applied_econometrics / PS4_Gilman.ipynb

In [3]:
```
# %load PS4_Gilman.py
#!/usr/bin/env python

#########################################
# Applied Econometrics, PS4             #
# Rudy Gilman                           #
# April 28, 2016                        #
#########################################

import pandas as pd
import numpy as np
from pandas import DataFrame
import statsmodels.formula.api as smf
import statsmodels.api as sm
import matplotlib.pyplot as plt
import os, copy
from scipy import stats
from scipy.stats import ttest_ind
from sklearn.tree import DecisionTreeClassifier, export_graphviz, DecisionTreeRegressor
from sklearn.ensemble import RandomForestClassifier
from sklearn.linear_model import LogisticRegression
from sklearn.cross_validation import cross_val_score
import seaborn as sns

path = "/home/rudebeans/Desktop/school_spring2016/applied_econometrics/"

#df = pd.read_stata(path+"poll7080.dta", convert_categoricals=False) dta not loading

df = pd.read_csv(path+"poll7080.csv")

df['intercept'] = 1 # Adding constant


"""
Problem Set 4

This exercise examines the following research question: What is the relationship between change
s in air pollution and housing prices? For background on the topic and the data source refer to
the paper, “Does Air Quality Matter? Evidence from the Housing Market,” by Kenneth Chay and Mic
hael Greenstone, Journal of Political Economy, April 2005, 376-424.  Please include a concise s
ummary of your empirical results when appropriate.  We will analyze the following data set:

Data Source: poll7080.dta
This STATA data extract is from a combination of the 1972 and 1983 City and County Data Books,
the EPA’s Air Quality Subsystem data file, and the Code of Federal Regulations. The data is mea
sured at the county-level in the United States.

Data Notes:
1.  There are 1,000 observations at the U.S. county level.  These are the counties with particu
lates pollution monitors both at the beginning and end of the 1970s and contain the vast majori
ty of the U.S. population (over 80%).

2. The key variables are:
dlhouse = change in log-housing values from 1970 to 1980 (1980 log-price minus 1970 log-price).
dgtsp = change in the annual geometric mean of total suspended particulates pollution (TSPs) fr
om 1969-72 to 1977-80 (1977-80 TSPs minus 1969-72 TSPs).
tsp75 = indicator equal to one if the county was regulated by the Environmental Protection Agen
cy (EPA) in 1975 and equal to zero, otherwise.
tsp7576 = indicator equal to one if the county was regulated by the Environmental Protection Ag
ency (EPA) in either 1975 or 1976 and equal to zero, otherwise.
mtspgm74 = annual geometric mean of TSPs in 1974.
mtspgm75 = annual geometric mean of TSPs in 1975.

3. The other relevant variables are:
ddens = 1970-80 change in population density,
dmnfcg = change in % manufacturing employment,
dwhite = change in fraction of population that is white,
dfeml = change in fraction female,
dage65 = change in fraction over 65 years old,
dhs = change in fraction with at least a high school degree,
dcoll = change in fraction with at least a college degree,
durban = change in fraction living in urban area,
dunemp = change in unemployment rate,
dincome = change in income per-capita,
dpoverty = change in poverty rate,
vacant70 and vacant80 = housing vacancy rate in 1970 and 1980,
vacrnt70 = rental vacancy rate in 1970,
downer = change in fraction of houses that are owner-occupied,
dplumb = change in fraction of houses with plumbing,
drevenue = change in government revenue per-capita,
dtaxprop = change in property taxes per-capita,
depend = change in general expenditures per-capita,
deduc = change in fraction of spending on education,
dhghwy = change in % spending on highways,
dwelfr = change in % spending on public welfare,
dhlth = change in % spending on health,
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dhlth = change in % spending on health,
blt1080 = % of houses built in the last 10 years as of 1980,
blt2080 = % of houses built in the last 20 years as of 1980,
bltold80 = % of houses built more than 20 years ago as of 1980.

The remaining variables in the data set are polynomials and interactions of the control variabl
es.

Research Question: Does Air Quality Get Capitalized into Housing Prices?
The outcome of interest is the change in county housing prices during the 1970s. We want to est
imate the “causal” effect of air pollution changes on housing price changes. According to hedon
ic price theory, the housing market may be used to estimate the implicit prices of clean air an
d the economic value of pollution reductions to individuals (if you’re interested in hedonic pr
icing, see this article: Rosen, Sherwin, “The Theory of Equalizing Differences,” Chapter 12 in
Handbook of Labor Economics, Volume 1, 1986, pp. 641-92. ) .  A statistically significant negat
ive relationship between changes in property values and pollution levels across counties is int
erpreted as evidence that clean air has economic benefits.

A basic model for the change in housing prices at the county level could be:
Change in housing price = g(economic shocks, changes in county characteristics, change in air p
ollution).
"""

print "a. Estimate the relationship between changes in air pollution and housing prices: 1) not
adjusting for any control variables; 2) adjusting for the main effects of the control variables
listed on the previous page; and 3) adjusting for the main effects, polynomials and interaction
s of the control variables included in the data set. What do your estimates imply and do they m
ake sense? Describe the potential omitted variables biases. What is the likely relationship bet
ween economic shocks and pollution and housing price changes? Using the observable measures of
economic shocks (dincome, dunemp, dmnfcg, ddens, durban, blt1080), provide evidence on this.\n
\n"

print "Answer: Model 1) with no controls shows a positive correlation btwn increases in polluti
on and increases in house prices. Adding controls drives this relationship in the direction we
would expect--towards a negative correlation. Our estimates make sense when we consider the eff
ects of economic shocks. As we can see in the scatterplot matrix below, increased unemployment
and decreased incomes are associated with lower levels of pollution as well as lower house pric
es. Without controlling for economic shocks, our estimate was biased downwards (ie being confou
nded by omitted variables working in the opposite direction). It probably still is, as we've on
ly used observable manifestations of economic shock. Model 3) with all the controls is difficul
t to interpret.\n\n"

### Creating Xs for linear models

# X_1

X_1 = df[['dgtsp', 'intercept']]

# X_2

# bag of words from which to draw control variables of interest
p = "intercept dgtsp tsp75 = indicator equal to one if the county was regulated by the Environm
ental Protection Agency (EPA) in 1975 and equal to zero, otherwise. tsp7576 = indicator equal t
o one if the county was regulated by the Environmental Protection Agency (EPA) in either 1975 o
r 1976 and equal to zero, otherwise. mtspgm74 = annual geometric mean of TSPs in 1974. mtspgm75
= annual geometric mean of TSPs in 1975. 3. The other relevant variables are: ddens = 1970-80 c
hange in population density,  dmnfcg = change in % manufacturing employment,  dwhite = change i
n fraction of population that is white,  dfeml = change in fraction female,  dage65 = change in
fraction over 65 years old,  dhs = change in fraction with at least a high school degree,  dcol
l = change in fraction with at least a college degree,  durban = change in fraction living in u
rban area,  dunemp = change in unemployment rate,  dincome = change in income per-capita,  dpov
erty = change in poverty rate,  vacant70 and vacant80 = housing vacancy rate in 1970 and 1980,
vacrnt70 = rental vacancy rate in 1970,  downer = change in fraction of houses that are owner-o
ccupied,  dplumb = change in fraction of houses with plumbing,  drevenue = change in government
revenue per-capita,  dtaxprop = change in property taxes per-capita,  depend = change in genera
l expenditures per-capita,  deduc = change in fraction of spending on education,  dhghwy = chan
ge in % spending on highways,  dwelfr = change in % spending on public welfare,  dhlth = change
in % spending on health,  blt1080 = % of houses built in the last 10 years as of 1980,  blt2080
= % of houses built in the last 20 years as of 1980,  bltold80 = % of houses built more than 20
years ago as of 1980"

p = p.split() # list of words
X_2_cols = (df.columns[df.columns.isin(p)==True]) # basic control variables
X_2 = df[X_2_cols]

# X_3

X_3 = df[df.columns[df.columns != 'dlhouse']]

# Returns df with variables and importance, descending
def get_imp(X,y):
    #rf = RandomForestClassifier()
    rf = DecisionTreeRegressor(random_state=9)
    rf.fit(X, y)
    imp_var = rf.feature_importances_
    imp_var = pd.DataFrame({'variable':X.columns, 'imp':imp_var}).sort('imp', ascending=False)
    return(imp_var)
```

```
var = get_imp(X_3.fillna(0), df.dlhouse)
imp_var = var[var.imp > 0.0005] # only keeping variables w some explanatory power

kill = ['lhouse80', 'house80'] # combined w numbers for 70, these perfectly predict dlhouse
X_3 = X_3[imp_var.variable]
X_3 = X_3[X_3.columns[X_3.columns.isin(kill)==False]]
X_3['intercept'] = 1 # adding back in intercept and dgtsp, as both were removed in Imp filter
X_3['dgtsp'] = df.dgtsp

print "X_1"
print "\n"
lm = sm.OLS(df.dlhouse, X_1, missing='drop').fit()
print lm.summary()
print "1) dgtsp coefficient: "+str(lm.params['dgtsp'])
print "\n\n\n"

print "X_2"
print "\n"
lm = sm.OLS(df.dlhouse, X_2, missing='drop').fit()
print lm.summary()
print "2) dgtsp coefficient: "+str(lm.params['dgtsp'])
print "\n\n\n"

print "X_3"
print "\n"
lm = sm.OLS(df.dlhouse, X_3, missing='drop').fit()
print lm.summary()
print "3) dgtsp coefficient: "+str(lm.params['dgtsp'])
print "\n\n\n"

cols = ['dincome','dunemp', 'dgtsp','dmnfcg', 'dlhouse']

pp = df[cols].dropna()
sns.set(style="ticks", color_codes=True)
#iris = sns.load_dataset("iris")

g = sns.PairGrid(pp)
g = g.map_upper(plt.scatter, alpha=.5)
g = g.map_lower(sns.kdeplot, cmap="Blues_d")
g = g.map_diag(sns.distplot)
#g = sns.pairplot(pp, kind='reg')

# Rescaling axis. Why doesn't Seaborn do this for me automatically?
axes = g.axes
for i in range(len(cols)):
    axes[i,i].set_ylim(np.min(pp[cols[i]]),np.max(pp[cols[i]]))
    axes[i,i].set_xlim(np.min(pp[cols[i]]),np.max(pp[cols[i]]))
#g.set(ylim=(0, 9))
#g.set(xlim=(0, 9)) sets all axes to this extent

plt.show()

print "b. Suppose that federal EPA pollution regulation is a potential instrumental variable fo
r pollution changes during the 1970s. What are the assumptions required for 1975-1976 regulator
y status, tsp7576, to be a valid instrument for pollution changes when the outcome of interest 
is housing price changes? Provide evidence on the relationship between the regulatory status in
dicator and the observable economic shock measures. Interpret your findings.\n\n"

print "Answer: tsp7576 must be strong, ie correlated w dgtsp, and valid, ie not correlated w dl
house except through dgtsp. As we can see in the correlation matrix below, tsp7576 is only slig
htly correlated w our economic shock variables, making it potentially a good IV.\n\n"

shock_cols = ['tsp7576','dincome','dunemp', 'dmnfcg', 'ddens', 'durban', 'blt1080']

d = df[shock_cols]
cor = d.corr()
print cor

#lm = sm.OLS(df.tsp7576, df[shock_cols], missing='drop').fit()
#print lm.summary()
#print "\n\n"

print "\n\n c. Document the “first-stage” relationship between regulation (tsp7576) and air pol
lution changes and the “reduced-form” relationship between regulation and housing price change
s, using the same three specifications you used in part a). Interpret your findings. How does t
wo-stage least squares use these two equations?  Now estimate the effect of air quality changes
on housing price changes using two-stage least squares and the tsp7576 indicator as an instrume
nt for the three specifications. Interpret the results. Now do the same using the 1975 regulati
on indicator, tsp75, as an instrumental variable. Compare the findings.\n\n"

print "Answer: the negative effect of regulation on air pollution decreases as we add controls 
(relationship gets less negative). The positive effect of regulation on changes in house prices
decreases as we add controls. In terms of IV, our 7576 and 75 results are similar, both around 
-.003 (elasticity of -0.3) for uncontrolled and basically controlled regressions. As we showed 
before, the IV is only slightly correlated with economic shock variables, so the model isn't pa
rticularly sensitive to control specification. Estimates for model w all interactions + higher-
order terms remains difficult to interpret. The reduced form results show that house prices in 
treated counties are 2.4% higher than they would be otherwise. First stage results suggest that
```

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treated counties are 2-4% higher than they would be otherwise. First-stage results suggest that
treatment results in pollution decreases of 5-10%.\n\n"

# FOr 7576
X_1 = df[['intercept', 'tsp7576']]
kill = ['dgtsp', 'tsp75']
X_2 = X_2[X_2.columns[X_2.columns.isin(kill)==False]]
X_3 = X_3[X_3.columns[X_3.columns.isin(kill)==False]]
X_3['tsp7576'] = df.tsp7576

Xs=[X_1, X_2, X_3]
Xs_str=['X_1', 'X_2', 'X_3']

for i in range(len(Xs)):
    print Xs_str[i]
    X = Xs[i]
    first = sm.OLS(df.dgtsp, X, missing="drop").fit()
    print first.summary()
    print '\n'
    print Xs_str[i]+": first stage tsp7576 coefficient:"
    print first.params['tsp7576']
    reduced = sm.OLS(df.dlhouse, X, missing="drop").fit()
    print reduced.summary()
    print '\n'
    print Xs_str[i]+": reduced form tsp7576 coefficient:"
    print reduced.params['tsp7576']
    # IV
    dgtsp_hat = first.predict(X)
    X['dgtsp_hat'] = dgtsp_hat
    X = X.drop(['tsp7576'], axis=1)
    IV = sm.OLS(df.dlhouse, X, missing="drop").fit()
    print Xs_str[i]+ ": IV estimate: "+ str(IV.params['dgtsp_hat'])
    print IV.summary()
    print '\n'



# for 75
X_1 = df[['intercept', 'tsp75']]
kill = ['dgtsp', 'tsp7576']
X_2 = X_2[X_2.columns[X_2.columns.isin(kill)==False]]
X_2['tsp75'] = df.tsp75
X_3 = X_3[X_3.columns[X_3.columns.isin(kill)==False]]
X_3['tsp75'] = df.tsp75

Xs=[X_1, X_2, X_3]
Xs_str=['X_1', 'X_2', 'X_3']

for i in range(len(Xs)):
    print Xs_str[i]
    X = Xs[i]
    first = sm.OLS(df.dgtsp, X, missing="drop").fit()
    print first.summary()
    print '\n'
    print Xs_str[i]+": first stage tsp75 coefficient:"
    print first.params['tsp75']
    reduced = sm.OLS(df.dlhouse, X, missing="drop").fit()
    print reduced.summary()
    print '\n'
    print Xs_str[i]+": reduced form tsp75 coefficient:"
    print reduced.params['tsp75']
    # IV
    dgtsp_hat = first.predict(X)
    X['dgtsp_hat'] = dgtsp_hat
    X = X.drop(['tsp75'], axis=1)
    IV = sm.OLS(df.dlhouse, X, missing="drop").fit()
    print Xs_str[i]+ ": IV estimate: "+ str(IV.params['dgtsp_hat'])
    print IV.summary()
    print '\n'


print("d. In principle, the 1975 regulation indicator variable, tsp75, should be a discrete fun
ction of pollution levels in 1974. Specifically, the EPA is supposed to regulate those counties
in 1975 who had either an annual geometric mean of TSPs above 75 units (μg/m3) or a 2nd highest
daily concentration above 260 units in 1974. Describe how one could use this discontinuity in t
reatment assignment to derive alternative estimates of the capitalization of pollution changes.
Under what conditions will these estimates be valid? Describe the graphical analysis you would
use to examine the validity of these conditions.\n\n")


print "Answer: We could take only the section of the dataframe + and - a certain delta around t
he threshhold value of pollution in 1974. Then we could construct a Wald Estimator with it, i.
e. find the difference in price changes and pollution changes for a group just under the thresh
hold, as well as for a group just over the threshhold, then divide the differences to find chan
ge in dlhouse per change in TSPs. I'd want to see that the discontinuity wasn't fuzzy, so a gra
ph like that below would be helpful. I'd want to verify that group means were similar in below-
threshhold and above-threshhold groups. \n\n"
```

```
y = 'tsp75'
x = 'mtspgm74'
fig = plt.figure()
ax = fig.add_subplot(111)
ax.scatter(df[x], df[y], c='blue', alpha=0.25)
ax.set_title(str(x)+' '+str(y))
ax.set_ylabel(str(y))
ax.set_xlabel(str(x))
#ax.set_ylim([0,7])
#ax.set_xlim([500,1500])
#ax.legend([y, y2])
plt.show()
fig.clf()
print '\n'


print "e. Describe (in words) the theoretical reasons why the effects of pollution changes on h
ousing price changes may be heterogeneous.  Under what assumptions will two-stage least squares
identify the average treatment effect (ATE)? What is the economic interpretation of ATE in the
context of hedonic theory? If ATE is not identified, describe what may be identifiable with two
-stage least squares estimation. Under what conditions is this effect identified? Give some int
uition on what this effect may represent when one uses EPA regulation as an instrument.\n\n"

print "Answer: Small, unnoticable changes in pollution might have no effect on changes in pric
e, while larger changes in pollution may have large effects on price changes, perhaps increasin
g at an increasing rate as pollution changes become noticable, then at a diminishing rate when
jumps in pollution are extreme. 2SLS will identify the ATE if effects of pollution changes on p
rice changes are homogenous. The ATE in the context of the hedonic theory represents the amount
people have revealed themselves willing to pay for clean air. \nIn this case, however, we've on
ly IDed the LATE, as our results are only applicable around the pollution threshhold. The LATE
is the effect of pollution changes on house price changes in the small window around the regula
tory threshhold for those cities which were induced into cleaning up as a result of regulation
s, but wouldn't have done so otherwise. We should also be aware of selection effects: People in
the highly-polluted areas eligable for treatment may be less sensitive to pollution, so we're m
easuring the effect amongst a demographic that may not be representative of the greater populat
ion.\n\n"



print "f. Now provide a concise synthesis/summary of your results.  Discuss the “credibility” o
f the research designs underlying the results.\n\n"


print "Answer: In our simple OLS models, we measured a slightly positive effect of changes in p
ollution on changes in house price. On the face of it, this runs counter to what we expect the
relationship to be. When we consider the omitted variable of economic shocks, however, we see h
ow this paradoxical result came about--negative economic shocks decrease both pollution and hou
se prices. Controlling for a few manifestations of economic shocks (unemployment, changes in in
come, etc) helped ameliorate OVB to some extent. \nTo more thoroughly purge our model of OVB, w
e used an IV approach, (hopefully) capturing only the variation in dgtsp uncorrelated with our
confounding omitted variable. Using this approach, we captured a more expected result: A 1% inc
rease in pollution is associated with an approximate .3% decrease in price. This result was rob
ust to our selection of control variables, probably bc our IV was uncorrelated with the OV. Thi
s strikes me as a credible approach. \n\n"
```

```
a. Estimate the relationship between changes in air pollution and housing prices: 1) not adjusti
ng for any control variables; 2) adjusting for the main effects of the control variables listed
on the previous page; and 3) adjusting for the main effects, polynomials and interactions of the
control variables included in the data set. What do your estimates imply and do they make sense?
Describe the potential omitted variables biases. What is the likely relationship between economi
c shocks and pollution and housing price changes? Using the observable measures of economic shoc
ks (dincome, dunemp, dmnfcg, ddens, durban, blt1080), provide evidence on this.


