

Final4

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1 Sic Transit Affordability

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UP 206A

1.1 Introduction

Our research question intends to explore the interrelationship between transportation and housing affordability. We will use the American Community Survey Data from Social Explorer to analyze if there are potential correlations between the use of transportation mode and rent across Los Angeles County. By analysing both data sets from 2010 and 2018, we can infer if public transit expansion may have an impact in housing affordability levels across different Census Tracts. We also import LA Tracts data from the Los Angeles Times and LA Metro lines from the Metro developer portal.

We use the following data: From **American Community Survey** 2010 and 2018: * Transit use by workers 16+ * Median Gross Rent * Housing Units

From **LA Times** Data Sets: * LA County census tract boundaries

From **LA Metro** developer portal: * Metro stations

2 Import data

We cleaned up our data in previous notebooks by doing these steps: * Importing 2010 data for housing units, median gross rent, and transit use * Importing 2018 data for housing units, median gross rent, and transit use * Removing extraneous columns * Combining the two datasets * Adding columns to show the change in each variable * Removing any census tracts with fewer than 100 housing units in 2010, as many were outliers

```
[1]: #import pandas and numpy
```

```
import pandas as pd
import numpy as np
```

```
[2]: # Read in our edited data, using the index column already in the data
```

```
df = pd.read_csv('Data/final_data.csv', index_col='Unnamed: 0', dtype=
{
    'FIPS':str,
    'Geo_STATE':str,
    'Geo_COUNTY': str,
    'Geo_TRACT' : str
})
```

[3]: *# Look at the head of the data*

```
df.head()
```

```
[3]:
```

	FIPS	Geo_NAME \
0	06037800324	Census Tract 8003.24 (part), Agoura Hills city...
1	06037800324	Census Tract 8003.24 (part), Westlake Village ...
2	06037800326	Census Tract 8003.26 (part), Agoura Hills city...
3	06037800326	Census Tract 8003.26 (part), Westlake Village ...
4	06037800326	Census Tract 8003.26 (part), Remainder of Agou...

	Geo_QName	Geo_STATE	Geo_COUNTY \
0	Census Tract 8003.24 (part), Agoura Hills city...	06	037
1	Census Tract 8003.24 (part), Westlake Village ...	06	037
2	Census Tract 8003.26 (part), Agoura Hills city...	06	037
3	Census Tract 8003.26 (part), Westlake Village ...	06	037
4	Census Tract 8003.26 (part), Remainder of Agou...	06	037

	Geo_TRACT	2010 Housing Units	2010 Median Gross Rent	2010 Percent Transit \
0	800324	2242	2310.0	0.55
1	800324	313	2310.0	0.00
2	800326	175	2162.0	0.00
3	800326	1346	2310.0	0.00
4	800326	546	748.0	0.00

	2018 Housing Units	2018 Median Gross Rent	2018 Percent Transit \
0	2468	2667.0	0.14
1	2468	2667.0	0.14
2	2135	2154.0	0.44
3	2135	2154.0	0.44
4	2135	2154.0	0.44

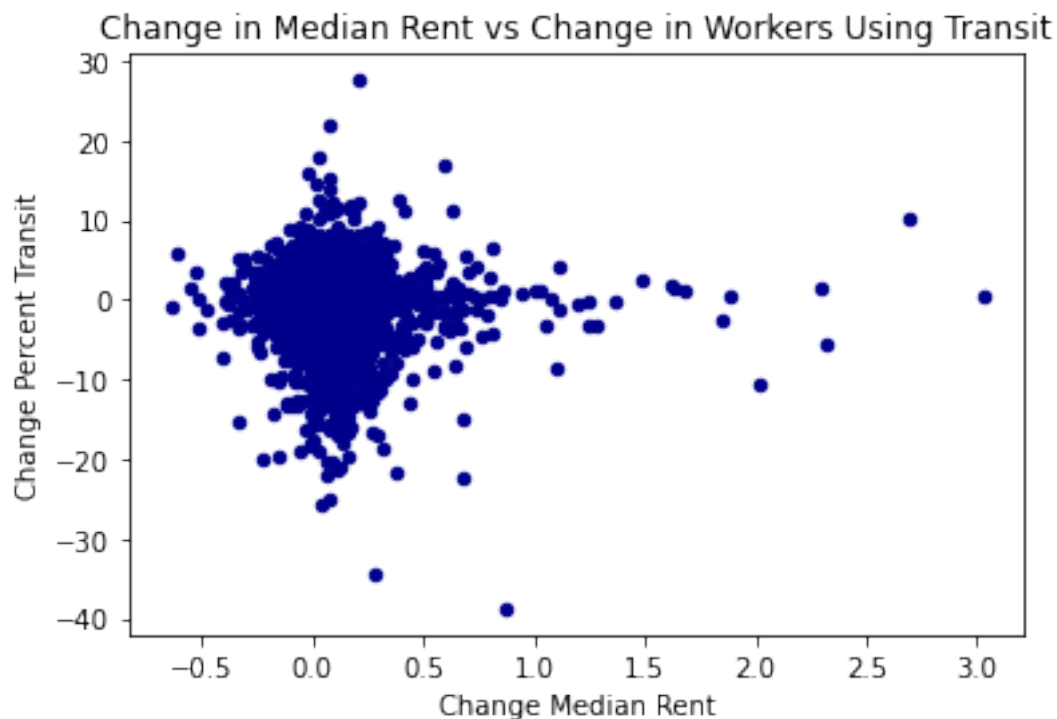
	Change Housing Units	Change Median Rent	Change Percent Transit
0	0.100803	0.154545	-0.41
1	6.884984	0.154545	0.14
2	11.200000	-0.003700	0.44
3	0.586181	-0.067532	0.44
4	2.910256	1.879679	0.44

2.1 Make a Scatter Plot

We start with a simple scatter plot to show the change in Median Rent and Percent Transit to analyze potential correlations between Rent and transit usage.

```
[4]: #make a scatter plot of Median Rent and Transit Use, adding a title and
      ↪changing the color
df.plot.scatter(x = 'Change Median Rent',
                y = 'Change Percent Transit',
                c = 'DarkBlue',
                title = 'Change in Median Rent vs Change in Workers Using
      ↪Transit')
```

```
[4]: <matplotlib.axes._subplots.AxesSubplot at 0x7fa4858052e0>
```



3 Folium Maps

We made Folium maps of the change in transit use and median rent. We updated the cutoff points for the color scales on each map to make it clear where these metrics have changed a slightly or a lot. We also use a new diverging color scale from colorbrewer2.org.

```
[5]: #import geopandas
import geopandas as gpd
```

```
#import LA Tracts data
tracts = gpd.read_file('Data/LA_Tracts.geojson')

#subset the data because we only need FIPS and geometry
tracts = tracts[['name','geometry']]

#rename the columns
tracts.columns = ['FIPS','geometry']
```

```
[6]: # create a new dataframe merging our data with the LA census tracts
tracts_data=tracts.merge(df,on="FIPS")

#look at the head
tracts_data.head()
```

```
[6]:
```

	FIPS	geometry \
0	06037101110	MULTIPOLYGON (((-118.30229 34.25870, -118.3007...
1	06037101122	MULTIPOLYGON (((-118.30333 34.27354, -118.3031...
2	06037101210	MULTIPOLYGON (((-118.29945 34.25598, -118.2859...
3	06037101220	MULTIPOLYGON (((-118.28592 34.24896, -118.2859...
4	06037101300	MULTIPOLYGON (((-118.27247 34.23253, -118.2719...

	Geo_NAME \
0	Census Tract 1011.10, Los Angeles city (part),...
1	Census Tract 1011.22, Los Angeles city (part),...
2	Census Tract 1012.10, Los Angeles city (part),...
3	Census Tract 1012.20, Los Angeles city (part),...
4	Census Tract 1013, Los Angeles city (part), Sa...

	Geo_QName	Geo_STATE	Geo_COUNTY \
0	Census Tract 1011.10, Los Angeles city (part),...	06	037
1	Census Tract 1011.22, Los Angeles city (part),...	06	037
2	Census Tract 1012.10, Los Angeles city (part),...	06	037
3	Census Tract 1012.20, Los Angeles city (part),...	06	037
4	Census Tract 1013, Los Angeles city (part), Sa...	06	037

	Geo_TRACT	2010 Housing Units	2010 Median Gross Rent	2010 Percent Transit \
0	101110	1748	1205.0	1.48
1	101122	1393	1581.0	1.92
2	101210	2331	1285.0	4.14
3	101220	1296	1038.0	0.00
4	101300	1547	1398.0	0.00

	2018 Housing Units	2018 Median Gross Rent	2018 Percent Transit \
0	1743	1609.0	2.39
1	1391	2120.0	0.37
2	2402	1318.0	3.43

3	1328	1198.0	3.64
4	1584	2435.0	4.21

	Change Housing Units	Change Median Rent	Change Percent Transit
0	-0.002860	0.335270	0.91
1	-0.001436	0.340923	-1.55
2	0.030459	0.025681	-0.71
3	0.024691	0.154143	3.64
4	0.023917	0.741774	4.21

3.1 Change in Transit Use

```
[7]: # import folium
```

```
import folium
```

```
[8]: # initiate a map centered on LA
```

```
m = folium.Map(location=[34.2,-118.2],
                zoom_start = 9,
                tiles='CartoDB positron',
                attribution='CartoDB')
```

```
# plot choropleth map of change in transit use
```

```
folium.Choropleth(
    geo_data=tracts_data,           # geo data
    data=tracts_data,              # data
    key_on='feature.properties.FIPS', # key, or merge
    ↪column
    columns=['FIPS', 'Change Percent Transit'], # [key, value]
    fill_color='RdYlBu',           # using a
    ↪diverging scale from colorbrewer2.org
    line_weight=0.1,
    fill_opacity=0.6,
    line_opacity=0.2,              # line opacity
    ↪(of the border)
    legend_name='Change in Transit Use',
    threshold_scale=[-67, -10, -1, 1, 10, 41], # change
    ↪thresholds
    nan_fill_color = 'lightgray').add_to(m) # change the ugly
    ↪black splotches
m
```

```
[8]: <folium.folium.Map at 0x7fa47c2fe7c0>
```

3.2 Change in Median Rent

```
[9]: # sort the dataframe by change in median rent so we can get a sense of the
      ↪minumum and maximum changes
df.sort_values(by = 'Change Median Rent')
```

```
[9]:
```

	FIPS	Geo_NAME \
460	06037406902	Census Tract 4069.02 (part), West Puente Valle...
1676	06037900505	Census Tract 9005.05, Lancaster city (part), N...
130	06037543603	Census Tract 5436.03, West Carson CDP, Compton...
2362	06037910301	Census Tract 9103.01 (part), Palmdale city (pa...
1708	06037901205	Census Tract 9012.05 (part), Lancaster city (p...
...
2804	06037500100	Census Tract 5001 (part), Remainder of Whittie...
2806	06037500201	Census Tract 5002.01 (part), La Habra Heights ...
2810	06037501600	Census Tract 5016 (part), Hacienda Heights CDP...
2830	06037500403	Census Tract 5004.03 (part), Remainder of Whit...
2882	06037503502	Census Tract 5035.02 (part), Whittier city (pa...

