Assignment 4

August 13, 2020

---

*You are currently looking at **version 1.1** of this notebook. To download notebooks and datafiles, as well as get help on Jupyter notebooks in the Coursera platform, visit the Jupyter Notebook FAQ course resource.*

```
In [1]: import pandas as pd
        import numpy as np
        import re
        from scipy.stats import ttest_ind
```

1 Assignment 4 - Hypothesis Testing

This assignment requires more individual learning than previous assignments - you are encouraged to check out the pandas documentation to find functions or methods you might not have used yet, or ask questions on Stack Overflow and tag them as pandas and python related. And of course, the discussion forums are open for interaction with your peers and the course staff.

Definitions: * A *quarter* is a specific three month period, Q1 is January through March, Q2 is April through June, Q3 is July through September, Q4 is October through December. * A *recession* is defined as starting with two consecutive quarters of GDP decline, and ending with two consecutive quarters of GDP growth. * A *recession bottom* is the quarter within a recession which had the lowest GDP. * A *university town* is a city which has a high percentage of university students compared to the total population of the city.

Hypothesis: University towns have their mean housing prices less effected by recessions. Run a t-test to compare the ratio of the mean price of houses in university towns the quarter before the recession starts compared to the recession bottom. (`price_ratio=quarter_before_recession/recession_bottom`)

The following data files are available for this assignment: * From the Zillow research data site there is housing data for the United States. In particular the datafile for all homes at a city level, `City_Zhvi_AllHomes.csv`, has median home sale prices at a fine grained level. * From the Wikipedia page on college towns is a list of university towns in the United States which has been copy and pasted into the file `university_towns.txt`. * From Bureau of Economic Analysis, US Department of Commerce, the GDP over time of the United States in current dollars (use the chained value in 2009 dollars), in quarterly intervals, in the file `gdplev.xls`. For this assignment, only look at GDP data from the first quarter of 2000 onward.

Each function in this assignment below is worth 10%, with the exception of `run_ttest()`, which is worth 50%.

```
In [2]: # Use this dictionary to map state names to two letter acronyms
        states = {'OH': 'Ohio', 'KY': 'Kentucky', 'AS': 'American Samoa', 'NV': 'Nevada', 'WY':

In [3]: def get_list_of_university_towns():
            ut = pd.read_csv('university_towns.txt', sep='\n', header = None, names = ['Location
            ut['RegionName'] = ut['Locations'].apply(lambda x: x.split('(')[0].strip() if x.coun
            ut['State'] = ut['Locations'].apply(lambda x: x.split('[')[0].strip() if x.count('[e
            ut = ut.dropna().drop('Locations', axis=1).reindex(columns=['State', 'RegionName']).
            return ut
        get_list_of_university_towns()

        #More pandorable solutions:

        #1) ut = ut['Locations'].str.extractall('(.+)\[|(.+)\(').apply(lambda x: x.ffill() if x.
        #.reset_index(drop=True).rename(columns={1:'Model',0:'Maker'})

        # 2) ut['Locations'].apply(lambda line: [line.split('[')[0],None] if line.count('[') els
        #.apply(pd.Series).rename(columns={0:'State',1:'RegionName'}).apply(lambda col: col.ffil
        #.dropna(subset=['RegionName']).reset_index(drop=True)
```

Out[3]:

	State	RegionName
0	Alabama	Auburn
1	Alabama	Florence
2	Alabama	Jacksonville
3	Alabama	Livingston
4	Alabama	Montevallo
5	Alabama	Troy
6	Alabama	Tuscaloosa
7	Alabama	Tuskegee
8	Alaska	Fairbanks
9	Arizona	Flagstaff
10	Arizona	Tempe
11	Arizona	Tucson
12	Arkansas	Arkadelphia
13	Arkansas	Conway
14	Arkansas	Fayetteville
15	Arkansas	Jonesboro
16	Arkansas	Magnolia
17	Arkansas	Monticello
18	Arkansas	Russellville
19	Arkansas	Searcy
20	California	Angwin
21	California	Arcata
22	California	Berkeley
23	California	Chico
24	California	Claremont
25	California	Cotati

```
26        California                               Davis
27        California                              Irvine
28        California                           Isla Vista
29        California    University Park, Los Angeles
..             ...                                   ...
487         Virginia                                Wise
488         Virginia                          Chesapeake
489       Washington                          Bellingham
490       Washington                              Cheney
491       Washington                          Ellensburg
492       Washington                             Pullman
493       Washington  University District, Seattle
494    West Virginia                              Athens
495    West Virginia                          Buckhannon
496    West Virginia                            Fairmont
497    West Virginia                           Glenville
498    West Virginia                          Huntington
499    West Virginia                          Montgomery
500    West Virginia                          Morgantown
501    West Virginia                        Shepherdstown
502    West Virginia                         West Liberty
503         Wisconsin                            Appleton
504         Wisconsin                          Eau Claire
505         Wisconsin                           Green Bay
506         Wisconsin                           La Crosse
507         Wisconsin                             Madison
508         Wisconsin                            Menomonie
509         Wisconsin                           Milwaukee
510         Wisconsin                             Oshkosh
511         Wisconsin                          Platteville
512         Wisconsin                          River Falls
513         Wisconsin                        Stevens Point
514         Wisconsin                            Waukesha
515         Wisconsin                          Whitewater
516           Wyoming                              Laramie

[517 rows x 2 columns]
```

```python
In [4]: def get_recession_start():
            gdplev = pd.read_excel('gdplev.xls', header = None, usecols = [4,6], skiprows = [i f
            i = 0
            for line in gdplev['Quarters']:
                if gdplev['GDP in billions of chained 2009 dollars'][i] > gdplev['GDP in billion
                    starttime = gdplev['Quarters'][i+1]
                else: i = i+1
            return starttime
        get_recession_start()

Out[4]: '2008q3'
```

```
In [5]: def get_recession_end():
            gdplev = pd.read_excel('gdplev.xls', header = None, usecols = [4,6], skiprows = [i f
            i = 34
            for line in gdplev['Quarters']:
                if gdplev['GDP in billions of chained 2009 dollars'][i] < gdplev['GDP in billion
                    endtime = gdplev['Quarters'][i+2]
                else: i = i+1
            return endtime
        get_recession_end()

Out[5]: '2009q4'

In [6]: def get_recession_bottom():
            gdplev = pd.read_excel('gdplev.xls', header = None, usecols = [4,6], skiprows = [i f
            gdplev = gdplev.reset_index(drop = True).set_index('Quarters')
            bottom = gdplev.loc[get_recession_start():get_recession_end()].loc[:,'GDP in billion
            bottom = gdplev[gdplev['GDP in billions of chained 2009 dollars']==bottom].index.val
            return bottom
        get_recession_bottom()

Out[6]: '2009q2'

In [7]: def convert_housing_data_to_quarters():
            ZHVI = pd.read_csv('City_Zhvi_AllHomes.csv', header = 0, index_col = [2,1])
            ZHVI = ZHVI.drop(ZHVI.iloc[:,0:49], axis =1)
            ZHVI.columns = pd.to_datetime(ZHVI.columns)
            ZHVI = ZHVI.resample('Q', axis = 1).mean()
            ZHVI = ZHVI.rename(columns=lambda x: str(x.to_period('Q')).lower())
            ZHVI = ZHVI.reset_index().replace(states).set_index(['State', 'RegionName'])
            return ZHVI
        convert_housing_data_to_quarters()

            #housing = housing.resample('Q',axis=1).mean()
            #housing = housing.rename(columns=lambda x: str(x.to_period('Q')).lower())
```

```
Out[7]:                                          2000q1        2000q2  \
        State             RegionName
        New York          New York              NaN           NaN
        California        Los Angeles    2.070667e+05  2.144667e+05
        Illinois          Chicago        1.384000e+05  1.436333e+05
        Pennsylvania      Philadelphia   5.300000e+04  5.363333e+04
        Arizona           Phoenix        1.118333e+05  1.143667e+05
        Nevada            Las Vegas      1.326000e+05  1.343667e+05
        California        San Diego      2.229000e+05  2.343667e+05
        Texas             Dallas         8.446667e+04  8.386667e+04
        California        San Jose       3.742667e+05  4.065667e+05
        Florida           Jacksonville   8.860000e+04  8.970000e+04
        California        San Francisco  4.305000e+05  4.644667e+05
        Texas             Austin         1.429667e+05  1.452667e+05
```

