Data Exploration of Housing Affordability in 2014 and 2018

5.1 Data exploration of 2014 housing affordability data

```python
[2]: ha2014 = pd.read_csv('2014ha.csv')
     ha2014.head()
```

```
[2]:            GEO_ID                          NAME  \
     0              id              Geographic Area Name
     1  0500000US09001   Fairfield County, Connecticut
     2  0500000US09005   Litchfield County, Connecticut
     3  0500000US09009    New Haven County, Connecticut
     4  0500000US34003        Bergen County, New Jersey


                                            DP04_0023M  \
     0  Margin of Error!!YEAR STRUCTURE BUILT!!Total h…
     1                                            1470
     2                                             592
     3                                            1379
     4                                            1712


                                           DP04_0023PE  \
     0  Percent!!YEAR STRUCTURE BUILT!!Total housing u…
     1                                            17.1
     2                                            12.9
     3                                            15.0
     4                                            23.1


                                           DP04_0023PM  \
     0  Percent Margin of Error!!YEAR STRUCTURE BUILT!…
     1                                             0.4
```

```
2                                                      0.7
3                                                      0.4
4                                                      0.5


                                           DP04_0024E  \
0  Estimate!!YEAR STRUCTURE BUILT!!Total housing …
1                                              27396
2                                               5031
3                                              25327
4                                              42181


                                           DP04_0024M  \
0  Margin of Error!!YEAR STRUCTURE BUILT!!Total h…
1                                               1002
2                                                463
3                                                909
4                                               1226


                                          DP04_0024PE  \
0  Percent!!YEAR STRUCTURE BUILT!!Total housing u…
1                                                7.6
2                                                5.8
3                                                7.0
4                                               11.9


                                          DP04_0024PM  \
0  Percent Margin of Error!!YEAR STRUCTURE BUILT!…
1                                                0.3
2                                                0.5
3                                                0.3
4                                                0.3


                                           DP04_0025E  …  \
0  Estimate!!YEAR STRUCTURE BUILT!!Total housing …  …
1                                              77682  …
2                                              22131  …
3                                              95576  …
4                                              71674  …


                                          DP04_0139PE  \
0  Percent!!GROSS RENT AS A PERCENTAGE OF HOUSEHO…
1                                                9.1
2                                               10.5
3                                                9.6
4                                                8.3


                                          DP04_0139PM  \
```

```
0  Percent Margin of Error!!GROSS RENT AS A PERCE…
1                                              0.7
2                                              1.6
3                                              0.7
4                                              0.7


                                       DP04_0140E  \
0  Estimate!!GROSS RENT AS A PERCENTAGE OF HOUSEH…
1                                            45019
2                                             5820
3                                            54174
4                                            47940


                                       DP04_0140M  \
0  Margin of Error!!GROSS RENT AS A PERCENTAGE OF…
1                                             1326
2                                              489
3                                             1594
4                                             1471


                                      DP04_0140PE  \
0  Percent!!GROSS RENT AS A PERCENTAGE OF HOUSEHO…
1                                             45.6
2                                             38.1
3                                             48.1
4                                             43.3


                                      DP04_0140PM  \
0  Percent Margin of Error!!GROSS RENT AS A PERCE…
1                                              1.2
2                                              2.6
3                                              1.0
4                                              1.2


                                       DP04_0141E  \
0  Estimate!!GROSS RENT AS A PERCENTAGE OF HOUSEH…
1                                             6434
2                                             1813
3                                             7865
4                                             7476


                                       DP04_0141M  \
0  Margin of Error!!GROSS RENT AS A PERCENTAGE OF…
1                                              581
2                                              242
3                                              599
4                                              595
```

```
                                         DP04_0141PE  \
0  Percent!!GROSS RENT AS A PERCENTAGE OF HOUSEHO…
1                                          (X)
2                                          (X)
3                                          (X)
4                                          (X)


                                         DP04_0141PM
0  Percent Margin of Error!!GROSS RENT AS A PERCE…
1                                          (X)
2                                          (X)
3                                          (X)
4                                          (X)


[5 rows x 566 columns]
```

[3]: ```python
#use .read_csv command to import 2014 ACS survey housing affordability data
hao2014 = pd.read_csv('hao2014.csv')
```

[4]: ```python
#look at the frist 5 rows of the dataset
hao2014.head()
```

[4]:
```
          GEO_ID                          NAME   FIPS  \
0              id          Geographic Area Name   FIPS
1  0500000US09001   Fairfield County, Connecticut   9001
2  0500000US09005  Litchfield County, Connecticut   9005
3  0500000US09009   New Haven County, Connecticut   9009
4  0500000US34003       Bergen County, New Jersey  34003


                        DP04_0079E         DP04_0080E  \
0  Estimate!!VALUE!!Owner-occupied units   ooh value<$50,000
1                            228331              4664
2                             58127              1248
3                            206556              5668
4                            217432              4207


        DP04_0080PE                   DP04_0081E  \
0  %ooh value<$50,000   ooh value $50,000 to $99,999
1                 2                        4247
2               2.1                        1696
3               2.7                        8206
4               1.9                        1989


                DP04_0081PE                    DP04_0082E  \
0  %ooh value $50,000 to $99,999  ooh value $100,000 to $149,999
1                       1.9                            7431
```

```
2                              2.9                        5991
3                                4                       21721
4                              0.9                        3260


                      DP04_0082PE   …                DP04_0136PE  \
0  %ooh value $100,000 to $149,999   …  % GRAPI 15.0 to 19.9 percent
1                              3.3   …                        10.6
2                             10.3   …                          11
3                             10.5   …                        10.7
4                              1.5   …                        12.8


                    DP04_0137E                 DP04_0137PE  \
0  GRAPI 20.0 to 24.9 percent  % GRAPI 20.0 to 24.9 percent
1                       11158                          11.3
2                        2324                          15.2
3                       12362                            11
4                       13847                          12.5


                    DP04_0138E                 DP04_0138PE  \
0  GRAPI 25.0 to 29.9 percent  %GRAPI 20.0 to 24.9 percent
1                       11511                         11.7
2                        1965                         12.9
3                       12281                         10.9
4                       12237                           11


                    DP04_0139E                 DP04_0139PE  \
0  GRAPI 30.0 to 34.9 percent  % GRAPI 30.0 to 34.9 percent
1                        9000                           9.1
2                        1604                          10.5
3                       10813                           9.6
4                        9235                           8.3


                DP04_0140E              DP04_0140PE            DP04_0141E
0  GRAPI > 35.0 percent  % GRAPI > 35.0 percent  GRAPI Not computed
1                 45019                    45.6                6434
2                  5820                    38.1                1813
3                 54174                    48.1                7865
4                 47940                    43.3                7476

[5 rows x 116 columns]
```

[5]:
```
#drop the first row (row 0)
hao2014 = hao2014.drop([0])
```

[6]:
```
#check datatypes and columns
hao2014.dtypes
```

```
[6]: GEO_ID          object
     NAME            object
     FIPS            object
     DP04_0079E      object
     DP04_0080E      object
                      …
     DP04_0139E      object
     DP04_0139PE     object
     DP04_0140E      object
     DP04_0140PE     object
     DP04_0141E      object
     Length: 116, dtype: object
```

```
[7]: #convert FIPS from object to integer so that I can merge the 2014 housing␣
     ↪affordability dataframe with county boundary dataframe
     hao2014['FIPS'] = hao2014['FIPS'].astype(str).astype(int)
     hao2014.dtypes
```

```
[7]: GEO_ID          object
     NAME            object
     FIPS             int64
     DP04_0079E      object
     DP04_0080E      object
                      …
     DP04_0139E      object
     DP04_0139PE     object
     DP04_0140E      object
     DP04_0140PE     object
     DP04_0141E      object
     Length: 116, dtype: object
```

5.2 Data exploration of 2018 housing afforability data

```
[8]: #import 2018 ACS survey housing affordability data
     hao2018 = pd.read_csv('hao2018.csv')
```

```
[9]: #looking at the first 5 rows of the dataframe
     hao2018.head()
```

```
[9]:           GEO_ID                            NAME    FIPS  \
     0             id                Geographic Area Name    FIPS
     1  0500000US09001    Fairfield County, Connecticut    9001
     2  0500000US09005   Litchfield County, Connecticut    9005
     3  0500000US09009    New Haven County, Connecticut    9009
     4  0500000US34003        Bergen County, New Jersey   34003

                            DP04_0080E          DP04_0081E  \
```

```
0   Estimate!!VALUE!!Owner-occupied units   ooh value<$50,000
1                                 229169                4667
2                                  57079                1214
3                                 204295                4853
4                                 217881                3109


         DP04_0081PE                        DP04_0082E  \
0   %ooh value<$50,000   ooh value $50,000 to $99,999
1                    2                           4269
2                  2.1                           2103
3                  2.4                          10039
4                  1.4                           1961


                  DP04_0082PE                         DP04_0083E  \
0   %ooh value $50,000 to $99,999   ooh value $100,000 to $149,999
1                           1.9                             7458
2                           3.7                             7068
3                           4.9                            22849
4                           0.9                             3082


                    DP04_0083PE   …                     DP04_0138PE  \
0   %ooh value $100,000 to $149,999   …   % GRAPI 15.0 to 19.9 percent
1                           3.3   …                            10.7
2                          12.4   …                            10.8
3                          11.2   …                            11.1
4                           1.4   …                            13.1


                 DP04_0139E                      DP04_0139PE  \
0   GRAPI 20.0 to 24.9 percent   % GRAPI 20.0 to 24.9 percent
1                       12366                            11.7
2                        2207                            14.1
3                       14309                            12.3
4                       14784                              13


                 DP04_0140E                      DP04_0140PE  \
0   GRAPI 25.0 to 29.9 percent   %GRAPI 20.0 to 24.9 percent
1                       11064                            10.5
2                        2089                            13.4
3                       14755                            12.6
4                       13417                            11.8


                 DP04_0141E                      DP04_0141PE  \
0   GRAPI 30.0 to 34.9 percent   % GRAPI 30.0 to 34.9 percent
1                        9455                               9
2                        1307                             8.4
3                       10224                             8.8
4                        9291                             8.2
```

```
            DP04_0142E              DP04_0142PE          DP04_0143E
0  GRAPI > 35.0 percent  % GRAPI > 35.0 percent  GRAPI Not computed
1                 48610                    46.2                6071
2                  6312                    40.3                1263
3                 52137                    44.7                8834
4                 45664                    40.3                6981

[5 rows x 112 columns]
```