Answer: Model 1) with no controls shows a positive correlation btwn increases in pollution and i
ncreases in house prices. Adding controls drives this relationship in the direction we would exp
ect--towards a negative correlation. Our estimates make sense when we consider the effects of ec
onomic shocks. As we can see in the scatterplot matrix below, increased unemployment and decreas
ed incomes are associated with lower levels of pollution as well as lower house prices. Without
controlling for economic shocks, our estimate was biased downwards (ie being confounded by omitt
ed variables working in the opposite direction). It probably still is, as we've only used observ
able manifestations of economic shock. Model 3) with all the controls is difficult to interpret.


/usr/local/lib/python2.7/dist-packages/ipykernel/__main__.py:118: FutureWarning: sort(columns
=....) is deprecated, use sort_values(by=.....)
X_1


                            OLS Regression Results
==============================================================================
Dep. Variable:                dlhouse   R-squared:                       0.017
Model:                            OLS   Adj. R-squared:                  0.016
Method:                 Least Squares   F-statistic:                     16.85
Date:                Thu, 28 Apr 2016   Prob (F-statistic):           4.38e-05
Time:                        19:09:25   Log-Likelihood:                 346.20
```

```
No. Observations:                1000   AIC:                            -688.4
Df Residuals:                     998   BIC:                            -678.6
Df Model:                           1
==============================================================================
                 coef    std err          t      P>|t|      [95.0% Conf. Int.]
------------------------------------------------------------------------------
dgtsp          0.0010      0.000      4.105      0.000         0.001     0.001
intercept      0.2822      0.006     49.133      0.000         0.271     0.293
==============================================================================
Omnibus:                       66.452   Durbin-Watson:                   1.023
Prob(Omnibus):                  0.000   Jarque-Bera (JB):               99.410
Skew:                           0.527   Prob(JB):                     2.59e-22
Kurtosis:                       4.129   Cond. No.                         25.1
==============================================================================
1) dgtsp coefficient: 0.000995299882288



X_2


                            OLS Regression Results
==============================================================================
Dep. Variable:                dlhouse   R-squared:                       0.573
Model:                            OLS   Adj. R-squared:                  0.559
Method:                 Least Squares   F-statistic:                     40.30
Date:                Thu, 28 Apr 2016   Prob (F-statistic):         6.30e-149
Time:                        19:09:25   Log-Likelihood:                 740.06
No. Observations:                 962   AIC:                            -1416.
Df Residuals:                     930   BIC:                            -1260.
Df Model:                          31
==============================================================================
                 coef    std err          t      P>|t|      [95.0% Conf. Int.]
------------------------------------------------------------------------------
ddens      -7.721e-06   1.74e-05     -0.443      0.658     -4.19e-05  2.65e-05
dmnfcg        -0.0874      0.111     -0.787      0.431        -0.305     0.131
dwhite        -0.5255      0.091     -5.777      0.000        -0.704    -0.347
dfeml         -0.7631      0.502     -1.519      0.129        -1.749     0.223
dage65        -1.7964      0.372     -4.833      0.000        -2.526    -1.067
dhs            0.4133      0.141      2.924      0.004         0.136     0.691
dcoll          0.1756      0.204      0.861      0.389        -0.224     0.576
durban        -0.1159      0.053     -2.180      0.029        -0.220    -0.012
dunemp        -0.9476      0.230     -4.124      0.000        -1.399    -0.497
dincome        6.6e-05   8.44e-06      7.824      0.000      4.94e-05  8.26e-05
dpoverty      -0.6197      0.163     -3.797      0.000        -0.940    -0.299
downer        -0.1407      0.093     -1.515      0.130        -0.323     0.042
dplumb        -0.1593      0.183     -0.868      0.386        -0.519     0.201
drevenue    1.807e-05   2.34e-05      0.774      0.439     -2.78e-05  6.39e-05
dtaxprop   -6.672e-05   3.15e-05     -2.121      0.034        -0.000 -4.99e-06
depend     -3.023e-05   2.46e-05     -1.229      0.220     -7.85e-05  1.81e-05
deduc          0.1101      0.049      2.228      0.026         0.013     0.207
dhghwy        -0.1694      0.119     -1.426      0.154        -0.403     0.064
dwelfr        -0.3150      0.101     -3.108      0.002        -0.514    -0.116
dhlth         -0.0513      0.067     -0.764      0.445        -0.183     0.080
vacant70      -1.0210      0.518     -1.973      0.049        -2.037    -0.005
vacant80       0.5242      0.142      3.698      0.000         0.246     0.802
vacrnt70      -0.1276      0.146     -0.872      0.383        -0.415     0.159
blt1080        0.3265      0.073      4.463      0.000         0.183     0.470
blt2080       -0.9466      0.128     -7.386      0.000        -1.198    -0.695
bltold80      -0.2222      0.069     -3.231      0.001        -0.357    -0.087
tsp7576        0.0387      0.021      1.882      0.060        -0.002     0.079
tsp75         -0.0221      0.021     -1.040      0.299        -0.064     0.020
dgtsp          0.0005      0.000      2.846      0.005         0.000     0.001
mtspgm74       0.0018      0.000      4.628      0.000         0.001     0.003
mtspgm75      -0.0018      0.000     -4.826      0.000        -0.003    -0.001
intercept      0.2858      0.062      4.588      0.000         0.164     0.408
==============================================================================
Omnibus:                       78.680   Durbin-Watson:                   1.423
Prob(Omnibus):                  0.000   Jarque-Bera (JB):              147.728
Skew:                           0.540   Prob(JB):                     8.34e-33
Kurtosis:                       4.587   Cond. No.                     1.90e+05
==============================================================================

Warnings:
[1] The condition number is large, 1.9e+05. This might indicate that there are
strong multicollinearity or other numerical problems.
2) dgtsp coefficient: 0.000505352938748



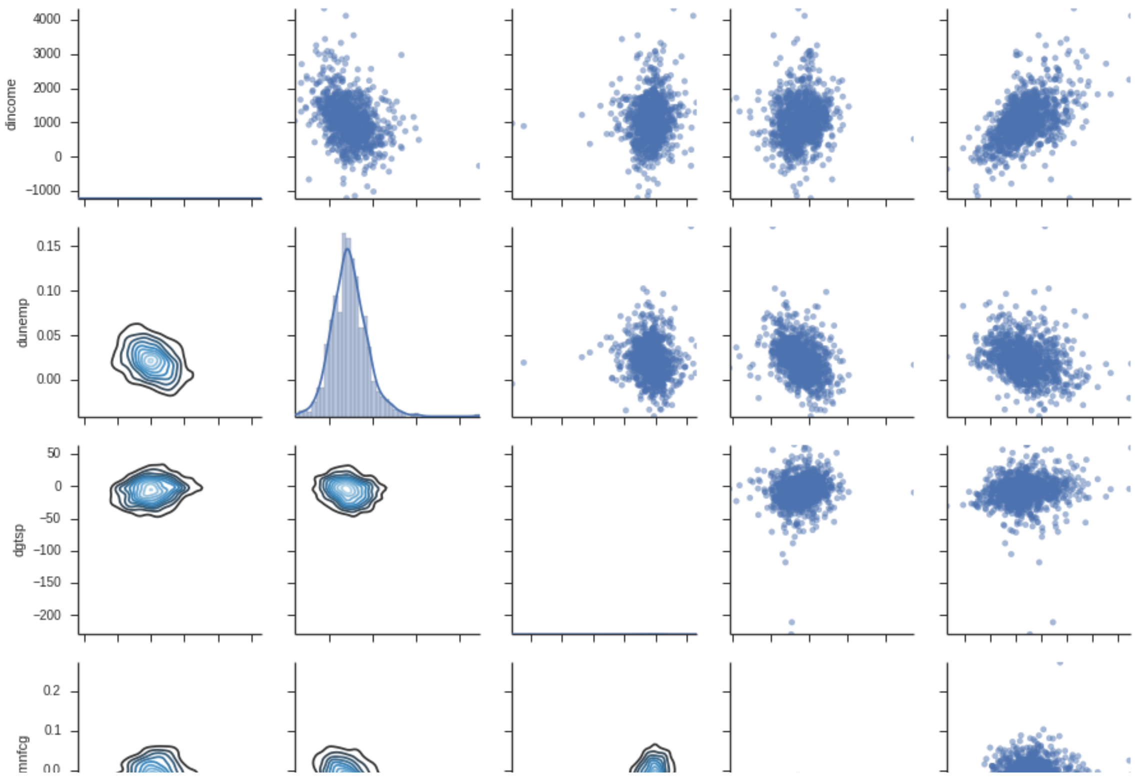
X_3

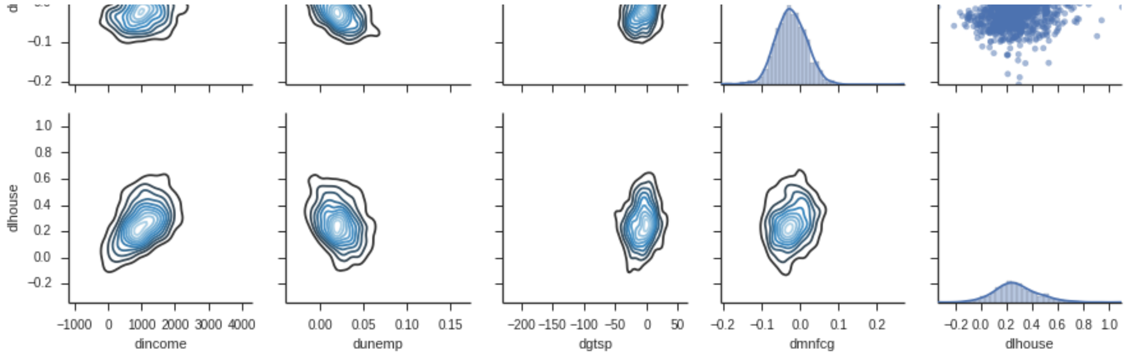

                            OLS Regression Results
==============================================================================
```

```
Dep. Variable:                dlhouse   R-squared:                       0.868
Model:                            OLS   Adj. R-squared:                  0.812
Method:                 Least Squares   F-statistic:                     15.51
Date:                Thu, 28 Apr 2016   Prob (F-statistic):           1.28e-63
Time:                        19:09:25   Log-Likelihood:                 434.67
No. Observations:                 331   AIC:                            -671.3
Df Residuals:                     232   BIC:                            -294.9
Df Model:                          98
==============================================================================
                 coef    std err          t      P>|t|      [95.0% Conf. Int.]
------------------------------------------------------------------------------
region         0.0280      0.005      5.864      0.000         0.019     0.037
inchs         -0.0002      0.000     -0.437      0.662        -0.001     0.001
dlincome       0.5145      0.802      0.642      0.522        -1.065     2.094
lhouse70      -0.5841      0.124     -4.696      0.000        -0.829    -0.339
incage        -0.0002      0.001     -0.221      0.826        -0.002     0.002
age6570        0.4662      0.555      0.840      0.402        -0.627     1.559
hs3           -6.4999     27.908     -0.233      0.816       -61.486    48.486
owner70       -0.6593      0.139     -4.758      0.000        -0.932    -0.386
welfr70        0.4128      0.206      2.005      0.046         0.007     0.818
TOTOBS70    1.862e-05   2.65e-05      0.703      0.483     -3.36e-05  7.08e-05
MAX1V80     2.641e-05   3.83e-05      0.690      0.491      -4.9e-05     0.000
built202     -10.6199      7.297     -1.455      0.147       -24.997     3.757
XAROBS74       0.0004      0.001      0.648      0.518        -0.001     0.002
revnue70    1.226e-05   7.97e-05      0.154      0.878        -0.000     0.000
MTSPGM83      -0.0009      0.001     -0.713      0.476        -0.003     0.002
vacant70      -3.0959      1.313     -2.359      0.019        -5.682    -0.510
built102      -1.3039      0.564     -2.314      0.022        -2.414    -0.194
dage65         0.4599      1.040      0.442      0.659        -1.589     2.509
urban80       -0.0732      0.058     -1.272      0.205        -0.187     0.040
age3         306.6796    379.571      0.808      0.420      -441.167  1054.526
XAROBS72      -0.0001      0.000     -0.313      0.755        -0.001     0.001
dgtsp         -0.0004      0.000     -0.896      0.371        -0.001     0.001
MAX1V78     -3.72e-06   5.11e-05     -0.073      0.942        -0.000  9.69e-05
dpoverty      -0.0253      0.399     -0.063      0.950        -0.812     0.761
pcthghw2       1.8554      2.285      0.812      0.418        -2.647     6.358
pctwelf3      21.8911     10.348      2.116      0.035         1.503    42.279
whtage        -3.2526     13.740     -0.237      0.813       -30.324    23.819
dwelfr        -0.2065      0.265     -0.779      0.437        -0.729     0.316
hospbed2   -3.177e-08   2.56e-08     -1.241      0.216     -8.22e-08  1.87e-08
dunemp        -0.6233      0.468     -1.333      0.184        -1.545     0.298
built203      14.9999     10.057      1.491      0.137        -4.815    34.815
white70        0.5644      0.248      2.277      0.024         0.076     1.053
pop7080    -1.421e-07   1.12e-07     -1.272      0.205     -3.62e-07   7.8e-08
coll2         -1.4325      6.656     -0.215      0.830       -14.547    11.682
vacrnt70      -0.4619      0.300     -1.537      0.126        -1.054     0.130
pcteduc2      -0.2356      0.596     -0.395      0.693        -1.411     0.939
vacant80      -0.3919      0.362     -1.083      0.280        -1.105     0.321
XGMOBS82       0.0004      0.000      1.938      0.054     -7.04e-06     0.001
feml80        -0.4440      0.763     -0.582      0.561        -1.948     1.060
epend2     -5.219e-08   3.46e-08     -1.506      0.133      -1.2e-07  1.61e-08
house70     5.731e-06    2.5e-06      2.290      0.023         8e-07  1.07e-05
dfeml         -0.1312      1.459     -0.090      0.928        -3.006     2.744
XAROBS83      -0.0003      0.000     -1.247      0.214        -0.001     0.000
XAROBS77      -0.0001      0.000     -0.339      0.735        -0.001     0.001
pophs          0.0017      0.001      1.363      0.174        -0.001     0.004
MTSPAR73      -0.0006      0.002     -0.364      0.716        -0.004     0.003
educ80         0.0171      0.136      0.126      0.900        -0.251     0.285
unemp70       -0.0341      0.495     -0.069      0.945        -1.010     0.942
TOTOBS74   -1.176e-05   5.36e-05     -0.219      0.827        -0.000  9.39e-05
XGMOBS77       0.0001      0.000      0.474      0.636        -0.000     0.001
XTSPAR74      -0.0002      0.000     -0.614      0.540        -0.001     0.000
MAX1V76      1.83e-05   3.07e-05      0.596      0.552     -4.22e-05  7.88e-05
hlth80         0.1057      0.112      0.940      0.348        -0.116     0.327
hs70           0.5997      0.189      3.180      0.002         0.228     0.971
MTSPGM84       0.0004      0.001      0.373      0.709        -0.002     0.003
gtsp7780       0.0030      0.002      1.577      0.116        -0.001     0.007
TOTOBS72   -3.799e-06   2.79e-05     -0.136      0.892     -5.88e-05  5.12e-05
XGMOBS73      -0.0002      0.000     -1.142      0.255        -0.001     0.000
polic80        0.0849      0.742      0.114      0.909        -1.376     1.546
linc70         0.0569      0.532      0.107      0.915        -0.991     1.105
femal3         0.0371      1.960      0.019      0.985        -3.824     3.898
age6580        0.7636      0.669      1.142      0.255        -0.554     2.081
MAX2V70    -1.366e-05   5.73e-05     -0.238      0.812        -0.000  9.93e-05
plumb80       -0.2223      0.600     -0.370      0.711        -1.405     0.960
femal2        11.2191     65.314      0.172      0.864      -117.466   139.904
poverty3      -5.2729     27.105     -0.195      0.846       -58.676    48.130
povrty80       0.1479      0.366      0.404      0.687        -0.574     0.870
MTSPGM74       0.0007      0.001      0.874      0.383        -0.001     0.002
fstate        -0.0005      0.000     -1.164      0.245        -0.001     0.000
dhghwy         0.2872      0.320      0.896      0.371        -0.344     0.918
dincome     3.698e-05      0.000      0.328      0.743        -0.000     0.000
XAROBS71      -0.0002      0.000     -1.284      0.200        -0.001     0.000
epend70    -7.222e-05    7.1e-05     -1.017      0.310        -0.000  6.77e-05
inccoll    -7.208e-05      0.001     -0.127      0.899        -0.001     0.001
XGMOBS72       0.0002      0.000      0.617      0.538        -0.000     0.001
revenue2    7.452e-08   2.12e-08      3.517      0.001      3.28e-08  1.16e-07
TOTOBS76    3.427e-05   3.61e-05      0.949      0.343     -3.69e-05     0.000
```