	Geo_QName	Geo_STATE	Geo_COUNTY \
460	Census Tract 4069.02 (part), West Puente Valle...	06	037
1676	Census Tract 9005.05, Lancaster city (part), N...	06	037
130	Census Tract 5436.03, West Carson CDP, Compton...	06	037
2362	Census Tract 9103.01 (part), Palmdale city (pa...	06	037
1708	Census Tract 9012.05 (part), Lancaster city (p...	06	037
...
2804	Census Tract 5001 (part), Remainder of Whittie...	06	037
2806	Census Tract 5002.01 (part), La Habra Heights ...	06	037
2810	Census Tract 5016 (part), Hacienda Heights CDP...	06	037
2830	Census Tract 5004.03 (part), Remainder of Whit...	06	037
2882	Census Tract 5035.02 (part), Whittier city (pa...	06	037

	Geo_TRACT	2010 Housing Units	2010 Median Gross Rent \
460	406902	676	1747.0
1676	900505	1395	1490.0
130	543603	1514	2310.0
2362	910301	388	2310.0
1708	901205	2316	1991.0
...
2804	500100	201	NaN
2806	500201	759	NaN
2810	501600	142	NaN
2830	500403	292	NaN
2882	503502	367	NaN

	2010 Percent Transit	2018 Housing Units	2018 Median Gross Rent \
460	3.21	866	628.0

1676	0.00	1371	584.0
130	0.00	1537	1031.0
2362	0.00	1522	1083.0
1708	0.97	3921	963.0
...
2804	0.00	1458	1682.0
2806	0.00	2172	2704.0
2810	0.00	2290	1320.0
2830	0.00	1084	1726.0
2882	0.00	1286	1657.0

	2018 Percent Transit	Change Housing Units	Change Median Rent \
460	2.25	0.281065	-0.640527
1676	5.95	-0.017204	-0.608054
130	1.61	0.015192	-0.553680
2362	3.55	2.922680	-0.531169
1708	0.94	0.693005	-0.516323
...
2804	0.11	6.253731	NaN
2806	0.82	1.861660	NaN
2810	2.22	15.126761	NaN
2830	0.61	2.712329	NaN
2882	0.04	2.504087	NaN

	Change Percent Transit
460	-0.96
1676	5.95
130	1.61
2362	3.55
1708	-0.03
...	...
2804	0.11
2806	0.82
2810	2.22
2830	0.61
2882	0.04

[2465 rows x 15 columns]

```
[10]: # the end of the dataframe has a lot of NaN, so let's look at the data another
      ↪ way
      # it's amazing that median rents have stayed constant (or decreased) in about
      ↪ ~25% of tracts!

      df['Change Median Rent'].describe()
```

```
[10]: count    2380.000000
      mean      0.100917
      std       0.232859
      min      -0.640527
      25%      -0.006816
      50%       0.073740
      75%       0.165738
      max       3.029586
      Name: Change Median Rent, dtype: float64
```

```
[11]: # initiate a map centered on LA
m_rent = folium.Map(location=[34.2,-118.2],
                    zoom_start = 9,
                    tiles='CartoDB positron',
                    attribution='CartoDB')

# plot chorpleth map of change in transit use
folium.Choropleth(
    geo_data=tracts_data,          # geo data
    data=tracts_data,             # data
    key_on='feature.properties.FIPS', # key, or merge
    ↪column
    columns=['FIPS', 'Change Median Rent'], # [key, value]
    fill_color='RdYlBu',          # using a
    ↪diverging scale from colorbrewer2.org
    line_weight=0.1,
    fill_opacity=0.6,
    line_opacity=0.2,             # line opacity
    ↪(of the border)
    legend_name='Change in Median Rent',
    threshold_scale=[-1, -0.5, -0.1, 0.1, 1, 4], # change
    ↪thresholds
    nan_fill_color = 'lightgray').add_to(m_rent) # change the
    ↪ugly black splotches

#show the map of change in rent
m_rent
```

```
[11]: <folium.folium.Map at 0x7fa4ac28d490>
```

4 Autocorrelation

This week we went with autocorrelation since we have tract-based data, rather than the point-based data that would be necessary for a point pattern analysis.


```
[12]: # to import data from LA Data portal
from sodapy import Socrata

# to create spatial data
import geopandas as gpd

# for basemaps
import contextily as ctx

# For spatial statistics
import esda
from esda.moran import Moran, Moran_Local

import splot
from splot.esda import moran_scatterplot, plot_moran, ↵
    ↪lisa_cluster, plot_moran_simulation

import libpysal as lps

# Graphics
import matplotlib.pyplot as plt
import plotly.express as px
```

```
[13]: # calculate spatial weight

wq = lps.weights.KNN.from_dataframe(tracts_data,k=8)
wq.transform = 'r'
```

```
[14]: # let's add lag for all three data columns that we have

tracts_data['transit_lag'] = lps.weights.lag_spatial(wq, tracts_data['Change_↵
    ↪Percent Transit'])
tracts_data['rent_lag'] = lps.weights.lag_spatial(wq, tracts_data['Change_↵
    ↪Median Rent'])
tracts_data['housing_lag'] = lps.weights.lag_spatial(wq, tracts_data['Change_↵
    ↪Housing Units'])
```

```
[15]: # check the new columns

tracts_data.sample(3)
```

```
[15]:          FIPS                                geometry \
508    06037201602  MULTIPOLYGON (((-118.17667 34.06920, -118.1766...
628    06037214502  MULTIPOLYGON (((-118.35566 34.06996, -118.3555...
2031   06037600304  MULTIPOLYGON (((-118.29665 33.93097, -118.2966...

                                Geo_NAME \
```

508	Census Tract	2016.02, Los Angeles city (part),...
628	Census Tract	2145.02, Los Angeles city (part),...
2031	Census Tract	6003.04, Westmont CDP, Inglewood ...

		Geo_QName	Geo_STATE	Geo_COUNTY	\
508	Census Tract	2016.02, Los Angeles city (part),...	06	037	
628	Census Tract	2145.02, Los Angeles city (part),...	06	037	
2031	Census Tract	6003.04, Westmont CDP, Inglewood ...	06	037	

	Geo_TRACT	2010 Housing Units	2010 Median Gross Rent	\
508	201602	854	1185.0	
628	214502	2893	2218.0	
2031	600304	1062	1040.0	

	2010 Percent Transit	2018 Housing Units	2018 Median Gross Rent	\
508	4.60	874	1165.0	
628	7.81	2869	2326.0	
2031	26.85	1183	982.0	

	2018 Percent Transit	Change Housing Units	Change Median Rent	\
508	3.55	0.023419	-0.016878	
628	2.61	-0.008296	0.048693	
2031	7.77	0.113936	-0.055769	

	Change Percent Transit	transit_lag	rent_lag	housing_lag
508	-1.05	0.1675	0.012334	-0.005404
628	-5.20	-0.3750	0.102830	0.035800
2031	-19.08	-0.8525	0.079815	0.031621

4.1 Moran's Plot: Transit

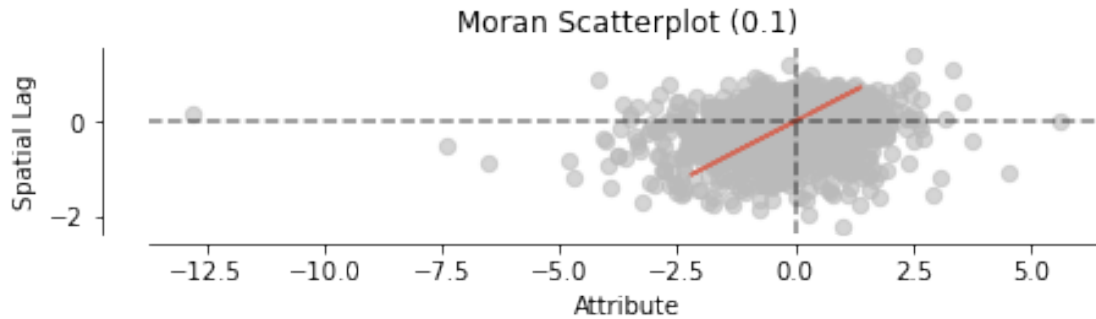
```
[16]: # find Moran's I for transit
y_transit = tracts_data['Change Percent Transit']
moran_transit = Moran(y_transit, wq)
moran_transit.I
```

```
[16]: 0.09777798640166724
```

Since the Moran's I is close to 0, there is not a strong positive or negative correlation.

```
[17]: # This scatterplot shows how Moran's I is calculated (slope of the red line)

fig, ax = moran_scatterplot(moran_transit, aspect_equal=True)
plt.show()
```



Is this just caused by random variation?

```
[18]: plot_moran_simulation(moran_transit, aspect_equal=False)
```

```
/opt/conda/lib/python3.8/site-packages/splot/_viz_esda_mpl.py:47:
```

```
MatplotlibDeprecationWarning:
```

```
The set_smart_bounds function was deprecated in Matplotlib 3.2 and will be
removed two minor releases later.
```

```
ax.spines['left'].set_smart_bounds(True)
```

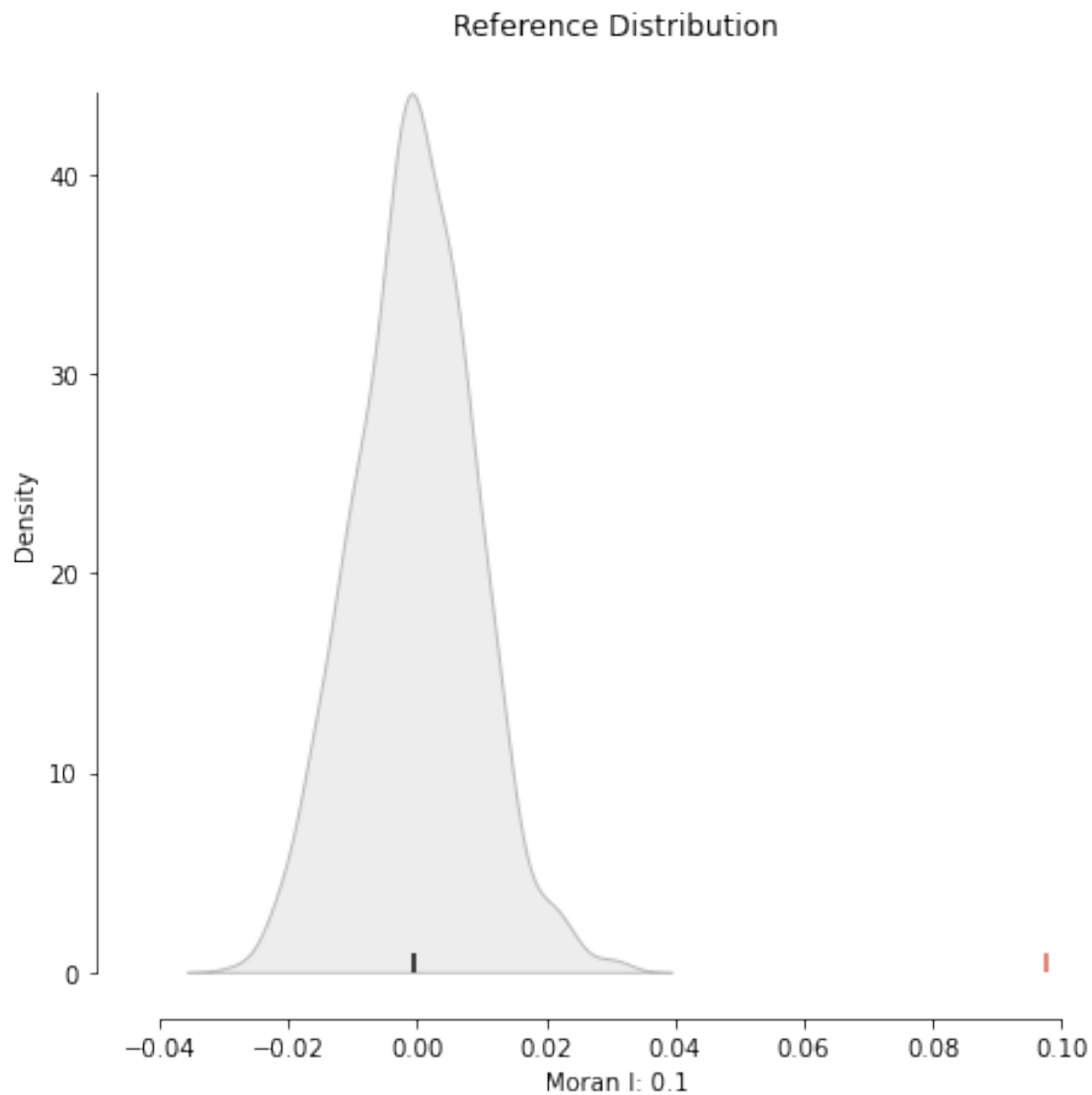
```
/opt/conda/lib/python3.8/site-packages/splot/_viz_esda_mpl.py:48:
```

```
MatplotlibDeprecationWarning:
```

```
The set_smart_bounds function was deprecated in Matplotlib 3.2 and will be
removed two minor releases later.
```

```
ax.spines['bottom'].set_smart_bounds(True)
```

```
[18]: (<Figure size 504x504 with 1 Axes>,
      <matplotlib.axes._subplots.AxesSubplot at 0x7fa464bccfa0>)
```



No, because Moran's I is outside of the gray curve, it is extremely likely that it is not random

```
[19]: # compute the p value  
      moran_transit.p_sim
```

```
[19]: 0.001
```

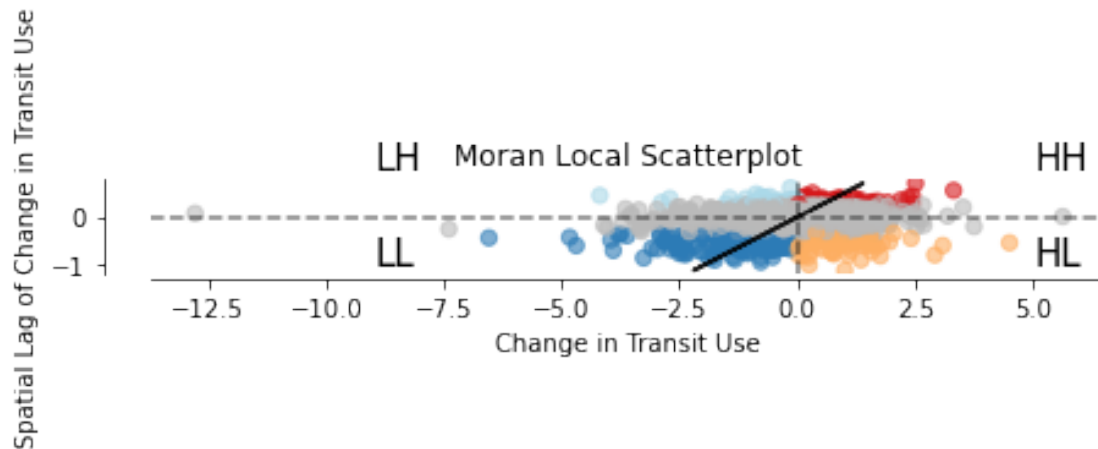
```
[20]: # calculate local moran values  
      lisa_transit = esda.moran.Moran_Local(y_transit, wq)
```

```
[21]: # Plot the aurocorrelated clusters over p = 0.05  
      fig, ax = moran_scatterplot(lisa_transit, p=0.05)  
      ax.set_xlabel("Change in Transit Use")
```

```

ax.set_ylabel('Spatial Lag of Change in Transit Use')
plt.text(5, 1, "HH", fontsize=15)
plt.text(5, -1, "HL", fontsize=15)
plt.text(-9, 1, "LH", fontsize=15)
plt.text(-9, -1, "LL", fontsize=15)
plt.show()