[10]:
```
#drop the first row (row 0)
hao2018 = hao2018.drop([0])
```

[11]:
```
#check datatypes
hao2018.dtypes
```

[11]:
```
GEO_ID        object
NAME          object
FIPS          object
DP04_0080E    object
DP04_0081E    object
                ...
DP04_0141E    object
DP04_0141PE   object
DP04_0142E    object
DP04_0142PE   object
DP04_0143E    object
Length: 112, dtype: object
```

[12]:
```
#convert FIPS from object to integer so that I can merge the 2018 housing
 →affordability dataframe with county boundary dataframe
hao2018['FIPS'] = hao2018['FIPS'].astype(str).astype(int)
hao2018.dtypes
```

[12]:
```
GEO_ID        object
NAME          object
FIPS           int64
DP04_0080E    object
DP04_0081E    object
                ...
DP04_0141E    object
DP04_0141PE   object
DP04_0142E    object
DP04_0142PE   object
DP04_0143E    object
Length: 112, dtype: object
```

```
[13]:  #change name of some columns to avoid repetition with hao2014 columns
       list(hao2018)

[13]: ['GEO_ID',
       'NAME',
       'FIPS',
       'DP04_0080E',
       'DP04_0081E',
       'DP04_0081PE',
       'DP04_0082E',
       'DP04_0082PE',
       'DP04_0083E',
       'DP04_0083PE',
       'DP04_0084E',
       'DP04_0084PE',
       'DP04_0085E',
       'DP04_0085PE',
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       'DP04_0086PE',
       'DP04_0087E',
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       'DP04_0091E',
       'DP04_0091PE',
       'DP04_0092E',
       'DP04_0092PE',
       'DP04_0093E',
       'DP04_0093PE',
       'DP04_0094E',
       'DP04_0094PE',
       'DP04_0098E',
       'DP04_0098PE',
       'DP04_0099E',
       'DP04_0099PE',
       'DP04_0100E',
       'DP04_0100PE',
       'DP04_0098E.1',
       'DP04_0098PE.1',
       'DP04_0099E.1',
       'DP04_0099PE.1',
       'DP04_0100E.1',
       'DP04_0100PE.1',
       'DP04_0102E',
       'DP04_0103E',
```

```
'DP04_0103PE',
'DP04_0104E',
'DP04_0104PE',
'DP04_0105E',
'DP04_0105PE',
'DP04_0106E',
'DP04_0106PE',
'DP04_0107E',
'DP04_0107PE',
'DP04_0108E',
'DP04_0108PE',
'DP04_0109E',
'DP04_0110E',
'DP04_0110PE',
'DP04_0111E',
'DP04_0111PE',
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'DP04_0128E',
'DP04_0128PE',
'DP04_0129E',
'DP04_0129PE',
'DP04_0130E',
'DP04_0130PE',
'DP04_0131E',
```

```
        'DP04_0131PE',
        'DP04_0132E',
        'DP04_0132PE',
        'DP04_0133E',
        'DP04_0133PE',
        'DP04_0134E',
        'DP04_0135E',
        'Unnamed: 98',
        'DP04_0137E',
        'DP04_0137PE',
        'DP04_0138E',
        'DP04_0138PE',
        'DP04_0139E',
        'DP04_0139PE',
        'DP04_0140E',
        'DP04_0140PE',
        'DP04_0141E',
        'DP04_0141PE',
        'DP04_0142E',
        'DP04_0142PE',
        'DP04_0143E']
```

```
[14]:  hao2018.columns=['GEO_ID',
        'NAME',
        'FIPS',
        'DP04_0080E',
        'DP04_0081E',
        'DP04_0081PE',
        'DP04_0082E',
        'DP04_0082PE',
        'DP04_0083E',
        'DP04_0083PE',
        'DP04_0084E',
        'DP04_0084PE',
        'DP04_0085E',
        'DP04_0085PE',
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        'DP04_0088PE',
        'DP04_0089E',
        'DP04_0090PE',
        'DP04_0091E',
        'DP04_0091PE',
        'DP04_0092E',
```

```
'DP04_0092PE',
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'DP04_0093PE',
'DP04_0094E',
'DP04_0094PE',
'DP04_0098E',
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'DP04_0108PE_y',
'DP04_0109E_y',
'DP04_0110E_y',
'DP04_0110PE_y',
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'DP04_0112E_y',
'DP04_0112PE_y',
'DP04_0113E_y',
'DP04_0113PE_y',
'DP04_0114E_y',
'DP04_0114PE_y',
'DP04_0115E_y',
'DP04_0115PE_y',
'DP04_0116E_y',
'DP04_0117E_y',
'DP04_0120E_y',
'DP04_0120PE_y',
```

```
 'DP04_0121E',
 'DP04_0121PE',
 'DP04_0122E',
 'DP04_0122PE',
 'DP04_0123E',
 'DP04_0123PE',
 'DP04_0124E',
 'DP04_0124PE',
 'DP04_0125E',
 'DP04_0126E',
 'DP04_0127E',
 'DP04_0127PE',
 'DP04_0128E',
 'DP04_0128PE',
 'DP04_0129E',
 'DP04_0129PE',
 'DP04_0130E',
 'DP04_0130PE',
 'DP04_0131E',
 'DP04_0131PE',
 'DP04_0132E',
 'DP04_0132PE',
 'DP04_0133E',
 'DP04_0133PE',
 'DP04_0134E',
 'DP04_0135E',
 'Unnamed: 98',
 'DP04_0137E',
 'DP04_0137PE',
 'DP04_0138E',
 'DP04_0138PE',
 'DP04_0139E',
 'DP04_0139PE',
 'DP04_0140E',
 'DP04_0140PE',
 'DP04_0141E',
 'DP04_0141PE',
 'DP04_0142E',
 'DP04_0142PE',
 'DP04_0143E']
```

5.3 Data analysis of the housing affordability data in 2014 and 2018

```python
[15]: #import county boundary data set
      tracts=gpd.read_file('Countyborder/tl_2017_us_county.shp')
      tracts.head()
```

```
[15]:    STATEFP COUNTYFP  COUNTYNS   GEOID        NAME           NAMELSAD LSAD CLASSFP  \
      0      31     039   00835841   31039     Cuming     Cuming County   06      H1
      1      53     069   01513275   53069  Wahkiakum  Wahkiakum County   06      H1
      2      35     011   00933054   35011    De Baca    De Baca County   06      H1
      3      31     109   00835876   31109  Lancaster  Lancaster County   06      H1
      4      31     129   00835886   31129   Nuckolls   Nuckolls County   06      H1

         MTFCC CSAFP CBSAFP METDIVFP FUNCSTAT       ALAND    AWATER    INTPTLAT  \
      0  G4020  None   None     None        A  1477641638  10701538  +41.9158651
      1  G4020  None   None     None        A   680956787  61588406  +46.2946377
      2  G4020  None   None     None        A  6016761648  29147345  +34.3592729
      3  G4020   339  30700     None        A  2169252486  22867561  +40.7835474
      4  G4020  None   None     None        A  1489645186   1718484  +40.1764918

            INTPTLON                                           geometry
      0  -096.7885168  POLYGON ((-97.01952 42.00410, -97.01952 42.004…
      1  -123.4244583  POLYGON ((-123.43639 46.23820, -123.44759 46.2…
      2  -104.3686961  POLYGON ((-104.56739 33.99757, -104.56772 33.9…
      3  -096.6886584  POLYGON ((-96.91060 40.95841, -96.91060 40.958…
      4  -098.0468422  POLYGON ((-98.27367 40.08940, -98.27367 40.089…
```

```python
[16]: #make a new column "FIPS"
      tracts['FIPS']=tracts['GEOID']
```

```python
[17]: tracts.head()
```

```
[17]:    STATEFP COUNTYFP  COUNTYNS   GEOID        NAME           NAMELSAD LSAD CLASSFP  \
      0      31     039   00835841   31039     Cuming     Cuming County   06      H1
      1      53     069   01513275   53069  Wahkiakum  Wahkiakum County   06      H1
      2      35     011   00933054   35011    De Baca    De Baca County   06      H1
      3      31     109   00835876   31109  Lancaster  Lancaster County   06      H1
      4      31     129   00835886   31129   Nuckolls   Nuckolls County   06      H1

         MTFCC CSAFP CBSAFP METDIVFP FUNCSTAT       ALAND    AWATER    INTPTLAT  \
      0  G4020  None   None     None        A  1477641638  10701538  +41.9158651
      1  G4020  None   None     None        A   680956787  61588406  +46.2946377
      2  G4020  None   None     None        A  6016761648  29147345  +34.3592729
      3  G4020   339  30700     None        A  2169252486  22867561  +40.7835474
      4  G4020  None   None     None        A  1489645186   1718484  +40.1764918

            INTPTLON                                           geometry   FIPS
      0  -096.7885168  POLYGON ((-97.01952 42.00410, -97.01952 42.004…  31039
      1  -123.4244583  POLYGON ((-123.43639 46.23820, -123.44759 46.2…  53069
      2  -104.3686961  POLYGON ((-104.56739 33.99757, -104.56772 33.9…  35011
      3  -096.6886584  POLYGON ((-96.91060 40.95841, -96.91060 40.958…  31109
      4  -098.0468422  POLYGON ((-98.27367 40.08940, -98.27367 40.089…  31129
```

```
[18]:  #check data types
       tracts.dtypes
```

```
[18]:  STATEFP        object
       COUNTYFP       object
       COUNTYNS       object
       GEOID          object
       NAME           object
       NAMELSAD       object
       LSAD           object
       CLASSFP        object
       MTFCC          object
       CSAFP          object
       CBSAFP         object
       METDIVFP       object
       FUNCSTAT       object
       ALAND           int64
       AWATER          int64
       INTPTLAT       object
       INTPTLON       object
       geometry     geometry
       FIPS           object
       dtype: object
```

```
[19]:  #convert FIPS data types in 'tracts' to integer to merge later with housing␣
       ↪affordability dataframe
       tracts['FIPS'] = tracts['FIPS'].astype(str).astype(int)
       tracts.dtypes
```

```
[19]:  STATEFP        object
       COUNTYFP       object
       COUNTYNS       object
       GEOID          object
       NAME           object
       NAMELSAD       object
       LSAD           object
       CLASSFP        object
       MTFCC          object
       CSAFP          object
       CBSAFP         object
       METDIVFP       object
       FUNCSTAT       object
       ALAND           int64
       AWATER          int64
       INTPTLAT       object
       INTPTLON       object
       geometry     geometry
```

```
FIPS              int64
dtype: object
```

```
[20]: #merge the county boundary dataframe wiht 2018 housing affordability dataframes
      →on FIPS
      tracts2018=tracts.merge(hao2018,on="FIPS")
      pd.set_option('display.max_columns', None)
      tracts2018.head()
```