```
TOTOBS76     3.427e-05   3.61e-05      0.949      0.343     -3.69e-05     0.000
blt1080         1.1429      0.425      2.692      0.008         0.306     1.980
TOTOBS75    -6.509e-06   5.25e-05     -0.124      0.901        -0.000  9.69e-05
lrent80         0.5133      0.096      5.335      0.000         0.324     0.703
mnfcg80         0.1930      0.102      1.895      0.059        -0.008     0.394
income80    -1.048e-07   5.53e-05     -0.002      0.998        -0.000     0.000
MTSPAR78       -0.0005      0.001     -0.421      0.674        -0.003     0.002
TOTOBS71    -1.551e-05   2.43e-05     -0.639      0.523     -6.34e-05  3.23e-05
hs2             5.5901      6.791      0.823      0.411        -7.789    18.970
MTSPGM73       -0.0007      0.002     -0.362      0.718        -0.004     0.003
manwhite       -7.9499      4.380     -1.815      0.071       -16.580     0.680
MAX1V73      -3.89e-05   4.17e-05     -0.933      0.352        -0.000  4.32e-05
MAX2V71     -2.456e-05   3.59e-05     -0.683      0.495     -9.54e-05  4.63e-05
downer         -0.1102      0.238     -0.462      0.644        -0.580     0.359
dmnfcg         -1.0173      0.388     -2.619      0.009        -1.783    -0.252
MTSPAR69    -5.153e-05      0.000     -0.431      0.667        -0.000     0.000
hospbed3       9.9e-12   1.07e-11      0.927      0.355     -1.11e-11  3.09e-11
blt2080         2.1959      1.710      1.284      0.200        -1.174     5.566
bltold80        0.1344      0.146      0.920      0.359        -0.154     0.422
XGMOBS75        0.0002      0.000      0.844      0.400        -0.000     0.001
txprop80      4.18e-05   6.47e-05      0.646      0.519     -8.58e-05     0.000
rent70         -0.0003      0.000     -1.037      0.301        -0.001     0.000
drevenue       -0.0001   6.07e-05     -2.193      0.029        -0.000 -1.35e-05
mnfcg2         -1.4452      4.144     -0.349      0.728        -9.610     6.719
hghwy70         0.3014      0.264      1.140      0.256        -0.220     0.822
pctpol3       -30.3144     32.551     -0.931      0.353       -94.448    33.819
MTSPGM77       -0.0007      0.001     -0.647      0.518        -0.003     0.001
educ70          0.0419      0.121      0.345      0.730        -0.197     0.281
MAX1V77     -1.119e-05   1.48e-05     -0.754      0.452     -4.04e-05  1.81e-05
poptot80     3.007e-07   2.17e-07      1.383      0.168     -1.28e-07  7.29e-07
crime82       -2.92e-10   3.03e-10     -0.962      0.337      -8.9e-10  3.06e-10
XAROBS84       -0.0002      0.000     -0.805      0.422        -0.001     0.000
MAX1V75     -2.248e-05   4.37e-05     -0.515      0.607        -0.000  6.36e-05
ddens          -0.0003      0.000     -1.517      0.131        -0.001  7.91e-05
XTSPGM75     3.349e-05      0.000      0.102      0.919        -0.001     0.001
white80        -0.4527      0.254     -1.779      0.077        -0.954     0.049
XGMOBS74       -0.0002      0.001     -0.384      0.701        -0.001     0.001
povrty70        0.2343      0.302      0.775      0.439        -0.361     0.830
XAROBS76       -0.0001      0.000     -0.592      0.554        -0.000     0.000
intercept       2.4191      3.975      0.609      0.543        -5.412    10.250
==============================================================================
Omnibus:                        0.507   Durbin-Watson:                   1.628
Prob(Omnibus):                  0.776   Jarque-Bera (JB):                0.291
Skew:                          -0.005   Prob(JB):                        0.864
Kurtosis:                       3.145   Cond. No.                          nan
==============================================================================

Warnings:
[1] The smallest eigenvalue is -0.00931. This might indicate that there are
strong multicollinearity problems or that the design matrix is singular.
3) dgtsp coefficient: -0.000424930439339
```





b. Suppose that federal EPA pollution regulation is a potential instrumental variable for pollution changes during the 1970s. What are the assumptions required for 1975-1976 regulatory status, tsp7576, to be a valid instrument for pollution changes when the outcome of interest is housing price changes? Provide evidence on the relationship between the regulatory status indicator and the observable economic shock measures. Interpret your findings.

Answer: tsp7576 must be strong, ie correlated w dgtsp, and valid, ie not correlated w dlhouse except through dgtsp. As we can see in the correlation matrix below, tsp7576 is only slightly correlated w our economic shock variables, making it potentially a good IV.

	tsp7576	dincome	dunemp	dmnfcg	ddens	durban	blt1080
tsp7576	1.000000	0.033421	0.006804	-0.005299	-0.021966	-0.004475	-0.029616
dincome	0.033421	1.000000	-0.355727	0.120453	0.202457	0.243080	0.452957
dunemp	0.006804	-0.355727	1.000000	-0.368449	-0.104737	-0.095059	-0.189928
dmnfcg	-0.005299	0.120453	-0.368449	1.000000	0.040436	-0.056728	0.124982
ddens	-0.021966	0.202457	-0.104737	0.040436	1.000000	0.045735	0.257792
durban	-0.004475	0.243080	-0.095059	-0.056728	0.045735	1.000000	0.325309
blt1080	-0.029616	0.452957	-0.189928	0.124982	0.257792	0.325309	1.000000

c. Document the “first-stage” relationship between regulation (tsp7576) and air pollution changes and the “reduced-form” relationship between regulation and housing price changes, using the same three specifications you used in part a). Interpret your findings. How does two-stage least squares use these two equations? Now estimate the effect of air quality changes on housing price changes using two-stage least squares and the tsp7576 indicator as an instrument for the three specifications. Interpret the results. Now do the same using the 1975 regulation indicator, tsp75, as an instrumental variable. Compare the findings.

Answer: the negative effect of regulation on air pollution decreases as we add controls (relationship gets less negative). The positive effect of regulation on changes in house prices decreases as we add controls. In terms of IV, our 7576 and 75 results are similar, both around -.003 (elasticity of -0.3) for uncontrolled and basically controlled regressions. As we showed before, the IV is only slightly correlated with economic shock variables, so the model isn't particularly sensitive to control specification. Estimates for model w all interactions + higher-order terms remains difficult to interpret. The reduced form results show that house prices in treated counties are 2-4% higher than they would be otherwise. First-stage results suggest that treatment results in pollution decreases of 5-10%.

```
X_1
                            OLS Regression Results
==============================================================================
Dep. Variable:                  dgtsp   R-squared:                       0.039
Model:                            OLS   Adj. R-squared:                  0.038
Method:                 Least Squares   F-statistic:                     40.72
Date:                Thu, 28 Apr 2016   Prob (F-statistic):           2.68e-10
Time:                        19:09:49   Log-Likelihood:                -4505.5
No. Observations:                1000   AIC:                             9015.
Df Residuals:                     998   BIC:                             9025.
Df Model:                           1
==============================================================================
                 coef    std err          t      P>|t|      [95.0% Conf. Int.]
------------------------------------------------------------------------------
intercept     -5.1013      0.817     -6.243      0.000        -6.705    -3.498
tsp7576       -9.8540      1.544     -6.382      0.000       -12.884    -6.824
==============================================================================
Omnibus:                      521.430   Durbin-Watson:                   1.900
Prob(Omnibus):                  0.000   Jarque-Bera (JB):            13678.349
Skew:                          -1.838   Prob(JB):                         0.00
Kurtosis:                      20.742   Cond. No.                         2.44
==============================================================================

X_1: first stage tsp7576 coefficient:
-9.85395322927
                            OLS Regression Results
==============================================================================
Dep. Variable:                dlhouse   R-squared:                       0.009
Model:                            OLS   Adj. R-squared:                  0.008
```

```
Method:                 Least Squares   F-statistic:                     9.026
Date:                Thu, 28 Apr 2016   Prob (F-statistic):            0.00273
Time:                        19:09:49   Log-Likelihood:                 342.33
No. Observations:                1000   AIC:                            -680.7
Df Residuals:                     998   BIC:                            -670.8
Df Model:                           1
==============================================================================
                 coef    std err          t      P>|t|      [95.0% Conf. Int.]
------------------------------------------------------------------------------
intercept      0.2642      0.006     41.214      0.000         0.252     0.277
tsp7576        0.0364      0.012      3.004      0.003         0.013     0.060
==============================================================================
Omnibus:                       69.692   Durbin-Watson:                   1.047
Prob(Omnibus):                  0.000   Jarque-Bera (JB):              113.534
Skew:                           0.518   Prob(JB):                     2.22e-25
Kurtosis:                       4.286   Cond. No.                         2.44
==============================================================================


X_1: reduced form tsp7576 coefficient:
0.0363932219048
```

```
/usr/local/lib/python2.7/dist-packages/ipykernel/__main__.py:216: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: http://pandas.pydata.org/pandas-docs/stable/indexing.html#
indexing-view-versus-copy
```

```
X_1: IV estimate: -0.00369326107584
                            OLS Regression Results
==============================================================================
Dep. Variable:                dlhouse   R-squared:                       0.009
Model:                            OLS   Adj. R-squared:                  0.008
Method:                 Least Squares   F-statistic:                     9.026
Date:                Thu, 28 Apr 2016   Prob (F-statistic):            0.00273
Time:                        19:09:49   Log-Likelihood:                 342.33
No. Observations:                1000   AIC:                            -680.7
Df Residuals:                     998   BIC:                            -670.8
Df Model:                           1
==============================================================================
                 coef    std err          t      P>|t|      [95.0% Conf. Int.]
------------------------------------------------------------------------------
intercept      0.2453      0.011     22.126      0.000         0.224     0.267
dgtsp_hat     -0.0037      0.001     -3.004      0.003        -0.006    -0.001
==============================================================================
Omnibus:                       69.692   Durbin-Watson:                   1.047
Prob(Omnibus):                  0.000   Jarque-Bera (JB):              113.534
Skew:                           0.518   Prob(JB):                     2.22e-25
Kurtosis:                       4.286   Cond. No.                         18.6
==============================================================================


X_2
                            OLS Regression Results
==============================================================================
Dep. Variable:                  dgtsp   R-squared:                       0.119
Model:                            OLS   Adj. R-squared:                  0.091
Method:                 Least Squares   F-statistic:                     4.333
Date:                Thu, 28 Apr 2016   Prob (F-statistic):           5.81e-13
Time:                        19:09:49   Log-Likelihood:                -4280.1
No. Observations:                 962   AIC:                             8620.
Df Residuals:                     932   BIC:                             8766.
Df Model:                          29
==============================================================================
                 coef    std err          t      P>|t|      [95.0% Conf. Int.]
------------------------------------------------------------------------------
ddens          0.0009      0.003      0.281      0.779        -0.005     0.007
dmnfcg        52.1047     20.384      2.556      0.011        12.100    92.109
dwhite       -11.9107     16.772     -0.710      0.478       -44.827    21.005
dfeml         86.3239     92.598      0.932      0.351       -95.401   268.049
dage65        72.0942     68.490      1.053      0.293       -62.318   206.506
dhs          -13.3483     26.069     -0.512      0.609       -64.508    37.812
dcoll         67.1590     37.494      1.791      0.074        -6.423   140.740
durban       -10.1453      9.783     -1.037      0.300       -29.345     9.055
dunemp        20.1578     42.375      0.476      0.634       -63.004   103.320
dincome        0.0024      0.002      1.523      0.128        -0.001     0.005
dpoverty     -13.4282     30.082     -0.446      0.655       -72.465    45.609
downer         9.9094     17.135      0.578      0.563       -23.719    43.538
dplumb       -17.2102     33.829     -0.509      0.611       -83.601    49.180
drevenue       0.0030      0.004      0.696      0.486        -0.005     0.011
dtaxprop      -0.0154      0.006     -2.660      0.008        -0.027    -0.004
depend        -0.0029      0.005     -0.647      0.518        -0.012     0.006
deduc         -1.0129      9.095     -0.111      0.911       -18.861    16.835
dhghwy        -4.4420     21.911     -0.203      0.839       -47.443    38.559
dwelfr       -12.5714     18.689     -0.673      0.501       -49.248    24.105
dhlth         -7.8801     12.375     -0.637      0.524       -32.166    16.406
vacant70     164.2036     95.315      1.723      0.085       -22.852   351.260
vacant80      16.8748     26.121      0.646      0.518       -34.387    68.137
```

```
vacrnt70      14.6256     26.977      0.542      0.588     -38.317    67.568
blt1080       18.5584     13.471      1.378      0.169      -7.878    44.994
blt2080      -11.8607     23.635     -0.502      0.616     -58.246    34.524
bltold80       6.2804     12.679      0.495      0.620     -18.603    31.164
tsp7576       -6.5183      2.107     -3.093      0.002     -10.654    -2.383
mtspgm74      -0.2715      0.070     -3.901      0.000      -0.408    -0.135
mtspgm75       0.1596      0.068      2.338      0.020       0.026     0.294
intercept     -9.9169     11.475     -0.864      0.388     -32.437    12.604
==============================================================================
Omnibus:                      514.119   Durbin-Watson:                   1.916
Prob(Omnibus):                  0.000   Jarque-Bera (JB):            15770.558
Skew:                          -1.848   Prob(JB):                         0.00
Kurtosis:                      22.488   Cond. No.                     1.89e+05
==============================================================================

Warnings:
[1] The condition number is large, 1.89e+05. This might indicate that there are
strong multicollinearity or other numerical problems.


X_2: first stage tsp7576 coefficient:
-6.51828681598
                            OLS Regression Results
==============================================================================
Dep. Variable:                dlhouse   R-squared:                       0.569
Model:                            OLS   Adj. R-squared:                  0.556
Method:                 Least Squares   F-statistic:                     42.43
Date:                Thu, 28 Apr 2016   Prob (F-statistic):          1.28e-148
Time:                        19:09:49   Log-Likelihood:                 735.33
No. Observations:                 962   AIC:                            -1411.
Df Residuals:                     932   BIC:                            -1265.
Df Model:                          29
==============================================================================
                 coef    std err          t      P>|t|      [95.0% Conf. Int.]
------------------------------------------------------------------------------
ddens      -6.938e-06   1.75e-05     -0.397      0.692     -4.12e-05  2.74e-05
dmnfcg        -0.0547      0.111     -0.493      0.622        -0.272     0.163
dwhite        -0.5296      0.091     -5.802      0.000        -0.709    -0.350
dfeml         -0.7348      0.504     -1.458      0.145        -1.724     0.254
dage65        -1.7494      0.373     -4.694      0.000        -2.481    -1.018
dhs            0.4084      0.142      2.879      0.004         0.130     0.687
dcoll          0.2186      0.204      1.071      0.284        -0.182     0.619
durban        -0.1241      0.053     -2.331      0.020        -0.229    -0.020
dunemp        -0.9334      0.231     -4.047      0.000        -1.386    -0.481
dincome     6.722e-05   8.46e-06      7.947      0.000      5.06e-05  8.38e-05
dpoverty      -0.6205      0.164     -3.790      0.000        -0.942    -0.299
downer        -0.1349      0.093     -1.446      0.148        -0.318     0.048
dplumb        -0.1652      0.184     -0.897      0.370        -0.527     0.196
drevenue    1.955e-05   2.34e-05      0.834      0.404     -2.64e-05  6.55e-05
dtaxprop   -7.503e-05   3.15e-05     -2.385      0.017        -0.000 -1.33e-05
depend     -3.154e-05   2.47e-05     -1.277      0.202         -8e-05  1.69e-05
deduc          0.1134      0.049      2.290      0.022         0.016     0.210
dhghwy        -0.1713      0.119     -1.437      0.151        -0.405     0.063
dwelfr        -0.3207      0.102     -3.153      0.002        -0.520    -0.121
dhlth         -0.0532      0.067     -0.790      0.430        -0.185     0.079
vacant70      -0.9395      0.519     -1.811      0.070        -1.958     0.078
vacant80       0.5380      0.142      3.785      0.000         0.259     0.817
vacrnt70      -0.1216      0.147     -0.828      0.408        -0.410     0.167
blt1080        0.3329      0.073      4.542      0.000         0.189     0.477
blt2080       -0.9507      0.129     -7.391      0.000        -1.203    -0.698
bltold80      -0.2211      0.069     -3.204      0.001        -0.356    -0.086
tsp7576        0.0177      0.011      1.540      0.124        -0.005     0.040
mtspgm74       0.0016      0.000      4.173      0.000         0.001     0.002
mtspgm75      -0.0017      0.000     -4.494      0.000        -0.002    -0.001
intercept      0.2831      0.062      4.533      0.000         0.161     0.406
==============================================================================
Omnibus:                       73.169   Durbin-Watson:                   1.414
Prob(Omnibus):                  0.000   Jarque-Bera (JB):              137.848
Skew:                           0.507   Prob(JB):                     1.17e-30
Kurtosis:                       4.553   Cond. No.                     1.89e+05
==============================================================================

Warnings:
[1] The condition number is large, 1.89e+05. This might indicate that there are
strong multicollinearity or other numerical problems.