```



```

[22]: # create the 1x2 subplots
fig, axs = plt.subplots(1, 2, figsize=(18, 18))

# name each subplot
ax1, ax2 = axs

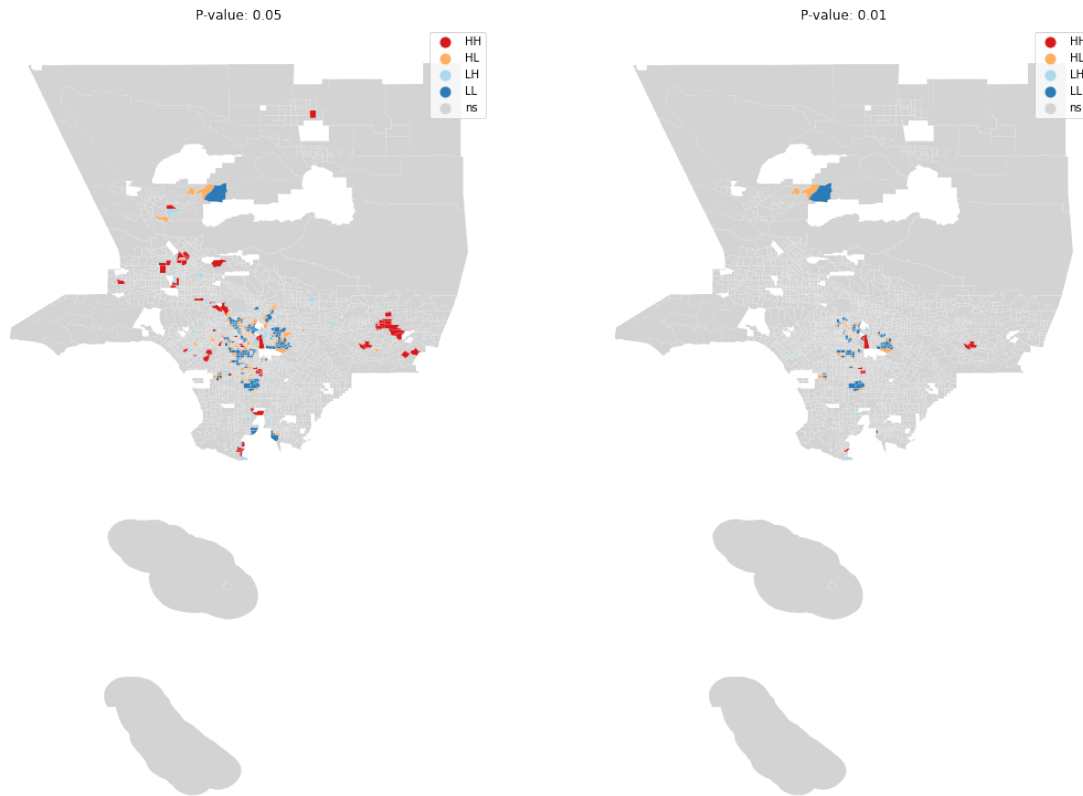
# regular count map on the left
lisa_cluster(lisa_transit, tracts_data, p=0.05, ax=ax1)

ax1.axis("off")
ax1.set_title("P-value: 0.05")

# spatial lag map on the right
lisa_cluster(lisa_transit, tracts_data, p=0.01, ax=ax2)
ax2.axis("off")
ax2.set_title("P-value: 0.01")

plt.show()

```



It looks like there are clusters of transit use *decrease* in Central, South Central, and East LA. This initially seems surprising, since that is where there is the most transit, but as those areas have become more expensive it's likely that people who can afford to have cars have moved in

4.2 Moran's Plot: Housing Units

Let's do this again for change in number of housing units

```
[23]: # find Moran's I for change in median rent
y_housing = tracts_data['Change Housing Units']
moran_housing = Moran(y_housing, wq)
moran_housing.I
```

```
[23]: 0.09247776004400801
```

```
[24]: # compute the p value
moran_housing.p_sim
```

```
[24]: 0.001
```

```
[25]: # calculate local moran values
lisa_housing = esda.moran.Moran_Local(y_housing, wq)

# create the 1x2 subplots
fig, axs = plt.subplots(1, 2, figsize=(18, 18))

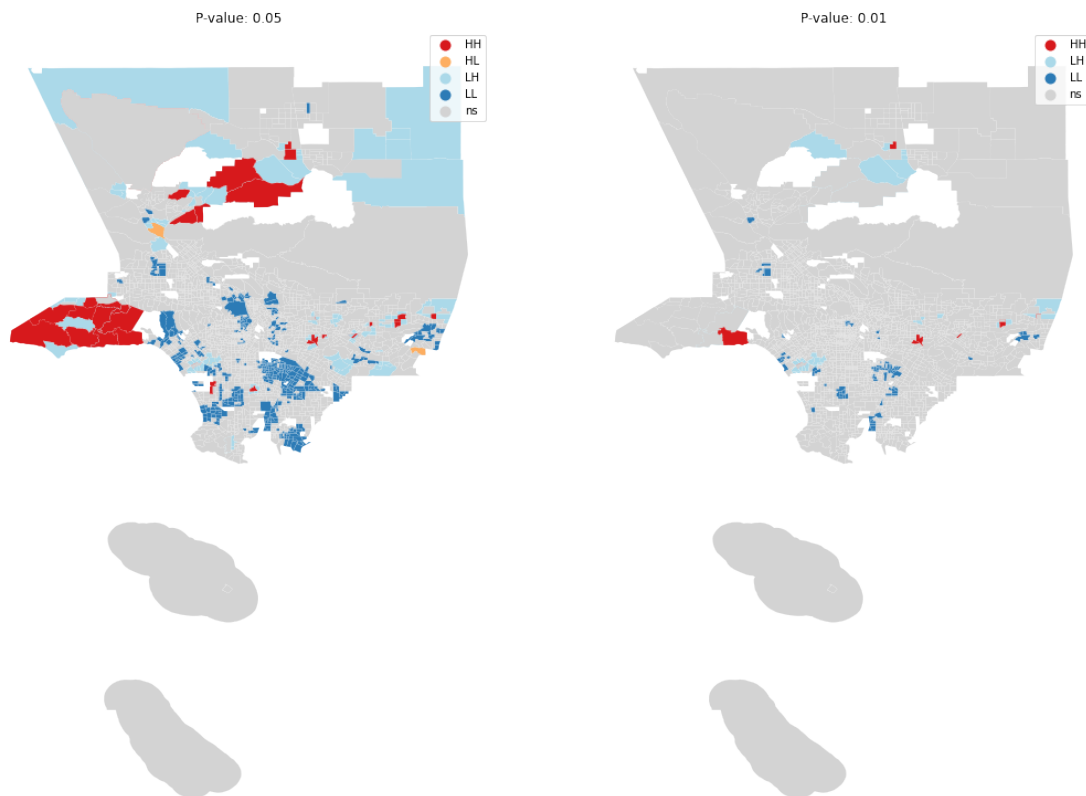
# name each subplot
ax1, ax2 = axs

# regular count map on the left
lisa_cluster(lisa_housing, tracts_data, p=0.05, ax=ax1)

ax1.axis("off")
ax1.set_title("P-value: 0.05")

# spatial lag map on the right
lisa_cluster(lisa_housing, tracts_data, p=0.01, ax=ax2)
ax2.axis("off")
ax2.set_title("P-value: 0.01")

plt.show()
```



5 Buffers - this is new!!

Now we are ready to figure out which census tracts are within a buffer around each station

```
[26]: # importing the index, stop number, and date opened for each station from a
      ↪different csv file

station_opened = pd.read_csv('Data/station_data.csv',
                             header = 1,
                             index_col = 'Unnamed: 0',
                             usecols = ['Unnamed: 0', 'STOPNUM', 'DATE OPENED'])
```

```
[27]: # display the head to check the data

station_opened.head()
```

```
[27]:  STOPNUM  DATE OPENED
0      80101          1990
1      80102          1990
2      80105          1990
3      80106          1990
4      80107          1990
```

```
[28]: # import the station data shapfile from LA Metro

sta = gpd.read_file('Data/Stations_All_0316.shp')
```

```
[29]: # display the head to check the data

sta.head()
```

```
[29]:  LINE  LINENUM  LINENUM2  STNSEQ  STNSEQ2  DIR  STOPNUM  \
0  Blue      801          0      21        0  None   80101
1  Blue      801          0      22        0  North  80102
2  Blue      801          0      18        0  None   80105
3  Blue      801          0      17        0  None   80106
4  Blue      801          0      16        0  None   80107
```

```
          STATION          LAT          LONG  TPIS_NAME          POINT_X  \
0  Downtown Long Beach Station  33.768071 -118.192921  Long Bch  6.503030e+06
1          Pacific Ave Station  33.772258 -118.193700   Pacific  6.502796e+06
2      Anaheim Street Station  33.781830 -118.189384   Anaheim  6.504115e+06
3  Pacific Coast Hwy Station  33.789090 -118.189382        PCH  6.504120e+06
4      Willow Street Station  33.807079 -118.189834    Willow  6.503995e+06
```

```
          POINT_Y          geometry
0  1.738034e+06  POINT (-118.19292 33.76807)
1  1.739558e+06  POINT (-118.19370 33.77226)
```



```

2 1.743039e+06 POINT (-118.18938 33.78183)
3 1.745681e+06 POINT (-118.18938 33.78909)
4 1.752228e+06 POINT (-118.18983 33.80708)

```

```
[30]: # merge the two files together to make one file with both geometry for the
      ↪ station and the station opening date
```

```
station = sta.merge(station_opened,on="STOPNUM")
```

```
[31]: # run a random sample to make sure entire data set is still working
```

```
station.sample(5)
```

```
[31]:
```

	LINE	LINENUM	LINENUM2	STNSEQ	STNSEQ2	DIR	STOPNUM	\
80	Gold	804	0	9	0	None	80419	
41	Red/Purple	802	805	5	5	None	80210	
52	Green	803	0	10	0	None	80305	
85	EXPO	806	0	15	0	None	80135	
33	Red	802	0	13	0	None	80202	

	STATION	LAT	LONG	TPIS_NAME	\
80	Lake Station	34.151806	-118.131390	Lake	
41	Westlake / MacArthur Park Station	34.056368	-118.274879	Westlake	
52	Aviation / LAX Station	33.929621	-118.377134	Aviat/LAX	
85	Expo / Sepulveda Station	34.035408	-118.434234	Sepulveda	
33	Universal / Studio City Station	34.140002	-118.362699	Univ City	

	POINT_X	POINT_Y	geometry	DATE OPENED
80	6.521914e+06	1.877653e+06	POINT (-118.13139 34.15181)	2003
41	6.478407e+06	1.843009e+06	POINT (-118.27488 34.05637)	1993
52	6.447261e+06	1.796984e+06	POINT (-118.37713 33.92962)	1995
85	6.430106e+06	1.835552e+06	POINT (-118.43423 34.03541)	2016
33	6.451916e+06	1.873530e+06	POINT (-118.36270 34.14000)	2000

```
[32]: # convert to web mercator
```

```
station = station.to_crs(epsg=3857)
tracts_data = tracts_data.to_crs(epsg=3857)
```

```
[33]: # create new column called buffer. Shoutout to Rayne for providing us with this
      ↪ line
```

```
station['buffers'] = station.geometry.buffer(1200)
```

```
[34]: # display the head to check the data - looks good!
```

```
station.head()
```

```
[34]:
```

	LINE	LINENUM	LINENUM2	STNSEQ	STNSEQ2	DIR	STOPNUM	\
0	Blue	801	0	21	0	None	80101	
1	Blue	801	0	22	0	North	80102	
2	Blue	801	0	18	0	None	80105	
3	Blue	801	0	17	0	None	80106	
4	Blue	801	0	16	0	None	80107	

	STATION	LAT	LONG	TPIS_NAME	POINT_X	\
0	Downtown Long Beach Station	33.768071	-118.192921	Long Bch	6.503030e+06	
1	Pacific Ave Station	33.772258	-118.193700	Pacific	6.502796e+06	
2	Anaheim Street Station	33.781830	-118.189384	Anaheim	6.504115e+06	
3	Pacific Coast Hwy Station	33.789090	-118.189382	PCH	6.504120e+06	
4	Willow Street Station	33.807079	-118.189834	Willow	6.503995e+06	

	POINT_Y	geometry	DATE OPENED	\
0	1.738034e+06	POINT (-13157175.781 3997701.981)	1990	
1	1.739558e+06	POINT (-13157262.499 3998262.680)	1990	
2	1.743039e+06	POINT (-13156782.044 3999544.611)	1990	
3	1.745681e+06	POINT (-13156781.821 4000517.002)	1990	
4	1.752228e+06	POINT (-13156832.138 4002926.773)	1990	


```

                                buffers
0  POLYGON ((-13155975.781 3997701.981, -13155981...
1  POLYGON ((-13156062.499 3998262.680, -13156068...
2  POLYGON ((-13155582.044 3999544.611, -13155587...
3  POLYGON ((-13155581.821 4000517.002, -13155587...
4  POLYGON ((-13155632.138 4002926.773, -13155637...