[20]:

	STATEFP	COUNTYFP	COUNTYNS	GEOID	NAME_x	NAMELSAD	LSAD	CLASSFP
0	34	037	00882236	34037	Sussex	Sussex County	06	H1
1	36	111	00974153	36111	Ulster	Ulster County	06	H1
2	36	103	00974149	36103	Suffolk	Suffolk County	06	H1
3	34	039	00882235	34039	Union	Union County	06	H1
4	36	027	00974112	36027	Dutchess	Dutchess County	06	H1

	MTFCC	CSAFP	CBSAFP	METDIVFP	FUNCSTAT	ALAND	AWATER	INTPTLAT
0	G4020	408	35620	35084	A	1343552956	43234734	+41.1374609
1	G4020	408	28740	None	A	2911757797	94596954	+41.9472124
2	G4020	408	35620	35004	A	2360846288	3785546967	+40.9435540
3	G4020	408	35620	35084	A	266170662	7046286	+40.6598707
4	G4020	408	35620	20524	A	2060678182	76956282	+41.7547699

	INTPTLON	geometry	FIPS
0	-074.6919141	POLYGON ((-74.93933 41.06918, -74.94004 41.069…	34037
1	-074.2654582	POLYGON ((-74.67402 41.97167, -74.68567 41.976…	36111
2	-072.6922184	POLYGON ((-72.86371 41.11338, -72.86351 41.113…	36103
3	-074.3086957	POLYGON ((-74.42857 40.69911, -74.42849 40.699…	34039
4	-073.7400411	POLYGON ((-73.94032 41.87275, -73.94075 41.873…	36027

	GEO_ID	NAME_y	DP04_0080E	DP04_0081E
0	0500000US34037	Sussex County, New Jersey	44007	895
1	0500000US36111	Ulster County, New York	47815	2131
2	0500000US36103	Suffolk County, New York	390897	7197
3	0500000US34039	Union County, New Jersey	111289	2027
4	0500000US36027	Dutchess County, New York	73809	2559

	DP04_0081PE	DP04_0082E	DP04_0082PE	DP04_0083E	DP04_0083PE	DP04_0084E
0	2	755	1.7	3144	7.1	6343
1	4.5	2623	5.5	5451	11.4	9511
2	1.8	4783	1.2	6753	1.7	12137
3	1.8	1195	1.1	2898	2.6	8602
4	3.5	2000	2.7	3652	4.9	8209

	DP04_0084PE	DP04_0085E	DP04_0085PE	DP04_0086E	DP04_0086PE	DP04_0087E
0	14.4	15762	35.8	13236	30.1	3291
1	19.9	14861	31.1	9746	20.4	2848

	DP04_0087PE	DP04_0088E	DP04_0088PE	DP04_0089E	DP04_0090PE	DP04_0091E	\
2	3.1	65663	16.8	187835	48.1	89407	
3	7.7	26144	23.5	39611	35.6	25141	
4	11.1	26253	35.6	24000	32.5	6112	

	DP04_0087PE	DP04_0088E	DP04_0088PE	DP04_0089E	DP04_0090PE	DP04_0091E	\
0	7.5	581	1.3	266000	44007	31635	
1	6	644	1.3	225500	47815	27977	
2	22.9	17122	4.4	386800	390897	264291	
3	22.6	5671	5.1	357300	111289	76034	
4	8.3	1024	1.4	278100	73809	49148	

	DP04_0091PE	DP04_0092E	DP04_0092PE	DP04_0093E	DP04_0093PE	DP04_0094E	\
0	71.9	12372	28.1	31635	31635	44	
1	58.5	19838	41.5	27977	27977	118	
2	67.6	126606	32.4	264291	264291	632	
3	68.3	35255	31.7	76034	76034	130	
4	66.6	24661	33.4	49148	49148	145	

	DP04_0094PE	DP04_0098E	DP04_0098PE	DP04_0099E	DP04_0099PE	DP04_0100E	\
0	0.1	846	2.7	4083	12.9	7416	
1	0.4	2022	7.2	5818	20.8	7230	
2	0.2	4121	1.6	13234	5	31662	
3	0.2	771	1	4767	6.3	10573	
4	0.3	1538	3.1	6036	12.3	11000	

	DP04_0100PE	DP04_0098E.1	DP04_0098PE.1	DP04_0099E.1	DP04_0099PE.1	\
0	23.4	7113	22.5	5312	16.8	
1	25.8	5766	20.6	3326	11.9	
2	12	51430	19.5	55037	20.8	
3	13.9	15129	19.9	16246	21.4	
4	22.4	11280	23	8250	16.8	

	DP04_0100E.1	DP04_0100PE.1	DP04_0102E	DP04_0103E	DP04_0103PE	DP04_0104E	\
0	6821	21.6	12372	191	1.5	249	
1	3697	13.2	19838	659	3.3	1374	
2	108175	40.9	126606	1474	1.2	2751	
3	28418	37.4	35255	469	1.3	573	
4	10899	22.2	24661	485	2	1323	

	DP04_0104PE	DP04_0105E	DP04_0105PE	DP04_0106E	DP04_0106PE	DP04_0107E	\
0	2	742	6	2278	18.4	3143	
1	6.9	4170	21	4904	24.7	3793	
2	2.2	5898	4.7	11971	9.5	18798	
3	1.6	997	2.8	2194	6.2	5840	
4	5.4	3572	14.5	5147	20.9	5503	

	DP04_0107PE	DP04_0108E_y	DP04_0108PE_y	DP04_0109E_y	DP04_0110E_y	\

```
      25.4        5769        46.6          974        31569
0
1     19.1        4938        24.9          754        27852
2     14.8       85714        67.7         1194       263078
3     16.6       25182        71.4         1196        75687
4     22.3        8631          35          863        49072


   DP04_0110PE_y DP04_0111E_y DP04_0111PE_y DP04_0112E_y DP04_0112PE_y  \
0         31569        10897          34.5         5128          16.2
1         27852        10046          36.1         4418          15.9
2        263078        75539          28.7        42813          16.3
3         75687        23777          31.4        12385          16.4
4         49072        16592          33.8         8185          16.7


   DP04_0113E_y DP04_0113PE_y DP04_0114E_y DP04_0114PE_y DP04_0115E_y  \
0          4472          14.2         2769           8.8         8303
1          3373          12.1         2322           8.3         7693
2         33963          12.9        24782           9.4        85981
3          9218          12.2         6365           8.4        23942
4          6313          12.9         4387           8.9        13595


   DP04_0115PE_y DP04_0116E_y DP04_0117E_y DP04_0120E_y DP04_0120PE_y  \
0          26.3           66        12205         7346          60.1
1          27.6          125        19623        12124          61.9
2          32.7         1213       125313        68664          54.8
3          31.6          347        34916        19381          55.6
4          27.7           76        24477        15905            65


   DP04_0121E DP04_0121PE DP04_0122E DP04_0122PE DP04_0123E DP04_0123PE  \
0        1310        10.7        784         6.4        669         5.5
1        1927         9.8       1240         6.3        845         4.3
2       12157         9.7       8235         6.6       6688         5.3
3        3424         9.8       2382         6.8       1966         5.6
4        1953           8       1400         5.7       1199         4.9


   DP04_0124E DP04_0124PE DP04_0125E DP04_0126E DP04_0127E DP04_0127PE  \
0        2096        17.2        167        8765        277         3.2
1        3487        17.8        215       20470       1321         6.5
2       29569        23.6       1293       91960       4916         5.3
3        7763        22.2        339       74937       4674         6.2
4        4020        16.4        184       31793       1772         5.6


   DP04_0128E DP04_0128PE DP04_0129E DP04_0129PE DP04_0130E DP04_0130PE  \
0        1691        19.3       3911        44.6       2029        23.1
1        7047        34.4       8306        40.6       2793        13.6
2        8369         9.1      21870        23.8      27381        29.8
3       14546        19.4      32414        43.3      15711          21
4        8178        25.7      13913        43.8       5205        16.4
```

```
    DP04_0131E DP04_0131PE DP04_0132E DP04_0132PE DP04_0133E DP04_0133PE  \
0         649         7.4       152        1.7        56        0.6
1         626         3.1       303        1.5        74        0.4
2       18756        20.4      6931        7.5      3737        4.1
3        5170         6.9      1493          2       929        1.2
4        1907           6       538        1.7       280        0.9


    DP04_0134E DP04_0135E Unnamed: 98 DP04_0137E DP04_0137PE DP04_0138E  \
0        1260        589        8624        787         9.1       1157
1        1086       1254       20042       1905         9.5       1991
2        1698       5124       90135       7435         8.2       8701
3        1248       2761       73956       8842          12       8751
4        1194       1745       31426       3392        10.8       4085


    DP04_0138PE DP04_0139E DP04_0139PE DP04_0140E DP04_0140PE DP04_0141E  \
0         13.4       1176        13.6       1018        11.8        815
1          9.9       2457        12.3       1716         8.6       2111
2          9.7      10047        11.1       9917          11       8180
3         11.8       8847          12       8186        11.1       6691
4           13       3583        11.4       3021         9.6       2754


    DP04_0141PE DP04_0142E DP04_0142PE DP04_0143E
0          9.5       3671        42.6        730
1         10.5       9862        49.2       1682
2          9.1      45855        50.9       6949
3            9      32639        44.1       3742
4          8.8      14591        46.4       2112
```

[21]: ```python
#merge tracts with hao2018 on FIPS plot it on the map
tracts2014=tracts.merge(hao2014,on="FIPS")
pd.set_option('display.max_columns', None)
tracts2014.head()
```

[21]: 
```
    STATEFP COUNTYFP COUNTYNS GEOID   NAME_x   NAMELSAD LSAD CLASSFP \
0   34   037 00882236 34037   Sussex   Sussex County   06   H1
1   36   111 00974153 36111   Ulster   Ulster County   06   H1
2   36   103 00974149 36103 Suffolk Suffolk County   06   H1
3   34   039 00882235 34039   Union   Union County   06   H1
4   36   027 00974112 36027 Dutchess Dutchess County 06   H1