X_2: reduced form tsp7576 coefficient:
0.0176592751237
X_2: IV estimate: -0.00270918964173
                            OLS Regression Results
==============================================================================
Dep. Variable:                dlhouse   R-squared:                       0.569
Model:                            OLS   Adj. R-squared:                  0.556
Method:                 Least Squares   F-statistic:                     42.43
Date:                Thu, 28 Apr 2016   Prob (F-statistic):          1.28e-148
Time:                        19:09:49   Log-Likelihood:                 735.33
```

```
No. Observations:                 962   AIC:                            -1411.
Df Residuals:                     932   BIC:                            -1265.
Df Model:                          29
==============================================================================
                 coef    std err          t      P>|t|      [95.0% Conf. Int.]
------------------------------------------------------------------------------
ddens      -4.492e-06   1.75e-05     -0.257      0.797     -3.88e-05  2.98e-05
dmnfcg         0.0864      0.142      0.607      0.544        -0.193     0.366
dwhite        -0.5619      0.093     -6.047      0.000        -0.744    -0.380
dfeml         -0.5009      0.526     -0.953      0.341        -1.532     0.531
dage65        -1.5541      0.390     -3.987      0.000        -2.319    -0.789
dhs            0.3723      0.143      2.595      0.010         0.091     0.654
dcoll          0.4005      0.231      1.736      0.083        -0.052     0.853
durban        -0.1516      0.057     -2.674      0.008        -0.263    -0.040
dunemp        -0.8788      0.233     -3.775      0.000        -1.336    -0.422
dincome     7.363e-05   9.18e-06      8.024      0.000      5.56e-05  9.16e-05
dpoverty      -0.6569      0.169     -3.890      0.000        -0.988    -0.326
downer        -0.1080      0.095     -1.133      0.257        -0.295     0.079
dplumb        -0.2118      0.188     -1.127      0.260        -0.581     0.157
drevenue    2.767e-05   2.42e-05      1.145      0.252     -1.97e-05  7.51e-05
dtaxprop      -0.0001   4.13e-05     -2.826      0.005        -0.000 -3.56e-05
depend     -3.949e-05   2.55e-05     -1.549      0.122     -8.95e-05  1.06e-05
deduc          0.1106      0.050      2.233      0.026         0.013     0.208
dhghwy        -0.1834      0.120     -1.533      0.126        -0.418     0.051
dwelfr        -0.3548      0.104     -3.417      0.001        -0.558    -0.151
dhlth         -0.0745      0.069     -1.087      0.278        -0.209     0.060
vacant70      -0.4947      0.617     -0.802      0.423        -1.705     0.716
vacant80       0.5838      0.144      4.057      0.000         0.301     0.866
vacrnt70      -0.0820      0.147     -0.557      0.578        -0.371     0.207
blt1080        0.3832      0.079      4.827      0.000         0.227     0.539
blt2080       -0.9828      0.129     -7.603      0.000        -1.236    -0.729
bltold80      -0.2040      0.070     -2.910      0.004        -0.342    -0.066
mtspgm74       0.0008      0.001      1.201      0.230        -0.001     0.002
mtspgm75      -0.0012      0.000     -2.844      0.005        -0.002    -0.000
intercept      0.2563      0.063      4.078      0.000         0.133     0.380
dgtsp_hat     -0.0027      0.002     -1.540      0.124        -0.006     0.001
==============================================================================
Omnibus:                       73.169   Durbin-Watson:                   1.414
Prob(Omnibus):                  0.000   Jarque-Bera (JB):              137.848
Skew:                           0.507   Prob(JB):                     1.17e-30
Kurtosis:                       4.553   Cond. No.                     2.31e+05
==============================================================================

Warnings:
[1] The condition number is large, 2.31e+05. This might indicate that there are
strong multicollinearity or other numerical problems.


X_3
                            OLS Regression Results
==============================================================================
Dep. Variable:                  dgtsp   R-squared:                       0.849
Model:                            OLS   Adj. R-squared:                  0.786
Method:                 Least Squares   F-statistic:                     13.35
Date:                Thu, 28 Apr 2016   Prob (F-statistic):           1.43e-57
Time:                        19:09:50   Log-Likelihood:                -1197.4
No. Observations:                 331   AIC:                             2593.
Df Residuals:                     232   BIC:                             2969.
Df Model:                          98
==============================================================================
                 coef    std err          t      P>|t|      [95.0% Conf. Int.]
------------------------------------------------------------------------------
region        -0.1653      0.661     -0.250      0.803        -1.467     1.137
inchs          0.0584      0.053      1.112      0.267        -0.045     0.162
dlincome     -89.9238    111.138     -0.809      0.419      -308.892   129.044
lhouse70       5.3509     17.224      0.311      0.756       -28.585    39.287
incage         0.0856      0.134      0.641      0.522        -0.178     0.349
age6570       63.5019     77.067      0.824      0.411       -88.339   215.342
hs3        -1687.4154   3863.464     -0.437      0.663     -9299.373  5924.543
owner70       32.5558     19.110      1.704      0.090        -5.095    70.207
welfr70      -15.8921     28.543     -0.557      0.578       -72.129    40.345
TOTOBS70       0.0169      0.004      4.821      0.000         0.010     0.024
MAX1V80        0.0026      0.005      0.482      0.631        -0.008     0.013
built202     908.1756   1011.346      0.898      0.370     -1084.421  2900.772
XAROBS74      -0.0223      0.081     -0.275      0.784        -0.182     0.138
revnue70      -0.0014      0.011     -0.129      0.898        -0.023     0.020
MTSPGM83       0.0377      0.169      0.223      0.824        -0.296     0.371
vacant70     138.0168    181.642      0.760      0.448      -219.861   495.895
built102     -81.4795     78.479     -1.038      0.300      -236.103    73.144
dage65      -127.0932    143.606     -0.885      0.377      -410.031   155.845
urban80        2.2782      7.975      0.286      0.775       -13.435    17.991
age3       -4297.1617   5.26e+04     -0.082      0.935     -1.08e+05  9.93e+04
XAROBS72       0.0550      0.045      1.223      0.222        -0.034     0.143
MAX1V78       -0.0041      0.007     -0.567      0.572        -0.018     0.010
dpoverty     -53.5883     55.638     -0.963      0.336      -163.209    56.032
pcthghw2       7.0780    319.139      0.022      0.982      -621.703   635.859
pctwelf3    -979.4367   1436.845     -0.682      0.496     -3810.369  1851.496
whtage      -760.3433   1902.234     -0.400      0.690     -4508.204  2987.517
```

dwelfr	15.0630	36.941	0.408	0.684	-57.719	87.846
hospbed2	-4.436e-06	3.53e-06	-1.255	0.211	-1.14e-05	2.53e-06
dunemp	-29.2411	64.856	-0.451	0.653	-157.024	98.542
built203	-1007.9768	1393.720	-0.723	0.470	-3753.943	1737.989
white70	0.4033	34.400	0.012	0.991	-67.373	68.180
pop7080	-1.117e-05	1.54e-05	-0.723	0.470	-4.16e-05	1.93e-05
coll2	335.8045	922.352	0.364	0.716	-1481.452	2153.061
vacrnt70	12.8388	41.608	0.309	0.758	-69.139	94.817
pcteduc2	61.7698	82.496	0.749	0.455	-100.767	224.307
vacant80	73.7602	50.108	1.472	0.142	-24.964	172.485
XGMOBS82	-0.0210	0.030	-0.701	0.484	-0.080	0.038
feml80	-62.5351	105.655	-0.592	0.555	-270.702	145.632
epend2	-3.997e-06	4.79e-06	-0.834	0.405	-1.34e-05	5.45e-06
house70	0.0001	0.000	0.381	0.704	-0.001	0.001
dfeml	-7.9380	203.211	-0.039	0.969	-408.313	392.437
XAROBS83	-0.0274	0.033	-0.822	0.412	-0.093	0.038
XAROBS77	0.0163	0.047	0.345	0.731	-0.077	0.110
pophs	0.0360	0.171	0.211	0.833	-0.300	0.372
MTSPAR73	0.1245	0.230	0.541	0.589	-0.329	0.578
educ80	4.1129	18.855	0.218	0.828	-33.036	41.261
unemp70	-35.0823	68.726	-0.510	0.610	-170.490	100.325
TOTOBS74	-0.0110	0.007	-1.494	0.137	-0.026	0.004
XGMOBS77	-0.0158	0.041	-0.382	0.703	-0.097	0.066
XTSPAR74	-0.0147	0.036	-0.410	0.682	-0.085	0.056
MAX1V76	-0.0061	0.004	-1.438	0.152	-0.015	0.002
hlth80	-25.8147	15.484	-1.667	0.097	-56.322	4.693
hs70	20.8747	26.094	0.800	0.425	-30.537	72.286
MTSPGM84	-0.0401	0.155	-0.258	0.797	-0.346	0.266
gtsp7780	1.0271	0.257	4.004	0.000	0.522	1.533
TOTOBS72	0.0038	0.004	0.979	0.328	-0.004	0.011
XGMOBS73	0.0461	0.025	1.829	0.069	-0.004	0.096
polic80	21.6946	102.688	0.211	0.833	-180.625	224.014
linc70	-43.6459	73.622	-0.593	0.554	-188.698	101.406
femal3	68.9136	300.586	0.229	0.819	-523.314	661.142
age6580	-60.8976	92.947	-0.655	0.513	-244.025	122.230
MAX2V70	-0.0902	0.005	-17.039	0.000	-0.101	-0.080
plumb80	124.3085	82.797	1.501	0.135	-38.822	287.438
femal2	1887.8294	9047.588	0.209	0.835	-1.59e+04	1.97e+04
poverty3	-746.3027	3753.398	-0.199	0.843	-8141.406	6648.800
povrty80	-84.1690	50.630	-1.662	0.098	-183.921	15.583
MTSPGM74	-0.2250	0.109	-2.065	0.040	-0.440	-0.010
fstate	0.1008	0.064	1.566	0.119	-0.026	0.228
dhghwy	22.0220	44.389	0.496	0.620	-65.435	109.479
dincome	-0.0085	0.016	-0.543	0.588	-0.039	0.022
XAROBS71	0.0643	0.025	2.614	0.010	0.016	0.113
epend70	0.0127	0.010	1.296	0.196	-0.007	0.032
inccoll	0.0452	0.079	0.575	0.566	-0.110	0.200
XGMOBS72	-0.0583	0.050	-1.174	0.242	-0.156	0.040
revenue2	6.979e-07	2.94e-06	0.238	0.812	-5.08e-06	6.48e-06
TOTOBS76	0.0021	0.005	0.412	0.681	-0.008	0.012
blt1080	-8.1680	59.306	-0.138	0.891	-125.016	108.680
TOTOBS75	0.0003	0.007	0.042	0.967	-0.014	0.015
lrent80	-16.1082	13.281	-1.213	0.226	-42.275	10.058
mnfcg80	4.3119	14.128	0.305	0.760	-23.524	32.147
income80	0.0006	0.008	0.082	0.935	-0.014	0.016
MTSPAR78	0.0437	0.168	0.261	0.795	-0.287	0.374
TOTOBS71	-0.0016	0.003	-0.476	0.634	-0.008	0.005
hs2	281.3381	940.605	0.299	0.765	-1571.881	2134.557
MTSPGM73	-0.5084	0.253	-2.008	0.046	-1.007	-0.009
manwhite	621.2448	605.507	1.026	0.306	-571.750	1814.240
MAX1V73	0.0152	0.006	2.673	0.008	0.004	0.026
MAX2V71	-0.0187	0.005	-3.861	0.000	-0.028	-0.009
downer	-5.0839	33.014	-0.154	0.878	-70.130	59.962
dmnfcg	98.6471	53.460	1.845	0.066	-6.682	203.976
MTSPAR69	-0.0837	0.016	-5.359	0.000	-0.114	-0.053
hospbed3	1.247e-09	1.48e-09	0.841	0.401	-1.67e-09	4.17e-09
blt2080	-278.8630	236.819	-1.178	0.240	-745.453	187.727
bltold80	-65.3324	19.863	-3.289	0.001	-104.467	-26.198
XGMOBS75	0.0050	0.031	0.162	0.871	-0.056	0.066
txprop80	0.0061	0.009	0.685	0.494	-0.012	0.024
rent70	-0.0384	0.038	-1.009	0.314	-0.113	0.037
drevenue	0.0028	0.008	0.334	0.739	-0.014	0.019
mnfcg2	680.6806	573.541	1.187	0.237	-449.334	1810.695
hghwy70	-33.0704	36.628	-0.903	0.368	-105.236	39.095
pctpol3	-528.0439	4511.827	-0.117	0.907	-9417.434	8361.346
MTSPGM77	-0.0886	0.144	-0.615	0.539	-0.372	0.195
educ70	-7.1610	16.788	-0.427	0.670	-40.237	25.915
MAX1V77	0.0018	0.002	0.872	0.384	-0.002	0.006
poptot80	2.045e-05	3.01e-05	0.680	0.497	-3.88e-05	7.97e-05
crime82	5.314e-08	4.22e-08	1.260	0.209	-2.99e-08	1.36e-07
XAROBS84	0.0732	0.036	2.042	0.042	0.003	0.144
MAX1V75	0.0072	0.006	1.201	0.231	-0.005	0.019
ddens	-0.0078	0.024	-0.321	0.748	-0.055	0.040
XTSPGM75	0.0220	0.045	0.485	0.628	-0.067	0.111
white80	-3.6965	35.362	-0.105	0.917	-73.367	65.974
XGMOBS74	0.0304	0.081	0.374	0.709	-0.130	0.191
povrty70	-31.5016	41.833	-0.753	0.452	-113.922	50.919

```
XAROBS76     -0.0397      0.024     -1.690      0.092        -0.086     0.007
intercept   462.7005    549.670      0.842      0.401      -620.282  1545.683
tsp7576       0.4082      2.048      0.199      0.842        -3.627     4.444
==============================================================================
Omnibus:                       41.017   Durbin-Watson:                   2.046
Prob(Omnibus):                  0.000   Jarque-Bera (JB):              206.790
Skew:                           0.318   Prob(JB):                     1.25e-45
Kurtosis:                       6.820   Cond. No.                          nan
==============================================================================

Warnings:
[1] The smallest eigenvalue is -0.00827. This might indicate that there are
strong multicollinearity problems or that the design matrix is singular.