```

Let's see if we can get these buffers onto a blank map

```
[35]: # initialize a new map centered on LA
m_buffer = folium.Map(location=[34,-118.2],
                        zoom_start = 10,
                        tiles='CartoDB positron',
                        attribution='CartoDB')

# add the buffer polygons to the map
folium.GeoJson(data=station['buffers']).add_to(m_buffer)

# display map
m_buffer
```

```
[35]: <folium.folium.Map at 0x7fa4639c45e0>
```

Let's see if we can add these buffers to a map we already have, the one of change in transit use.

```
[36]: # make a copy of the folium map with change in transit
```

```
m_station = m
```

```
[37]: #add the buffers to the transit map
```

```
folium.GeoJson(data=station['buffers']).add_to(m_station)
```

```
m_station
```

```
[37]: <folium.folium.Map at 0x7fa47c2fe7c0>
```

6 Trying polygon intersect

Now we want to find which census tracts intersect those buffers. We first test it out for one station using code from <https://medium.com/nam-r/10-essential-operations-for-spatial-data-in-python-4603d933bdda>

```
[38]: # assign the buffer for Mariachi Station to the variable G1
```

```
g1 = station.buffers[67]
```

```
[39]: # lets see how it looks
```

```
print(g1)
```

```
POLYGON ((-13158951.01712004 4035143.610382665, -13158956.79544804
4035025.989814269, -13158974.07478356 4034909.501996246, -13159002.68871716
4034795.268769959, -13159042.36168103 4034684.390263827, -13159092.71160283
4034577.934298474, -13159153.25358528 4034476.926103042, -13159223.40457601
4034382.338441669, -13159302.48898262 4034295.082245241, -13159389.74517905
4034215.99783863, -13159484.33284042 4034145.846847902, -13159585.34103585
4034085.304865447, -13159691.79700121 4034034.954943651, -13159802.67550734
4033995.281979786, -13159916.90873362 4033966.668046181, -13160033.39655165
4033949.388710659, -13160151.01712004 4033943.610382665, -13160268.63768844
4033949.388710659, -13160385.12550646 4033966.668046181, -13160499.35873275
4033995.281979786, -13160610.23723888 4034034.954943651, -13160716.69320423
4034085.304865447, -13160817.70139967 4034145.846847902, -13160912.28906104
4034215.99783863, -13160999.54525747 4034295.082245241, -13161078.62966408
4034382.338441669, -13161148.78065481 4034476.926103042, -13161209.32263726
4034577.934298474, -13161259.67255906 4034684.390263827, -13161299.34552292
4034795.268769959, -13161327.95945653 4034909.501996246, -13161345.23879205
4035025.989814269, -13161351.01712004 4035143.610382665, -13161345.23879205
4035261.230951061, -13161327.95945653 4035377.718769084, -13161299.34552292
4035491.95199537, -13161259.67255906 4035602.830501503, -13161209.32263726
4035709.286466856, -13161148.78065481 4035810.294662288, -13161078.62966408
4035904.882323661, -13160999.54525747 4035992.138520089, -13160912.28906104
```

```

4036071.2229267, -13160817.70139967 4036141.373917428, -13160716.69320423
4036201.915899883, -13160610.23723888 4036252.265821679, -13160499.35873275
4036291.938785544, -13160385.12550646 4036320.552719149, -13160268.63768844
4036337.832054671, -13160151.01712004 4036343.610382665, -13160033.39655165
4036337.832054671, -13159916.90873362 4036320.552719149, -13159802.67550734
4036291.938785544, -13159691.79700121 4036252.265821679, -13159585.34103585
4036201.915899883, -13159484.33284042 4036141.373917428, -13159389.74517905
4036071.2229267, -13159302.48898262 4035992.138520089, -13159223.40457601
4035904.882323661, -13159153.25358528 4035810.294662288, -13159092.71160283
4035709.286466856, -13159042.36168103 4035602.830501503, -13159002.68871716
4035491.95199537, -13158974.07478356 4035377.718769084, -13158956.79544804
4035261.230951061, -13158951.01712004 4035143.610382665))

```

```

[40]: # Use method #5 at this site
# https://medium.com/nam-r/
      ↪ 10-essential-operations-for-spatial-data-in-python-4603d933bdda
intersect_list = tracts_data['geometry'].apply(lambda g: g.intersects(g1))

# calculate the area of the intersections
areas = tracts_data.loc[intersect_list, 'geometry'].apply(lambda g: g.
      ↪ intersection(g1).area)

```

```

[41]: # Display the area of intersection for the tracts that intersect
# We won't use the areas, but the list of tracts that intersect will come in_
      ↪ handy

areas

```

```

[41]: 513    1.102824e+06
      514    3.168349e+05
      521    3.918856e+01
      522    1.018275e+03
      523    4.330632e+05
      524    4.123460e+05
      525    2.958571e+05
      535    6.638131e+04
      536    1.426569e+06
      537    4.647259e+05
      Name: geometry, dtype: float64

```

```

[42]: # let's see what intersect_list looks like just to help us understand how this_
      ↪ works
# looks like it just shows True/False for each tract if it intersects with the_
      ↪ Mariachi Station buffer

intersect_list

```

```
[42]: 0      False
      1      False
      2      False
      3      False
      4      False
      ...
      2460   False
      2461   False
      2462   False
      2463   False
      2464   False
      Name: geometry, Length: 2465, dtype: bool
```

6.1 Plot the Census Tracts that intersect with the Mariachi Station buffer

```
[43]: # find the row that hold Mariachi Station
      station[station['STATION'].str.contains('Mariachi')]
```

```
[43]:  LINE  LINENUM  LINENUM2  STNSEQ  STNSEQ2  DIR  STOPNUM  \
67  Gold      804         0      22         0  None    80406

      STATION          LAT          LONG TPIS_NAME  \
67  Mariachi Plaza / Boyle Heights Station  34.047215 -118.219648  Mariachi

      POINT_X      POINT_Y          geometry  \
67  6.495129e+06  1.839637e+06  POINT (-13160151.017 4035143.610)

      DATE OPENED          buffers
67      2009  POLYGON ((-13158951.017 4035143.610, -13158956...
```

```
[44]: # initialize a blank map stationed on Mariachi Plaza station
m_mariachi = folium.Map(location=[34.047, -118.219],
                        zoom_start = 14,
                        tiles='CartoDB positron',
                        attribution='CartoDB')

# add Mariachi buffer to map
folium.GeoJson(data=station[station['STATION'].str.contains('Mariachi')].
    ↪ buffers).add_to(m_mariachi)

# show map
m_mariachi
```

```
[44]: <folium.folium.Map at 0x7fa46435a880>
```

```
[45]: # use area intercept data to make a list of census tracts surrounding Mariachi_
      ↪ Plaza
```

```
# select those rows and all columns
```

```
mariachi_tracts = tracts_data.loc[[513, 514, 521, 522, 523, 524, 525, 535, 536, 537],:]
mariachi_tracts
```

```
[45]:
```

	FIPS	geometry \
513	06037203500	MULTIPOLYGON (((-13161130.740 4035935.902, -13...
514	06037203600	MULTIPOLYGON (((-13159515.828 4035495.479, -13...
521	06037204200	MULTIPOLYGON (((-13159050.847 4034671.916, -13...
522	06037204300	MULTIPOLYGON (((-13159272.595 4034256.396, -13...
523	06037204410	MULTIPOLYGON (((-13160013.760 4034765.286, -13...
524	06037204420	MULTIPOLYGON (((-13159685.034 4034478.730, -13...
525	06037204600	MULTIPOLYGON (((-13160234.952 4032801.051, -13...
535	06037206031	MULTIPOLYGON (((-13162384.309 4030788.941, -13...
536	06037206032	MULTIPOLYGON (((-13161302.061 4035236.716, -13...
537	06037206050	MULTIPOLYGON (((-13160499.892 4030849.912, -13...

	Geo_NAME \
513	Census Tract 2035, Los Angeles city (part), Lo...
514	Census Tract 2036, Los Angeles city (part), Lo...
521	Census Tract 2042, Los Angeles city (part), Lo...
522	Census Tract 2043, Los Angeles city (part), Lo...
523	Census Tract 2044.10, Los Angeles city (part),...
524	Census Tract 2044.20, Los Angeles city (part),...
525	Census Tract 2046, Los Angeles city (part), Lo...
535	Census Tract 2060.31, Los Angeles city (part),...
536	Census Tract 2060.32, Los Angeles city (part),...
537	Census Tract 2060.50, Los Angeles city (part),...

	Geo_QName	Geo_STATE	Geo_COUNTY \
513	Census Tract 2035, Los Angeles city (part), Lo...	06	037
514	Census Tract 2036, Los Angeles city (part), Lo...	06	037
521	Census Tract 2042, Los Angeles city (part), Lo...	06	037
522	Census Tract 2043, Los Angeles city (part), Lo...	06	037
523	Census Tract 2044.10, Los Angeles city (part),...	06	037
524	Census Tract 2044.20, Los Angeles city (part),...	06	037
525	Census Tract 2046, Los Angeles city (part), Lo...	06	037
535	Census Tract 2060.31, Los Angeles city (part),...	06	037
536	Census Tract 2060.32, Los Angeles city (part),...	06	037
537	Census Tract 2060.50, Los Angeles city (part),...	06	037

	Geo_TRACT	2010 Housing Units	2010 Median Gross Rent \
513	203500	1077	864.0
514	203600	1474	929.0
521	204200	975	924.0
522	204300	1347	986.0

523	204410	640	931.0
524	204420	957	948.0
525	204600	1127	1031.0
535	206031	1300	1916.0
536	206032	1470	940.0
537	206050	746	804.0

	2010 Percent Transit	2018 Housing Units	2018 Median Gross Rent \
513	15.70	1040	1082.0
514	16.84	1489	1158.0
521	26.35	1020	993.0
522	12.30	1366	1069.0
523	9.98	667	1070.0
524	27.13	1007	1000.0
525	22.36	1212	973.0
535	9.58	2643	2366.0
536	14.39	1780	1051.0
537	18.06	848	825.0

	2018 Percent Transit	Change Housing Units	Change Median Rent \
513	13.64	-0.034355	0.252315
514	14.98	0.010176	0.246502
521	20.67	0.046154	0.074675
522	18.01	0.014105	0.084178
523	16.21	0.042188	0.149302
524	28.68	0.052247	0.054852
525	20.31	0.075421	-0.056256
535	13.17	1.033077	0.234864
536	12.54	0.210884	0.118085
537	17.69	0.136729	0.026119

	Change Percent Transit	transit_lag	rent_lag	housing_lag
513	-2.06	2.29500	0.119733	0.203471
514	-1.86	-3.47250	0.095787	-0.010584
521	-5.68	-4.52750	0.145623	-0.006907
522	5.71	-2.83375	0.098008	0.022836
523	6.23	-1.67875	0.104115	0.040995
524	1.55	-2.47250	0.093149	0.041872
525	-2.05	-0.91000	0.089232	0.057508
535	3.59	2.93250	0.081942	0.247501
536	-1.85	5.08750	0.129236	0.269152
537	-0.37	-2.14000	0.107625	0.166680

```
[46]: # initialize a blank map stationed on Mariachi Plaza station
m_mariachi_tracts = folium.Map(location=[34.047, -118.219],
                                zoom_start = 14,
                                tiles='CartoDB positron',
```

```

        attribution='CartoDB')

# plot chorpleth map of change in transit use JUST for the tracts that
→ intersect the buffer of Mariachi Plaza
folium.Choropleth(
    geo_data=mariachi_tracts,          # geo data
    data=mariachi_tracts,              # data
    →
    key_on='feature.properties.FIPS',  # key, or merge
    → column
    columns=['FIPS', 'Change Percent Transit'], # [key, value]
    fill_color='RdYlBu',               # using a
    → diverging scale from colorbrewer2.org
    line_weight=0.1,
    fill_opacity=0.6,
    line_opacity=0.2,                 # line opacity
    → (of the border)
    legend_name='Change in Transit Use',
    threshold_scale=[-67, -10, -1, 1, 10, 41], # change
    → thresholds
    nan_fill_color = 'lightgray').add_to(m_mariachi_tracts)

# add Mariachi buffer to map
folium.GeoJson(data=station[station['STATION'].str.contains('Mariachi')].
    → buffers).add_to(m_mariachi_tracts)

# show map
m_mariachi_tracts