    MTFCC CSAFP CBSAFP METDIVFP FUNCSTAT   ALAND   AWATER   INTPTLAT \
0 G4020   408 35620   35084   A 1343552956   43234734 +41.1374609
1 G4020   408 28740   None   A 2911757797   94596954 +41.9472124
2 G4020   408 35620   35004   A 2360846288 3785546967 +40.9435540
3 G4020   408 35620   35084   A   266170662   7046286 +40.6598707
4 G4020   408 35620   20524   A 2060678182   76956282 +41.7547699
```

```
        INTPTLON                                          geometry   FIPS  \
0  -074.6919141  POLYGON ((-74.93933 41.06918, -74.94004 41.069…  34037
1  -074.2654582  POLYGON ((-74.67402 41.97167, -74.68567 41.976…  36111
2  -072.6922184  POLYGON ((-72.86371 41.11338, -72.86351 41.113…  36103
3  -074.3086957  POLYGON ((-74.42857 40.69911, -74.42849 40.699…  34039
4  -073.7400411  POLYGON ((-73.94032 41.87275, -73.94075 41.873…  36027

           GEO_ID                     NAME_y DP04_0079E DP04_0080E  \
0  0500000US34037    Sussex County, New Jersey      45642       1002
1  0500000US36111      Ulster County, New York      48242       2494
2  0500000US36103     Suffolk County, New York     393936       9261
3  0500000US34039     Union County, New Jersey     111028       2298
4  0500000US36027   Dutchess County, New York      74252       2980

  DP04_0080PE DP04_0081E DP04_0081PE DP04_0082E DP04_0082PE DP04_0083E  \
0         2.2        592         1.3       2519         5.5       6336
1         5.2       2094         4.3       5002        10.4       9860
2         2.4       5373         1.4       7398         1.9      13976
3         2.1       1211         1.1       3365           3       8616
4           4       1989         2.7       2964           4       7689

  DP04_0083PE DP04_0084E DP04_0084PE DP04_0085E DP04_0085PE DP04_0086E  \
0        13.9      16183        35.5      14291        31.3       4164
1        20.4      15806        32.8       9247        19.2       3085
2         3.5      71250        18.1     189896        48.2      80437
3         7.8      25684        23.1      42557        38.3      22790
4        10.4      26482        35.7      25104        33.8       5773

  DP04_0086PE DP04_0087E DP04_0087PE DP04_0088E DP04_0089E DP04_0090E  \
0         9.1        555         1.2     277600      45642      34326
1         6.4        654         1.4     226600      48242      30144
2        20.4      16345         4.1     376800     393936     275950
3        20.5       4507         4.1     353300     111028      78045
4         7.8       1271         1.7     282100      74252      52242

  DP04_0090PE DP04_0091E DP04_0091PE DP04_0092E DP04_0092PE DP04_0093E  \
0        75.2      11316        24.8      34326      34326         12
1        62.5      18098        37.5      30144      30144         11
2          70     117986          30     275950     275950        202
3        70.3      32983        29.7      78045      78045         75
4        70.4      22010        29.6      52242      52242         15

  DP04_0093PE DP04_0094E DP04_0094PE DP04_0095E DP04_0095PE DP04_0096E  \
0           0        100         0.3        124         0.4        711
1           0        183         0.6        417         1.4       1783
2         0.1        699         0.3       1591         0.6       4482
```

3	0.1	258	0.3	307	0.4	1008
4	0	138	0.3	456	0.9	1753

	DP04_0096PE	DP04_0097E	DP04_0097PE	DP04_0098E	DP04_0098PE	DP04_0099E	\
0	2.1	4030	11.7	7377	21.5	21972
1	5.9	6190	20.5	7910	26.2	13650
2	1.6	15772	5.7	34159	12.4	219045
3	1.3	4741	6.1	11418	14.6	60238
4	3.4	6053	11.6	11183	21.4	32644

	DP04_0099M	DP04_0099PE	DP04_0100E	DP04_0101E	DP04_0102E	DP04_0102PE	\
0	661	64	2304	11316	39	0.3
1	667	45.3	1908	18098	26	0.1
2	2186	79.4	2776	117986	280	0.2
3	1193	77.2	2688	32983	28	0.1
4	780	62.5	2276	22010	13	0.1

	DP04_0103E	DP04_0103PE	DP04_0104E	DP04_0104PE	DP04_0105E	DP04_0105PE	\
0	80	0.7	138	1.2	223	2
1	120	0.7	574	3.2	1059	5.9
2	531	0.5	1317	1.1	2219	1.9
3	227	0.7	354	1.1	449	1.4
4	123	0.6	305	1.4	876	4

	DP04_0106E	DP04_0106PE	DP04_0107E	DP04_0108E	DP04_0108PE	DP04_0109E	\
0	10836	95.8	952	34237	34237	8937
1	16319	90.2	739	30025	30025	8986
2	113639	96.3	1,000+	274895	274895	64353
3	31925	96.8	1,000+	77588	77588	20583
4	20693	94	836	52110	52110	14690

	DP04_0109PE	DP04_0110E	DP04_0110PE	DP04_0111E	DP04_0111PE	DP04_0112E	\
0	26.1	5934	17.3	4719	13.8	3766
1	29.9	4300	14.3	4281	14.3	2790
2	23.4	40407	14.7	38373	14	28291
3	26.5	10809	13.9	9854	12.7	7390
4	28.2	7916	15.2	6983	13.4	5548

	DP04_0112PE	DP04_0113E	DP04_0113PE	DP04_0114E	DP04_0115E	DP04_0116E	\
0	11	10881	31.8	89	11261	2362
1	9.3	9668	32.2	119	17862	4134
2	10.3	103471	37.6	1055	116764	20637
3	9.5	28952	37.3	457	32638	6437
4	10.6	16973	32.6	132	21840	5339

	DP04_0116PE	DP04_0117E	DP04_0117PE	DP04_0118E	DP04_0118PE	DP04_0119E	\
0	21	2249	20	1782	15.8	1252

1	23.1	3287	18.4	2912	16.3	1736
2	17.7	22002	18.8	17533	15	12323
3	19.7	5862	18	4526	13.9	3017
4	24.4	4416	20.2	3187	14.6	2406

	DP04_0119PE	DP04_0120E	DP04_0120PE	DP04_0121E	DP04_0121PE	DP04_0122E	\
0	11.1	728	6.5	703	6.2	2185
1	9.7	1211	6.8	883	4.9	3699
2	10.6	8127	7	6309	5.4	29833
3	9.2	2622	8	1937	5.9	8237
4	11	1562	7.2	1103	5.1	3827

	DP04_0122PE	DP04_0123E	DP04_0124E	DP04_0125E	DP04_0125PE	DP04_0126E	\
0	19.4	55	7996	90	1.1	161
1	20.7	236	19682	142	0.7	417
2	25.5	1222	97718	355	0.4	1511
3	25.2	345	72659	649	0.9	1511
4	17.5	170	31058	165	0.5	603

	DP04_0126PE	DP04_0127E	DP04_0127PE	DP04_0128E	DP04_0128PE	DP04_0129E	\
0	2	174	2.2	321	4	1429
1	2.1	889	4.5	2582	13.1	5510
2	1.5	3021	3.1	4501	4.6	7362
3	2.1	2544	3.5	4232	5.8	14241
4	1.9	1348	4.3	2970	9.6	6136

	DP04_0129PM	DP04_0130E	DP04_0130PE	DP04_0131E	DP04_0131PE	DP04_0132E	\
0	3	3543	44.3	2278	28.5	1219
1	2.3	7917	40.2	2225	11.3	1014
2	0.6	31087	31.8	49881	51	1519
3	1	31509	43.4	17973	24.7	1181
4	1.7	13423	43.2	6413	20.6	1124

	DP04_0133E	DP04_0134E	DP04_0135E	DP04_0135PE	DP04_0136E	DP04_0136PE	\
0	610	7937	688	8.7	809	10.2
1	1464	19227	1457	7.6	2074	10.8
2	5126	95932	7779	8.1	9384	9.8
3	2001	71536	6895	9.6	8093	11.3
4	1588	30634	2884	9.4	3716	12.1

	DP04_0137E	DP04_0137PE	DP04_0138E	DP04_0138PE	DP04_0139E	DP04_0139PE	\
0	915	11.5	651	8.2	600	7.6
1	2403	12.5	1833	9.5	2005	10.4
2	11194	11.7	10693	11.1	8803	9.2
3	8439	11.8	8532	11.9	6006	8.4
4	3617	11.8	3876	12.7	2251	7.3

```
   DP04_0140E DP04_0140PE DP04_0141E
0       4274        53.8        669
1       9455        49.2       1919
2      48079        50.1       6912
3      33571        46.9       3124
4      14290        46.6       2012
```

```python
[22]: #convert the data type of columns in 2014 housing affordability dataframe from␣
      ↪object to integers for mapping
      tracts2014["DP04_0109E"] =tracts2014["DP04_0109E"].astype(str).astype(int)
      tracts2014["DP04_0109PE"] =tracts2014["DP04_0109PE"].astype(float).astype(int)
      tracts2014["DP04_0110E"] =tracts2014["DP04_0110E"].astype(str).astype(int)
      tracts2014["DP04_0110PE"] =tracts2014["DP04_0110PE"].astype(float).astype(int)
      tracts2014["DP04_0111E"] =tracts2014["DP04_0111E"].astype(float).astype(int)
      tracts2014["DP04_0111PE"] =tracts2014["DP04_0111PE"].astype(float).astype(int)
      tracts2014["DP04_0112E"] =tracts2014["DP04_0112E"].astype(float).astype(int)
      tracts2014["DP04_0112PE"] =tracts2014["DP04_0112PE"].astype(float).astype(int)
      tracts2014["DP04_0113E"] =tracts2014["DP04_0113E"].astype(float).astype(int)
      tracts2014["DP04_0113PE"] =tracts2014["DP04_0113PE"].astype(float).astype(int)
      tracts2014["DP04_0114E"] =tracts2014["DP04_0114E"].astype(float).astype(int)
```