X_3: first stage tsp7576 coefficient:
0.408180519449
                            OLS Regression Results
==============================================================================
Dep. Variable:                dlhouse   R-squared:                       0.869
Model:                            OLS   Adj. R-squared:                  0.813
Method:                 Least Squares   F-statistic:                     15.67
Date:                Thu, 28 Apr 2016   Prob (F-statistic):           4.79e-64
Time:                        19:09:52   Log-Likelihood:                 436.17
No. Observations:                 331   AIC:                            -674.3
Df Residuals:                     232   BIC:                            -297.9
Df Model:                          98
==============================================================================
                 coef    std err          t      P>|t|      [95.0% Conf. Int.]
------------------------------------------------------------------------------
region         0.0277      0.005      5.829      0.000         0.018     0.037
inchs         -0.0001      0.000     -0.343      0.732        -0.001     0.001
dlincome       0.4630      0.799      0.580      0.563        -1.111     2.037
lhouse70      -0.5845      0.124     -4.721      0.000        -0.828    -0.341
incage        -0.0003      0.001     -0.331      0.741        -0.002     0.002
age6570        0.4133      0.554      0.746      0.456        -0.678     1.505
hs3           -5.4369     27.771     -0.196      0.845       -60.153    49.279
owner70       -0.6889      0.137     -5.015      0.000        -0.960    -0.418
welfr70        0.4402      0.205      2.146      0.033         0.036     0.844
TOTOBS70    8.436e-06   2.52e-05      0.335      0.738     -4.12e-05  5.81e-05
MAX1V80     3.004e-05   3.82e-05      0.787      0.432     -4.51e-05     0.000
built202     -11.9030      7.270     -1.637      0.103       -26.226     2.420
XAROBS74       0.0004      0.001      0.702      0.483        -0.001     0.002
revnue70    1.081e-05   7.94e-05      0.136      0.892        -0.000     0.000
MTSPGM83      -0.0010      0.001     -0.781      0.435        -0.003     0.001
vacant70      -3.0813      1.306     -2.360      0.019        -5.654    -0.509
built102      -1.3906      0.564     -2.465      0.014        -2.502    -0.279
dage65         0.5930      1.032      0.574      0.566        -1.441     2.627
urban80       -0.0697      0.057     -1.215      0.226        -0.183     0.043
age3         302.9151    377.864      0.802      0.424      -441.569  1047.399
XAROBS72   -6.273e-05      0.000     -0.194      0.846        -0.001     0.001
MAX1V78    -1.597e-05   5.15e-05     -0.310      0.757        -0.000  8.54e-05
dpoverty      -0.0915      0.400     -0.229      0.819        -0.879     0.696
pcthghw2       1.3445      2.294      0.586      0.558        -3.175     5.864
pctwelf3      20.8003     10.328      2.014      0.045         0.451    41.149
whtage        -2.8147     13.674     -0.206      0.837       -29.755    24.125
dwelfr        -0.1588      0.266     -0.598      0.550        -0.682     0.364
hospbed2   -3.123e-08   2.54e-08     -1.229      0.220     -8.13e-08  1.88e-08
dunemp        -0.5605      0.466     -1.202      0.231        -1.479     0.358
built203      16.4704     10.018      1.644      0.102        -3.268    36.209
white70        0.5922      0.247      2.395      0.017         0.105     1.079
pop7080    -1.381e-07   1.11e-07     -1.244      0.215     -3.57e-07  8.07e-08
coll2         -1.1123      6.630     -0.168      0.867       -14.175    11.950
vacrnt70      -0.4770      0.299     -1.595      0.112        -1.066     0.112
pcteduc2      -0.2490      0.593     -0.420      0.675        -1.417     0.919
vacant80      -0.4828      0.360     -1.340      0.181        -1.192     0.227
XGMOBS82       0.0004      0.000      2.016      0.045      9.84e-06     0.001
feml80        -0.4328      0.759     -0.570      0.569        -1.929     1.063
epend2      -4.93e-08   3.44e-08     -1.431      0.154     -1.17e-07  1.86e-08
house70     5.789e-06   2.49e-06      2.323      0.021       8.8e-07  1.07e-05
dfeml         -0.3929      1.461     -0.269      0.788        -3.271     2.485
XAROBS83      -0.0003      0.000     -1.193      0.234        -0.001     0.000
XAROBS77      -0.0002      0.000     -0.482      0.630        -0.001     0.001
pophs          0.0017      0.001      1.402      0.162        -0.001     0.004
MTSPAR73      -0.0009      0.002     -0.526      0.600        -0.004     0.002
educ80         0.0244      0.136      0.180      0.857        -0.243     0.291
unemp70        0.0400      0.494      0.081      0.936        -0.933     1.013
TOTOBS74   -7.715e-06   5.32e-05     -0.145      0.885        -0.000   9.7e-05
XGMOBS77       0.0002      0.000      0.551      0.582        -0.000     0.001
XTSPAR74      -0.0002      0.000     -0.914      0.362        -0.001     0.000
MAX1V76     1.359e-05   3.07e-05      0.442      0.659     -4.69e-05  7.41e-05
hlth80         0.1215      0.111      1.092      0.276        -0.098     0.341
hs70           0.5808      0.188      3.096      0.002         0.211     0.950
MTSPGM84       0.0006      0.001      0.510      0.611        -0.002     0.003
gtsp7780       0.0023      0.002      1.221      0.223        -0.001     0.006
TOTOBS72   -5.911e-06   2.77e-05     -0.213      0.831     -6.05e-05  4.87e-05
XGMOBS73      -0.0002      0.000     -1.132      0.259        -0.001     0.000
```

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polic80       0.0687      0.738      0.093      0.926        -1.386     1.523
linc70        0.0639      0.529      0.121      0.904        -0.979     1.107
femal3       -0.3438      2.161     -0.159      0.874        -4.601     3.913
age6580       0.8377      0.668      1.254      0.211        -0.479     2.154
MAX2V70    2.564e-05    3.8e-05      0.674      0.501     -4.93e-05     0.000
plumb80      -0.3191      0.595     -0.536      0.592        -1.492     0.854
femal2       13.4227     65.035      0.206      0.837      -114.713   141.558
poverty3     -5.0142     26.980     -0.186      0.853       -58.171    48.143
povrty80      0.1268      0.364      0.348      0.728        -0.590     0.844
MTSPGM74      0.0005      0.001      0.658      0.511        -0.001     0.002
fstate       -0.0006      0.000     -1.299      0.195        -0.002     0.000
dhghwy        0.2545      0.319      0.798      0.426        -0.374     0.883
dincome    4.832e-05      0.000      0.431      0.667        -0.000     0.000
XAROBS71     -0.0002      0.000     -1.350      0.178        -0.001     0.000
epend70   -7.859e-05   7.05e-05     -1.115      0.266        -0.000  6.02e-05
inccoll      -0.0002      0.001     -0.324      0.746        -0.001     0.001
XGMOBS72      0.0001      0.000      0.419      0.675        -0.001     0.001
revenue2   7.354e-08   2.11e-08      3.486      0.001       3.2e-08  1.15e-07
TOTOBS76   4.622e-05   3.67e-05      1.260      0.209     -2.61e-05     0.000
blt1080       1.2423      0.426      2.914      0.004         0.402     2.082
TOTOBS75  -1.289e-05   5.24e-05     -0.246      0.806        -0.000  9.03e-05
lrent80       0.5195      0.095      5.442      0.000         0.331     0.708
mnfcg80       0.1803      0.102      1.776      0.077        -0.020     0.380
income80  -9.234e-07    5.5e-05     -0.017      0.987        -0.000     0.000
MTSPAR78     -0.0004      0.001     -0.299      0.765        -0.003     0.002
TOTOBS71  -1.727e-05   2.42e-05     -0.714      0.476       -6.5e-05  3.04e-05
hs2           5.1582      6.761      0.763      0.446        -8.163    18.479
MTSPGM73     -0.0001      0.002     -0.081      0.936        -0.004     0.003
manwhite     -8.4516      4.352     -1.942      0.053       -17.027     0.124
MAX1V73   -4.523e-05   4.09e-05     -1.107      0.270        -0.000  3.53e-05
MAX2V71   -1.292e-05   3.47e-05     -0.372      0.710     -8.14e-05  5.55e-05
downer       -0.1132      0.237     -0.477      0.634        -0.581     0.354
dmnfcg       -1.0920      0.384     -2.842      0.005        -1.849    -0.335
MTSPAR69  -2.201e-05      0.000     -0.196      0.845        -0.000     0.000
hospbed3    1.01e-11   1.06e-11      0.948      0.344     -1.09e-11  3.11e-11
blt2080       2.5384      1.702      1.491      0.137        -0.816     5.892
bltold80      0.1853      0.143      1.298      0.196        -0.096     0.467
XGMOBS75      0.0002      0.000      0.940      0.348        -0.000     0.001
txprop80   3.772e-05   6.44e-05      0.586      0.559     -8.91e-05     0.000
rent70       -0.0002      0.000     -0.887      0.376        -0.001     0.000
drevenue     -0.0001   6.06e-05     -2.342      0.020        -0.000 -2.25e-05
mnfcg2       -1.2469      4.123     -0.302      0.763        -9.370     6.876
hghwy70       0.3450      0.263      1.310      0.191        -0.174     0.864
pctpol3     -27.7296     32.432     -0.855      0.393       -91.628    36.169
MTSPGM77     -0.0005      0.001     -0.449      0.653        -0.003     0.002
educ70        0.0429      0.121      0.355      0.723        -0.195     0.281
MAX1V77     -1.28e-05   1.48e-05     -0.867      0.387     -4.19e-05  1.63e-05
poptot80   2.919e-07   2.16e-07      1.351      0.178     -1.34e-07  7.18e-07
crime82   -2.554e-10   3.03e-10     -0.843      0.400     -8.52e-10  3.42e-10
XAROBS84     -0.0003      0.000     -0.981      0.328        -0.001     0.000
MAX1V75   -2.824e-05   4.34e-05     -0.651      0.516        -0.000  5.72e-05
ddens        -0.0003      0.000     -1.564      0.119        -0.001  7.05e-05
XTSPGM75   1.297e-05      0.000      0.040      0.968        -0.001     0.001
white80      -0.4882      0.254     -1.920      0.056        -0.989     0.013
XGMOBS74     -0.0003      0.001     -0.514      0.608        -0.001     0.001
povrty70      0.2740      0.301      0.911      0.363        -0.318     0.866
XAROBS76     -0.0001      0.000     -0.676      0.500        -0.000     0.000
intercept     2.3069      3.951      0.584      0.560        -5.478    10.092
tsp7576       0.0252      0.015      1.710      0.089        -0.004     0.054
==============================================================================
Omnibus:                        0.855   Durbin-Watson:                   1.639
Prob(Omnibus):                  0.652   Jarque-Bera (JB):                0.612
Skew:                           0.057   Prob(JB):                        0.736
Kurtosis:                       3.177   Cond. No.                          nan
==============================================================================

Warnings:
[1] The smallest eigenvalue is -0.00827. This might indicate that there are
strong multicollinearity problems or that the design matrix is singular.


X_3: reduced form tsp7576 coefficient:
0.0251801195173
X_3: IV estimate: 0.0616905607797
                            OLS Regression Results
==============================================================================
Dep. Variable:                dlhouse   R-squared:                       0.869
Model:                            OLS   Adj. R-squared:                  0.813
Method:                 Least Squares   F-statistic:                     15.67
Date:                Thu, 28 Apr 2016   Prob (F-statistic):           4.79e-64
Time:                        19:09:54   Log-Likelihood:                 436.17
No. Observations:                 331   AIC:                            -674.3
Df Residuals:                     232   BIC:                            -297.9
Df Model:                          98
==============================================================================
                 coef    std err          t      P>|t|      [95.0% Conf. Int.]
------------------------------------------------------------------------------
region        0.0379      0.007      5.075      0.000         0.023     0.053
```

```
inchs        -0.0037      0.002     -1.773      0.078        -0.008     0.000
dlincome      6.0103      3.290      1.827      0.069        -0.471    12.492
lhouse70     -0.9146      0.228     -4.005      0.000        -1.364    -0.465
incage       -0.0056      0.003     -1.711      0.088        -0.012     0.001
age6570      -3.6083      2.392     -1.508      0.133        -8.322     1.105
hs3          98.6646     67.087      1.471      0.143       -33.512   230.842
owner70      -2.6973      1.191     -2.264      0.025        -5.045    -0.350
welfr70       1.4206      0.620      2.291      0.023         0.199     2.642
TOTOBS70     -0.0010      0.001     -1.690      0.092        -0.002     0.000
MAX1V80      -0.0001   9.72e-05     -1.313      0.190        -0.000  6.39e-05
built202    -67.9282     34.061     -1.994      0.047      -135.036    -0.821
XAROBS74      0.0018      0.001      1.780      0.076        -0.000     0.004
revnue70   9.847e-05   9.39e-05      1.049      0.295     -8.64e-05     0.000
MTSPGM83     -0.0033      0.002     -1.769      0.078        -0.007     0.000
vacant70    -11.5958      5.106     -2.271      0.024       -21.655    -1.537
built102      3.6358      2.923      1.244      0.215        -2.123     9.394
dage65        8.3294      4.723      1.764      0.079        -0.976    17.634
urban80      -0.2102      0.098     -2.144      0.033        -0.403    -0.017
age3        568.0123    407.177      1.395      0.164      -234.225  1370.249
XAROBS72     -0.0035      0.002     -1.750      0.081        -0.007     0.000
MAX1V78       0.0002      0.000      1.591      0.113     -5.58e-05     0.001
dpoverty      3.2015      1.919      1.668      0.097        -0.580     6.983
pcthghw2      0.9078      2.341      0.388      0.698        -3.704     5.519
pctwelf3     81.2230     35.959      2.259      0.025        10.376   152.070
whtage       44.0928     30.706      1.436      0.152       -16.405   104.591
dwelfr       -1.0881      0.576     -1.889      0.060        -2.223     0.047
hospbed2   2.424e-07   1.61e-07      1.504      0.134     -7.53e-08    5.6e-07
dunemp        1.2434      1.180      1.054      0.293        -1.081     3.568
built203     78.6524     38.293      2.054      0.041         3.207   154.098
white70       0.5673      0.247      2.299      0.022         0.081     1.053
pop7080    5.511e-07   4.18e-07      1.320      0.188     -2.72e-07  1.37e-06
coll2       -21.8270     13.570     -1.608      0.109       -48.564     4.910
vacrnt70     -1.2690      0.556     -2.282      0.023        -2.364    -0.174
pcteduc2     -4.0595      2.298     -1.766      0.079        -8.588     0.469
vacant80     -5.0331      2.719     -1.851      0.065       -10.390     0.324
XGMOBS82      0.0017      0.001      2.188      0.030         0.000     0.003
feml80        3.4248      2.372      1.444      0.150        -1.248     8.097
epend2     1.973e-07   1.49e-07      1.325      0.187     -9.61e-08  4.91e-07
house70   -2.351e-06   5.31e-06     -0.442      0.659     -1.28e-05  8.12e-06
dfeml         0.0964      1.459      0.066      0.947        -2.777     2.970
XAROBS83      0.0014      0.001      1.379      0.169        -0.001     0.003
XAROBS77     -0.0012      0.001     -1.672      0.096        -0.003     0.000
pophs        -0.0005      0.002     -0.284      0.776        -0.004     0.003
MTSPAR73     -0.0085      0.005     -1.745      0.082        -0.018     0.001
educ80       -0.2293      0.197     -1.164      0.246        -0.617     0.159
unemp70       2.2043      1.390      1.586      0.114        -0.535     4.943
TOTOBS74      0.0007      0.000      1.678      0.095        -0.000     0.001
XGMOBS77      0.0011      0.001      1.750      0.082        -0.000     0.002
XTSPAR74      0.0007      0.001      1.237      0.217        -0.000     0.002
MAX1V76       0.0004      0.000      1.789      0.075     -3.98e-05     0.001
hlth80        1.7140      0.941      1.822      0.070        -0.139     3.567
hs70         -0.7070      0.782     -0.905      0.367        -2.247     0.833
MTSPGM84      0.0030      0.002      1.611      0.108        -0.001     0.007
gtsp7780     -0.0611      0.037     -1.639      0.103        -0.135     0.012
TOTOBS72     -0.0002      0.000     -1.715      0.088        -0.001  3.56e-05
XGMOBS73     -0.0031      0.002     -1.838      0.067        -0.006     0.000
polic80      -1.2697      1.079     -1.177      0.240        -3.395     0.856
linc70        2.7563      1.655      1.666      0.097        -0.503     6.016
femal3        0.5394      3.246      0.166      0.868        -5.857     6.935
age6580       4.6987      2.340      2.008      0.046         0.089     9.308
MAX2V70       0.0056      0.003      1.718      0.087        -0.001     0.012
plumb80      -7.9877      4.549     -1.756      0.080       -16.949     0.974
femal2     -103.1854     92.927     -1.110      0.268      -286.275    79.904
poverty3     41.0255     38.089      1.077      0.283       -34.019   116.070
povrty80      5.3320      3.028      1.761      0.080        -0.634    11.298
MTSPGM74      0.0144      0.008      1.799      0.073        -0.001     0.030
fstate       -0.0068      0.004     -1.856      0.065        -0.014     0.000
dhghwy       -1.1040      0.869     -1.271      0.205        -2.815     0.607
dincome       0.0006      0.000      1.732      0.085     -7.86e-05     0.001
XAROBS71     -0.0042      0.002     -1.817      0.071        -0.009     0.000
epend70      -0.0009      0.000     -1.858      0.064        -0.002  5.23e-05
inccoll      -0.0030      0.002     -1.674      0.095        -0.006     0.001
XGMOBS72      0.0037      0.002      1.803      0.073        -0.000     0.008
revenue2   3.048e-08   3.32e-08      0.920      0.359     -3.48e-08  9.58e-08
TOTOBS76  -8.363e-05   7.73e-05     -1.082      0.281        -0.000  6.87e-05
blt1080       1.7462      0.549      3.181      0.002         0.665     2.828
TOTOBS75  -3.176e-05   5.43e-05     -0.585      0.559        -0.000  7.51e-05
lrent80       1.5132      0.588      2.571      0.011         0.354     2.673
mnfcg80      -0.0857      0.191     -0.449      0.654        -0.462     0.291
income80    -3.95e-05   5.96e-05     -0.663      0.508        -0.000  7.79e-05
MTSPAR78     -0.0031      0.002     -1.604      0.110        -0.007     0.001
TOTOBS71   8.169e-05   6.14e-05      1.330      0.185     -3.93e-05     0.000
hs2         -12.1989     12.345     -0.988      0.324       -36.521    12.123
MTSPGM73      0.0312      0.019      1.678      0.095        -0.005     0.068
manwhite    -46.7766     22.963     -2.037      0.043       -92.019    -1.534
MAX1V73      -0.0010      0.001     -1.788      0.075        -0.002     0.000
MAX2V71       0.0011      0.001      1.683      0.094        -0.000     0.002
```

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downer         0.2005      0.298      0.673      0.502        -0.387     0.788
dmnfcg        -7.1776      3.598     -1.995      0.047       -14.266    -0.089
MTSPAR69       0.0051      0.003      1.704      0.090        -0.001     0.011
hospbed3   -6.675e-11   4.57e-11     -1.459      0.146     -1.57e-10  2.34e-11
blt2080       19.7414     10.329      1.911      0.057        -0.610    40.093
bltold80       4.2157      2.374      1.776      0.077        -0.462     8.894
XGMOBS75      -0.0001      0.000     -0.361      0.719        -0.001     0.000
txprop80      -0.0003      0.000     -1.473      0.142        -0.001     0.000
rent70         0.0021      0.001      1.490      0.137        -0.001     0.005
drevenue      -0.0003      0.000     -2.588      0.010        -0.001 -7.53e-05
mnfcg2       -43.2382     24.616     -1.757      0.080       -91.737     5.261
hghwy70        2.3851      1.238      1.926      0.055        -0.055     4.825
pctpol3        4.8461     38.299      0.127      0.899       -70.613    80.305
MTSPGM77       0.0050      0.003      1.449      0.149        -0.002     0.012
educ70         0.4846      0.284      1.706      0.089        -0.075     1.044
MAX1V77       -0.0001   6.67e-05     -1.847      0.066        -0.000  8.21e-06
poptot80   -9.695e-07   7.69e-07     -1.261      0.208     -2.48e-06  5.45e-07
crime82    -3.533e-09   1.91e-09     -1.854      0.065     -7.29e-09  2.22e-10
XAROBS84      -0.0048      0.003     -1.793      0.074        -0.010     0.000
MAX1V75       -0.0005      0.000     -1.783      0.076        -0.001  4.98e-05
ddens          0.0002      0.000      0.639      0.524        -0.000     0.001
XTSPGM75      -0.0013      0.001     -1.556      0.121        -0.003     0.000
white80       -0.2602      0.277     -0.940      0.348        -0.806     0.285
XGMOBS74      -0.0022      0.001     -1.708      0.089        -0.005     0.000
povrty70       2.2045      1.187      1.858      0.064        -0.134     4.543
XAROBS76       0.0023      0.001      1.639      0.102        -0.000     0.005
intercept    -26.2368     17.104     -1.534      0.126       -59.935     7.461
dgtsp_hat      0.0617      0.036      1.710      0.089        -0.009     0.133
==============================================================================
Omnibus:                        0.858   Durbin-Watson:                   1.639
Prob(Omnibus):                  0.651   Jarque-Bera (JB):                0.615
Skew:                           0.058   Prob(JB):                        0.735
Kurtosis:                       3.177   Cond. No.                          nan
==============================================================================

Warnings:
[1] The smallest eigenvalue is -0.0103. This might indicate that there are
strong multicollinearity problems or that the design matrix is singular.