```

[46]: <folium.folium.Map at 0x7fa464375910>

6.2 Loop through the stations and census tracts

```

[47]: # create a sorted list of unique years t

years = station['DATE OPENED'].unique().tolist()
years = np.sort(years)
years

```

[47]: array([1990, 1991, 1993, 1995, 1996, 1999, 2000, 2003, 2009, 2012, 2016])

```

[48]: # subset the data: stations that opened before 2010, in 2012, and in 2016

station10 = station[station['DATE OPENED'] <= 2010]
station12 = station[station['DATE OPENED'] == 2012]

```



```
station16 = station[station['DATE OPENED'] == 2016]
```

```
[49]: # explore data to check if stations that opened in 2010 under Date Opened works
```

```
station10.sample(2)
```

```
[49]:
```

	LINE	LINENUM	LINENUM2	STNSEQ	STNSEQ2	DIR	STOPNUM	\
3	Blue	801	0	17	0	None	80106	
78	Gold	804	0	11	0	None	80417	

		STATION	LAT	LONG	TPIS_NAME	POINT_X	\
3	Pacific Coast Hwy Station	33.78909	-118.189382		PCH	6.504120e+06	
78	Del Mar Station	34.14191	-118.148214		Del Mar	6.516819e+06	

	POINT_Y	geometry	DATE OPENED	\
3	1.745681e+06	POINT (-13156781.821 4000517.002)	1990	
78	1.874059e+06	POINT (-13152199.021 4047873.026)	2003	


```

buffers
3 POLYGON ((-13155581.821 4000517.002, -13155587...
78 POLYGON ((-13150999.021 4047873.026, -13151004...
```

```
[50]: # now let's do it for stations opened in 2012
```

```
station12.sample(2)
```

```
[50]:
```

	LINE	LINENUM	LINENUM2	STNSEQ	STNSEQ2	DIR	STOPNUM	\
20	EXPO	806	0	3	0	None	80123	
24	EXPO	806	0	7	0	None	80127	

		STATION	LAT	LONG	TPIS_NAME	\
20	LATTC / Ortho Institute Station	34.029112	-118.273603		LATTC/Ortho	
24	Expo / Western Station	34.018331	-118.308910		Ex/Wstrn	

	POINT_X	POINT_Y	geometry	\
20	6.478766e+06	1.833089e+06	POINT (-13166157.260 4032711.727)	
24	6.468056e+06	1.829197e+06	POINT (-13170087.618 4031263.697)	


```

DATE OPENED buffers
20 2012 POLYGON ((-13164957.260 4032711.727, -13164963...
24 2012 POLYGON ((-13168887.618 4031263.697, -13168893...
```

```
[51]: # and now lets do it one more time to check for stations that opened in 2016
```

```
station16.sample(2)
```

```
[51]:
```

	LINE	LINENUM	LINENUM2	STNSEQ	STNSEQ2	DIR	STOPNUM	\
92	Gold	804	0	4	0	None	80424	
84	EXPO	806	0	14	0	None	80134	

	STATION	LAT	LONG	TPIS_NAME	\
92	Duarte / City of Hope Station	34.132518	-117.967680	Duarte	
84	Westwood / Rancho Park Station	34.036816	-118.424576	Westwood	

	POINT_X	POINT_Y	geometry	DATE OPENED	\
92	6571447.0	1870610.0	POINT (-13132102.068 4046609.866)	2016	
84	6433034.0	1836052.0	POINT (-13182963.498 4033746.587)	2016	


```

buffers
92 POLYGON ((-13130902.068 4046609.866, -13130907...
84 POLYGON ((-13181763.498 4033746.587, -13181769...

```

```
[52]: # Add three columns to the tracts data to say if there are stations that opened
      ↪ before 2010, in 2012, or in 2016.
      # Set the default value to false.
      # In the loop we will change them to true if a station opened.

tracts_data['Station10'] = False
tracts_data['Station12'] = False
tracts_data['Station16'] = False
```

```
[53]: # take a look at the new columns

tracts_data.sample(2)
```

```
[53]:
```

	FIPS	geometry	\
1823	06037551201	MULTIPOLYGON (((-13152616.469 4018609.155, -13...	
588	06037211500	MULTIPOLYGON (((-13171641.749 4038085.456, -13...	

	Geo_NAME	\
1823	Census Tract 5512.01, Downey city, Downey-Norw...	
588	Census Tract 2115, Los Angeles city (part), Lo...	

	Geo_QName	Geo_STATE	Geo_COUNTY	\
1823	Census Tract 5512.01, Downey city, Downey-Norw...	06	037	
588	Census Tract 2115, Los Angeles city (part), Lo...	06	037	

	Geo_TRACT	2010 Housing Units	2010 Median Gross Rent	\
1823	551201	1159	1367.0	
588	211500	1829	1197.0	

	2010 Percent Transit	...	2018 Percent Transit	Change Housing Units	\
1823	0.78	...	2.70	-0.007765	

588		17.37	...		13.14		0.047567
-----	--	-------	-----	--	-------	--	----------

	Change Median Rent	Change Percent	Transit	transit_lag	rent_lag	\
1823	0.004389		1.92	0.37375	0.084904	
588	0.024227		-4.23	-4.25375	0.084186	

	housing_lag	Station10	Station12	Station16
1823	-0.015279	False	False	False
588	0.006999	False	False	False

[2 rows x 22 columns]

6.3 The loop!

With help from <https://stackoverflow.com/questions/23330654/update-a-dataframe-in-pandas-while-iterating-row-by-row>

```
[54]: # iterates through each of the stations
for index_s, row_s in station12.iterrows():

    geom = row_s.buffers                                #Takes buffer from each line and
    ↪ assigns it to variable geom

    for index_t, row_t in tracts_data.iterrows():      # iterate through tracts
    ↪ data

        if row_t.geometry.intersects(geom) == True:    # if geometry
    ↪ intercepts geom...

            # print(row_s.STATION + " " + row_t.Geo_TRACT) # this line was just
    ↪ used for testing if it was working

            tracts_data.at[index_t, 'Station12'] = True    #... then set the
    ↪ value to True
```

```
[55]: # take a look at rows that intersect buffers from stations opened in 2012

tracts_data[tracts_data.Station12 == True]
```

```
[55]:
```

	FIPS	geometry	\
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686	06037221900	MULTIPOLYGON	(((-13168639.240 4032448.997, -13...
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730	06037231220	MULTIPOLYGON	(((-13168640.019 4030424.728, -13...
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733	06037231500	MULTIPOLYGON	(((-13171000.103 4029418.502, -13...
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749	06037234200	MULTIPOLYGON	(((-13173002.630 4030370.875, -13...
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764	06037236203	MULTIPOLYGON	(((-13174929.236 4031691.062, -13...
765	06037236204	MULTIPOLYGON	(((-13174825.598 4030446.483, -13...
875	06037269500	MULTIPOLYGON	(((-13180086.779 4034185.061, -13...
878	06037269700	MULTIPOLYGON	(((-13179548.772 4033253.459, -13...
879	06037269800	MULTIPOLYGON	(((-13180584.155 4032770.022, -13...
885	06037270100	MULTIPOLYGON	(((-13180627.792 4032705.279, -13...
886	06037270200	MULTIPOLYGON	(((-13179166.724 4032966.672, -13...
2233	06037702400	MULTIPOLYGON	(((-13180044.033 4031879.635, -13...
2235	06037702502	MULTIPOLYGON	(((-13179798.573 4029762.674, -13...

			Geo_NAME \
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660	Census Tract	2189,	Los Angeles city (part), Lo...
661	Census Tract	2190.10,	Los Angeles city (part),...
662	Census Tract	2190.20,	Los Angeles city (part),...
663	Census Tract	2193,	Los Angeles city (part), Lo...
664	Census Tract	2195,	Los Angeles city (part), Lo...
665	Census Tract	2197,	Los Angeles city (part), Lo...
666	Census Tract	2198,	Los Angeles city (part), Lo...
667	Census Tract	2199.01,	Los Angeles city (part),...
668	Census Tract	2199.02,	Los Angeles city (part),...
669	Census Tract	2200,	Los Angeles city (part), Lo...
670	Census Tract	2201,	Los Angeles city (part), Lo...
685	Census Tract	2218.20,	Los Angeles city (part),...
686	Census Tract	2219,	Los Angeles city (part), Lo...
687	Census Tract	2220.01,	Los Angeles city (part),...
688	Census Tract	2220.02,	Los Angeles city (part),...
689	Census Tract	2221,	Los Angeles city (part), Lo...
691	Census Tract	2225,	Los Angeles city (part), Lo...
692	Census Tract	2226,	Los Angeles city (part), Lo...
693	Census Tract	2227,	Los Angeles city (part), Lo...
694	Census Tract	2240.10,	Los Angeles city (part),...
695	Census Tract	2240.20,	Los Angeles city (part),...
699	Census Tract	2244.10,	Los Angeles city (part),...
700	Census Tract	2244.20,	Los Angeles city (part),...
701	Census Tract	2246,	Los Angeles city (part), Lo...
702	Census Tract	2247,	Los Angeles city (part), Lo...
705	Census Tract	2264.10,	Los Angeles city (part),...
707	Census Tract	2267,	Los Angeles city (part), Lo...
715	Census Tract	2284.10,	Los Angeles city (part),...
728	Census Tract	2311,	Los Angeles city (part), Lo...
729	Census Tract	2312.10,	Los Angeles city (part),...
730	Census Tract	2312.20,	Los Angeles city (part),...
731	Census Tract	2313,	Los Angeles city (part), Lo...
732	Census Tract	2314,	Los Angeles city (part), Lo...
733	Census Tract	2315,	Los Angeles city (part), Lo...
734	Census Tract	2316,	Los Angeles city (part), Lo...
735	Census Tract	2317.10,	Los Angeles city (part),...
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737	Census Tract	2318,	Los Angeles city (part), Lo...
748	Census Tract	2340,	Los Angeles city (part), Lo...
749	Census Tract	2342,	Los Angeles city (part), Lo...
761	Census Tract	2360 (part),	Los Angeles city (pa...
762	Census Tract	2361,	Los Angeles city (part), Lo...
763	Census Tract	2362.02,	Los Angeles city (part),...
764	Census Tract	2362.03,	Los Angeles city (part),...
765	Census Tract	2362.04,	Los Angeles city (part),...

875 Census Tract 2695, Los Angeles city (part), Lo...
 878 Census Tract 2697, Los Angeles city (part), Lo...
 879 Census Tract 2698, Los Angeles city (part), Lo...
 885 Census Tract 2701, Los Angeles city (part), Lo...
 886 Census Tract 2702, Los Angeles city (part), Lo...
 2233 Census Tract 7024, Culver City city, Los Angel...
 2235 Census Tract 7025.02 (part), Culver City city,...

		Geo_QName	Geo_STATE	Geo_COUNTY	\
658	Census Tract	2187.02, Los Angeles city (part),...	06	037	
660	Census Tract	2189, Los Angeles city (part), Lo...	06	037	
661	Census Tract	2190.10, Los Angeles city (part),...	06	037	
662	Census Tract	2190.20, Los Angeles city (part),...	06	037	
663	Census Tract	2193, Los Angeles city (part), Lo...	06	037	
664	Census Tract	2195, Los Angeles city (part), Lo...	06	037	
665	Census Tract	2197, Los Angeles city (part), Lo...	06	037	
666	Census Tract	2198, Los Angeles city (part), Lo...	06	037	
667	Census Tract	2199.01, Los Angeles city (part),...	06	037	
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669	Census Tract	2200, Los Angeles city (part), Lo...	06	037	
670	Census Tract	2201, Los Angeles city (part), Lo...	06	037	
685	Census Tract	2218.20, Los Angeles city (part),...	06	037	
686	Census Tract	2219, Los Angeles city (part), Lo...	06	037	
687	Census Tract	2220.01, Los Angeles city (part),...	06	037	
688	Census Tract	2220.02, Los Angeles city (part),...	06	037	
689	Census Tract	2221, Los Angeles city (part), Lo...	06	037	
691	Census Tract	2225, Los Angeles city (part), Lo...	06	037	
692	Census Tract	2226, Los Angeles city (part), Lo...	06	037	
693	Census Tract	2227, Los Angeles city (part), Lo...	06	037	
694	Census Tract	2240.10, Los Angeles city (part),...	06	037	
695	Census Tract	2240.20, Los Angeles city (part),...	06	037	
699	Census Tract	2244.10, Los Angeles city (part),...	06	037	
700	Census Tract	2244.20, Los Angeles city (part),...	06	037	
701	Census Tract	2246, Los Angeles city (part), Lo...	06	037	
702	Census Tract	2247, Los Angeles city (part), Lo...	06	037	
705	Census Tract	2264.10, Los Angeles city (part),...	06	037	
707	Census Tract	2267, Los Angeles city (part), Lo...	06	037	
715	Census Tract	2284.10, Los Angeles city (part),...	06	037	
728	Census Tract	2311, Los Angeles city (part), Lo...	06	037	
729	Census Tract	2312.10, Los Angeles city (part),...	06	037	
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734	Census Tract	2316, Los Angeles city (part), Lo...	06	037	
735	Census Tract	2317.10, Los Angeles city (part),...	06	037	
736	Census Tract	2317.20, Los Angeles city (part),...	06	037	

737	Census Tract 2318, Los Angeles city (part), Lo...	06	037
748	Census Tract 2340, Los Angeles city (part), Lo...	06	037
749	Census Tract 2342, Los Angeles city (part), Lo...	06	037
761	Census Tract 2360 (part), Los Angeles city (pa...	06	037
762	Census Tract 2361, Los Angeles city (part), Lo...	06	037
763	Census Tract 2362.02, Los Angeles city (part),...	06	037
764	Census Tract 2362.03, Los Angeles city (part),...	06	037
765	Census Tract 2362.04, Los Angeles city (part),...	06	037
875	Census Tract 2695, Los Angeles city (part), Lo...	06	037
878	Census Tract 2697, Los Angeles city (part), Lo...	06	037
879	Census Tract 2698, Los Angeles city (part), Lo...	06	037
885	Census Tract 2701, Los Angeles city (part), Lo...	06	037
886	Census Tract 2702, Los Angeles city (part), Lo...	06	037
2233	Census Tract 7024, Culver City city, Los Angel...	06	037
2235	Census Tract 7025.02 (part), Culver City city,...	06	037

	Geo_TRACT	2010 Housing Units	2010 Median Gross Rent \
658	218702	844	974.0
660	218900	2206	1036.0
661	219010	864	1005.0
662	219020	1487	1079.0
663	219300	1473	1118.0
664	219500	802	1117.0
665	219700	1369	1096.0
666	219800	1118	1064.0
667	219901	1520	1118.0
668	219902	1259	1151.0
669	220000	2076	1068.0
670	220100	1085	383.0
685	221820	1118	1274.0
686	221900	1144	1121.0
687	222001	946	952.0
688	222002	1409	1101.0
689	222100	1174	1003.0
691	222500	1378	1193.0
692	222600	1804	1041.0
693	222700	121	1409.0
694	224010	1145	634.0
695	224020	880	783.0
699	224410	1098	1222.0
700	224420	735	762.0
701	224600	850	926.0
702	224700	890	1309.0
705	226410	892	874.0
707	226700	1385	1054.0
715	228410	725	1105.0
728	231100	764	906.0

729	231210	1166	1064.0
730	231220	1146	936.0
731	231300	1526	1192.0
732	231400	1421	953.0
733	231500	1508	1060.0
734	231600	2179	1006.0
735	231710	1338	996.0
736	231720	1515	878.0
737	231800	1419	953.0
748	234000	2153	953.0
749	234200	1179	1190.0
761	236000	2197	1288.0
762	236100	2884	1046.0
763	236202	2628	1072.0
764	236203	1343	1053.0
765	236204	1469	1084.0
875	269500	1459	2310.0
878	269700	1732	1442.0
879	269800	1722	1521.0
885	270100	2489	1413.0
886	270200	1302	1328.0
2233	702400	1999	1313.0
2235	702502	2174	1826.0

	2010 Percent Transit	...	2018 Percent Transit	Change Housing Units	\
658	23.63	...	10.70	0.024882	
660	12.06	...	15.61	0.005893	
661	7.91	...	9.49	0.078704	
662	15.52	...	10.04	0.032280	
663	21.69	...	16.07	0.038697	
664	10.66	...	6.96	0.001247	
665	7.50	...	7.78	0.075237	
666	19.17	...	16.73	-0.033989	
667	9.52	...	13.16	0.030263	
668	22.30	...	5.48	-0.003971	
669	12.75	...	10.94	0.064547	
670	10.09	...	4.48	0.006452	
685	14.72	...	26.85	-0.047406	
686	5.87	...	12.88	-0.139860	
687	15.43	...	9.05	0.033827	
688	24.06	...	16.95	-0.034776	
689	15.75	...	13.04	0.059625	
691	14.49	...	17.30	0.002903	
692	13.50	...	19.04	0.006652	
693	1.02	...	12.36	0.231405	
694	49.56	...	36.73	0.410480	
695	21.72	...	32.91	0.194318	

699	29.44	...	16.33	0.038251
700	26.79	...	22.08	0.115646
701	23.47	...	27.63	-0.003529
702	3.36	...	8.84	0.237079
705	35.04	...	24.92	0.013453
707	23.67	...	19.93	0.090975
715	29.71	...	18.16	0.030345
728	23.44	...	30.06	0.001309
729	33.81	...	20.59	0.058319
730	37.70	...	21.42	0.137871
731	23.97	...	13.37	0.132372
732	16.26	...	16.01	0.114004
733	12.29	...	9.31	-0.005968
734	20.36	...	12.27	0.032125
735	25.47	...	29.49	-0.057549
736	31.58	...	22.06	0.077228
737	31.01	...	16.81	0.031008
748	7.62	...	5.11	-0.013005
749	9.16	...	0.00	0.004241
761	1.04	...	3.07	0.034593
762	18.11	...	13.56	0.107143
763	24.02	...	19.90	0.007610
764	13.23	...	20.88	0.198809
765	18.89	...	21.53	0.039483
875	0.00	...	2.83	-0.027416
878	7.88	...	6.64	0.010393
879	3.38	...	6.59	0.013357
885	6.32	...	5.78	0.031740
886	7.58	...	12.19	0.027650
2233	5.34	...	5.42	-0.006503
2235	2.29	...	3.65	-0.019319

	Change Median Rent	Change Percent Transit	transit_lag	rent_lag \
658	0.054415	-12.93	-2.50750	0.102530
660	0.166988	3.55	-5.88000	0.131716
661	0.323383	1.58	-5.86000	0.120218
662	-0.006487	-5.48	-3.23750	0.194038
663	-0.021467	-5.62	-4.99000	0.148176
664	0.078782	-3.70	-1.83625	0.073489
665	0.024635	0.28	1.87875	0.033932
666	0.121241	-2.44	-3.45875	0.350323
667	-0.029517	3.64	-3.58750	0.374685
668	0.165074	-16.82	-1.92125	0.386685
669	0.132022	-1.81	-1.31000	0.026368
670	2.318538	-5.61	-2.38750	0.114142
685	0.210361	12.13	-1.42125	0.156828
686	-0.016057	7.01	1.65000	0.204123

687	0.410714	-6.38	-3.58250	0.179369
688	0.044505	-7.11	-3.63750	0.197500
689	0.273180	-2.71	-1.53875	0.142653
691	0.083822	2.81	-5.09000	0.134420
692	0.132565	5.54	-1.73000	0.131244
693	0.419446	11.34	1.77250	0.148727
694	0.249211	-12.83	-3.77500	0.481560
695	0.047254	11.19	-5.57875	0.208385
699	-0.118658	-13.11	-6.39250	0.197809
700	0.125984	-4.71	-2.86250	0.167184
701	0.003240	4.16	0.56375	0.196475
702	0.331551	5.48	0.66875	0.111926
705	0.211670	-10.12	0.49125	0.087317
707	0.136622	-3.74	-1.87250	0.108759
715	0.170136	-11.55	-2.93500	0.078356
728	0.129139	6.62	-5.08875	0.164680
729	-0.092105	-13.22	-5.69375	0.091295
730	0.106838	-16.28	0.46250	0.106394
731	0.004195	-10.60	-3.25125	0.090243
732	0.113326	-0.25	-5.68375	0.099967
733	0.099057	-2.98	-7.46250	0.088136
734	0.067594	-8.09	-9.52250	0.058511
735	0.001004	4.02	-12.31750	0.107548
736	0.209567	-9.52	-8.08750	0.085046
737	0.147954	-14.20	-7.70625	0.089407
748	0.256034	-2.51	-4.34875	0.061556
749	0.258824	-9.16	-3.46500	0.101297
761	0.301242	2.03	-1.44500	0.306422
762	0.043977	-4.55	-1.84125	0.035710
763	0.071828	-4.12	0.20125	0.067256
764	0.053181	7.65	-1.75000	0.048434
765	0.024908	2.64	-1.12375	0.051968
875	0.515584	2.83	-1.32250	0.052501
878	0.010402	-1.24	-0.33500	0.166177
879	0.104536	3.21	-1.97625	0.195234
885	0.223638	-0.54	-2.05625	0.139385
886	-0.063253	4.61	-3.33875	0.118111
2233	0.343488	0.08	-2.85125	0.063700
2235	-0.042716	1.36	0.24500	0.172620

	housing_lag	Station10	Station12	Station16
658	0.042114	False	True	False
660	0.041554	False	True	False
661	0.023863	False	True	False
662	0.028448	False	True	False
663	0.028221	False	True	False
664	0.066971	False	True	False

665	0.039238	False	True	False
666	0.029278	False	True	False
667	0.025483	False	True	False
668	0.011266	False	True	False
669	0.049783	False	True	False
670	0.015939	False	True	False
685	0.084477	False	True	False
686	0.076872	False	True	False
687	0.011138	False	True	False
688	0.054594	False	True	False
689	0.015930	False	True	False
691	0.060482	False	True	False
692	0.062651	False	True	False
693	0.038748	False	True	False
694	0.370294	False	True	False
695	0.237230	False	True	False
699	0.040557	False	True	False
700	0.058463	False	True	False
701	0.114316	False	True	False
702	0.026768	False	True	False
705	0.129290	False	True	False
707	0.073910	False	True	False
715	0.021150	False	True	False
728	0.093013	False	True	False
729	0.047097	False	True	False
730	0.026204	False	True	False
731	0.029110	False	True	False
732	0.025744	False	True	False
733	0.073095	False	True	False
734	0.036796	False	True	False
735	0.069009	False	True	False
736	0.055221	False	True	False
737	0.056419	False	True	False
748	0.042064	False	True	False
749	0.036805	False	True	False
761	0.033318	False	True	False
762	0.033686	False	True	False
763	0.053717	False	True	False
764	0.033562	False	True	False
765	0.053478	False	True	False
875	0.024242	False	True	False
878	0.021774	False	True	False
879	0.020236	False	True	False
885	0.000991	False	True	False
886	0.023767	False	True	False
2233	0.007594	False	True	False
2235	0.016113	False	True	False

[53 rows x 22 columns]

```
[56]: #repeat the process for stations opened pre-2010

for index_s, row_s in station10.iterrows():

    geom = row_s.buffers

    for index_t, row_t in tracts_data.iterrows():

        if row_t.geometry.intersects(geom) == True:

            tracts_data.at[index_t, 'Station10'] = True
```

```
[57]: # look at a sample again

tracts_data[tracts_data.Station10 == True].sample(10)
```

```
[57]:
```

	FIPS	geometry \
700	06037224420	MULTIPOLYGON (((-13166962.768 4033038.133, -13...
1444	06037463900	MULTIPOLYGON (((-13154376.541 4045499.606, -13...
1740	06037540600	MULTIPOLYGON (((-13162311.951 4018089.179, -13...
420	06037190401	MULTIPOLYGON (((-13169654.807 4042566.061, -13...
198	06037124203	MULTIPOLYGON (((-13177893.229 4052552.596, -13...
1994	06037575901	MULTIPOLYGON (((-13158582.080 3998350.798, -13...
1742	06037540800	MULTIPOLYGON (((-13165229.858 4016745.347, -13...
422	06037190510	MULTIPOLYGON (((-13170957.023 4042464.023, -13...
564	06037208904	MULTIPOLYGON (((-13166025.792 4036653.405, -13...
1738	06037540501	MULTIPOLYGON (((-13161172.930 4018437.840, -13...

	Geo_NAME \
700	Census Tract 2244.20, Los Angeles city (part),...
1444	Census Tract 4639, Pasadena city, Pasadena CCD...
1740	Census Tract 5406, Willowbrook CDP, Compton CC...
420	Census Tract 1904.01, Los Angeles city (part),...
198	Census Tract 1242.03, Los Angeles city (part),...
1994	Census Tract 5759.01, Long Beach city, Long Be...
1742	Census Tract 5408, Willowbrook CDP, Compton CC...
422	Census Tract 1905.10, Los Angeles city (part),...
564	Census Tract 2089.04, Los Angeles city (part),...
1738	Census Tract 5405.01, Lynwood city, Compton CC...