```python
[23]: #convert the data type of columns in 2018 housing affordability dataframe from␣
      ↪object to integers for mapping
      tracts2018["DP04_0111E_y"] =tracts2018["DP04_0111E_y"].astype(str).astype(int)
      tracts2018["DP04_0111PE_y"] =tracts2018["DP04_0111PE_y"].astype(float).
      ↪astype(int)
      tracts2018["DP04_0112E_y"] =tracts2018["DP04_0112E_y"].astype(str).astype(int)
      tracts2018["DP04_0112PE_y"] =tracts2018["DP04_0112PE_y"].astype(float).
      ↪astype(int)
      tracts2018["DP04_0113E_y"] =tracts2018["DP04_0113E_y"].astype(float).astype(int)
      tracts2018["DP04_0113PE_y"] =tracts2018["DP04_0113PE_y"].astype(float).
      ↪astype(int)
      tracts2018["DP04_0114E_y"] =tracts2018["DP04_0114E_y"].astype(float).astype(int)
      tracts2018["DP04_0114PE_y"] =tracts2018["DP04_0114PE_y"].astype(float).
      ↪astype(int)
      tracts2018["DP04_0115E_y"] =tracts2018["DP04_0115E_y"].astype(float).astype(int)
      tracts2018["DP04_0115PE_y"] =tracts2018["DP04_0115PE_y"].astype(float).
      ↪astype(int)
      tracts2018["DP04_0116E_y"] =tracts2018["DP04_0116E_y"].astype(float).astype(int)
```

5.3.1 Comparing housing affordability for owner occupied housing in 2014 and 2018 with Plotly.Express

```
[24]: #calculating the SMOCAPI<30 for 2014 by adding three SMOCAPI categories
      tracts2014['SMOCAPI1430']=␣
       ↪tracts2014['DP04_0109PE']+tracts2014['DP04_0110PE']+tracts2014['DP04_0111PE']
      tracts2014.head()
```

```
[24]:    STATEFP COUNTYFP  COUNTYNS  GEOID    NAME_x        NAMELSAD LSAD CLASSFP  \
      0       34      037  00882236  34037    Sussex    Sussex County   06      H1
      1       36      111  00974153  36111    Ulster    Ulster County   06      H1
      2       36      103  00974149  36103   Suffolk   Suffolk County   06      H1
      3       34      039  00882235  34039     Union     Union County   06      H1
      4       36      027  00974112  36027  Dutchess  Dutchess County   06      H1

         MTFCC CSAFP CBSAFP METDIVFP FUNCSTAT        ALAND      AWATER    INTPTLAT  \
      0  G4020   408  35620    35084        A   1343552956    43234734  +41.1374609
      1  G4020   408  28740     None        A   2911757797    94596954  +41.9472124
      2  G4020   408  35620    35004        A   2360846288  3785546967  +40.9435540
      3  G4020   408  35620    35084        A    266170662     7046286  +40.6598707
      4  G4020   408  35620    20524        A   2060678182    76956282  +41.7547699

            INTPTLON                                   geometry   FIPS   \
      0  -074.6919141  POLYGON ((-74.93933 41.06918, -74.94004 41.069…  34037
      1  -074.2654582  POLYGON ((-74.67402 41.97167, -74.68567 41.976…  36111
      2  -072.6922184  POLYGON ((-72.86371 41.11338, -72.86351 41.113…  36103
      3  -074.3086957  POLYGON ((-74.42857 40.69911, -74.42849 40.699…  34039
      4  -073.7400411  POLYGON ((-73.94032 41.87275, -73.94075 41.873…  36027

                GEO_ID                    NAME_y DP04_0079E DP04_0080E  \
      0  0500000US34037    Sussex County, New Jersey      45642       1002
      1  0500000US36111     Ulster County, New York      48242       2494
      2  0500000US36103    Suffolk County, New York     393936       9261
      3  0500000US34039     Union County, New Jersey     111028       2298
      4  0500000US36027  Dutchess County, New York      74252       2980

         DP04_0080PE DP04_0081E DP04_0081PE DP04_0082E DP04_0082PE DP04_0083E  \
      0          2.2        592         1.3       2519         5.5       6336
      1          5.2       2094         4.3       5002        10.4       9860
      2          2.4       5373         1.4       7398         1.9      13976
      3          2.1       1211         1.1       3365           3       8616
      4            4       1989         2.7       2964           4       7689

         DP04_0083PE DP04_0084E DP04_0084PE DP04_0085E DP04_0085PE DP04_0086E  \
      0         13.9      16183        35.5      14291        31.3       4164
      1         20.4      15806        32.8       9247        19.2       3085
      2          3.5      71250        18.1     189896        48.2      80437
```

```
3         7.8        25684       23.1       42557       38.3       22790
4        10.4        26482       35.7       25104       33.8        5773


     DP04_0086PE DP04_0087E DP04_0087PE DP04_0088E DP04_0089E DP04_0090E  \
0         9.1        555         1.2      277600      45642      34326
1         6.4        654         1.4      226600      48242      30144
2        20.4      16345         4.1      376800     393936     275950
3        20.5       4507         4.1      353300     111028      78045
4         7.8       1271         1.7      282100      74252      52242


     DP04_0090PE DP04_0091E DP04_0091PE DP04_0092E DP04_0092PE DP04_0093E  \
0        75.2      11316        24.8       34326       34326         12
1        62.5      18098        37.5       30144       30144         11
2          70     117986          30      275950      275950        202
3        70.3      32983        29.7       78045       78045         75
4        70.4      22010        29.6       52242       52242         15


     DP04_0093PE DP04_0094E DP04_0094PE DP04_0095E DP04_0095PE DP04_0096E  \
0           0        100         0.3         124         0.4        711
1           0        183         0.6         417         1.4       1783
2         0.1        699         0.3        1591         0.6       4482
3         0.1        258         0.3         307         0.4       1008
4           0        138         0.3         456         0.9       1753


     DP04_0096PE DP04_0097E DP04_0097PE DP04_0098E DP04_0098PE DP04_0099E  \
0         2.1       4030        11.7        7377        21.5      21972
1         5.9       6190        20.5        7910        26.2      13650
2         1.6      15772         5.7       34159        12.4     219045
3         1.3       4741         6.1       11418        14.6      60238
4         3.4       6053        11.6       11183        21.4      32644


     DP04_0099M DP04_0099PE DP04_0100E DP04_0101E DP04_0102E DP04_0102PE  \
0        661         64        2304       11316         39         0.3
1        667        45.3        1908       18098         26         0.1
2       2186        79.4        2776      117986        280         0.2
3       1193        77.2        2688       32983         28         0.1
4        780        62.5        2276       22010         13         0.1


     DP04_0103E DP04_0103PE DP04_0104E DP04_0104PE DP04_0105E DP04_0105PE  \
0         80         0.7        138         1.2        223          2
1        120         0.7        574         3.2       1059        5.9
2        531         0.5       1317         1.1       2219        1.9
3        227         0.7        354         1.1        449        1.4
4        123         0.6        305         1.4        876          4


     DP04_0106E DP04_0106PE DP04_0107E DP04_0108E DP04_0108PE  DP04_0109E  \
0      10836        95.8        952       34237       34237       8937
```

1	16319	90.2	739	30025	30025	8986
2	113639	96.3	1,000+	274895	274895	64353
3	31925	96.8	1,000+	77588	77588	20583
4	20693	94	836	52110	52110	14690

	DP04_0109PE	DP04_0110E	DP04_0110PE	DP04_0111E	DP04_0111PE	DP04_0112E	\
0	26	5934	17	4719	13	3766	
1	29	4300	14	4281	14	2790	
2	23	40407	14	38373	14	28291	
3	26	10809	13	9854	12	7390	
4	28	7916	15	6983	13	5548	

	DP04_0112PE	DP04_0113E	DP04_0113PE	DP04_0114E	DP04_0115E	DP04_0116E	\
0	11	10881	31	89	11261	2362	
1	9	9668	32	119	17862	4134	
2	10	103471	37	1055	116764	20637	
3	9	28952	37	457	32638	6437	
4	10	16973	32	132	21840	5339	

	DP04_0116PE	DP04_0117E	DP04_0117PE	DP04_0118E	DP04_0118PE	DP04_0119E	\
0	21	2249	20	1782	15.8	1252	
1	23.1	3287	18.4	2912	16.3	1736	
2	17.7	22002	18.8	17533	15	12323	
3	19.7	5862	18	4526	13.9	3017	
4	24.4	4416	20.2	3187	14.6	2406	

	DP04_0119PE	DP04_0120E	DP04_0120PE	DP04_0121E	DP04_0121PE	DP04_0122E	\
0	11.1	728	6.5	703	6.2	2185	
1	9.7	1211	6.8	883	4.9	3699	
2	10.6	8127	7	6309	5.4	29833	
3	9.2	2622	8	1937	5.9	8237	
4	11	1562	7.2	1103	5.1	3827	

	DP04_0122PE	DP04_0123E	DP04_0124E	DP04_0125E	DP04_0125PE	DP04_0126E	\
0	19.4	55	7996	90	1.1	161	
1	20.7	236	19682	142	0.7	417	
2	25.5	1222	97718	355	0.4	1511	
3	25.2	345	72659	649	0.9	1511	
4	17.5	170	31058	165	0.5	603	

	DP04_0126PE	DP04_0127E	DP04_0127PE	DP04_0128E	DP04_0128PE	DP04_0129E	\
0	2	174	2.2	321	4	1429	
1	2.1	889	4.5	2582	13.1	5510	
2	1.5	3021	3.1	4501	4.6	7362	
3	2.1	2544	3.5	4232	5.8	14241	
4	1.9	1348	4.3	2970	9.6	6136	

```
       DP04_0129PM  DP04_0130E  DP04_0130PE  DP04_0131E  DP04_0131PE  DP04_0132E  \
    0            3        3543         44.3        2278         28.5        1219
    1          2.3        7917         40.2        2225         11.3        1014
    2          0.6       31087         31.8       49881           51        1519
    3            1       31509         43.4       17973         24.7        1181
    4          1.7       13423         43.2        6413         20.6        1124


       DP04_0133E  DP04_0134E  DP04_0135E  DP04_0135PE  DP04_0136E  DP04_0136PE  \
    0         610        7937         688          8.7         809         10.2
    1        1464       19227        1457          7.6        2074         10.8
    2        5126       95932        7779          8.1        9384          9.8
    3        2001       71536        6895          9.6        8093         11.3
    4        1588       30634        2884          9.4        3716         12.1


       DP04_0137E  DP04_0137PE  DP04_0138E  DP04_0138PE  DP04_0139E  DP04_0139PE  \
    0         915         11.5         651          8.2         600          7.6
    1        2403         12.5        1833          9.5        2005         10.4
    2       11194         11.7       10693         11.1        8803          9.2
    3        8439         11.8        8532         11.9        6006          8.4
    4        3617         11.8        3876         12.7        2251          7.3