X_1
                            OLS Regression Results
==============================================================================
Dep. Variable:                  dgtsp   R-squared:                       0.042
Model:                            OLS   Adj. R-squared:                  0.041
Method:                 Least Squares   F-statistic:                     43.05
Date:                Thu, 28 Apr 2016   Prob (F-statistic):           8.64e-11
Time:                        19:09:56   Log-Likelihood:                -4380.5
No. Observations:                 975   AIC:                             8765.
Df Residuals:                     973   BIC:                             8775.
Df Model:                           1
==============================================================================
                 coef    std err          t      P>|t|      [95.0% Conf. Int.]
------------------------------------------------------------------------------
intercept     -5.1772      0.798     -6.484      0.000        -6.744    -3.610
tsp75        -10.5599      1.609     -6.562      0.000       -13.718    -7.402
==============================================================================
Omnibus:                      505.183   Durbin-Watson:                   1.859
Prob(Omnibus):                  0.000   Jarque-Bera (JB):            14285.473
Skew:                          -1.793   Prob(JB):                         0.00
Kurtosis:                      21.406   Cond. No.                         2.49
==============================================================================


X_1: first stage tsp75 coefficient:
-10.5599254927
                            OLS Regression Results
==============================================================================
Dep. Variable:                dlhouse   R-squared:                       0.008
Model:                            OLS   Adj. R-squared:                  0.007
Method:                 Least Squares   F-statistic:                     8.153
Date:                Thu, 28 Apr 2016   Prob (F-statistic):            0.00439
Time:                        19:09:56   Log-Likelihood:                 328.84
No. Observations:                 975   AIC:                            -653.7
Df Residuals:                     973   BIC:                            -643.9
Df Model:                           1
==============================================================================
                 coef    std err          t      P>|t|      [95.0% Conf. Int.]
------------------------------------------------------------------------------
intercept      0.2653      0.006     41.612      0.000         0.253     0.278
tsp75          0.0367      0.013      2.855      0.004         0.011     0.062
==============================================================================
Omnibus:                       70.215   Durbin-Watson:                   1.057
Prob(Omnibus):                  0.000   Jarque-Bera (JB):              114.236
Skew:                           0.531   Prob(JB):                     1.56e-25
Kurtosis:                       4.298   Cond. No.                         2.49
==============================================================================
```

```
X_1: reduced form tsp75 coefficient:
0.0366977705017
X_1: IV estimate: -0.00347519218078
                            OLS Regression Results
==============================================================================
Dep. Variable:                dlhouse   R-squared:                       0.008
Model:                            OLS   Adj. R-squared:                  0.007
Method:                 Least Squares   F-statistic:                     8.153
Date:                Thu, 28 Apr 2016   Prob (F-statistic):            0.00439
Time:                        19:09:56   Log-Likelihood:                 328.84
No. Observations:                 975   AIC:                            -653.7
Df Residuals:                     973   BIC:                            -643.9
Df Model:                           1
==============================================================================
                 coef    std err          t      P>|t|      [95.0% Conf. Int.]
------------------------------------------------------------------------------
intercept      0.2474      0.011     22.558      0.000         0.226     0.269
dgtsp_hat     -0.0035      0.001     -2.855      0.004        -0.006    -0.001
==============================================================================
Omnibus:                       70.215   Durbin-Watson:                   1.057
Prob(Omnibus):                  0.000   Jarque-Bera (JB):              114.236
Skew:                           0.531   Prob(JB):                     1.56e-25
Kurtosis:                       4.298   Cond. No.                         18.0
==============================================================================


X_2
/usr/local/lib/python2.7/dist-packages/ipykernel/__main__.py:251: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: http://pandas.pydata.org/pandas-docs/stable/indexing.html#
indexing-view-versus-copy
                            OLS Regression Results
==============================================================================
Dep. Variable:                  dgtsp   R-squared:                       0.119
Model:                            OLS   Adj. R-squared:                  0.090
Method:                 Least Squares   F-statistic:                     4.184
Date:                Thu, 28 Apr 2016   Prob (F-statistic):           1.23e-12
Time:                        19:09:56   Log-Likelihood:                -4280.1
No. Observations:                 962   AIC:                             8622.
Df Residuals:                     931   BIC:                             8773.
Df Model:                          30
==============================================================================
                 coef    std err          t      P>|t|      [95.0% Conf. Int.]
------------------------------------------------------------------------------
ddens       3.647e-06      0.003      0.001      0.999        -0.006     0.006
dmnfcg         0.2319     35.525      0.007      0.995       -69.486    69.950
dwhite        -0.0588     18.136     -0.003      0.997       -35.650    35.532
dfeml          0.4287    106.336      0.004      0.997      -208.257   209.114
dage65         0.3180     78.870      0.004      0.997      -154.465   155.101
dhs           -0.0655     27.227     -0.002      0.998       -53.498    53.367
dcoll          0.2974     52.411      0.006      0.995      -102.560   103.155
durban        -0.0420     11.294     -0.004      0.997       -22.207    22.123
dunemp         0.0870     43.738      0.002      0.998       -85.749    85.923
dincome       1.1e-05      0.002      0.005      0.996        -0.004     0.004
dpoverty      -0.0727     31.945     -0.002      0.998       -62.765    62.620
downer         0.0447     18.119      0.002      0.998       -35.515    35.604
dplumb        -0.0849     35.666     -0.002      0.998       -70.080    69.910
drevenue    1.403e-05      0.005      0.003      0.998        -0.009     0.009
dtaxprop   -7.075e-05      0.011     -0.007      0.995        -0.021     0.021
depend     -1.398e-05      0.005     -0.003      0.998        -0.010     0.010
deduc         -0.0111      9.178     -0.001      0.999       -18.023    18.000
dhghwy        -0.0213     22.102     -0.001      0.999       -43.397    43.355
dwelfr        -0.0597     20.062     -0.003      0.998       -39.432    39.313
dhlth         -0.0403     13.284     -0.003      0.998       -26.111    26.030
vacant70       0.7679    138.468      0.006      0.996      -270.977   272.513
vacant80       0.0695     27.414      0.003      0.998       -53.732    53.871
vacrnt70       0.0705     28.015      0.003      0.998       -54.910    55.051
blt1080        0.0915     17.399      0.005      0.996       -34.055    34.238
blt2080       -0.0586     24.527     -0.002      0.998       -48.193    48.076
bltold80       0.0327     13.327      0.002      0.998       -26.121    26.187
mtspgm74      -0.0011      0.170     -0.006      0.995        -0.336     0.333
mtspgm75       0.0006      0.102      0.006      0.995        -0.201     0.202
intercept     -0.0503     12.671     -0.004      0.997       -24.918    24.817
dgtsp_hat      0.9953      0.581      1.714      0.087        -0.145     2.135
tsp75         -0.0378      3.916     -0.010      0.992        -7.722     7.647
==============================================================================
Omnibus:                      514.115   Durbin-Watson:                   1.916
Prob(Omnibus):                  0.000   Jarque-Bera (JB):            15770.348
Skew:                          -1.848   Prob(JB):                         0.00
Kurtosis:                      22.488   Cond. No.                     3.07e+05
==============================================================================

Warnings:
```

```
[1] The condition number is large, 3.07e+05. This might indicate that there are
strong multicollinearity or other numerical problems.


X_2: first stage tsp75 coefficient:
-0.0378290867166
                            OLS Regression Results
==============================================================================
Dep. Variable:                dlhouse   R-squared:                       0.570
Model:                            OLS   Adj. R-squared:                  0.556
Method:                 Least Squares   F-statistic:                     41.06
Date:                Thu, 28 Apr 2016   Prob (F-statistic):          4.99e-148
Time:                        19:09:56   Log-Likelihood:                 735.89
No. Observations:                 962   AIC:                            -1410.
Df Residuals:                     931   BIC:                            -1259.
Df Model:                          30
==============================================================================
                 coef    std err          t      P>|t|      [95.0% Conf. Int.]
------------------------------------------------------------------------------
ddens      -2.364e-06   1.76e-05     -0.134      0.893     -3.69e-05  3.22e-05
dmnfcg         0.2218      0.193      1.148      0.251        -0.157     0.601
dwhite        -0.5962      0.099     -6.044      0.000        -0.790    -0.403
dfeml         -0.2507      0.578     -0.433      0.665        -1.386     0.884
dage65        -1.3685      0.429     -3.190      0.001        -2.210    -0.527
dhs            0.3340      0.148      2.256      0.024         0.043     0.625
dcoll          0.5742      0.285      2.014      0.044         0.015     1.134
durban        -0.1761      0.061     -2.867      0.004        -0.297    -0.056
dunemp        -0.8280      0.238     -3.481      0.001        -1.295    -0.361
dincome     8.005e-05   1.11e-05      7.232      0.000      5.83e-05     0.000
dpoverty      -0.6994      0.174     -4.025      0.000        -1.040    -0.358
downer        -0.0819      0.099     -0.831      0.406        -0.275     0.111
dplumb        -0.2614      0.194     -1.348      0.178        -0.642     0.119
drevenue    3.586e-05   2.54e-05      1.411      0.159      -1.4e-05  8.57e-05
dtaxprop      -0.0002   5.74e-05     -2.754      0.006        -0.000 -4.54e-05
depend     -4.765e-05   2.67e-05     -1.786      0.074        -0.000  4.72e-06
deduc          0.1041      0.050      2.086      0.037         0.006     0.202
dhghwy        -0.1958      0.120     -1.629      0.104        -0.432     0.040
dwelfr        -0.3896      0.109     -3.570      0.000        -0.604    -0.175
dhlth         -0.0981      0.072     -1.357      0.175        -0.240     0.044
vacant70      -0.0464      0.753     -0.062      0.951        -1.524     1.432
vacant80       0.6243      0.149      4.187      0.000         0.332     0.917
vacrnt70      -0.0408      0.152     -0.268      0.789        -0.340     0.258
blt1080        0.4366      0.095      4.614      0.000         0.251     0.622
blt2080       -1.0170      0.133     -7.624      0.000        -1.279    -0.755
bltold80      -0.1850      0.072     -2.552      0.011        -0.327    -0.043
mtspgm74       0.0002      0.001      0.236      0.813        -0.002     0.002
mtspgm75      -0.0009      0.001     -1.571      0.117        -0.002     0.000
intercept      0.2269      0.069      3.292      0.001         0.092     0.362
dgtsp_hat     -0.0054      0.003     -1.719      0.086        -0.012     0.001
tsp75         -0.0221      0.021     -1.037      0.300        -0.064     0.020
==============================================================================
Omnibus:                       74.453   Durbin-Watson:                   1.412
Prob(Omnibus):                  0.000   Jarque-Bera (JB):              141.674
Skew:                           0.511   Prob(JB):                     1.72e-31
Kurtosis:                       4.578   Cond. No.                     3.07e+05
==============================================================================

Warnings:
[1] The condition number is large, 3.07e+05. This might indicate that there are
strong multicollinearity or other numerical problems.


X_2: reduced form tsp75 coefficient:
-0.0220829309408
X_2: IV estimate: -0.00270346245856
                            OLS Regression Results
==============================================================================
Dep. Variable:                dlhouse   R-squared:                       0.569
Model:                            OLS   Adj. R-squared:                  0.556
Method:                 Least Squares   F-statistic:                     42.43
Date:                Thu, 28 Apr 2016   Prob (F-statistic):          1.29e-148
Time:                        19:09:56   Log-Likelihood:                 735.33
No. Observations:                 962   AIC:                            -1411.
Df Residuals:                     932   BIC:                            -1265.
Df Model:                          29
==============================================================================
                 coef    std err          t      P>|t|      [95.0% Conf. Int.]
------------------------------------------------------------------------------
ddens      -4.495e-06   1.75e-05     -0.257      0.797     -3.88e-05  2.98e-05
dmnfcg         0.0861      0.142      0.605      0.545        -0.193     0.366
dwhite        -0.5618      0.093     -6.046      0.000        -0.744    -0.379
dfeml         -0.5014      0.526     -0.954      0.340        -1.533     0.530
dage65        -1.5545      0.390     -3.988      0.000        -2.320    -0.789
dhs            0.3723      0.143      2.596      0.010         0.091     0.654
dcoll          0.4002      0.231      1.735      0.083        -0.053     0.853
durban        -0.1515      0.057     -2.673      0.008        -0.263    -0.040
dunemp        -0.8789      0.233     -3.775      0.000        -1.336    -0.422
dincome     7.362e-05   9.18e-06      8.023      0.000      5.56e-05  9.16e-05
```

```
dlincome     7.362e-05   9.18e-06      8.023      0.000      5.56e-05  9.16e-05
dpoverty       -0.6568      0.169     -3.889      0.000        -0.988    -0.325
downer         -0.1081      0.095     -1.134      0.257        -0.295     0.079
dplumb         -0.2117      0.188     -1.126      0.260        -0.581     0.157
drevenue     2.765e-05   2.42e-05      1.145      0.253     -1.98e-05  7.51e-05
dtaxprop       -0.0001   4.13e-05     -2.824      0.005        -0.000 -3.56e-05
depend      -3.947e-05   2.55e-05     -1.548      0.122     -8.95e-05  1.06e-05
deduc           0.1106      0.050      2.233      0.026         0.013     0.208
dhghwy         -0.1833      0.120     -1.533      0.126        -0.418     0.051
dwelfr         -0.3547      0.104     -3.416      0.001        -0.558    -0.151
dhlth          -0.0745      0.069     -1.086      0.278        -0.209     0.060
vacant70       -0.4958      0.617     -0.804      0.422        -1.706     0.715
vacant80        0.5837      0.144      4.057      0.000         0.301     0.866
vacrnt70       -0.0820      0.147     -0.557      0.577        -0.371     0.207
blt1080         0.3831      0.079      4.826      0.000         0.227     0.539
blt2080        -0.9827      0.129     -7.603      0.000        -1.236    -0.729
bltold80       -0.2041      0.070     -2.911      0.004        -0.342    -0.066
mtspgm74        0.0008      0.001      1.204      0.229        -0.001     0.002
mtspgm75       -0.0012      0.000     -2.846      0.005        -0.002    -0.000
intercept       0.2563      0.063      4.079      0.000         0.133     0.380
dgtsp_hat      -0.0027      0.002     -1.537      0.125        -0.006     0.001
==============================================================================
Omnibus:                       73.161   Durbin-Watson:                   1.414
Prob(Omnibus):                  0.000   Jarque-Bera (JB):              137.826
Skew:                           0.507   Prob(JB):                     1.18e-30
Kurtosis:                       4.553   Cond. No.                     2.31e+05
==============================================================================

Warnings:
[1] The condition number is large, 2.31e+05. This might indicate that there are
strong multicollinearity or other numerical problems.