4

Michigan	Detroit	6.616667e+04	6.830000e+04
Ohio	Columbus	9.436667e+04	9.583333e+04
Tennessee	Memphis	7.250000e+04	7.320000e+04
North Carolina	Charlotte	1.269333e+05	1.283667e+05
Texas	El Paso	7.626667e+04	7.686667e+04
Massachusetts	Boston	2.069333e+05	2.191667e+05
Washington	Seattle	2.486000e+05	2.556000e+05
Maryland	Baltimore	5.966667e+04	5.950000e+04
Colorado	Denver	1.622333e+05	1.678333e+05
District of Columbia	Washington	1.377667e+05	1.442000e+05
Tennessee	Nashville	1.138333e+05	1.152667e+05
Wisconsin	Milwaukee	7.803333e+04	7.906667e+04
Arizona	Tucson	1.018333e+05	1.029667e+05
Oregon	Portland	1.528000e+05	1.547667e+05
Oklahoma	Oklahoma City	7.643333e+04	7.750000e+04
Nebraska	Omaha	1.128000e+05	1.141000e+05
New Mexico	Albuquerque	1.258667e+05	1.267000e+05
California	Fresno	9.410000e+04	9.526667e+04
...		...	...
Texas	Granite Shoals	NaN	NaN
Maryland	Piney Point	1.556667e+05	1.551667e+05
Wisconsin	Maribel	NaN	NaN
Idaho	Middleton	1.060667e+05	1.043333e+05
Colorado	Bennett	1.329000e+05	1.358333e+05
New Hampshire	East Hampstead	1.618333e+05	1.691000e+05
Missouri	Garden City	NaN	NaN
Arkansas	Mountainburg	5.716667e+04	6.433333e+04
Wisconsin	Oostburg	1.072667e+05	1.081000e+05
California	Twin Peaks	9.736667e+04	1.001667e+05
New York	Upper Brookville	1.230967e+06	1.230967e+06
Hawaii	Volcano	9.870000e+04	1.053667e+05
South Carolina	Wedgefield	NaN	NaN
Michigan	Williamston	1.591667e+05	1.613000e+05
Arkansas	Decatur	6.360000e+04	6.440000e+04
Tennessee	Briceville	4.000000e+04	4.173333e+04
Indiana	Edgewood	9.170000e+04	9.186667e+04
Tennessee	Palmyra	NaN	NaN
Maryland	Saint Inigoes	1.480667e+05	1.476000e+05
Indiana	Marysville	NaN	NaN
California	Forest Falls	1.135333e+05	1.144000e+05
Missouri	Bois D Arc	1.078000e+05	1.069667e+05
Virginia	Henrico	1.285667e+05	1.307667e+05
New Jersey	Diamond Beach	1.739667e+05	1.831000e+05
Tennessee	Gruetli Laager	3.540000e+04	3.546667e+04
Wisconsin	Town of Wrightstown	1.017667e+05	1.054000e+05
New York	Urbana	7.920000e+04	8.166667e+04
Wisconsin	New Denmark	1.145667e+05	1.192667e+05
California	Angels	1.510000e+05	1.559000e+05

State	RegionName		
Wisconsin	Holland	1.510333e+05	1.505000e+05

		2000q3	2000q4 \
State	RegionName		
New York	New York	NaN	NaN
California	Los Angeles	2.209667e+05	2.261667e+05
Illinois	Chicago	1.478667e+05	1.521333e+05
Pennsylvania	Philadelphia	5.413333e+04	5.470000e+04
Arizona	Phoenix	1.160000e+05	1.174000e+05
Nevada	Las Vegas	1.354000e+05	1.370000e+05
California	San Diego	2.454333e+05	2.560333e+05
Texas	Dallas	8.486667e+04	8.783333e+04
California	San Jose	4.318667e+05	4.555000e+05
Florida	Jacksonville	9.170000e+04	9.310000e+04
California	San Francisco	4.835333e+05	4.930000e+05
Texas	Austin	1.494667e+05	1.557333e+05
Michigan	Detroit	6.676667e+04	6.703333e+04
Ohio	Columbus	9.713333e+04	9.826667e+04
Tennessee	Memphis	7.386667e+04	7.400000e+04
North Carolina	Charlotte	1.302000e+05	1.315667e+05
Texas	El Paso	7.673333e+04	7.730000e+04
Massachusetts	Boston	2.331000e+05	2.425000e+05
Washington	Seattle	2.625333e+05	2.674000e+05
Maryland	Baltimore	5.883333e+04	5.950000e+04
Colorado	Denver	1.743333e+05	1.803333e+05
District of Columbia	Washington	1.487000e+05	1.477000e+05
Tennessee	Nashville	1.158667e+05	1.169333e+05
Wisconsin	Milwaukee	8.103333e+04	8.233333e+04
Arizona	Tucson	1.044667e+05	1.056667e+05
Oregon	Portland	1.565667e+05	1.574667e+05
Oklahoma	Oklahoma City	7.856667e+04	7.916667e+04
Nebraska	Omaha	1.167333e+05	1.189000e+05
New Mexico	Albuquerque	1.264333e+05	1.267333e+05
California	Fresno	9.646667e+04	9.823333e+04
...		...	...
Texas	Granite Shoals	NaN	NaN
Maryland	Piney Point	1.584667e+05	1.637000e+05
Wisconsin	Maribel	NaN	NaN
Idaho	Middleton	1.019000e+05	1.041667e+05
Colorado	Bennett	1.398000e+05	1.446667e+05
New Hampshire	East Hampstead	1.739667e+05	1.805000e+05
Missouri	Garden City	NaN	NaN
Arkansas	Mountainburg	6.783333e+04	6.900000e+04
Wisconsin	Oostburg	1.124333e+05	1.155000e+05
California	Twin Peaks	1.013333e+05	1.017000e+05
New York	Upper Brookville	1.237700e+06	1.261567e+06
Hawaii	Volcano	1.146667e+05	1.247667e+05
South Carolina	Wedgefield	NaN	NaN

State	RegionName		
Michigan	Williamston	1.643000e+05	1.662000e+05
Arkansas	Decatur	6.566667e+04	6.673333e+04
Tennessee	Briceville	4.366667e+04	4.490000e+04
Indiana	Edgewood	9.293333e+04	9.490000e+04
Tennessee	Palmyra	NaN	NaN
Maryland	Saint Inigoes	1.572333e+05	1.633667e+05
Indiana	Marysville	NaN	NaN
California	Forest Falls	1.141667e+05	1.111333e+05
Missouri	Bois D Arc	1.071000e+05	1.081000e+05
Virginia	Henrico	1.322667e+05	1.332667e+05
New Jersey	Diamond Beach	1.889667e+05	1.931333e+05
Tennessee	Gruetli Laager	3.666667e+04	3.730000e+04
Wisconsin	Town of Wrightstown	1.113667e+05	1.148667e+05
New York	Urbana	9.170000e+04	9.836667e+04
Wisconsin	New Denmark	1.260667e+05	1.319667e+05
California	Angels	1.581000e+05	1.674667e+05
Wisconsin	Holland	1.532333e+05	1.558333e+05

		2001q1	2001q2 \
State	RegionName		
New York	New York	NaN	NaN
California	Los Angeles	2.330000e+05	2.391000e+05
Illinois	Chicago	1.569333e+05	1.618000e+05
Pennsylvania	Philadelphia	5.533333e+04	5.553333e+04
Arizona	Phoenix	1.196000e+05	1.215667e+05
Nevada	Las Vegas	1.395333e+05	1.417333e+05
California	San Diego	2.672000e+05	2.762667e+05
Texas	Dallas	8.973333e+04	8.930000e+04
California	San Jose	4.706667e+05	4.702000e+05
Florida	Jacksonville	9.440000e+04	9.560000e+04
California	San Francisco	4.940667e+05	4.961333e+05
Texas	Austin	1.612333e+05	1.607333e+05
Michigan	Detroit	6.750000e+04	6.836667e+04
Ohio	Columbus	9.940000e+04	1.002667e+05
Tennessee	Memphis	7.416667e+04	7.493333e+04
North Carolina	Charlotte	1.329333e+05	1.332000e+05
Texas	El Paso	7.823333e+04	7.830000e+04
Massachusetts	Boston	2.496000e+05	2.570667e+05
Washington	Seattle	2.710000e+05	2.724333e+05
Maryland	Baltimore	5.956667e+04	6.013333e+04
Colorado	Denver	1.865000e+05	1.925333e+05
District of Columbia	Washington	1.497667e+05	1.551333e+05
Tennessee	Nashville	1.180333e+05	1.191667e+05
Wisconsin	Milwaukee	8.403333e+04	8.556667e+04
Arizona	Tucson	1.072000e+05	1.087667e+05
Oregon	Portland	1.599000e+05	1.618000e+05
Oklahoma	Oklahoma City	7.983333e+04	8.040000e+04
Nebraska	Omaha	1.208667e+05	1.197667e+05

State	RegionName		
New Mexico	Albuquerque	1.271000e+05	1.277333e+05
California	Fresno	1.005667e+05	1.035667e+05
...		...	...
Texas	Granite Shoals	NaN	NaN
Maryland	Piney Point	1.634000e+05	1.648333e+05
Wisconsin	Maribel	NaN	NaN
Idaho	Middleton	1.061667e+05	1.083667e+05
Colorado	Bennett	1.483000e+05	1.521000e+05
New Hampshire	East Hampstead	1.909000e+05	1.950667e+05
Missouri	Garden City	NaN	NaN
Arkansas	Mountainburg	6.866667e+04	6.386667e+04
Wisconsin	Oostburg	1.191000e+05	1.204333e+05
California	Twin Peaks	1.040000e+05	1.076667e+05
New York	Upper Brookville	1.295167e+06	1.340033e+06
Hawaii	Volcano	1.181333e+05	1.194000e+05
South Carolina	Wedgefield	NaN	NaN
Michigan	Williamston	1.664333e+05	1.686333e+05
Arkansas	Decatur	6.720000e+04	6.770000e+04
Tennessee	Briceville	4.480000e+04	4.530000e+04
Indiana	Edgewood	9.893333e+04	1.000667e+05
Tennessee	Palmyra	NaN	NaN
Maryland	Saint Inigoes	1.642333e+05	1.682000e+05
Indiana	Marysville	NaN	NaN
California	Forest Falls	1.134333e+05	1.130000e+05
Missouri	Bois D Arc	1.107000e+05	1.136667e+05
Virginia	Henrico	1.352333e+05	1.367333e+05
New Jersey	Diamond Beach	1.944000e+05	2.102667e+05
Tennessee	Gruetli Laager	3.773333e+04	3.790000e+04
Wisconsin	Town of Wrightstown	1.259667e+05	1.299000e+05
New York	Urbana	9.486667e+04	9.853333e+04
Wisconsin	New Denmark	1.438000e+05	1.469667e+05
California	Angels	1.768333e+05	1.837667e+05
Wisconsin	Holland	1.618667e+05	1.657333e+05

State	RegionName	2001q3	2001q4 \
New York	New York	NaN	NaN
California	Los Angeles	2.450667e+05	2.530333e+05
Illinois	Chicago	1.664000e+05	1.704333e+05
Pennsylvania	Philadelphia	5.626667e+04	5.753333e+04
Arizona	Phoenix	1.227000e+05	1.243000e+05
Nevada	Las Vegas	1.433667e+05	1.461333e+05
California	San Diego	2.845000e+05	2.919333e+05
Texas	Dallas	8.906667e+04	9.090000e+04
California	San Jose	4.568000e+05	4.455667e+05
Florida	Jacksonville	9.706667e+04	9.906667e+04
California	San Francisco	5.041000e+05	5.134000e+05
Texas	Austin	1.595333e+05	1.600333e+05

Michigan	Detroit	6.926667e+04	6.996667e+04
Ohio	Columbus	1.010667e+05	1.022000e+05
Tennessee	Memphis	7.550000e+04	7.606667e+04
North Carolina	Charlotte	1.328000e+05	1.331000e+05
Texas	El Paso	7.743333e+04	7.680000e+04
Massachusetts	Boston	2.669333e+05	2.749667e+05
Washington	Seattle	2.741667e+05	2.781667e+05
Maryland	Baltimore	6.210000e+04	6.340000e+04
Colorado	Denver	1.964000e+05	1.991000e+05
District of Columbia	Washington	1.646333e+05	1.725333e+05
Tennessee	Nashville	1.201000e+05	1.208000e+05
Wisconsin	Milwaukee	8.706667e+04	8.840000e+04
Arizona	Tucson	1.105667e+05	1.128000e+05
Oregon	Portland	1.642667e+05	1.677667e+05
Oklahoma	Oklahoma City	8.113333e+04	8.173333e+04
Nebraska	Omaha	1.178667e+05	1.174000e+05
New Mexico	Albuquerque	1.285667e+05	1.299000e+05
California	Fresno	1.072333e+05	1.103000e+05
...		...	...
Texas	Granite Shoals	NaN	NaN
Maryland	Piney Point	1.647000e+05	1.679000e+05
Wisconsin	Maribel	NaN	NaN
Idaho	Middleton	1.110333e+05	1.112333e+05
Colorado	Bennett	1.542333e+05	1.562000e+05
New Hampshire	East Hampstead	1.992667e+05	2.074000e+05
Missouri	Garden City	NaN	NaN
Arkansas	Mountainburg	6.376667e+04	6.546667e+04
Wisconsin	Oostburg	1.203667e+05	1.196333e+05
California	Twin Peaks	1.098333e+05	1.111333e+05
New York	Upper Brookville	1.403667e+06	1.481933e+06
Hawaii	Volcano	1.232667e+05	1.211667e+05
South Carolina	Wedgefield	NaN	NaN
Michigan	Williamston	1.716667e+05	1.750333e+05
Arkansas	Decatur	6.650000e+04	6.540000e+04
Tennessee	Briceville	4.463333e+04	4.370000e+04
Indiana	Edgewood	1.008333e+05	1.010000e+05
Tennessee	Palmyra	NaN	NaN
Maryland	Saint Inigoes	1.665000e+05	1.653333e+05
Indiana	Marysville	NaN	NaN
California	Forest Falls	1.130333e+05	1.151667e+05
Missouri	Bois D Arc	1.126333e+05	1.127333e+05
Virginia	Henrico	1.386000e+05	1.413333e+05
New Jersey	Diamond Beach	2.302667e+05	2.486667e+05
Tennessee	Gruetli Laager	3.936667e+04	4.040000e+04
Wisconsin	Town of Wrightstown	1.299000e+05	1.294333e+05
New York	Urbana	1.029667e+05	9.803333e+04
Wisconsin	New Denmark	1.483667e+05	1.491667e+05
California	Angels	1.902333e+05	1.845667e+05

		2002q1	2002q2	\
Wisconsin	Holland	1.680333e+05	1.674000e+05	

		2002q1	2002q2	\
State	RegionName			
New York	New York	NaN	NaN	
California	Los Angeles	2.619667e+05	2.727000e+05	
Illinois	Chicago	1.755000e+05	1.775667e+05	
Pennsylvania	Philadelphia	5.913333e+04	6.073333e+04	
Arizona	Phoenix	1.265333e+05	1.283667e+05	
Nevada	Las Vegas	1.493333e+05	1.509333e+05	
California	San Diego	3.012333e+05	3.128667e+05	
Texas	Dallas	9.256667e+04	9.380000e+04	
California	San Jose	4.414333e+05	4.577667e+05	
Florida	Jacksonville	1.012333e+05	1.034333e+05	
California	San Francisco	5.204333e+05	5.381667e+05	
Texas	Austin	1.589667e+05	1.575000e+05	
Michigan	Detroit	7.100000e+04	7.233333e+04	
Ohio	Columbus	1.034000e+05	1.048000e+05	
Tennessee	Memphis	7.633333e+04	7.676667e+04	
North Carolina	Charlotte	1.343667e+05	1.353667e+05	
Texas	El Paso	7.660000e+04	7.640000e+04	
Massachusetts	Boston	2.825000e+05	2.893000e+05	
Washington	Seattle	2.805000e+05	2.846000e+05	
Maryland	Baltimore	6.366667e+04	6.490000e+04	
Colorado	Denver	2.012333e+05	2.024333e+05	
District of Columbia	Washington	1.805000e+05	1.933000e+05	
Tennessee	Nashville	1.215667e+05	1.226333e+05	
Wisconsin	Milwaukee	8.953333e+04	9.136667e+04	
Arizona	Tucson	1.150000e+05	1.172000e+05	
Oregon	Portland	1.707667e+05	1.741333e+05	
Oklahoma	Oklahoma City	8.260000e+04	8.343333e+04	
Nebraska	Omaha	1.180667e+05	1.176333e+05	
New Mexico	Albuquerque	1.310667e+05	1.321000e+05	
California	Fresno	1.140333e+05	1.185333e+05	
...		...	...	
Texas	Granite Shoals	NaN	NaN	
Maryland	Piney Point	1.782667e+05	1.812000e+05	
Wisconsin	Maribel	NaN	NaN	
Idaho	Middleton	1.141000e+05	1.141667e+05	
Colorado	Bennett	1.587333e+05	1.606333e+05	
New Hampshire	East Hampstead	2.123000e+05	2.122333e+05	
Missouri	Garden City	NaN	NaN	
Arkansas	Mountainburg	6.533333e+04	6.600000e+04	
Wisconsin	Oostburg	1.198667e+05	1.185667e+05	
California	Twin Peaks	1.132000e+05	1.166000e+05	
New York	Upper Brookville	1.536167e+06	1.562033e+06	
Hawaii	Volcano	1.233000e+05	1.169000e+05	
South Carolina	Wedgefield	NaN	NaN	

State	RegionName		
Michigan	Williamston	1.786667e+05	1.793333e+05
Arkansas	Decatur	6.460000e+04	6.490000e+04
Tennessee	Briceville	4.446667e+04	4.340000e+04
Indiana	Edgewood	1.021667e+05	1.017667e+05
Tennessee	Palmyra	NaN	NaN
Maryland	Saint Inigoes	1.673000e+05	1.688000e+05
Indiana	Marysville	NaN	NaN
California	Forest Falls	1.187000e+05	1.250667e+05
Missouri	Bois D Arc	1.130667e+05	1.154000e+05
Virginia	Henrico	1.435333e+05	1.461333e+05
New Jersey	Diamond Beach	2.599333e+05	2.656333e+05
Tennessee	Gruetli Laager	4.156667e+04	4.163333e+04
Wisconsin	Town of Wrightstown	1.319000e+05	1.342000e+05
New York	Urbana	9.396667e+04	9.460000e+04
Wisconsin	New Denmark	1.531333e+05	1.567333e+05
California	Angels	1.840333e+05	1.861333e+05
Wisconsin	Holland	1.657667e+05	1.619667e+05

		...	2014q2 \
State	RegionName	...	
New York	New York	...	5.154667e+05
California	Los Angeles	...	4.980333e+05
Illinois	Chicago	...	1.926333e+05
Pennsylvania	Philadelphia	...	1.137333e+05
Arizona	Phoenix	...	1.642667e+05
Nevada	Las Vegas	...	1.700667e+05
California	San Diego	...	4.802000e+05
Texas	Dallas	...	1.066333e+05
California	San Jose	...	6.794000e+05
Florida	Jacksonville	...	1.207667e+05
California	San Francisco	...	9.269333e+05
Texas	Austin	...	2.488667e+05
Michigan	Detroit	...	3.730000e+04
Ohio	Columbus	...	1.031333e+05
Tennessee	Memphis	...	6.810000e+04
North Carolina	Charlotte	...	1.494667e+05
Texas	El Paso	...	1.118000e+05
Massachusetts	Boston	...	4.266667e+05
Washington	Seattle	...	4.418000e+05
Maryland	Baltimore	...	1.092333e+05
Colorado	Denver	...	2.708667e+05
District of Columbia	Washington	...	4.469333e+05
Tennessee	Nashville	...	1.607000e+05
Wisconsin	Milwaukee	...	9.216667e+04
Arizona	Tucson	...	1.424667e+05
Oregon	Portland	...	2.822333e+05
Oklahoma	Oklahoma City	...	1.180333e+05
Nebraska	Omaha	...	1.301000e+05

State	RegionName		
New Mexico	Albuquerque	...	1.632667e+05
California	Fresno	...	1.696333e+05
...		...	...
Texas	Granite Shoals	...	1.169667e+05
Maryland	Piney Point	...	2.964000e+05
Wisconsin	Maribel	...	1.306000e+05
Idaho	Middleton	...	1.443667e+05
Colorado	Bennett	...	1.514667e+05
New Hampshire	East Hampstead	...	2.495000e+05
Missouri	Garden City	...	1.055000e+05
Arkansas	Mountainburg	...	8.160000e+04
Wisconsin	Oostburg	...	1.295667e+05
California	Twin Peaks	...	1.501000e+05
New York	Upper Brookville	...	1.780633e+06
Hawaii	Volcano	...	2.064667e+05
South Carolina	Wedgefield	...	7.436667e+04
Michigan	Williamston	...	1.657000e+05
Arkansas	Decatur	...	8.966667e+04
Tennessee	Briceville	...	5.623333e+04
Indiana	Edgewood	...	9.213333e+04
Tennessee	Palmyra	...	1.227667e+05
Maryland	Saint Inigoes	...	2.822333e+05
Indiana	Marysville	...	1.166000e+05
California	Forest Falls	...	1.653667e+05
Missouri	Bois D Arc	...	1.375667e+05
Virginia	Henrico	...	2.016333e+05
New Jersey	Diamond Beach	...	3.818000e+05
Tennessee	Gruetli Laager	...	5.556667e+04
Wisconsin	Town of Wrightstown	...	1.448667e+05
New York	Urbana	...	1.321333e+05
Wisconsin	New Denmark	...	1.745667e+05
California	Angels	...	2.444667e+05
Wisconsin	Holland	...	2.012667e+05

		2014q3	2014q4 \
State	RegionName		
New York	New York	5.228000e+05	5.280667e+05
California	Los Angeles	5.090667e+05	5.188667e+05
Illinois	Chicago	1.957667e+05	2.012667e+05
Pennsylvania	Philadelphia	1.153000e+05	1.156667e+05
Arizona	Phoenix	1.653667e+05	1.685000e+05
Nevada	Las Vegas	1.734000e+05	1.754667e+05
California	San Diego	4.890333e+05	4.964333e+05
Texas	Dallas	1.089000e+05	1.115333e+05
California	San Jose	6.970333e+05	7.149333e+05
Florida	Jacksonville	1.217333e+05	1.231667e+05
California	San Francisco	9.545333e+05	9.687667e+05
Texas	Austin	2.528000e+05	2.581333e+05

```
Michigan                Detroit             3.710000e+04  3.713333e+04
Ohio                    Columbus            1.045000e+05  1.064333e+05
Tennessee               Memphis             6.910000e+04  7.116667e+04
North Carolina          Charlotte           1.506333e+05  1.527333e+05
Texas                   El Paso             1.117333e+05  1.117667e+05
Massachusetts           Boston              4.314333e+05  4.407333e+05
Washington              Seattle             4.515000e+05  4.591667e+05
Maryland                Baltimore           1.095333e+05  1.073667e+05
Colorado                Denver              2.775000e+05  2.872333e+05
District of Columbia    Washington          4.530000e+05  4.603000e+05
Tennessee               Nashville           1.623000e+05  1.669000e+05
Wisconsin               Milwaukee           9.216667e+04  9.196667e+04
Arizona                 Tucson              1.434333e+05  1.442333e+05
Oregon                  Portland            2.872667e+05  2.955333e+05
Oklahoma                Oklahoma City       1.189667e+05  1.201000e+05
Nebraska                Omaha               1.303000e+05  1.325000e+05
New Mexico              Albuquerque         1.640000e+05  1.648000e+05
California              Fresno              1.736000e+05  1.781333e+05
...                                                  ...           ...
Texas                   Granite Shoals      1.175333e+05  1.175333e+05
Maryland                Piney Point         3.090000e+05  3.092333e+05
Wisconsin               Maribel             1.289667e+05  1.296333e+05
Idaho                   Middleton           1.457000e+05  1.462333e+05
Colorado                Bennett             1.620667e+05  1.714000e+05
New Hampshire           East Hampstead      2.521000e+05  2.557333e+05
Missouri                Garden City         1.043000e+05  1.047667e+05
Arkansas                Mountainburg        8.506667e+04  8.846667e+04
Wisconsin               Oostburg            1.279333e+05  1.274333e+05
California              Twin Peaks          1.475333e+05  1.460667e+05
New York                Upper Brookville    1.749233e+06  1.729467e+06
Hawaii                  Volcano             2.276333e+05  2.332000e+05
South Carolina          Wedgefield          7.026667e+04  7.206667e+04
Michigan                Williamston         1.689333e+05  1.708667e+05
Arkansas                Decatur             9.256667e+04  9.470000e+04
Tennessee               Briceville          5.423333e+04  5.260000e+04
Indiana                 Edgewood            9.406667e+04  9.466667e+04
Tennessee               Palmyra             1.269333e+05  1.262333e+05
Maryland                Saint Inigoes       2.884333e+05  2.869667e+05
Indiana                 Marysville          1.151000e+05  1.165000e+05
California              Forest Falls        1.675000e+05  1.771000e+05
Missouri                Bois D Arc          1.375667e+05  1.404000e+05
Virginia                Henrico             2.040000e+05  2.059000e+05
New Jersey              Diamond Beach       3.878667e+05  3.876667e+05
Tennessee               Gruetli Laager      5.636667e+04  5.713333e+04
Wisconsin               Town of Wrightstown 1.468667e+05  1.492333e+05
New York                Urbana              1.370333e+05  1.400667e+05
Wisconsin               New Denmark         1.811667e+05  1.861667e+05
California              Angels              2.540667e+05  2.599333e+05
```

State	RegionName		
Wisconsin	Holland	2.015667e+05	2.012667e+05

		2015q1	2015q2 \
State	RegionName		
New York	New York	5.322667e+05	5.408000e+05
California	Los Angeles	5.288000e+05	5.381667e+05
Illinois	Chicago	2.010667e+05	2.060333e+05
Pennsylvania	Philadelphia	1.162000e+05	1.179667e+05
Arizona	Phoenix	1.715333e+05	1.741667e+05
Nevada	Las Vegas	1.775000e+05	1.816000e+05
California	San Diego	5.033667e+05	5.120667e+05
Texas	Dallas	1.137000e+05	1.211333e+05
California	San Jose	7.314333e+05	7.567333e+05
Florida	Jacksonville	1.241667e+05	1.269000e+05
California	San Francisco	1.000733e+06	1.060800e+06
Texas	Austin	2.665000e+05	2.750333e+05
Michigan	Detroit	3.620000e+04	3.583333e+04
Ohio	Columbus	1.078667e+05	1.094333e+05
Tennessee	Memphis	7.053333e+04	6.870000e+04
North Carolina	Charlotte	1.551667e+05	1.579000e+05
Texas	El Paso	1.115000e+05	1.113000e+05
Massachusetts	Boston	4.485000e+05	4.553667e+05
Washington	Seattle	4.679333e+05	4.933667e+05
Maryland	Baltimore	1.080667e+05	1.114333e+05
Colorado	Denver	2.976333e+05	3.103667e+05
District of Columbia	Washington	4.661667e+05	4.810667e+05
Tennessee	Nashville	1.714667e+05	1.762667e+05
Wisconsin	Milwaukee	9.333333e+04	9.410000e+04
Arizona	Tucson	1.441667e+05	1.451333e+05
Oregon	Portland	3.019333e+05	3.119000e+05
Oklahoma	Oklahoma City	1.208000e+05	1.223667e+05
Nebraska	Omaha	1.330667e+05	1.344667e+05
New Mexico	Albuquerque	1.651667e+05	1.659000e+05
California	Fresno	1.804667e+05	1.820333e+05
...		...	...
Texas	Granite Shoals	1.171667e+05	1.191000e+05
Maryland	Piney Point	3.095667e+05	3.017000e+05
Wisconsin	Maribel	1.312667e+05	1.301333e+05
Idaho	Middleton	1.461667e+05	1.477333e+05
Colorado	Bennett	1.780333e+05	1.844333e+05
New Hampshire	East Hampstead	2.587333e+05	2.613667e+05
Missouri	Garden City	1.060333e+05	9.606667e+04
Arkansas	Mountainburg	8.903333e+04	8.556667e+04
Wisconsin	Oostburg	1.270667e+05	1.274000e+05
California	Twin Peaks	1.435000e+05	1.523000e+05
New York	Upper Brookville	1.749867e+06	1.789600e+06
Hawaii	Volcano	2.346333e+05	2.323667e+05
South Carolina	Wedgefield	7.570000e+04	7.206667e+04

State	RegionName		
Michigan	Williamston	1.744333e+05	1.758667e+05
Arkansas	Decatur	9.350000e+04	9.490000e+04
Tennessee	Briceville	4.963333e+04	4.590000e+04
Indiana	Edgewood	9.586667e+04	9.433333e+04
Tennessee	Palmyra	1.223000e+05	1.204667e+05
Maryland	Saint Inigoes	2.847000e+05	2.807667e+05
Indiana	Marysville	1.118667e+05	1.118000e+05
California	Forest Falls	1.765333e+05	1.818000e+05
Missouri	Bois D Arc	1.450333e+05	1.475667e+05
Virginia	Henrico	2.065667e+05	2.104333e+05
New Jersey	Diamond Beach	3.931667e+05	3.980000e+05
Tennessee	Gruetli Laager	5.890000e+04	6.536667e+04
Wisconsin	Town of Wrightstown	1.486667e+05	1.493333e+05
New York	Urbana	1.417000e+05	1.378667e+05
Wisconsin	New Denmark	1.876000e+05	1.886667e+05
California	Angels	2.601000e+05	2.506333e+05
Wisconsin	Holland	2.060000e+05	2.076000e+05

		2015q3	2015q4 \
State	RegionName		
New York	New York	5.572000e+05	5.728333e+05
California	Los Angeles	5.472667e+05	5.577333e+05
Illinois	Chicago	2.083000e+05	2.079000e+05
Pennsylvania	Philadelphia	1.212333e+05	1.222000e+05
Arizona	Phoenix	1.790667e+05	1.838333e+05
Nevada	Las Vegas	1.867667e+05	1.906333e+05
California	San Diego	5.197667e+05	5.254667e+05
Texas	Dallas	1.285667e+05	1.346000e+05
California	San Jose	7.764000e+05	7.891333e+05
Florida	Jacksonville	1.301333e+05	1.320000e+05
California	San Francisco	1.095100e+06	1.105467e+06
Texas	Austin	2.816333e+05	2.872333e+05
Michigan	Detroit	3.706667e+04	3.836667e+04
Ohio	Columbus	1.115667e+05	1.150000e+05
Tennessee	Memphis	6.866667e+04	6.953333e+04
North Carolina	Charlotte	1.601667e+05	1.628667e+05
Texas	El Paso	1.110667e+05	1.102667e+05
Massachusetts	Boston	4.639667e+05	4.716333e+05
Washington	Seattle	5.142667e+05	5.334667e+05
Maryland	Baltimore	1.139667e+05	1.139000e+05
Colorado	Denver	3.205000e+05	3.301000e+05
District of Columbia	Washington	4.934000e+05	5.009000e+05
Tennessee	Nashville	1.818000e+05	1.892000e+05
Wisconsin	Milwaukee	9.413333e+04	9.456667e+04
Arizona	Tucson	1.466000e+05	1.481667e+05
Oregon	Portland	3.257333e+05	3.430667e+05
Oklahoma	Oklahoma City	1.247000e+05	1.271000e+05
Nebraska	Omaha	1.367333e+05	1.400667e+05

New Mexico	Albuquerque	1.665333e+05	1.673333e+05
California	Fresno	1.857000e+05	1.874667e+05
...		...	...
Texas	Granite Shoals	1.216000e+05	1.280000e+05
Maryland	Piney Point	3.052333e+05	3.099667e+05
Wisconsin	Maribel	1.297333e+05	1.293000e+05
Idaho	Middleton	1.482000e+05	1.511333e+05
Colorado	Bennett	1.916667e+05	1.958000e+05
New Hampshire	East Hampstead	2.616000e+05	2.688000e+05
Missouri	Garden City	9.930000e+04	1.034333e+05
Arkansas	Mountainburg	8.370000e+04	9.043333e+04
Wisconsin	Oostburg	1.303333e+05	1.320333e+05
California	Twin Peaks	1.552667e+05	1.591667e+05
New York	Upper Brookville	1.777267e+06	1.834367e+06
Hawaii	Volcano	2.249667e+05	2.324333e+05
South Carolina	Wedgefield	7.033333e+04	6.903333e+04
Michigan	Williamston	1.794667e+05	1.823000e+05
Arkansas	Decatur	9.543333e+04	9.700000e+04
Tennessee	Briceville	4.793333e+04	4.360000e+04
Indiana	Edgewood	9.663333e+04	9.996667e+04
Tennessee	Palmyra	1.198000e+05	1.258000e+05
Maryland	Saint Inigoes	2.778333e+05	2.768333e+05
Indiana	Marysville	1.156667e+05	1.201667e+05
California	Forest Falls	1.911667e+05	1.987333e+05
Missouri	Bois D Arc	1.463000e+05	1.494333e+05
Virginia	Henrico	2.121000e+05	2.139667e+05
New Jersey	Diamond Beach	3.992333e+05	4.004333e+05
Tennessee	Gruetli Laager	6.950000e+04	7.170000e+04
Wisconsin	Town of Wrightstown	1.498667e+05	1.499333e+05
New York	Urbana	1.364667e+05	1.361667e+05
Wisconsin	New Denmark	1.884333e+05	1.889333e+05
California	Angels	2.635000e+05	2.795000e+05
Wisconsin	Holland	2.128667e+05	2.178333e+05

		2016q1	2016q2 \
State	RegionName		
New York	New York	5.828667e+05	5.916333e+05
California	Los Angeles	5.660333e+05	5.774667e+05
Illinois	Chicago	2.060667e+05	2.082000e+05
Pennsylvania	Philadelphia	1.234333e+05	1.269333e+05
Arizona	Phoenix	1.879000e+05	1.914333e+05
Nevada	Las Vegas	1.946000e+05	1.972000e+05
California	San Diego	5.293333e+05	5.362333e+05
Texas	Dallas	1.405000e+05	1.446000e+05
California	San Jose	8.036000e+05	8.189333e+05
Florida	Jacksonville	1.339667e+05	1.372000e+05
California	San Francisco	1.121767e+06	1.119267e+06
Texas	Austin	2.935000e+05	3.014333e+05

```
Michigan               Detroit              3.796667e+04  3.746667e+04
Ohio                   Columbus             1.167000e+05  1.182000e+05
Tennessee              Memphis              7.090000e+04  7.416667e+04
North Carolina         Charlotte            1.664667e+05  1.694333e+05
Texas                  El Paso              1.106667e+05  1.114667e+05
Massachusetts          Boston               4.826000e+05  4.903667e+05
Washington             Seattle              5.517333e+05  5.755333e+05
Maryland               Baltimore            1.146667e+05  1.147333e+05
Colorado               Denver               3.355667e+05  3.427667e+05
District of Columbia   Washington           5.041000e+05  5.058000e+05
Tennessee              Nashville            1.950667e+05  2.003667e+05
Wisconsin              Milwaukee            9.466667e+04  9.636667e+04
Arizona                Tucson               1.495333e+05  1.511667e+05
Oregon                 Portland             3.560000e+05  3.698000e+05
Oklahoma               Oklahoma City        1.279000e+05  1.293000e+05
Nebraska               Omaha                1.416333e+05  1.426667e+05
New Mexico             Albuquerque          1.691000e+05  1.706333e+05
California             Fresno               1.890333e+05  1.927333e+05
...                                                ...           ...
Texas                  Granite Shoals       1.337667e+05  1.400667e+05
Maryland               Piney Point          3.195000e+05  3.241667e+05
Wisconsin              Maribel              1.278333e+05  1.292667e+05
Idaho                  Middleton            1.539000e+05  1.571667e+05
Colorado               Bennett              1.997667e+05  2.074667e+05
New Hampshire          East Hampstead       2.725333e+05  2.778000e+05
Missouri               Garden City          1.062667e+05  1.116667e+05
Arkansas               Mountainburg         9.833333e+04  1.019000e+05
Wisconsin              Oostburg             1.327667e+05  1.341000e+05
California             Twin Peaks           1.641667e+05  1.679667e+05
New York               Upper Brookville     1.904500e+06  1.944067e+06
Hawaii                 Volcano              2.420667e+05  2.489667e+05
South Carolina         Wedgefield           6.886667e+04  7.426667e+04
Michigan               Williamston          1.814667e+05  1.824000e+05
Arkansas               Decatur              9.650000e+04  9.663333e+04
Tennessee              Briceville           4.080000e+04  4.180000e+04
Indiana                Edgewood             9.943333e+04  9.996667e+04
Tennessee              Palmyra              1.276667e+05  1.328667e+05
Maryland               Saint Inigoes        2.793333e+05  2.826333e+05
Indiana                Marysville           1.282333e+05  1.232333e+05
California             Forest Falls         1.886333e+05  1.898667e+05
Missouri               Bois D Arc           1.468667e+05  1.437667e+05
Virginia               Henrico              2.160333e+05  2.162000e+05
New Jersey             Diamond Beach        4.045333e+05  4.039000e+05
Tennessee              Gruetli Laager       7.533333e+04  7.646667e+04
Wisconsin              Town of Wrightstown  1.498333e+05  1.512667e+05
New York               Urbana               1.389667e+05  1.442000e+05
Wisconsin              New Denmark          1.910667e+05  1.928333e+05
California             Angels               2.765333e+05  2.716000e+05
```

State	RegionName		
Wisconsin	Holland	2.219667e+05	2.280333e+05

		2016q3
State	RegionName	
New York	New York	587200.0
California	Los Angeles	584050.0
Illinois	Chicago	212000.0
Pennsylvania	Philadelphia	128700.0
Arizona	Phoenix	195200.0
Nevada	Las Vegas	199950.0
California	San Diego	539750.0
Texas	Dallas	149300.0
California	San Jose	822200.0
Florida	Jacksonville	139900.0
California	San Francisco	1106400.0
Texas	Austin	304450.0
Michigan	Detroit	37900.0
Ohio	Columbus	120100.0
Tennessee	Memphis	75900.0
North Carolina	Charlotte	172400.0
Texas	El Paso	112200.0
Massachusetts	Boston	501700.0
Washington	Seattle	589700.0
Maryland	Baltimore	115150.0
Colorado	Denver	351550.0
District of Columbia	Washington	516250.0
Tennessee	Nashville	206100.0
Wisconsin	Milwaukee	98850.0
Arizona	Tucson	152700.0
Oregon	Portland	387050.0
Oklahoma	Oklahoma City	130300.0
Nebraska	Omaha	143450.0
New Mexico	Albuquerque	171900.0
California	Fresno	196450.0
...		...
Texas	Granite Shoals	146450.0
Maryland	Piney Point	324600.0
Wisconsin	Maribel	134200.0
Idaho	Middleton	160750.0
Colorado	Bennett	212600.0
New Hampshire	East Hampstead	282450.0
Missouri	Garden City	113600.0
Arkansas	Mountainburg	103400.0
Wisconsin	Oostburg	136350.0
California	Twin Peaks	173500.0
New York	Upper Brookville	1968800.0
Hawaii	Volcano	247850.0
South Carolina	Wedgefield	80700.0

```
        Michigan            Williamston          183000.0
        Arkansas            Decatur               96850.0
        Tennessee           Briceville            40850.0
        Indiana             Edgewood             100950.0
        Tennessee           Palmyra              137750.0
        Maryland            Saint Inigoes        281400.0
        Indiana             Marysville           124200.0
        California          Forest Falls         186650.0
        Missouri            Bois D Arc           144000.0
        Virginia            Henrico              220150.0
        New Jersey          Diamond Beach        399000.0
        Tennessee           Gruetli Laager        77500.0
        Wisconsin           Town of Wrightstown  155000.0
        New York            Urbana               143000.0
        Wisconsin           New Denmark          197600.0
        California          Angels               269950.0
        Wisconsin           Holland              234950.0

        [10730 rows x 67 columns]
```

```python
In [62]: def run_ttest():
            housing = convert_housing_data_to_quarters().loc[:,'2008q2':get_recession_bottom()]
            housing['p'] = housing['2008q2']/housing[get_recession_bottom()]
            housing = housing.drop(['2008q2', '2008q3', '2008q4', '2009q1', '2009q2'], axis =1)
            ut = housing.merge(get_list_of_university_towns(), how = 'inner', left_index = True
            nut = housing.merge(get_list_of_university_towns(), how = 'outer', left_index = Tru
            nut = nut.drop(nut[nut['_merge'] == 'both'].index)['p'].to_frame()
            pvalue = ttest_ind(ut['p'], nut['p'], nan_policy='omit')[1]
            different = pvalue < 0.01
            if ut['p'].mean() < nut['p'].mean():
                better = 'university town'
            else:
                better = 'non-univeristy town'

            return (different, pvalue, better)
         run_ttest()

Out[62]: (True, 0.0027240637047531249, 'university town')

In [ ]:

In [ ]:

In [ ]:
```