       DP04_0140E  DP04_0140PE  DP04_0141E  SMOCAPI1430
    0        4274         53.8         669           56
    1        9455         49.2        1919           57
    2       48079         50.1        6912           51
    3       33571         46.9        3124           51
    4       14290         46.6        2012           56
```

[25]:
```
#calculating the SMOCAPI<30 for 2018 by adding three SMOCAPI categories
tracts2018['SMOCAPI1830']=␣
 ↪tracts2018['DP04_0111PE_y']+tracts2018['DP04_0112PE_y']+tracts2018['DP04_0113PE_y']
tracts2018.head()
```

[25]:
```
   STATEFP  COUNTYFP   COUNTYNS   GEOID    NAME_x          NAMELSAD  LSAD  CLASSFP  \
0       34       037   00882236   34037    Sussex     Sussex County    06       H1
1       36       111   00974153   36111    Ulster     Ulster County    06       H1
2       36       103   00974149   36103   Suffolk    Suffolk County    06       H1
3       34       039   00882235   34039     Union      Union County    06       H1
4       36       027   00974112   36027  Dutchess   Dutchess County    06       H1


   MTFCC  CSAFP  CBSAFP  METDIVFP  FUNCSTAT        ALAND      AWATER     INTPTLAT  \
0  G4020    408   35620     35084         A   1343552956    43234734   +41.1374609
1  G4020    408   28740      None         A   2911757797    94596954   +41.9472124
2  G4020    408   35620     35004         A   2360846288  3785546967   +40.9435540
3  G4020    408   35620     35084         A    266170662     7046286   +40.6598707
4  G4020    408   35620     20524         A   2060678182    76956282   +41.7547699
```

```
        INTPTLON                                    geometry   FIPS  \
0  -074.6919141  POLYGON ((-74.93933 41.06918, -74.94004 41.069…  34037
1  -074.2654582  POLYGON ((-74.67402 41.97167, -74.68567 41.976…  36111
2  -072.6922184  POLYGON ((-72.86371 41.11338, -72.86351 41.113…  36103
3  -074.3086957  POLYGON ((-74.42857 40.69911, -74.42849 40.699…  34039
4  -073.7400411  POLYGON ((-73.94032 41.87275, -73.94075 41.873…  36027

            GEO_ID                     NAME_y DP04_0080E DP04_0081E  \
0  0500000US34037    Sussex County, New Jersey      44007        895
1  0500000US36111     Ulster County, New York      47815       2131
2  0500000US36103    Suffolk County, New York     390897       7197
3  0500000US34039     Union County, New Jersey     111289       2027
4  0500000US36027  Dutchess County, New York      73809       2559

  DP04_0081PE DP04_0082E DP04_0082PE DP04_0083E DP04_0083PE DP04_0084E  \
0           2        755         1.7       3144         7.1       6343
1         4.5       2623         5.5       5451        11.4       9511
2         1.8       4783         1.2       6753         1.7      12137
3         1.8       1195         1.1       2898         2.6       8602
4         3.5       2000         2.7       3652         4.9       8209

  DP04_0084PE DP04_0085E DP04_0085PE DP04_0086E DP04_0086PE DP04_0087E  \
0        14.4      15762        35.8      13236        30.1       3291
1        19.9      14861        31.1       9746        20.4       2848
2         3.1      65663        16.8     187835        48.1      89407
3         7.7      26144        23.5      39611        35.6      25141
4        11.1      26253        35.6      24000        32.5       6112

  DP04_0087PE DP04_0088E DP04_0088PE DP04_0089E DP04_0090PE DP04_0091E  \
0         7.5        581         1.3     266000       44007      31635
1           6        644         1.3     225500       47815      27977
2        22.9      17122         4.4     386800      390897     264291
3        22.6       5671         5.1     357300      111289      76034
4         8.3       1024         1.4     278100       73809      49148

  DP04_0091PE DP04_0092E DP04_0092PE DP04_0093E DP04_0093PE DP04_0094E  \
0        71.9      12372        28.1      31635       31635         44
1        58.5      19838        41.5      27977       27977        118
2        67.6     126606        32.4     264291      264291        632
3        68.3      35255        31.7      76034       76034        130
4        66.6      24661        33.4      49148       49148        145

  DP04_0094PE DP04_0098E DP04_0098PE DP04_0099E DP04_0099PE DP04_0100E  \
0         0.1        846         2.7       4083        12.9       7416
1         0.4       2022         7.2       5818        20.8       7230
2         0.2       4121         1.6      13234           5      31662
3         0.2        771           1       4767         6.3      10573
```

4	0.3	1538	3.1	6036	12.3	11000

	DP04_0100PE	DP04_0098E.1	DP04_0098PE.1	DP04_0099E.1	DP04_0099PE.1	\
0	23.4	7113	22.5	5312	16.8
1	25.8	5766	20.6	3326	11.9
2	12	51430	19.5	55037	20.8
3	13.9	15129	19.9	16246	21.4
4	22.4	11280	23	8250	16.8

	DP04_0100E.1	DP04_0100PE.1	DP04_0102E	DP04_0103E	DP04_0103PE	DP04_0104E	\
0	6821	21.6	12372	191	1.5	249
1	3697	13.2	19838	659	3.3	1374
2	108175	40.9	126606	1474	1.2	2751
3	28418	37.4	35255	469	1.3	573
4	10899	22.2	24661	485	2	1323

	DP04_0104PE	DP04_0105E	DP04_0105PE	DP04_0106E	DP04_0106PE	DP04_0107E	\
0	2	742	6	2278	18.4	3143
1	6.9	4170	21	4904	24.7	3793
2	2.2	5898	4.7	11971	9.5	18798
3	1.6	997	2.8	2194	6.2	5840
4	5.4	3572	14.5	5147	20.9	5503

	DP04_0107PE	DP04_0108E_y	DP04_0108PE_y	DP04_0109E_y	DP04_0110E_y	\
0	25.4	5769	46.6	974	31569
1	19.1	4938	24.9	754	27852
2	14.8	85714	67.7	1194	263078
3	16.6	25182	71.4	1196	75687
4	22.3	8631	35	863	49072

	DP04_0110PE_y	DP04_0111E_y	DP04_0111PE_y	DP04_0112E_y	DP04_0112PE_y	\
0	31569	10897	34	5128	16
1	27852	10046	36	4418	15
2	263078	75539	28	42813	16
3	75687	23777	31	12385	16
4	49072	16592	33	8185	16

	DP04_0113E_y	DP04_0113PE_y	DP04_0114E_y	DP04_0114PE_y	DP04_0115E_y	\
0	4472	14	2769	8	8303
1	3373	12	2322	8	7693
2	33963	12	24782	9	85981
3	9218	12	6365	8	23942
4	6313	12	4387	8	13595

	DP04_0115PE_y	DP04_0116E_y	DP04_0117E_y	DP04_0120E_y	DP04_0120PE_y	\
0	26	66	12205	7346	60.1
1	27	125	19623	12124	61.9

2	32	1213	125313	68664	54.8
3	31	347	34916	19381	55.6
4	27	76	24477	15905	65

	DP04_0121E	DP04_0121PE	DP04_0122E	DP04_0122PE	DP04_0123E	DP04_0123PE	\
0	1310	10.7	784	6.4	669	5.5	
1	1927	9.8	1240	6.3	845	4.3	
2	12157	9.7	8235	6.6	6688	5.3	
3	3424	9.8	2382	6.8	1966	5.6	
4	1953	8	1400	5.7	1199	4.9	

	DP04_0124E	DP04_0124PE	DP04_0125E	DP04_0126E	DP04_0127E	DP04_0127PE	\
0	2096	17.2	167	8765	277	3.2	
1	3487	17.8	215	20470	1321	6.5	
2	29569	23.6	1293	91960	4916	5.3	
3	7763	22.2	339	74937	4674	6.2	
4	4020	16.4	184	31793	1772	5.6	

	DP04_0128E	DP04_0128PE	DP04_0129E	DP04_0129PE	DP04_0130E	DP04_0130PE	\
0	1691	19.3	3911	44.6	2029	23.1	
1	7047	34.4	8306	40.6	2793	13.6	
2	8369	9.1	21870	23.8	27381	29.8	
3	14546	19.4	32414	43.3	15711	21	
4	8178	25.7	13913	43.8	5205	16.4	

	DP04_0131E	DP04_0131PE	DP04_0132E	DP04_0132PE	DP04_0133E	DP04_0133PE	\
0	649	7.4	152	1.7	56	0.6	
1	626	3.1	303	1.5	74	0.4	
2	18756	20.4	6931	7.5	3737	4.1	
3	5170	6.9	1493	2	929	1.2	
4	1907	6	538	1.7	280	0.9	

	DP04_0134E	DP04_0135E	Unnamed: 98	DP04_0137E	DP04_0137PE	DP04_0138E	\
0	1260	589	8624	787	9.1	1157	
1	1086	1254	20042	1905	9.5	1991	
2	1698	5124	90135	7435	8.2	8701	
3	1248	2761	73956	8842	12	8751	
4	1194	1745	31426	3392	10.8	4085	

	DP04_0138PE	DP04_0139E	DP04_0139PE	DP04_0140E	DP04_0140PE	DP04_0141E	\
0	13.4	1176	13.6	1018	11.8	815	
1	9.9	2457	12.3	1716	8.6	2111	
2	9.7	10047	11.1	9917	11	8180	
3	11.8	8847	12	8186	11.1	6691	
4	13	3583	11.4	3021	9.6	2754	

DP04_0141PE	DP04_0142E	DP04_0142PE	DP04_0143E	SMOCAPI1830