X_3
                            OLS Regression Results
==============================================================================
Dep. Variable:                  dgtsp   R-squared:                       0.852
Model:                            OLS   Adj. R-squared:                  0.788
Method:                 Least Squares   F-statistic:                     13.39
Date:                Thu, 28 Apr 2016   Prob (F-statistic):           1.09e-57
Time:                        19:09:57   Log-Likelihood:                -1195.0
No. Observations:                 331   AIC:                             2590.
Df Residuals:                     231   BIC:                             2970.
Df Model:                          99
==============================================================================
                 coef    std err          t      P>|t|      [95.0% Conf. Int.]
------------------------------------------------------------------------------
region         -2.1525      1.556     -1.384      0.168        -5.218     0.913
inchs           0.7265      0.489      1.486      0.139        -0.237     1.690
dlincome    -1116.3105    755.743     -1.477      0.141     -2605.340   372.719
lhouse70       66.5294     47.867      1.390      0.166       -27.782   160.840
incage          1.0830      0.740      1.464      0.145        -0.375     2.541
age6570       793.2809    541.339      1.465      0.144      -273.312  1859.874
hs3         -2.129e+04   1.48e+04     -1.440      0.151     -5.04e+04  7839.157
owner70       405.1673    274.088      1.478      0.141      -134.864   945.199
welfr70      -191.3388    134.368     -1.424      0.156      -456.082    73.404
TOTOBS70        0.2106      0.142      1.485      0.139        -0.069     0.490
MAX1V80         0.0316      0.022      1.454      0.147        -0.011     0.075
built202     1.108e+04   7620.384      1.454      0.147     -3934.419  2.61e+04
XAROBS74       -0.2802      0.205     -1.363      0.174        -0.685     0.125
revnue70       -0.0202      0.017     -1.191      0.235        -0.054     0.013
MTSPGM83        0.5125      0.377      1.358      0.176        -0.231     1.256
vacant70     1727.7465   1170.860      1.476      0.141      -579.184  4034.677
built102    -1030.7030    688.349     -1.497      0.136     -2386.947   325.541
dage65      -1552.3025   1063.753     -1.459      0.146     -3648.200   543.595
urban80        28.0186     20.330      1.378      0.169       -12.037    68.075
age3        -6.249e+04   6.57e+04     -0.951      0.342     -1.92e+05  6.69e+04
XAROBS72        0.6816      0.459      1.487      0.138        -0.222     1.585
MAX1V78        -0.0515      0.034     -1.493      0.137        -0.119     0.016
dpoverty     -657.0775    443.095     -1.483      0.139     -1530.102   215.947
pcthghw2       11.8179    323.992      0.036      0.971      -626.539   650.175
pctwelf3    -1.221e+04   8266.405     -1.478      0.141     -2.85e+04  4072.603
whtage      -9656.6937   6729.932     -1.435      0.153     -2.29e+04  3603.202
dwelfr        199.7880    134.193      1.489      0.138       -64.610   464.186
hospbed2    -5.584e-05   3.75e-05     -1.488      0.138        -0.000  1.81e-05
dunemp       -357.4530    252.912     -1.413      0.159      -855.762   140.856
built203    -1.228e+04   8492.303     -1.446      0.150      -2.9e+04  4452.764
white70         4.5702     34.237      0.133      0.894       -62.887    72.028
pop7080        -0.0001    9.5e-05     -1.468      0.143        -0.000  4.77e-05
coll2        4117.5690   2911.679      1.414      0.159     -1619.273  9854.411
vacrnt70      158.4176    115.103      1.376      0.170       -68.368   385.204
pcteduc2      788.0918    531.554      1.483      0.140      -259.222  1835.406
vacant80      913.0097    620.491      1.471      0.143      -309.536  2135.555
XGMOBS82       -0.2615      0.179     -1.464      0.145        -0.613     0.090
feml80       -780.4326    534.395     -1.460      0.146     -1833.345   272.480
epend2      -4.837e-05   3.33e-05     -1.453      0.148        -0.000  1.72e-05
house70         0.0016      0.001      1.426      0.155        -0.001     0.004
dfeml        -134.6756    214.578     -0.628      0.531      -557.455   288.104
```

```
XAROBS83      -0.3453      0.234     -1.477      0.141        -0.806     0.115
XAROBS77       0.1965      0.144      1.367      0.173        -0.087     0.480
pophs          0.4399      0.341      1.291      0.198        -0.231     1.111
MTSPAR73       1.5772      1.089      1.448      0.149        -0.569     3.723
educ80        56.1113     40.778      1.376      0.170       -24.233   136.456
unemp70     -438.4895    305.221     -1.437      0.152     -1039.863   162.884
TOTOBS74      -0.1387      0.093     -1.487      0.138        -0.323     0.045
XGMOBS77      -0.1936      0.138     -1.402      0.162        -0.466     0.078
XTSPAR74      -0.1917      0.128     -1.498      0.135        -0.444     0.060
MAX1V76       -0.0761      0.051     -1.489      0.138        -0.177     0.025
hlth80      -320.4276    216.625     -1.479      0.140      -747.241   106.385
hs70         266.9284    180.300      1.480      0.140       -88.313   622.170
MTSPGM84      -0.5278      0.387     -1.365      0.174        -1.290     0.234
gtsp7780      12.7637      8.613      1.482      0.140        -4.207    29.734
TOTOBS72       0.0465      0.032      1.468      0.143        -0.016     0.109
XGMOBS73       0.5766      0.387      1.489      0.138        -0.186     1.339
polic80      277.9258    211.756      1.312      0.191      -139.295   695.146
linc70      -529.6397    366.527     -1.445      0.150     -1251.803   192.524
femal3       340.6824    472.618      0.721      0.472      -590.511  1271.876
age6580     -748.9738    518.081     -1.446      0.150     -1769.741   271.794
MAX2V70       -1.1231      0.756     -1.486      0.139        -2.612     0.366
plumb80     1569.1813   1056.072      1.486      0.139      -511.583  3649.945
femal2      2.387e+04   1.82e+04      1.310      0.191      -1.2e+04  5.98e+04
poverty3   -9918.2708   7517.393     -1.319      0.188     -2.47e+04  4893.149
povrty80   -1044.0167    703.127     -1.485      0.139     -2429.378   341.345
MTSPGM74      -2.8376      1.891     -1.500      0.135        -6.564     0.889
fstate         1.2371      0.840      1.473      0.142        -0.418     2.892
dhghwy       265.4162    187.130      1.418      0.157      -103.283   634.115
dincome       -0.1045      0.073     -1.440      0.151        -0.247     0.038
XAROBS71       0.8010      0.538      1.487      0.138        -0.260     1.862
epend70        0.1600      0.108      1.485      0.139        -0.052     0.372
inccoll        0.5744      0.396      1.451      0.148        -0.206     1.354
XGMOBS72      -0.7169      0.482     -1.486      0.139        -1.668     0.234
revenue2    7.878e-06   6.26e-06      1.259      0.209     -4.45e-06  2.02e-05
TOTOBS76       0.0265      0.018      1.482      0.140        -0.009     0.062
blt1080      -92.4368     90.926     -1.017      0.310      -271.587    86.714
TOTOBS75       0.0055      0.008      0.679      0.498        -0.010     0.021
lrent80     -200.6693    135.616     -1.480      0.140      -467.872    66.533
mnfcg80       53.4429     39.147      1.365      0.174       -23.687   130.573
income80       0.0063      0.009      0.707      0.480        -0.011     0.024
MTSPAR78       0.5485      0.397      1.382      0.168        -0.233     1.330
TOTOBS71      -0.0203      0.014     -1.462      0.145        -0.048     0.007
hs2         3581.8037   2581.712      1.387      0.167     -1504.908  8668.516
MTSPGM73      -6.3676      4.298     -1.482      0.140       -14.835     2.100
manwhite    7731.7286   5249.317      1.473      0.142     -2610.931  1.81e+04
MAX1V73        0.1886      0.127      1.483      0.139        -0.062     0.439
MAX2V71       -0.2323      0.157     -1.484      0.139        -0.541     0.076
downer       -63.3971     53.625     -1.182      0.238      -169.053    42.259
dmnfcg      1240.2234    834.918      1.485      0.139      -404.804  2885.250
MTSPAR69      -1.0437      0.702     -1.487      0.138        -2.426     0.339
hospbed3    1.578e-08   1.06e-08      1.486      0.139     -5.15e-09  3.67e-08
blt2080    -3417.9713   2335.609     -1.463      0.145     -8019.791  1183.848
bltold80    -815.4448    549.679     -1.483      0.139     -1898.471   267.581
XGMOBS75       0.0583      0.050      1.172      0.243        -0.040     0.156
txprop80       0.0765      0.052      1.463      0.145        -0.027     0.180
rent70        -0.4819      0.327     -1.475      0.142        -1.126     0.162
drevenue       0.0346      0.025      1.373      0.171        -0.015     0.084
mnfcg2      8543.0261   5737.389      1.489      0.138     -2761.275  1.98e+04
hghwy70     -415.7583    282.565     -1.471      0.143      -972.492   140.976
pctpol3    -6293.4589   6297.597     -0.999      0.319     -1.87e+04  6114.612
MTSPGM77      -1.0680      0.749     -1.426      0.155        -2.544     0.408
educ70       -93.0503     63.824     -1.458      0.146      -218.801    32.701
MAX1V77        0.0222      0.015      1.466      0.144        -0.008     0.052
poptot80       0.0003      0.000      1.465      0.144     -8.8e-05     0.001
crime82     6.649e-07   4.46e-07      1.492      0.137     -2.13e-07  1.54e-06
XAROBS84       0.9109      0.615      1.482      0.140        -0.300     2.122
MAX1V75        0.0909      0.061      1.480      0.140        -0.030     0.212
ddens         -0.0960      0.069     -1.400      0.163        -0.231     0.039
XTSPGM75       0.2831      0.194      1.458      0.146        -0.100     0.666
white80      -45.3676     45.486     -0.997      0.320      -134.987    44.252
XGMOBS74       0.3762      0.269      1.397      0.164        -0.154     0.907
povrty70    -389.6375    266.662     -1.461      0.145      -915.039   135.764
XAROBS76      -0.4887      0.330     -1.482      0.140        -1.138     0.161
intercept   5643.9753   3860.652      1.462      0.145     -1962.617  1.33e+04
dgtsp_hat    -11.4559      8.380     -1.367      0.173       -27.967     5.055
tsp75          6.8139      3.683      1.850      0.066        -0.442    14.070
==============================================================================
Omnibus:                       40.407   Durbin-Watson:                   2.031
Prob(Omnibus):                  0.000   Jarque-Bera (JB):              194.174
Skew:                           0.330   Prob(JB):                     6.85e-43
Kurtosis:                       6.694   Cond. No.                          nan
==============================================================================

Warnings:
[1] The smallest eigenvalue is -0.0114. This might indicate that there are
strong multicollinearity problems or that the design matrix is singular.
```

```
X_3: first stage tsp75 coefficient:
6.81392673115
                            OLS Regression Results
==============================================================================
Dep. Variable:                dlhouse   R-squared:                       0.869
Model:                            OLS   Adj. R-squared:                  0.813
Method:                 Least Squares   F-statistic:                     15.45
Date:                Thu, 28 Apr 2016   Prob (F-statistic):           1.82e-63
Time:                        19:09:59   Log-Likelihood:                 436.24
No. Observations:                 331   AIC:                            -672.5
Df Residuals:                     231   BIC:                            -292.3
Df Model:                          99
==============================================================================
                 coef    std err          t      P>|t|      [95.0% Conf. Int.]
------------------------------------------------------------------------------
region         0.0405      0.011      3.592      0.000         0.018     0.063
inchs         -0.0046      0.004     -1.301      0.195        -0.012     0.002
dlincome       7.3481      5.471      1.343      0.181        -3.432    18.128
lhouse70      -0.9943      0.347     -2.869      0.004        -1.677    -0.311
incage        -0.0069      0.005     -1.287      0.199        -0.017     0.004
age6570       -4.5364      3.919     -1.157      0.248       -12.258     3.185
hs3          124.1738    107.022      1.160      0.247       -86.690   335.037
owner70       -3.1828      1.984     -1.604      0.110        -7.093     0.727
welfr70        1.6499      0.973      1.696      0.091        -0.267     3.567
TOTOBS70      -0.0013      0.001     -1.252      0.212        -0.003     0.001
MAX1V80       -0.0002      0.000     -1.051      0.294        -0.000     0.000
built202     -81.2062     55.170     -1.472      0.142      -189.906    27.494
XAROBS74       0.0021      0.001      1.427      0.155        -0.001     0.005
revnue70       0.0001      0.000      0.998      0.319        -0.000     0.000
MTSPGM83      -0.0039      0.003     -1.424      0.156        -0.009     0.001
vacant70     -13.6662      8.477     -1.612      0.108       -30.368     3.035
built102       4.8710      4.983      0.977      0.329        -4.948    14.690
dage65        10.2123      7.701      1.326      0.186        -4.961    25.386
urban80       -0.2438      0.147     -1.656      0.099        -0.534     0.046
age3         642.8365    475.514      1.352      0.178      -294.062  1579.735
XAROBS72      -0.0043      0.003     -1.286      0.200        -0.011     0.002
MAX1V78        0.0003      0.000      1.186      0.237        -0.000     0.001
dpoverty       3.9723      3.208      1.238      0.217        -2.348    10.293
pcthghw2       0.8937      2.346      0.381      0.704        -3.728     5.515
pctwelf3      95.8605     59.847      1.602      0.111       -22.054   213.775
whtage        55.6654     48.723      1.142      0.254       -40.333   151.664
dwelfr        -1.3275      0.972     -1.366      0.173        -3.242     0.587
hospbed2    3.094e-07   2.72e-07      1.139      0.256     -2.26e-07  8.45e-07
dunemp         1.6718      1.831      0.913      0.362        -1.936     5.279
built203      93.3681     61.482      1.519      0.130       -27.769   214.505
white70        0.5619      0.248      2.267      0.024         0.073     1.050
pop7080     7.183e-07   6.88e-07      1.045      0.297     -6.36e-07  2.07e-06
coll2        -26.7613     21.080     -1.270      0.206       -68.295    14.772
vacrnt70      -1.4588      0.833     -1.751      0.081        -3.101     0.183
pcteduc2      -5.0040      3.848     -1.300      0.195       -12.586     2.578
vacant80      -6.1272      4.492     -1.364      0.174       -14.978     2.724
XGMOBS82       0.0020      0.001      1.578      0.116        -0.001     0.005
feml80         4.3601      3.869      1.127      0.261        -3.263    11.983
epend2      2.552e-07   2.41e-07      1.059      0.291      -2.2e-07    7.3e-07
house70    -4.324e-06   8.36e-06     -0.517      0.605     -2.08e-05  1.21e-05
dfeml          0.2578      1.553      0.166      0.868        -2.803     3.319
XAROBS83       0.0018      0.002      1.074      0.284        -0.002     0.005
XAROBS77      -0.0014      0.001     -1.351      0.178        -0.003     0.001
pophs         -0.0010      0.002     -0.417      0.677        -0.006     0.004
MTSPAR73      -0.0104      0.008     -1.324      0.187        -0.026     0.005
educ80        -0.2966      0.295     -1.005      0.316        -0.878     0.285
unemp70        2.7298      2.210      1.235      0.218        -1.624     7.084
TOTOBS74       0.0008      0.001      1.243      0.215        -0.000     0.002
XGMOBS77       0.0014      0.001      1.372      0.171        -0.001     0.003
XTSPAR74       0.0009      0.001      0.973      0.332        -0.001     0.003
MAX1V76        0.0005      0.000      1.307      0.192        -0.000     0.001
hlth80         2.0980      1.568      1.338      0.182        -0.992     5.188
hs70          -1.0269      1.305     -0.787      0.432        -3.599     1.545
MTSPGM84       0.0037      0.003      1.312      0.191        -0.002     0.009
gtsp7780      -0.0764      0.062     -1.225      0.222        -0.199     0.046
TOTOBS72      -0.0003      0.000     -1.285      0.200        -0.001     0.000
XGMOBS73      -0.0037      0.003     -1.335      0.183        -0.009     0.002
polic80       -1.6027      1.533     -1.045      0.297        -4.623     1.418
linc70         3.3910      2.654      1.278      0.203        -1.837     8.619
femal3        -0.1081      3.422     -0.032      0.975        -6.850     6.634
age6580        5.5736      3.751      1.486      0.139        -1.816    12.964
MAX2V70        0.0069      0.005      1.268      0.206        -0.004     0.018
plumb80       -9.8682      7.646     -1.291      0.198       -24.932     5.196
femal2      -131.7801    131.863     -0.999      0.319      -391.587   128.027
poverty3      52.9107     54.424      0.972      0.332       -54.320   160.141
povrty80       6.5998      5.090      1.297      0.196        -3.430    16.629
MTSPGM74       0.0178      0.014      1.299      0.195        -0.009     0.045
fstate        -0.0083      0.006     -1.365      0.173        -0.020     0.004
dhghwy        -1.4221      1.355     -1.050      0.295        -4.091     1.247
dincome        0.0007      0.001      1.324      0.187        -0.000     0.002
XAROBS71      -0.0052      0.004     -1.325      0.186        -0.013     0.003
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epend70      -0.0011      0.001     -1.332      0.178        -0.003     0.000
inccoll      -0.0037      0.003     -1.277      0.203        -0.009     0.002
XGMOBS72      0.0046      0.003      1.318      0.189        -0.002     0.011
revenue2    2.104e-08   4.53e-08     0.464      0.643      -6.82e-08   1.1e-07
TOTOBS76     -0.0001      0.000     -0.892      0.373        -0.000     0.000
blt1080       1.8570      0.658      2.821      0.005         0.560     3.154
TOTOBS75   -3.833e-05   5.84e-05    -0.656      0.513        -0.000  7.68e-05
lrent80       1.7537      0.982      1.786      0.075        -0.181     3.688
mnfcg80      -0.1497      0.283     -0.528      0.598        -0.708     0.409
income80   -4.707e-05   6.46e-05    -0.728      0.467        -0.000  8.03e-05
MTSPAR78     -0.0037      0.003     -1.293      0.197        -0.009     0.002
TOTOBS71      0.0001      0.000      1.056      0.292      -9.17e-05    0.000
hs2         -16.4912     18.691     -0.882      0.379       -53.318    20.335
MTSPGM73      0.0388      0.031      1.249      0.213        -0.022     0.100
manwhite    -56.0418     38.004     -1.475      0.142      -130.920    18.836
MAX1V73      -0.0012      0.001     -1.313      0.191        -0.003     0.001
MAX2V71       0.0014      0.001      1.250      0.213        -0.001     0.004
downer        0.2765      0.388      0.712      0.477        -0.488     1.041
dmnfcg       -8.6638      6.045     -1.433      0.153       -20.573     3.246
MTSPAR69      0.0064      0.005      1.258      0.210        -0.004     0.016
hospbed3   -8.568e-11   7.69e-11    -1.114      0.266      -2.37e-10  6.58e-11
blt2080      23.8374     16.909      1.410      0.160        -9.479    57.153
bltold80      5.1929      3.980      1.305      0.193        -2.648    13.034
XGMOBS75     -0.0002      0.000     -0.473      0.637        -0.001     0.001
txprop80     -0.0004      0.000     -1.142      0.255        -0.001     0.000
rent70        0.0027      0.002      1.142      0.255        -0.002     0.007
drevenue     -0.0004      0.000     -1.959      0.051        -0.001  2.09e-06
mnfcg2      -53.4758     41.537     -1.287      0.199      -135.316    28.364
hghwy70       2.8833      2.046      1.409      0.160        -1.147     6.914
pctpol3      12.3874     45.593      0.272      0.786       -77.444   102.219
MTSPGM77      0.0063      0.005      1.158      0.248        -0.004     0.017
educ70        0.5962      0.462      1.290      0.198        -0.314     1.507
MAX1V77      -0.0001      0.000     -1.368      0.173        -0.000  6.59e-05
poptot80   -1.275e-06   1.26e-06    -1.012      0.313      -3.76e-06  1.21e-06
crime82     -4.33e-09   3.23e-09    -1.342      0.181      -1.07e-08  2.03e-09
XAROBS84     -0.0059      0.004     -1.317      0.189        -0.015     0.003
MAX1V75      -0.0006      0.000     -1.313      0.190        -0.001     0.000
ddens         0.0003      0.000      0.649      0.517        -0.001     0.001
XTSPGM75     -0.0017      0.001     -1.198      0.232        -0.004     0.001
white80      -0.2058      0.329     -0.625      0.533        -0.855     0.443
XGMOBS74     -0.0026      0.002     -1.349      0.179        -0.006     0.001
povrty70      2.6547      1.931      1.375      0.170        -1.149     6.459
XAROBS76      0.0029      0.002      1.225      0.222        -0.002     0.008
intercept   -33.0003     27.950     -1.181      0.239       -88.070    22.069
dgtsp_hat     0.0766      0.061      1.263      0.208        -0.043     0.196
tsp75        -0.0082      0.027     -0.306      0.760        -0.061     0.044
==============================================================================
Omnibus:                        0.919   Durbin-Watson:                   1.633
Prob(Omnibus):                  0.632   Jarque-Bera (JB):                0.672
Skew:                           0.060   Prob(JB):                        0.715
Kurtosis:                       3.185   Cond. No.                          nan
==============================================================================

Warnings:
[1] The smallest eigenvalue is -0.0114. This might indicate that there are
strong multicollinearity problems or that the design matrix is singular.