	Geo_QName	Geo_STATE	Geo_COUNTY \
700	Census Tract 2244.20, Los Angeles city (part),...	06	037
1444	Census Tract 4639, Pasadena city, Pasadena CCD...	06	037
1740	Census Tract 5406, Willowbrook CDP, Compton CC...	06	037

420	Census Tract 1904.01, Los Angeles city (part),...	06	037
198	Census Tract 1242.03, Los Angeles city (part),...	06	037
1994	Census Tract 5759.01, Long Beach city, Long Be...	06	037
1742	Census Tract 5408, Willowbrook CDP, Compton CC...	06	037
422	Census Tract 1905.10, Los Angeles city (part),...	06	037
564	Census Tract 2089.04, Los Angeles city (part),...	06	037
1738	Census Tract 5405.01, Lynwood city, Compton CC...	06	037

	Geo_TRACT	2010 Housing Units	2010 Median Gross Rent \
700	224420	735	762.0
1444	463900	1622	1674.0
1740	540600	1096	1018.0
420	190401	1863	1065.0
198	124203	886	1162.0
1994	575901	1438	1118.0
1742	540800	1915	888.0
422	190510	1672	1147.0
564	208904	1350	810.0
1738	540501	1160	1005.0

	2010 Percent Transit ...	2018 Percent Transit	Change Housing Units \
700	26.79 ...	22.08	0.115646
1444	3.25 ...	3.09	0.086930
1740	8.00 ...	5.96	0.063869
420	10.47 ...	12.13	0.008588
198	11.04 ...	10.80	0.004515
1994	20.37 ...	11.18	0.034771
1742	8.34 ...	3.29	-0.197911
422	28.76 ...	27.15	0.144139
564	57.26 ...	56.28	0.035556
1738	0.59 ...	10.92	-0.016379

	Change Median Rent	Change Percent Transit	transit_lag	rent_lag \
700	0.125984	-4.71	-2.86250	0.167184
1444	0.116487	-0.16	0.28250	0.180379
1740	0.157171	-2.04	-0.31875	0.103770
420	0.232864	1.66	-0.66750	0.133851
198	0.098107	-0.24	-0.37375	0.071173
1994	0.002683	-9.19	-5.61125	0.066903
1742	0.288288	-5.05	-9.61750	0.185994
422	0.165650	-1.61	-3.39375	0.126597
564	0.032099	-0.98	-6.02500	0.100517
1738	0.181095	10.33	0.07250	0.050187

	housing_lag	Station10	Station12	Station16
700	0.058463	True	True	False
1444	0.154559	True	False	False

1740	0.034349	True	False	False
420	0.024713	True	False	False
198	0.050923	True	False	False
1994	0.070682	True	False	False
1742	1.905747	True	False	False
422	0.029369	True	False	False
564	0.102372	True	False	False
1738	0.008139	True	False	False

[10 rows x 22 columns]

```
[58]: # for the last time with the stations that opened in 2016
```

```
for index_s, row_s in station16.iterrows():

    geom = row_s.buffers

    for index_t, row_t in tracts_data.iterrows():

        if row_t.geometry.intersects(geom) == True:

            tracts_data.at[index_t, 'Station16'] = True
```

```
[59]: # now let's look at a sample of all the data to see if the new columns look okay
```

```
tracts_data.sample(20)
```

```
[59]:
```

	FIPS	geometry \
478	06037195902	MULTIPOLYGON (((-13167041.694 4040502.089, -13...
754	06037234700	MULTIPOLYGON (((-13173302.524 4026957.229, -13...
1542	06037501503	MULTIPOLYGON (((-13140380.230 4026517.422, -13...
1026	06037302201	MULTIPOLYGON (((-13164091.170 4048075.989, -13...
2320	06037901102	MULTIPOLYGON (((-13160013.872 4115859.689, -13...
2073	06037602200	MULTIPOLYGON (((-13177819.090 4018108.631, -13...
300	06037135114	MULTIPOLYGON (((-13204118.765 4053486.050, -13...
2386	06037920013	MULTIPOLYGON (((-13195913.739 4085686.863, -13...
634	06037214902	MULTIPOLYGON (((-13178419.325 4038173.747, -13...
882	06037269905	MULTIPOLYGON (((-13180859.782 4031852.504, -13...
1017	06037301801	MULTIPOLYGON (((-13165149.040 4049240.980, -13...
2121	06037620301	MULTIPOLYGON (((-13181546.289 4015052.167, -13...
1944	06037572100	MULTIPOLYGON (((-13158568.054 4004524.501, -13...
1991	06037575801	MULTIPOLYGON (((-13158576.069 3999653.633, -13...
2167	06037651101	MULTIPOLYGON (((-13174773.834 4002722.869, -13...
732	06037231400	MULTIPOLYGON (((-13170996.430 4030393.571, -13...
1782	06037543100	MULTIPOLYGON (((-13165311.121 4011818.196, -13...
1745	06037541001	MULTIPOLYGON (((-13167173.385 4013441.303, -13...
1631	06037531603	MULTIPOLYGON (((-13154060.505 4032592.047, -13...

783 06037238310 MULTIPOLYGON (((-13168156.447 4024166.298, -13...

		Geo_NAME \
478	Census Tract 1959.02, Los Angeles city (part),...	
754	Census Tract 2347, Los Angeles city (part), Lo...	
1542	Census Tract 5015.03, Whittier city (part), Wh...	
1026	Census Tract 3022.01, Glendale city (part), Sa...	
2320	Census Tract 9011.02 (part), Quartz Hill CDP (...)	
2073	Census Tract 6022 (part), Hawthorne city, Ingl...	
300	Census Tract 1351.14, Los Angeles city (part),...	
2386	Census Tract 9200.13 (part), Santa Clarita cit...	
634	Census Tract 2149.02, Los Angeles city (part),...	
882	Census Tract 2699.05, Los Angeles city (part),...	
1017	Census Tract 3018.01, Glendale city (part), Sa...	
2121	Census Tract 6203.01, Manhattan Beach city, So...	
1944	Census Tract 5721, Long Beach city, Long Beach...	
1991	Census Tract 5758.01, Long Beach city, Long Be...	
2167	Census Tract 6511.01, Torrance city, Torrance ...	
732	Census Tract 2314, Los Angeles city (part), Lo...	
1782	Census Tract 5431 (part), Compton city, Compto...	
1745	Census Tract 5410.01, West Rancho Dominguez CD...	
1631	Census Tract 5316.03, East Los Angeles CDP (pa...	
783	Census Tract 2383.10, Los Angeles city (part),...	

		Geo_QName	Geo_STATE	Geo_COUNTY \
478	Census Tract 1959.02, Los Angeles city (part),...		06	037
754	Census Tract 2347, Los Angeles city (part), Lo...		06	037
1542	Census Tract 5015.03, Whittier city (part), Wh...		06	037
1026	Census Tract 3022.01, Glendale city (part), Sa...		06	037
2320	Census Tract 9011.02 (part), Quartz Hill CDP (...)		06	037
2073	Census Tract 6022 (part), Hawthorne city, Ingl...		06	037
300	Census Tract 1351.14, Los Angeles city (part),...		06	037
2386	Census Tract 9200.13 (part), Santa Clarita cit...		06	037
634	Census Tract 2149.02, Los Angeles city (part),...		06	037
882	Census Tract 2699.05, Los Angeles city (part),...		06	037
1017	Census Tract 3018.01, Glendale city (part), Sa...		06	037
2121	Census Tract 6203.01, Manhattan Beach city, So...		06	037
1944	Census Tract 5721, Long Beach city, Long Beach...		06	037
1991	Census Tract 5758.01, Long Beach city, Long Be...		06	037
2167	Census Tract 6511.01, Torrance city, Torrance ...		06	037
732	Census Tract 2314, Los Angeles city (part), Lo...		06	037
1782	Census Tract 5431 (part), Compton city, Compto...		06	037
1745	Census Tract 5410.01, West Rancho Dominguez CD...		06	037
1631	Census Tract 5316.03, East Los Angeles CDP (pa...		06	037
783	Census Tract 2383.10, Los Angeles city (part),...		06	037

Geo_TRACT 2010 Housing Units 2010 Median Gross Rent \

478	195902	1109	1190.0
754	234700	1503	1060.0
1542	501503	2036	1237.0
1026	302201	1527	1108.0
2320	901102	1628	1259.0
2073	602200	935	1176.0
300	135114	2760	1626.0
2386	920013	1319	1301.0
634	214902	1710	1880.0
882	269905	1391	1385.0
1017	301801	1868	1327.0
2121	620301	1716	2310.0
1944	572100	342	1380.0
1991	575801	721	1005.0
2167	651101	1887	1908.0
732	231400	1421	953.0
1782	543100	1681	1679.0
1745	541001	368	681.0
1631	531603	884	1087.0
783	238310	1442	1060.0

	2010 Percent Transit	...	2018 Percent Transit	Change Housing Units	\
478	5.86	...	6.23	-0.038774	
754	15.20	...	5.71	0.036593	
1542	4.87	...	0.68	-0.025049	
1026	7.38	...	7.01	0.275704	
2320	1.55	...	0.76	0.202703	
2073	1.04	...	3.78	1.860963	
300	2.20	...	5.85	0.035870	
2386	2.52	...	3.52	0.589841	
634	2.91	...	3.45	0.045029	
882	10.59	...	8.46	0.059669	
1017	4.87	...	4.67	0.164882	
2121	0.59	...	0.27	0.035548	
1944	0.00	...	4.68	-0.052632	
1991	21.04	...	15.49	0.022191	
2167	1.85	...	0.00	0.032326	
732	16.26	...	16.01	0.114004	
1782	2.11	...	5.07	0.106484	
1745	10.24	...	5.36	0.002717	
1631	5.09	...	9.76	0.016968	
783	15.95	...	6.26	0.028433	

	Change Median Rent	Change Percent Transit	transit_lag	rent_lag	\
478	0.232773	0.37	-3.96250	0.200631	
754	0.046226	-9.49	-1.64375	-0.020633	
1542	0.100243	-4.19	-0.41500	0.014984	

1026	0.174188	-0.37	-1.26875	0.050194
2320	-0.020651	-0.79	0.01375	-0.126472
2073	0.343537	2.74	-1.11000	0.006058
300	0.094711	3.65	-1.90875	0.050274
2386	-0.166026	1.00	-0.27625	NaN
634	0.211170	0.54	-0.23875	0.111810
882	0.168953	-2.13	-2.30250	0.146575
1017	0.177091	-0.20	0.88375	0.124720
2121	0.340693	-0.32	0.50875	0.122791
1944	-0.081159	4.68	1.33625	NaN
1991	0.017910	-5.55	-6.36125	0.048547
2167	-0.064465	-1.85	0.62000	0.082099
732	0.113326	-0.25	-5.68375	0.099967
1782	-0.157236	2.96	-1.50500	0.260251
1745	0.421439	-4.88	-3.69000	0.285119
1631	-0.040478	4.67	-8.10250	0.097661
783	-0.004717	-9.69	-4.23000	0.070642

	housing_lag	Station10	Station12	Station16
478	-0.013754	True	False	False
754	0.054563	False	False	False
1542	0.040999	False	False	False
1026	0.032803	False	False	False
2320	1.715014	False	False	False
2073	1.840477	True	False	False
300	0.119065	False	False	False
2386	0.950059	False	False	False
634	0.064681	False	False	False
882	-0.003777	False	False	True
1017	0.079006	False	False	False
2121	0.011371	False	False	False
1944	-0.015117	True	False	False
1991	0.038236	True	False	False
2167	0.006104	False	False	False
732	0.025744	False	True	False
1782	1.349943	False	False	False
1745	0.385245	False	False	False
1631	0.289464	True	False	False
783	0.019234	False	False	False

[20 rows x 22 columns]

```
[60]: # creating a new column with default value "no rail transit"
```

```
tracts_data['Transit'] = 'No rail transit'
```

```
[61]: # change the values in this new column, based on when a station opened in the
      ↪previous three columns
```

```
for index, row in tracts_data.iterrows():
    if row.Station10 == True:
        tracts_data.at[index, 'Transit'] = 'Pre-2010'
    elif row.Station12 == True:
        tracts_data.at[index, 'Transit'] = '2012'
    elif row.Station16 == True:
        tracts_data.at[index, 'Transit'] = '2016'
```

```
[62]: # take a look at the new column
```

```
tracts_data.sample(20)
```

```
[62]:
```

	FIPS	geometry \
1926	06037571000	MULTIPOLYGON (((-13147694.143 4006563.887, -13...
527	06037204810	MULTIPOLYGON (((-13159034.483 4032437.580, -13...
2285	06037900104	MULTIPOLYGON (((-13122407.365 4104055.103, -13...
1845	06037553000	MULTIPOLYGON (((-13147740.118 4013648.347, -13...
2147	06037650003	MULTIPOLYGON (((-13174085.434 4012269.908, -13...
1476	06037481102	MULTIPOLYGON (((-13146786.667 4041929.112, -13...
2382	06037910813	MULTIPOLYGON (((-13178813.841 4094438.700, -13...
574	06037209520	MULTIPOLYGON (((-13166851.783 4035748.606, -13...
1712	06037535503	MULTIPOLYGON (((-13159884.073 4022430.952, -13...
951	06037293306	MULTIPOLYGON (((-13170160.643 3999240.990, -13...
1608	06037530301	MULTIPOLYGON (((-13153455.261 4032376.599, -13...
1811	06037550300	MULTIPOLYGON (((-13148096.897 4017684.055, -13...
2119	06037620102	MULTIPOLYGON (((-13183185.914 4018545.700, -13...
1542	06037501503	MULTIPOLYGON (((-13140380.230 4026517.422, -13...
1739	06037540502	MULTIPOLYGON (((-13159865.483 4017157.682, -13...
2060	06037601700	MULTIPOLYGON (((-13175430.619 4019842.247, -13...
131	06037119201	MULTIPOLYGON (((-13185589.413 4062026.069, -13...
1198	06037404803	MULTIPOLYGON (((-13132803.937 4038000.256, -13...
276	06037134104	MULTIPOLYGON (((-13200237.388 4057134.214, -13...
1589	06037503702	MULTIPOLYGON (((-13135070.068 4017706.054, -13...

```
Geo_NAME \
```

1926	Census Tract 5710, Lakewood city, Long Beach-L...
527	Census Tract 2048.10, Los Angeles city (part),...
2285	Census Tract 9001.04 (part), Lake Los Angeles ...
1845	Census Tract 5530, Norwalk city, Downey-Norwal...
2147	Census Tract 6500.03, Torrance city, Torrance ...
1476	Census Tract 4811.02 (part), San Gabriel city,...
2382	Census Tract 9108.13 (part), Agua Dulce CDP, S...
574	Census Tract 2095.20, Los Angeles city (part),...
1712	Census Tract 5355.03, South Gate city, South G...

951	Census Tract 2933.06, Los Angeles city (part),...
1608	Census Tract 5303.01, East Los Angeles CDP (pa...
1811	Census Tract 5503 (part), Norwalk city, Downey...
2119	Census Tract 6201.02, El Segundo city, South B...
1542	Census Tract 5015.03, Whittier city (part), Wh...
1739	Census Tract 5405.02, Lynwood city, Compton CC...
2060	Census Tract 6017 (part), Lennox CDP, Inglewoo...
131	Census Tract 1192.01, Los Angeles city (part),...
1198	Census Tract 4048.03, Baldwin Park city, East ...
276	Census Tract 1341.04, Los Angeles city (part),...
1589	Census Tract 5037.02 (part), East La Mirada CD...

		Geo_QName	Geo_STATE	Geo_COUNTY	\
1926	Census Tract 5710, Lakewood city, Long Beach-L...		06	037	
527	Census Tract 2048.10, Los Angeles city (part),...		06	037	
2285	Census Tract 9001.04 (part), Lake Los Angeles ...		06	037	
1845	Census Tract 5530, Norwalk city, Downey-Norwal...		06	037	
2147	Census Tract 6500.03, Torrance city, Torrance ...		06	037	
1476	Census Tract 4811.02 (part), San Gabriel city,...		06	037	
2382	Census Tract 9108.13 (part), Agua Dulce CDP, S...		06	037	
574	Census Tract 2095.20, Los Angeles city (part),...		06	037	
1712	Census Tract 5355.03, South Gate city, South G...		06	037	
951	Census Tract 2933.06, Los Angeles city (part),...		06	037	
1608	Census Tract 5303.01, East Los Angeles CDP (pa...		06	037	
1811	Census Tract 5503 (part), Norwalk city, Downey...		06	037	
2119	Census Tract 6201.02, El Segundo city, South B...		06	037	
1542	Census Tract 5015.03, Whittier city (part), Wh...		06	037	
1739	Census Tract 5405.02, Lynwood city, Compton CC...		06	037	
2060	Census Tract 6017 (part), Lennox CDP, Inglewoo...		06	037	
131	Census Tract 1192.01, Los Angeles city (part),...		06	037	
1198	Census Tract 4048.03, Baldwin Park city, East ...		06	037	
276	Census Tract 1341.04, Los Angeles city (part),...		06	037	
1589	Census Tract 5037.02 (part), East La Mirada CD...		06	037	

	Geo_TRACT	2010 Housing Units	2010 Median Gross Rent	\
1926	571000	1918	2022.0	
527	204810	1143	1033.0	
2285	900104	1840	1379.0	
1845	553000	1291	1674.0	
2147	650003	1295	1205.0	
1476	481102	1493	1494.0	
2382	910813	1066	NaN	
574	209520	1015	900.0	
1712	535503	624	976.0	
951	293306	830	1034.0	
1608	530301	655	1041.0	
1811	550300	2152	1418.0	

2119	620102	1838	1670.0
1542	501503	2036	1237.0
1739	540502	1582	1041.0
2060	601700	1164	1120.0
131	119201	886	1912.0
1198	404803	485	1173.0
276	134104	1353	1347.0
1589	503702	1734	1472.0

	2010 Percent Transit	...	Change Housing Units	Change Median Rent	\
1926	1.16	...	0.030761	0.074184	
527	12.36	...	0.122485	0.102614	
2285	1.23	...	0.009783	-0.251632	
1845	3.19	...	-0.022463	0.050179	
2147	2.74	...	-0.006950	0.103734	
1476	3.73	...	0.036839	0.038822	
2382	1.54	...	0.276735	NaN	
574	42.10	...	0.014778	0.074444	
1712	13.51	...	0.008013	0.080943	
951	3.42	...	-0.019277	0.314313	
1608	14.23	...	-0.013740	0.089337	
1811	1.81	...	-0.014870	0.155853	
2119	2.53	...	-0.098477	0.061078	
1542	4.87	...	-0.025049	0.100243	
1739	4.25	...	-0.020860	0.066282	
2060	13.96	...	0.193299	0.056250	
131	10.06	...	0.024831	0.088912	
1198	2.19	...	-0.061856	0.120205	
276	4.17	...	0.070953	0.056422	
1589	3.77	...	0.021338	0.122283	

	Change Percent Transit	transit_lag	rent_lag	housing_lag	Station10	\
1926	0.77	0.09750	0.098532	0.337711	False	
527	2.66	-2.52875	0.069325	0.045680	True	
2285	0.01	-0.41875	NaN	2.522825	False	
1845	-2.60	-0.61625	0.097787	0.007217	False	
2147	1.22	-0.48750	-0.003592	-0.010368	False	
1476	-0.33	-1.87000	-0.027692	3.027571	False	
2382	-1.54	-0.46000	NaN	3.313477	False	
574	1.59	-7.94125	0.100374	0.061150	True	
1712	-0.66	-2.27750	0.017743	-0.010989	False	
951	1.63	-1.37000	0.016203	0.082405	False	
1608	-11.45	-5.32875	0.067010	0.290564	True	
1811	2.89	0.44625	0.017300	-0.013489	True	
2119	-0.76	0.10875	0.142624	-0.006548	False	
1542	-4.19	-0.41500	0.014984	0.040999	False	
1739	2.63	-0.07250	0.064707	0.017411	True	

2060	-11.29	-8.37875	0.065927	0.962384	True
131	-4.67	-0.30250	-0.007227	0.093205	False
1198	6.24	-1.39000	NaN	2.671008	False
276	-0.16	-0.80250	0.058521	0.041107	False
1589	-2.83	-0.33750	NaN	0.365625	False

	Station12	Station16	Transit
1926	False	False	No rail transit
527	False	False	Pre-2010
2285	False	False	No rail transit
1845	False	False	No rail transit
2147	False	False	No rail transit
1476	False	False	No rail transit
2382	False	False	No rail transit
574	False	False	Pre-2010
1712	False	False	No rail transit
951	False	False	No rail transit
1608	False	False	Pre-2010
1811	False	False	Pre-2010
2119	False	False	No rail transit
1542	False	False	No rail transit
1739	False	False	Pre-2010
2060	False	False	Pre-2010
131	False	False	No rail transit
1198	False	False	No rail transit
276	False	False	No rail transit
1589	False	False	No rail transit

[20 rows x 23 columns]

```
[63]: # subset data for only the rows that DO NOT have 'no rail transit' to get all
      ↪ census tracts that are within station buffers
```

```
transit_tracts = tracts_data[tracts_data['Transit'] != 'No rail transit']
```

```
[64]: # look at a sample
```

```
transit_tracts.sample(3)
```

```
[64]:
```

	FIPS	geometry \	Geo_NAME \
1463	06037480600	MULTIPOLYGON (((-13155312.961 4043911.461, -13...	Census Tract 4806, South Pasadena city, Pasade...
2200	06037700101	MULTIPOLYGON (((-13175941.130 4041139.227, -13...	Census Tract 7001.01, West Hollywood city, Los...
1752	06037541400	MULTIPOLYGON (((-13161983.225 4016226.663, -13...	

1752 Census Tract 5414, Willowbrook CDP, Compton CC...

		Geo_QName	Geo_STATE	Geo_COUNTY	\
1463	Census Tract 4806, South Pasadena city, Pasade...		06	037	
2200	Census Tract 7001.01, West Hollywood city, Los...		06	037	
1752	Census Tract 5414, Willowbrook CDP, Compton CC...		06	037	

	Geo_TRACT	2010 Housing Units	2010 Median Gross Rent	\
1463	480600	3586	1494.0	
2200	700101	3420	1202.0	
1752	541400	1616	1103.0	

	2010 Percent Transit	...	Change Housing Units	Change Median Rent	\
1463	3.07	...	0.008087	0.113788	
2200	6.79	...	0.117544	0.194676	
1752	4.95	...	0.063119	0.216682	

	Change Percent Transit	transit_lag	rent_lag	housing_lag	Station10	\
1463	3.68	0.20500	0.083568	0.009434	True	
2200	0.41	-0.60500	0.153153	0.052160	True	
1752	-3.66	-0.83375	0.103424	0.033990	True	

	Station12	Station16	Transit
1463	False	False	Pre-2010
2200	False	False	Pre-2010
1752	False	False	Pre-2010

[3 rows x 23 columns]

Now we can make a map with only those tracts that intersect with a station buffer!

```
[65]: # initialize a new map centered on LA
m_transit_tracts = folium.Map(location=[34, -118.3],
                               zoom_start = 10,
                               tiles='CartoDB positron',
                               attribution='CartoDB')

# plot choropleth map of change in transit use JUST for the tracts that
# intersect the buffer of Mariachi Plaza
folium.Choropleth(
    geo_data=transit_tracts,          # geo data
    data=transit_tracts,              # data
    key_on='feature.properties.FIPS', # key, or merge
    columns=['FIPS', 'Change Percent Transit'], # [key, value]
```

```

        fill_color='RdYlBu',                                # using a
    ↪diverging scale from colorbrewer2.org
        line_weight=0.1,
        fill_opacity=0.6,
        line_opacity=0.2,                                   # line opacity
    ↪(of the border)
        legend_name='Change in Transit Use',
        threshold_scale=[-67, -10, -1, 1, 10, 41], # change
    ↪thresholds
        nan_fill_color = 'lightgray').add_to(m_transit_tracts)

# add buffers to map
folium.GeoJson(data=station.buffers).add_to(m_transit_tracts)

# show map
m_transit_tracts

```

[65]: <folium.folium.Map at 0x7fa463ae7a30>

7 Next steps

Now that we have the column that divides every census tract by whether it is close to transit and when that transit opened, we can do additional analysis about how these different groups of tracts compare.

As a first step, let's take the the scatterplot we made at the beginning and colorcode it by proximity to transit

```

[66]: # import plotly express
import plotly.express as px

#create the plot
fig = px.scatter(tracts_data,
                 x = 'Change Median Rent',
                 y = 'Change Percent Transit',
                 color= "Transit",
                 title = 'Change in Median Rent vs Workers Using Transit,
    ↪Colored by Opening of Rail Station')

#show the plot
fig.show()

```

We definitely have more work to do since this chart is so crowded, but we need something for next week to finish up!

8 Distribution of Labor

This week Ryan accidentally did the autocorrelation assignment over Thanksgiving just out of curiosity. Since we couldn't do a point analysis, we decided to go ahead with buffers this week. We met to work through it together but kept running into errors. There were three challenges: figuring out how to plot the buffers, figuring out how to find which census tracts intersect the buffers, and figuring out the for loop to find all intersecting tracts for each station. Ryan figured out these challenges, so we met again to go over the code, and Fernando added some edits.

At this point we feel we are in pretty good shape for the final. We are missing charts and graphs to help us better analyze the data. That will be one of our focus for this forthcoming week.