```
0          9.5        3671       42.6        730          64
1         10.5        9862       49.2       1682          63
2          9.1       45855       50.9       6949          56
3            9       32639       44.1       3742          59
4          8.8       14591       46.4       2112          61
```

[26]:
```python
#exclude 5 NYC counties from analysis and plotting since they are most likely
 ↪to be outliers
tracts2018=tracts2018.loc[tracts2018['GEOID'] != '36081']
tracts2018=tracts2018.loc[tracts2018['GEOID'] != '36047']
tracts2018=tracts2018.loc[tracts2018['GEOID'] != '36061']
tracts2018=tracts2018.loc[tracts2018['GEOID'] != '36005']
tracts2018=tracts2018.loc[tracts2018['GEOID'] != '36085']
#calculate housing affordability change betwen 2014 and 2018
tracts2018['ac']=tracts2018['SMOCAPI1830']-tracts2014['SMOCAPI1430']
#get top 5 (oadt5) and bottom 5 (oacb5) counties in NYMA experienced most and
 ↪least amount of changes in affordability
oact5=tracts2018 .sort_values(by='ac',ascending = False).head(5)
oacb5=tracts2018 .sort_values(by='ac',ascending = False).tail(5)
#create new dataframe by combining the top 5 and bottom 5 counties for plotting
ooaffordability=oact5.append(oacb5)
```

[27]:
```python
#look at the change of housing affordability between 2014 and 2018 on county
 ↪level
figac=px.bar(
      ooaffordability,
      x='ac',
      y='NAME_x',
      orientation='h', #change orientation of bar chart
      color='ac',
      labels={'ac':'% change','NAME_x':'County Names'},#change labels
      color_continuous_scale='Bluered' #change color of the bars
)
#update bar charts
figac.update_layout(title={
       'text': "% of affordable housing change in top five and bottom five
 ↪counties", #add title
       'y':1,#change position of the title
       'x':0.5}
)
figac
```

[28]:
```python
#again, exlude 5 counties in NYC from analysis
tracts2018=tracts2018.loc[tracts2018['GEOID'] != '36081']
tracts2018=tracts2018.loc[tracts2018['GEOID'] != '36047']
tracts2018=tracts2018.loc[tracts2018['GEOID'] != '36061']
tracts2018=tracts2018.loc[tracts2018['GEOID'] != '36005']
```

```
tracts2018=tracts2018.loc[tracts2018['GEOID'] != '36085']
#plot the chane of housing affordability on the map
tracts2018.plot(figsize=(12,10),
    cmap='coolwarm',
    column='ac',
    legend = True,
    edgecolor='Black',
    alpha=0.6,
    legend_kwds={'shrink': 0.75}) #change the size of legend
plt.axis('off');
plt.title('% of affordable housing change between 2014 and 2018',fontsize=16)
```

[28]: Text(0.5, 1.0, '% of affordable housing change between 2014 and 2018')

% of affordable housing change between 2014 and 2018
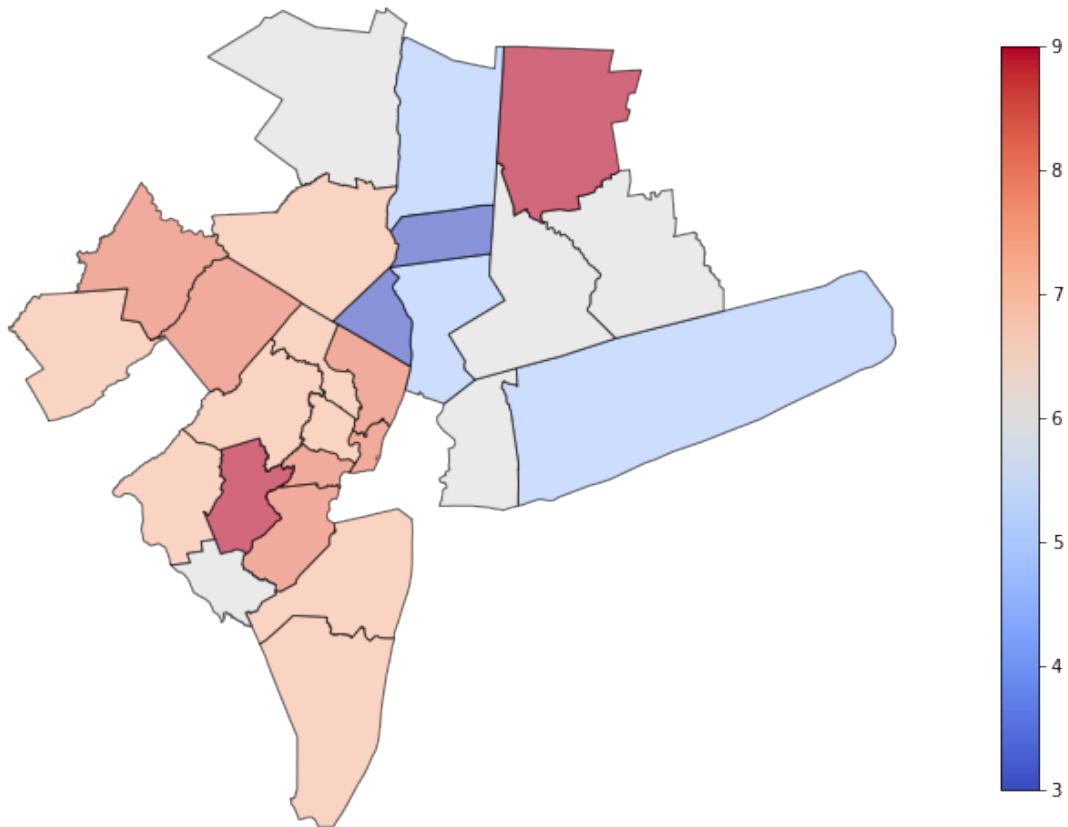
5.3.2 Comparing housing affordability for rental housing in 2014 and 2018

```
[45]: #convert data type from object to integer for later calculation
      tracts2014["DP04_0135PE"] =tracts2014["DP04_0135PE"].astype(float).astype(int)
      tracts2014["DP04_0136PE"] =tracts2014["DP04_0136PE"].astype(float).astype(int)
      tracts2014["DP04_0137PE"] =tracts2014["DP04_0137PE"].astype(float).astype(int)
      tracts2014["DP04_0138PE"] =tracts2014["DP04_0138PE"].astype(float).astype(int)
      tracts2018["DP04_0137PE"] =tracts2018["DP04_0137PE"].astype(float).astype(int)
      tracts2018["DP04_0138PE"] =tracts2018["DP04_0138PE"].astype(float).astype(int)
      tracts2018["DP04_0139PE"] =tracts2018["DP04_0139PE"].astype(float).astype(int)
      tracts2018["DP04_0140PE"] =tracts2018["DP04_0140PE"].astype(float).astype(int)
```

```
[49]: #calculate housing affordability change for rental housing units between 2014
      ↪and 2018
      tracts2014['GRAPI1430']=␣
      ↪tracts2014['DP04_0135PE']+tracts2014['DP04_0136PE']+tracts2014['DP04_0137PE']+tracts2014['D
      tracts2018['GRAPI1830']=␣
      ↪tracts2018['DP04_0137PE']+tracts2018['DP04_0138PE']+tracts2018['DP04_0139PE']+tracts2018['D
      tracts2018['rac']=tracts2018['GRAPI1830']-tracts2014['GRAPI1430']
      #get top 5 (radt5) and bottom 5 (racb5) counties in NYMA experienced most and␣
      ↪least amount of changes in affordability
      ract5=tracts2018 .sort_values(by='rac',ascending = False).head(5)
      racb5=tracts2018 .sort_values(by='rac',ascending = False).tail(5)
      #create new dataframe by combining the top 5 and bottom 5 counties for plotting
      raffordability=ract5.append(racb5)
```

```
[53]: #look at the change of rental housing affordability between 2014 and 2018 on␣
      ↪county level
      figrac=px.bar(
              raffordability,
              x='rac',
              y='NAME_x',
              orientation='h', #change orientation of bar chart
              color='rac',
              labels={'rac':'% change','NAME_x':'County Names'},#change labels
              color_continuous_scale='Bluered' #change color of the bars
      )
      #update bar charts
      figrac.update_layout(title={
              'text': "% of affordable rental housing change in top five and bottom␣
      ↪five counties", #add title
              'y':1,#change position of the title
              'x':0.5}
      )
      figrac
```

```
[54]: #plot rental housing affordaibility change on the map
      tracts2018.plot(figsize=(12,10),
          cmap='coolwarm',
          column='rac',
          legend = True,
          edgecolor='Black',
          alpha=0.6,
          legend_kwds={'shrink': 0.75}) #change the size of legend
      plt.axis('off');
      plt.title('% of affordable rental housing change between 2014 and␣
       ↪2018',fontsize=16)
```

[54]: Text(0.5, 1.0, '% of affordable rental housing change between 2014 and 2018')

% of affordable rental housing change between 2014 and 2018
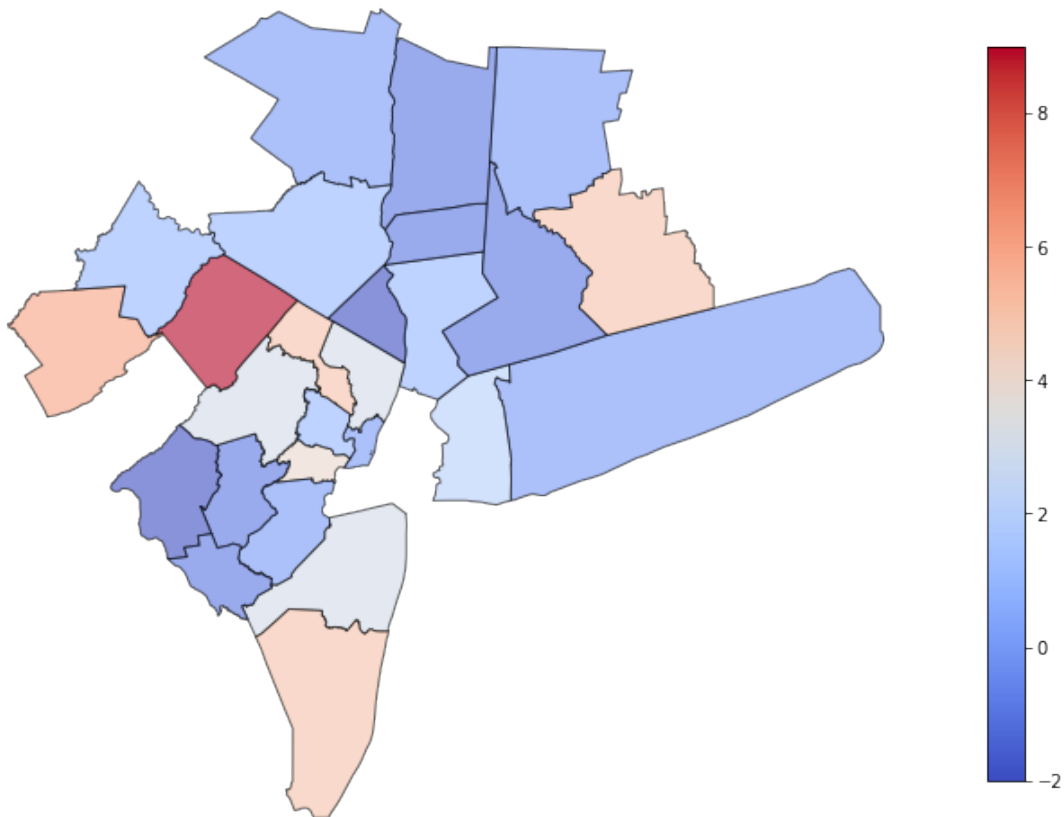
5.4   Conclusion

From the data exploration and analysis of housing affordability of owner occupied housing units
with mortgage in NYMA, there is an overall increase in housing afforability in NYMA counties,

ranging from two to eight percent. The highest increase is in counties further away from New York County (NYC), but also in Hudson County, which is located across from New York Conty.

Next step of the affordability analysis will be focused on the relationship between migration, housing affordability, and transit density on the county level.

6 Data exploration and analysis of median housing value of owner-occupied housing and median rent in 2014 and 2018

6.1 Data exploration of median housing value

```
[29]: #change the data type of the columns under analysis from object to integer
      tracts2014["DP04_0088E"] =tracts2014["DP04_0088E"].astype(str).astype(int)
```

```
[30]: tracts2018["DP04_0089E"] =tracts2018["DP04_0089E"].astype(str).astype(int)
```

```
[31]: #calculate the change of owner occupied median housing cost between 2014 and␣
      ↪2018, and adding it onto tracts2018 dataframe
      tracts2018['omc']=tracts2018['DP04_0089E']-tracts2014['DP04_0088E']
```

```
[32]: #plot the chane of housing median value on the map
      tracts2018.plot(figsize=(12,10),
          cmap='coolwarm',
          column='omc',
          legend = True,
          edgecolor='Black',
          alpha=0.6,
          legend_kwds={'shrink': 0.75})
      plt.axis('off');
      plt.title('Owner-occupied Median Value-2014 v 2018',fontsize=16)
```

```
[32]: Text(0.5, 1.0, 'Owner-occupied Median Value-2014 v 2018')
```

Owner-occupied Median Value-2014 v 2018
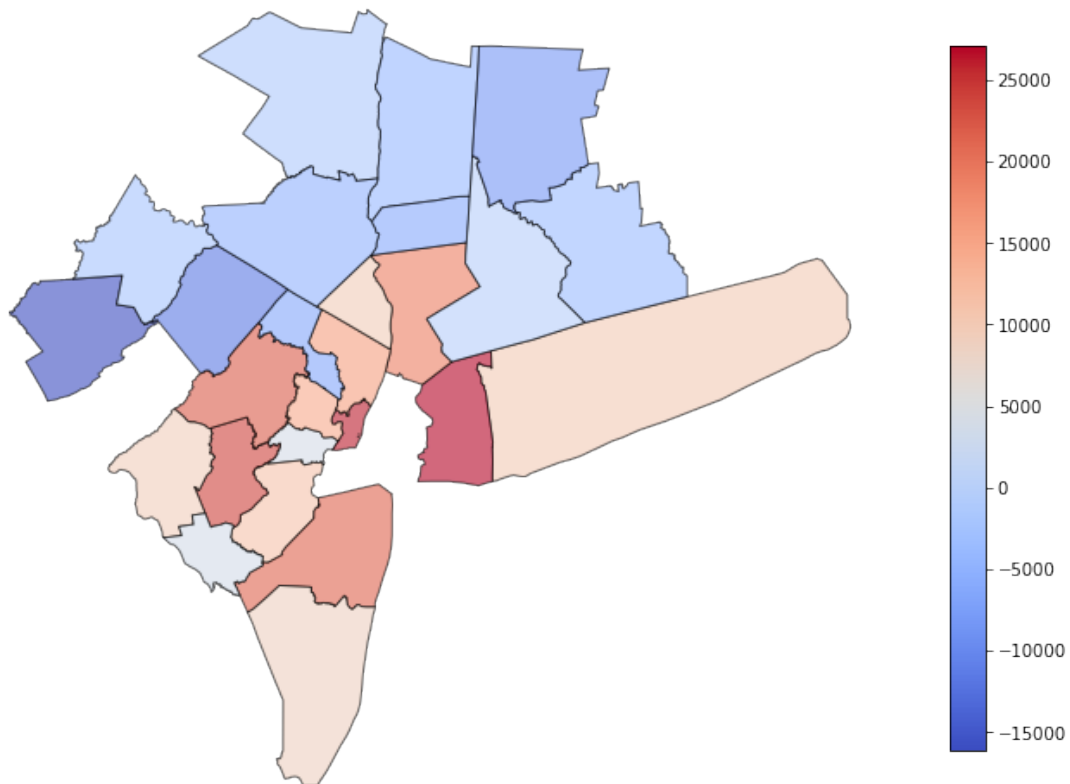
[33]:
```
#use sort function to find the top 5 and bottom 5 counties experienced most␣
 ↪increases and most descreases in median value
top5m = tracts2018 .sort_values(by='omc',ascending = False).head(5)
bot5m = tracts2018 .sort_values(by='omc',ascending = False).tail(5)
```

[34]:
```
#create a new dataframe with top 5 and bottom 5
oomedian = top5m.append(bot5m)
```

[35]:
```
#plot the counties with top 5 and bottom 5 changes of median housing value of␣
 ↪owner-occupied units
figm=px.bar(
        oomedian,
        x='omc',
        y='NAME_x',
        orientation='h',
        color='omc',
        color_continuous_scale='Bluered',
        labels={'omc':'median value change','NAME_x':'County Names'}, #change␣
 ↪labels
```

```
)
figm.update_layout(title={
        'text': "owner occupied median value: 2014 v 2018", #add title
        'y':1,#change position of the title
        'x':0.5}
)
figm
```

6.2   Data exploration of median rent

```
[36]: #change the data type of the columns under analysis from object to integer
      tracts2014["DP04_0132E"] =tracts2014["DP04_0132E"].astype(str).astype(int)
```

```
[37]: tracts2018["DP04_0134E"] =tracts2018["DP04_0134E"].astype(str).astype(int)
```

```
[38]: #calculate the change of median rent
      tracts2018['rmc']=tracts2018['DP04_0134E']-tracts2014['DP04_0132E']
```

```
[39]: #plot the chane of housing median value on the map
      tracts2018.plot(figsize=(12,10),
          cmap='coolwarm',
          column='rmc',
          legend = True,
          edgecolor='Black',
          alpha=0.6,
          legend_kwds={'shrink': 0.75})
      plt.axis('off');
      plt.title('Median Rent-2014 v 2018',fontsize=16)
```

```
[39]: Text(0.5, 1.0, 'Median Rent-2014 v 2018')
```

Median Rent-2014 v 2018
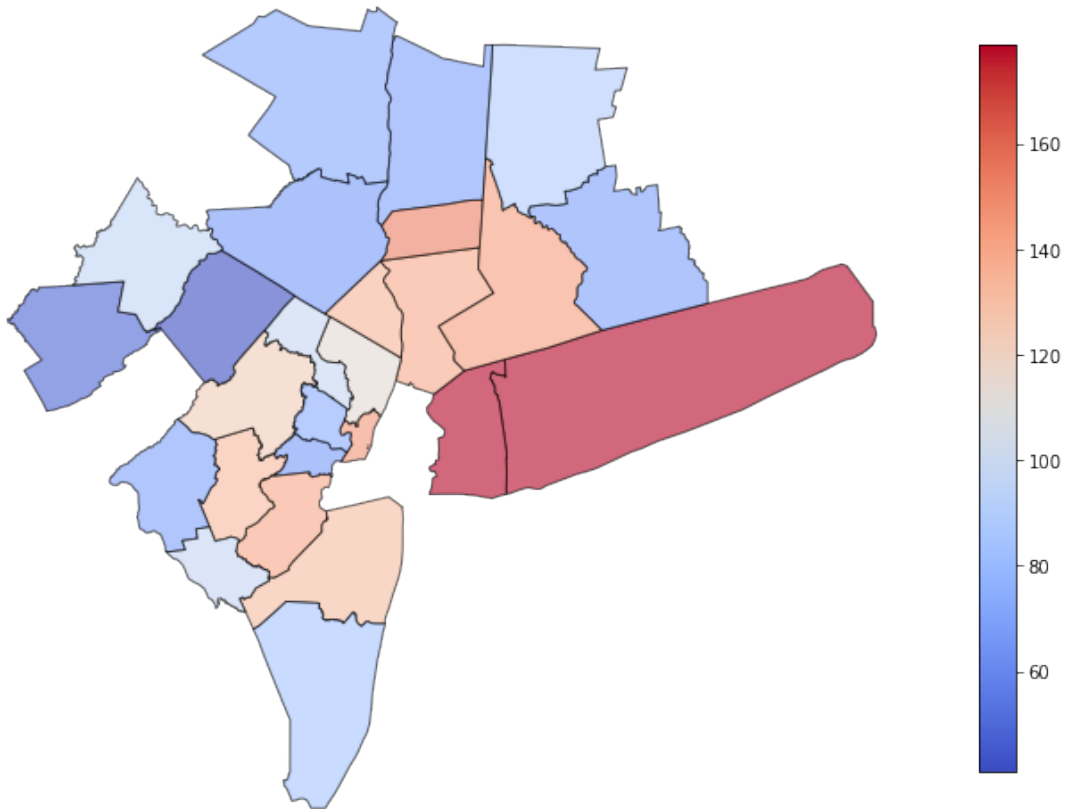
[40]:
```
#use sort function to find the top 5 and bottom 5 counties experienced most
 ↪increases and most descreases in median value
top5rm = tracts2018 .sort_values(by='rmc',ascending = False).head(5)
bot5rm = tracts2018 .sort_values(by='rmc',ascending = False).tail(5)
```

[41]:
```
#create a new dataframe with top 5 and bottom 5
rmedian = top5rm.append(bot5rm)
```

[42]:
```
figm=px.bar(
      rmedian,
      x='rmc',
      y='NAME_x',
      orientation='h',
      color='rmc',
      color_continuous_scale='Bluered',
      labels={'rmc':'median rent change','NAME_x':'County Names'}, #change
 ↪labels
)
```

```
figm.update_layout(title={
        'text': "owner occupied median value: 2014 v 2018", #add title
        'y':1,#change position of the title
        'x':0.5}
)
figm
```

7 Conclusion on housing affordability and housing value in NYMA between 2014 and 2018

In this data exploration and analysis notebook, I conducted basic data exploration of housing affordability datasets, housing value datasets and county boundary datasets. I analyzed and mapped housing affordability anbd housing value in 2014 and 2018 across 31 counties in New York Metro Area. In the future weeks during this quarter, I will conduct more analysis on the impact of migration on housing price and affordability in NYMA.