X_3: reduced form tsp75 coefficient:
-0.00816685798422
X_3: IV estimate: -0.000471408758903
                            OLS Regression Results
==============================================================================
Dep. Variable:                dlhouse   R-squared:                       0.867
Model:                            OLS   Adj. R-squared:                  0.811
Method:                 Least Squares   F-statistic:                     15.45
Date:                Thu, 28 Apr 2016   Prob (F-statistic):           1.86e-63
Time:                        19:10:01   Log-Likelihood:                 434.11
No. Observations:                 331   AIC:                            -670.2
Df Residuals:                     232   BIC:                            -293.8
Df Model:                          98
==============================================================================
                 coef    std err          t      P>|t|      [95.0% Conf. Int.]
------------------------------------------------------------------------------
region        0.0280      0.005      5.804      0.000         0.018     0.037
inchs        -0.0002      0.000     -0.370      0.712        -0.001     0.001
dlincome      0.5104      0.873      0.584      0.560        -1.211     2.231
lhouse70     -0.5839      0.126     -4.623      0.000        -0.833    -0.335
incage       -0.0002      0.001     -0.204      0.839        -0.002     0.002
age6570       0.4554      0.599      0.761      0.448        -0.724     1.635
hs3          -6.5790     28.716     -0.229      0.819       -63.156    49.998
owner70      -0.6577      0.188     -3.493      0.001        -1.029    -0.287
welfr70       0.4121      0.216      1.911      0.057        -0.013     0.837
TOTOBS70    1.941e-05   7.08e-05     0.274      0.784        -0.000     0.000
MAX1V80     2.652e-05   3.95e-05     0.671      0.503      -5.13e-05    0.000
built202    -10.5772      8.138     -1.300      0.195       -26.610     5.456
XAROBS74      0.0004      0.001      0.638      0.524        -0.001     0.002
revnue70     1.22e-05   8.01e-05     0.152      0.879        -0.000     0.000
```

MTSPGM83	-0.0009	0.001	-0.705	0.481	-0.003	0.002
vacant70	-3.0895	1.418	-2.179	0.030	-5.883	-0.296
built102	-1.3076	0.643	-2.033	0.043	-2.575	-0.040
dage65	0.4402	1.164	0.378	0.706	-1.853	2.733
urban80	-0.0731	0.058	-1.254	0.211	-0.188	0.042
age3	306.4641	380.576	0.805	0.421	-443.364	1056.292
XAROBS72	-9.858e-05	0.000	-0.256	0.799	-0.001	0.001
MAX1V78	-3.898e-06	5.33e-05	-0.073	0.942	-0.000	0.000
dpoverty	-0.0290	0.448	-0.065	0.949	-0.913	0.855
pcthghw2	1.8562	2.290	0.811	0.418	-2.656	6.368
pctwelf3	21.8466	11.007	1.985	0.048	0.160	43.533
whtage	-3.2880	14.077	-0.234	0.816	-31.023	24.447
dwelfr	-0.2058	0.271	-0.759	0.448	-0.740	0.328
hospbed2	-3.197e-08	3.08e-08	-1.037	0.301	-9.27e-08	2.88e-08
dunemp	-0.6247	0.483	-1.294	0.197	-1.576	0.326
built203	14.9526	10.829	1.381	0.169	-6.383	36.288
white70	0.5644	0.248	2.273	0.024	0.075	1.054
pop7080	-1.426e-07	1.2e-07	-1.189	0.236	-3.79e-07	9.37e-08
coll2	-1.4174	6.788	-0.209	0.835	-14.792	11.957
vacrnt70	-0.4613	0.305	-1.512	0.132	-1.062	0.140
pcteduc2	-0.2327	0.643	-0.362	0.718	-1.500	1.035
vacant80	-0.3884	0.464	-0.837	0.403	-1.303	0.526
XGMOBS82	0.0004	0.000	1.806	0.072	-3.81e-05	0.001
feml80	-0.4469	0.802	-0.557	0.578	-2.027	1.133
epend2	-5.238e-08	3.8e-08	-1.377	0.170	-1.27e-07	2.26e-08
house70	5.737e-06	2.56e-06	2.243	0.026	6.99e-07	1.08e-05
dfeml	-0.1314	1.462	-0.090	0.928	-3.011	2.749
XAROBS83	-0.0003	0.000	-1.144	0.254	-0.001	0.000
XAROBS77	-0.0001	0.000	-0.330	0.741	-0.001	0.001
pophs	0.0017	0.001	1.354	0.177	-0.001	0.004
MTSPAR73	-0.0006	0.002	-0.345	0.731	-0.004	0.003
educ80	0.0173	0.137	0.126	0.900	-0.253	0.287
unemp70	-0.0358	0.515	-0.069	0.945	-1.051	0.980
TOTOBS74	-1.227e-05	6.87e-05	-0.179	0.858	-0.000	0.000
XGMOBS77	0.0001	0.000	0.461	0.646	-0.000	0.001
XTSPAR74	-0.0002	0.000	-0.603	0.547	-0.001	0.000
MAX1V76	1.802e-05	3.86e-05	0.466	0.641	-5.81e-05	9.41e-05
hlth80	0.1045	0.151	0.693	0.489	-0.193	0.402
hs70	0.6007	0.206	2.919	0.004	0.195	1.006
MTSPGM84	0.0004	0.001	0.367	0.714	-0.002	0.003
gtsp7780	0.0031	0.004	0.689	0.492	-0.006	0.012
TOTOBS72	-3.623e-06	3.16e-05	-0.115	0.909	-6.58e-05	5.86e-05
XGMOBS73	-0.0002	0.000	-0.811	0.418	-0.001	0.000
polic80	0.0859	0.748	0.115	0.909	-1.387	1.559
linc70	0.0549	0.559	0.098	0.922	-1.046	1.156
femal3	-0.6102	2.112	-0.289	0.773	-4.771	3.551
age6580	0.7745	0.699	1.107	0.269	-0.603	2.152
MAX2V70	-1.786e-05	0.000	-0.050	0.960	-0.001	0.001
plumb80	-0.2165	0.772	-0.280	0.780	-1.738	1.305
femal2	11.3232	65.818	0.172	0.864	-118.354	141.000
poverty3	-5.3077	27.305	-0.194	0.846	-59.104	48.489
povrty80	0.1454	0.489	0.298	0.766	-0.817	1.108
MTSPGM74	0.0007	0.001	0.579	0.563	-0.002	0.003
fstate	-0.0005	0.001	-0.884	0.378	-0.002	0.001
dhghwy	0.2882	0.333	0.867	0.387	-0.367	0.943
dincome	3.658e-05	0.000	0.311	0.756	-0.000	0.000
XAROBS71	-0.0002	0.000	-0.743	0.458	-0.001	0.000
epend70	-7.162e-05	8.66e-05	-0.827	0.409	-0.000	9.9e-05
inccoll	-6.99e-05	0.001	-0.117	0.907	-0.001	0.001
XGMOBS72	0.0002	0.000	0.517	0.605	-0.001	0.001
revenue2	7.456e-08	2.14e-08	3.483	0.001	3.24e-08	1.17e-07
TOTOBS76	3.436e-05	3.69e-05	0.931	0.353	-3.84e-05	0.000
blt1080	1.1425	0.427	2.676	0.008	0.301	1.984
TOTOBS75	-6.49e-06	5.26e-05	-0.123	0.902	-0.000	9.71e-05
lrent80	0.5125	0.115	4.464	0.000	0.286	0.739
mnfcg80	0.1932	0.103	1.867	0.063	-0.011	0.397
income80	-7.594e-08	5.54e-05	-0.001	0.999	-0.000	0.000
MTSPAR78	-0.0005	0.001	-0.416	0.678	-0.003	0.002
TOTOBS71	-1.559e-05	2.51e-05	-0.622	0.535	-6.5e-05	3.38e-05
hs2	5.6035	6.892	0.813	0.417	-7.976	19.183
MTSPGM73	-0.0007	0.003	-0.254	0.800	-0.006	0.005
manwhite	-7.9209	5.013	-1.580	0.115	-17.797	1.955
MAX1V73	-3.819e-05	7.22e-05	-0.529	0.597	-0.000	0.000
MAX2V71	-2.543e-05	8.1e-05	-0.314	0.754	-0.000	0.000
downer	-0.1104	0.240	-0.461	0.645	-0.582	0.362
dmnfcg	-1.0127	0.547	-1.851	0.065	-2.091	0.065
MTSPAR69	-5.541e-05	0.000	-0.160	0.873	-0.001	0.001
hospbed3	9.924e-12	1.17e-11	0.846	0.398	-1.32e-11	3.3e-11
blt2080	2.1828	2.033	1.074	0.284	-1.823	6.189
bltold80	0.1314	0.294	0.447	0.655	-0.448	0.710
XGMOBS75	0.0002	0.000	0.841	0.401	-0.000	0.001
txprop80	4.209e-05	6.91e-05	0.609	0.543	-9.41e-05	0.000
rent70	-0.0003	0.000	-0.914	0.362	-0.001	0.000
drevenue	-0.0001	6.19e-05	-2.150	0.033	-0.000	-1.11e-05
mnfcg2	-1.4140	4.903	-0.288	0.773	-11.074	8.246
hghwy70	0.2998	0.295	1.016	0.311	-0.282	0.881
pctpol3	-30.3408	32.680	-0.928	0.354	-94.729	34.047

```
MTSPGM77      -0.0007      0.001     -0.616      0.539        -0.003     0.001
educ70         0.0416      0.125      0.334      0.739        -0.204     0.287
MAX1V77    -1.111e-05   1.64e-05     -0.676      0.500     -4.35e-05  2.13e-05
poptot80    3.016e-07   2.32e-07      1.302      0.194     -1.55e-07  7.58e-07
crime82    -2.896e-10   3.65e-10     -0.793      0.429     -1.01e-09   4.3e-10
XAROBS84      -0.0002      0.000     -0.535      0.593        -0.001     0.001
MAX1V75    -2.214e-05   5.21e-05     -0.425      0.671        -0.000  8.05e-05
ddens         -0.0003      0.000     -1.495      0.136        -0.001  8.42e-05
XTSPGM75    3.452e-05      0.000      0.102      0.919        -0.001     0.001
white80       -0.4528      0.255     -1.775      0.077        -0.955     0.050
XGMOBS74      -0.0002      0.001     -0.373      0.709        -0.001     0.001
povrty70       0.2315      0.326      0.709      0.479        -0.412     0.875
XAROBS76      -0.0001      0.000     -0.448      0.654        -0.001     0.000
intercept      2.4405      4.365      0.559      0.577        -6.160    11.041
dgtsp_hat     -0.0005      0.004     -0.121      0.904        -0.008     0.007
==============================================================================
Omnibus:                        0.603   Durbin-Watson:                   1.625
Prob(Omnibus):                  0.740   Jarque-Bera (JB):                0.375
Skew:                          -0.015   Prob(JB):                        0.829
Kurtosis:                       3.162   Cond. No.                          nan
==============================================================================

Warnings:
[1] The smallest eigenvalue is -0.0106. This might indicate that there are
strong multicollinearity problems or that the design matrix is singular.
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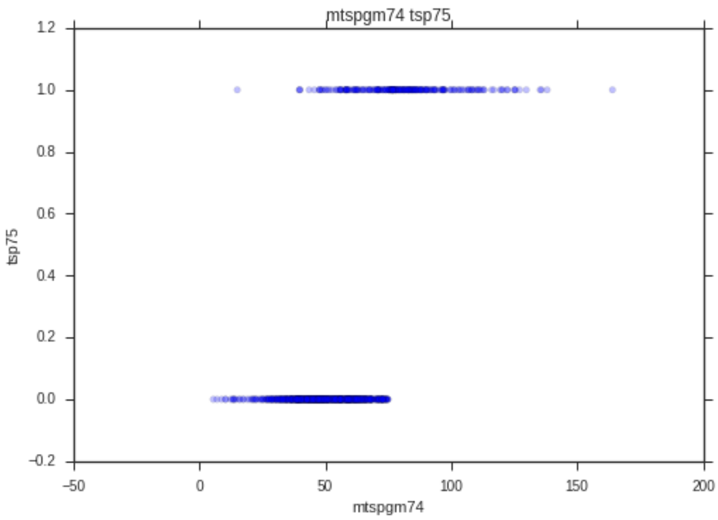
d. In principle, the 1975 regulation indicator variable, tsp75, should be a discrete function of
pollution levels in 1974. Specifically, the EPA is supposed to regulate those counties in 1975 w
ho had either an annual geometric mean of TSPs above 75 units (μg/m3) or a 2nd highest daily con
centration above 260 units in 1974. Describe how one could use this discontinuity in treatment a
ssignment to derive alternative estimates of the capitalization of pollution changes. Under what
conditions will these estimates be valid? Describe the graphical analysis you would use to exami
ne the validity of these conditions.

Answer: We could take only the section of the dataframe + and - a certain delta around the thres
hhold value of pollution in 1974. Then we could construct a Wald Estimator with it, i.e. find th
e difference in price changes and pollution changes for a group just under the threshhold, as we
ll as for a group just over the threshhold, then divide the differences to find change in dlhous
e per change in TSPs. I'd want to see that the discontinuity wasn't fuzzy, so a graph like that
below would be helpful. I'd want to verify that group means were similar in below-threshhold and
above-threshhold groups.



e. Describe (in words) the theoretical reasons why the effects of pollution changes on housing p
rice changes may be heterogeneous. Under what assumptions will two-stage least squares identify
the average treatment effect (ATE)? What is the economic interpretation of ATE in the context of
hedonic theory? If ATE is not identified, describe what may be identifiable with two-stage least
squares estimation. Under what conditions is this effect identified? Give some intuition on what
this effect may represent when one uses EPA regulation as an instrument.

Answer: Small, unnoticable changes in pollution might have no effect on changes in price, while
larger changes in pollution may have large effects on price changes, perhaps increasing at an in
creasing rate as pollution changes become noticable, then at a diminishing rate when jumps in po
llution are extreme. 2SLS will identify the ATE if effects of pollution changes on price changes
are homogenous. The ATE in the context of the hedonic theory represents the amount people have r
evealed themselves willing to pay for clean air.
In this case, however, we've only IDed the LATE, as our results are only applicable around the p
ollution threshhold. The LATE is the effect of pollution changes on house price changes in the s
mall window around the regulatory threshhold for those cities which were induced into cleaning u
p as a result of regulations, but wouldn't have done so otherwise. We should also be aware of se
lection effects: People in the highly-polluted areas eligable for treatment may be less sensitiv

e to pollution, so we're measuring the effect amongst a demographic that may not be representative of the greater population.

f. Now provide a concise synthesis/summary of your results. Discuss the “credibility” of the research designs underlying the results.

Answer: In our simple OLS models, we measured a slightly positive effect of changes in pollution on changes in house price. On the face of it, this runs counter to what we expect the relationship to be. When we consider the omitted variable of economic shocks, however, we see how this paradoxical result came about--negative economic shocks decrease both pollution and house prices. Controlling for a few manifestations of economic shocks (unemployment, changes in income, etc) helped ameliorate OVB to some extent.
To more thoroughly purge our model of OVB, we used an IV approach, (hopefully) capturing only the variation in dgtsp uncorrelated with our confounding omitted variable. Using this approach, we captured a more expected result: A 1% increase in pollution is associated with an approximate .3% decrease in price. This result was robust to our selection of control variables, probably bc our IV was uncorrelated with the OV. This strikes me as a credible approach.

In [ ]: