Homework 2 - Grant Jackson

September 6, 2024

[1]:
```python
import os
os.chdir('C:\\Users\gmoor\Documents\Economic Analytics 1\Data')
```

[2]:
```python
import numpy as np
import pandas as pd
import math
```

[3]:
```python
raw0 = pd.read_csv('College.csv')
```

[4]:
```python
raw0.head()
```

[4]:
```
                     Unnamed: 0 Private  Apps  Accept  Enroll  Top10perc  \
0  Abilene Christian University     Yes  1660    1232     721         23
1            Adelphi University     Yes  2186    1924     512         16
2                Adrian College     Yes  1428    1097     336         22
3           Agnes Scott College     Yes   417     349     137         60
4     Alaska Pacific University     Yes   193     146      55         16

   Top25perc  F.Undergrad  P.Undergrad  Outstate  Room.Board  Books  Personal  \
0         52         2885          537      7440        3300    450      2200
1         29         2683         1227     12280        6450    750      1500
2         50         1036           99     11250        3750    400      1165
3         89          510           63     12960        5450    450       875
4         44          249          869      7560        4120    800      1500

   PhD  Terminal  S.F.Ratio  perc.alumni  Expend  Grad.Rate
0   70        78       18.1           12    7041         60
1   29        30       12.2           16   10527         56
2   53        66       12.9           30    8735         54
3   92        97        7.7           37   19016         59
4   76        72       11.9            2   10922         15
```

[5]:
```python
# Convert "private" variable to a dummy using a built-in function
raw0['Private']=pd.get_dummies(raw0['Private'],drop_first=True,dtype=float)
```

[6]:
```python
raw0.Private
```

[6]:
```
0      1.0
1      1.0
2      1.0
3      1.0
4      1.0
      …
772    0.0
773    1.0
774    1.0
775    1.0
776    1.0
Name: Private, Length: 777, dtype: float64
```

[7]:
```
# Change the column name perc.alumni
raw0.rename(columns = {'perc.alumni':'palumni'}, inplace = True)
```

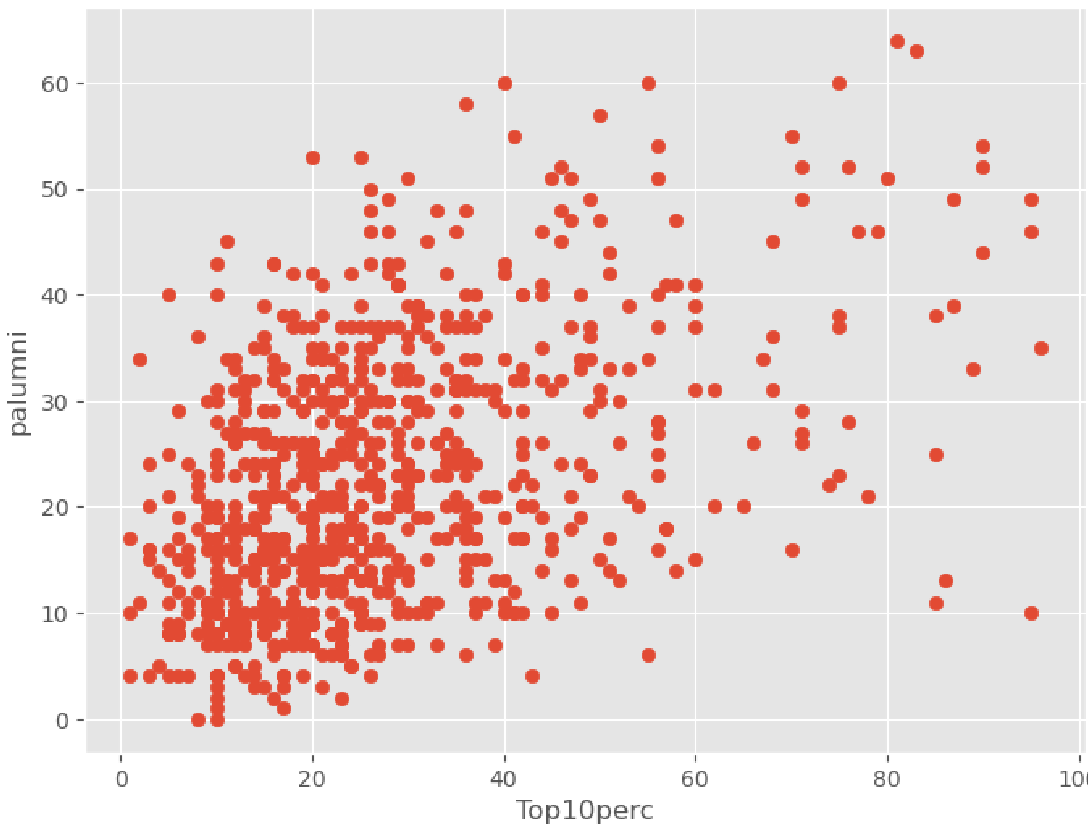
[8]:
```
raw0.head()
```

[8]:
```
                     Unnamed: 0  Private  Apps  Accept  Enroll  Top10perc  \
0  Abilene Christian University      1.0  1660    1232     721         23
1            Adelphi University      1.0  2186    1924     512         16
2                Adrian College      1.0  1428    1097     336         22
3           Agnes Scott College      1.0   417     349     137         60
4     Alaska Pacific University      1.0   193     146      55         16

   Top25perc  F.Undergrad  P.Undergrad  Outstate  Room.Board  Books  Personal  \
0         52         2885          537      7440        3300    450      2200
1         29         2683         1227     12280        6450    750      1500
2         50         1036           99     11250        3750    400      1165
3         89          510           63     12960        5450    450       875
4         44          249          869      7560        4120    800      1500

   PhD  Terminal  S.F.Ratio  palumni  Expend  Grad.Rate
0   70        78       18.1       12    7041         60
1   29        30       12.2       16   10527         56
2   53        66       12.9       30    8735         54
3   92        97        7.7       37   19016         59
4   76        72       11.9        2   10922         15
```

0.0.1 Plotting Library: matplotlib.pyplot

- matplotlib.pyplot is a collection of functions for creating static, animated, and interactive visualizations in Python.
    1. Introduction: https://matplotlib.org/tutorials/index.html
    2. Useful examples and codes: https://matplotlib.org/gallery/index.html
    3. Style reference: https://matplotlib.org/3.2.1/gallery/style_sheets/style_sheets_reference.html

[9]:
```
# Simple scatter plot
import matplotlib.pyplot as plt

plt.style.use('ggplot')
plt.figure(figsize=(8, 6), dpi=100)
plt.scatter('Top10perc', 'palumni', data=raw0)
plt.xlabel('Top10perc')
plt.ylabel('palumni')
#plt.savefig('scatter.png') # Will save picture of scatter plot into your data␣
↪folder
plt.show()
```



0.0.2 Running OLS usig "statsmodels"

- statsmodels.formula.api provides an interface for specifying models using formula strings and DataFrames. (API reference: https://www.statsmodels.org/stable/api.html)
- Useful examples and codes: https://www.statsmodels.org/stable/examples/index.html

[10]:
```
# Import statsmodels.formula.api
import statsmodels.formula.api as smf
```

```
# Fit a regression model
OLSres = smf.ols('palumni ~ Top10perc + Outstate', data=raw0).fit()
```

[11]:
```
# A summary of the result
print(OLSres.summary())
```

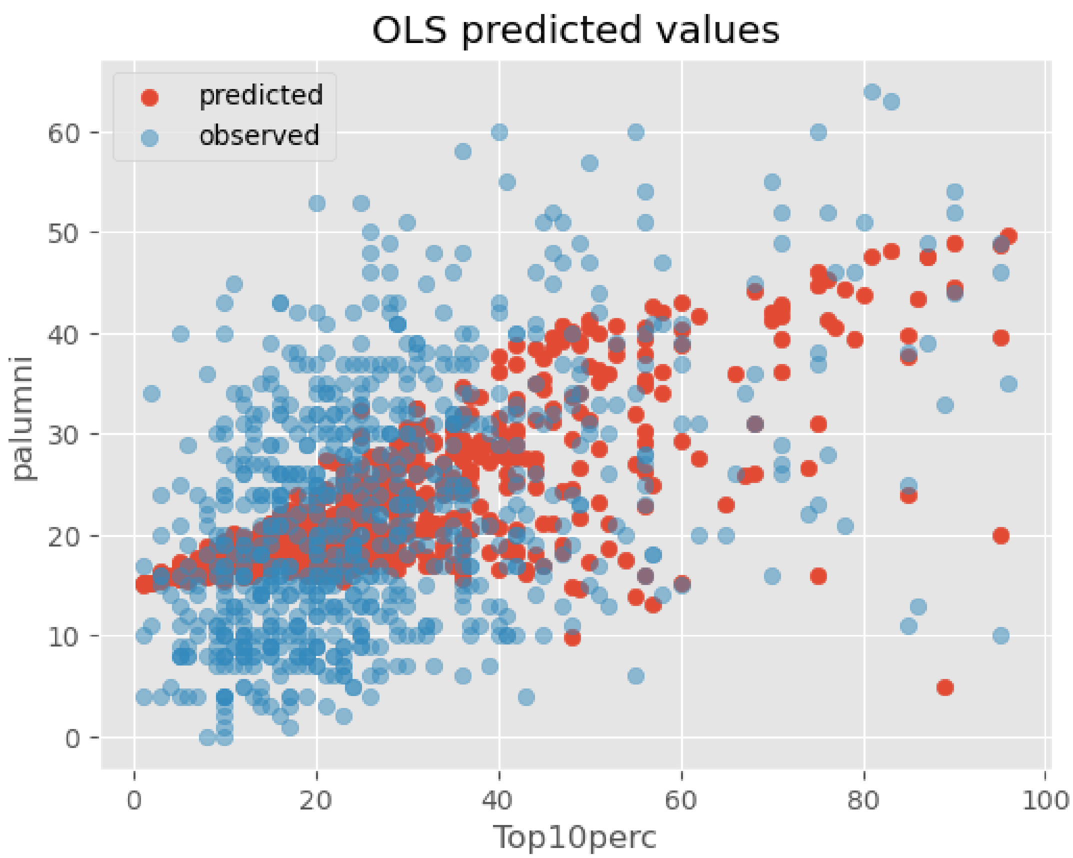
```
                            OLS Regression Results
==============================================================================
Dep. Variable:                palumni   R-squared:                       0.348
Model:                            OLS   Adj. R-squared:                  0.346
Method:                 Least Squares   F-statistic:                     206.7
Date:                Wed, 04 Sep 2024   Prob (F-statistic):           1.21e-72
Time:                        18:37:44   Log-Likelihood:                -2891.5
No. Observations:                 777   AIC:                             5789.
Df Residuals:                     774   BIC:                             5803.
Df Model:                           2
Covariance Type:            nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
Intercept      4.2776      1.001      4.273      0.000       2.312       6.243
Top10perc      0.1408      0.025      5.711      0.000       0.092       0.189
Outstate       0.0014      0.000     12.923      0.000       0.001       0.002
==============================================================================
Omnibus:                       23.166   Durbin-Watson:                   1.950
Prob(Omnibus):                  0.000   Jarque-Bera (JB):               24.444
Skew:                           0.418   Prob(JB):                     4.92e-06
Kurtosis:                       3.236   Cond. No.                     3.12e+04
==============================================================================

Notes:
[1] Standard Errors assume that the covariance matrix of the errors is correctly
specified.
[2] The condition number is large, 3.12e+04. This might indicate that there are
strong multicollinearity or other numerical problems.
```

[12]:
```
# interaction and higer order terms
OLSres = smf.ols('palumni ~ np.power(Top10perc,2) + Top10perc:Outstate',
 ↪data=raw0).fit()
print(OLSres.summary())
```

```
                            OLS Regression Results
==============================================================================
Dep. Variable:                palumni   R-squared:                       0.326
Model:                            OLS   Adj. R-squared:                  0.324
Method:                 Least Squares   F-statistic:                     187.3
Date:                Wed, 04 Sep 2024   Prob (F-statistic):           4.64e-67
```

```
Time:                        18:37:44   Log-Likelihood:                -2904.4
No. Observations:                 777   AIC:                             5815.
Df Residuals:                     774   BIC:                             5829.
Df Model:                           2
Covariance Type:            nonrobust
================================================================================
==========
                          coef    std err          t      P>|t|      [0.025
0.975]
--------------------------------------------------------------------------------
----------
Intercept              14.8920      0.547     27.203      0.000      13.817
15.967
np.power(Top10perc, 2)    -0.0039      0.001     -6.582      0.000      -0.005
-0.003
Top10perc:Outstate      3.687e-05   2.74e-06     13.476      0.000    3.15e-05
4.22e-05
==============================================================================
Omnibus:                       22.532   Durbin-Watson:                   1.960
Prob(Omnibus):                  0.000   Jarque-Bera (JB):               23.726
Skew:                           0.421   Prob(JB):                     7.05e-06
Kurtosis:                       3.157   Cond. No.                     6.92e+05
==============================================================================

Notes:
[1] Standard Errors assume that the covariance matrix of the errors is correctly
specified.
[2] The condition number is large, 6.92e+05. This might indicate that there are
strong multicollinearity or other numerical problems.
```

[13]:
```python
# Scatterplot fitted(predicted) values (palumni ~ Top10perc)

plt.scatter(raw0['Top10perc'], OLSres.predict(), alpha=1, label='predicted') #␣
 ↪fitted / alpha changes the transparency of the plotted points
plt.scatter(raw0['Top10perc'], raw0['palumni'], alpha=0.5, label='observed') #␣
 ↪original

plt.legend()
plt.title('OLS predicted values')
plt.xlabel('Top10perc')
plt.ylabel('palumni')
plt.show()
```



[14]:
```
# Access individual estimate:
# https://www.statsmodels.org/stable/generated/statsmodels.regression.linear_model.OLSResults.html#statsmodels.regression.linear_model.OLSResults

OLSres.params # parameter estimates
```

[14]:
```
Intercept                  14.892000
np.power(Top10perc, 2)     -0.003948
Top10perc:Outstate          0.000037
dtype: float64
```

[15]:
```
### <font color='green'> Making a table for multiple regressions using "statsmodels.iolib.summary2"
```

[16]:
```
OLS1 = smf.ols('palumni ~ Top10perc', data=raw0).fit()
OLS2 = smf.ols('palumni ~ Top10perc + Private + Outstate', data=raw0).fit()
OLS3 = smf.ols('palumni ~ Top10perc + Private + Outstate + Personal + Expend', data=raw0).fit()
```

[17]:

```python
from statsmodels.iolib.summary2 import summary_col

info_dict={'BIC' : lambda x: x.bic,
    'No. observations' : lambda x: f"{int(x.nobs)}"}

# "dictionary" is another way to store data, which use "keys" to index elements␣
↪(instead of numbers): key-value pair
# e.g., A = {"BIC":40} and then type A["BIC"] to get 40
# e.g., A = [40,50,60] and then type A[0] to get 40

# lambda is a function to define a function, which define a parameter then a␣
↪function: https://www.w3schools.com/python/python_lambda.asp

results_table = summary_col(results=[OLS1,OLS2,OLS3],
                            float_format='%0.2f',
                            stars = True,
                            model_names=['Model 1',
                                         'Model 2',
                                         'Model 3'],
                            # info_dict=info_dict,
                            regressor_order=['Intercept',
                                             'Top10perc',
                                             'Private',
                                             'Outstate',
                                             'Personal',
                                             'Expend'])

results_table.add_title('OLS Regressions')

print(results_table)
```

```
            OLS Regressions
========================================
               Model 1  Model 2 Model 3
----------------------------------------
Intercept      13.93*** 3.74*** 7.94***
               (0.73)   (0.99)  (1.43)
Top10perc      0.32***  0.17*** 0.18***
               (0.02)   (0.02)  (0.03)
Private                 5.50*** 4.86***
                        (0.97)  (0.98)
Outstate                0.00*** 0.00***
                        (0.00)  (0.00)
Personal                        -0.00***
                                (0.00)
Expend                          -0.00
                                (0.00)
R-squared      0.21     0.37    0.39
```

```
R-squared Adj. 0.21     0.37    0.38
========================================
Standard errors in parentheses.
* p<.1, ** p<.05, ***p<.01
```

0.0.3 HW2: Pick five combinations of the regressors to explain the percent of alumni. The regressors may include interactions of two variables or squared/cubed variables.

1. Run five regressions with each combination
2. Produce a table summarizing the results of your five regressions as above

0.0.4 One of you will present your regression results in the coming python session. Please check/interpret your regression results carefully

[18]:
```python
# Number 1

import statsmodels.formula.api as smf
import pandas as pd

# Define the 5 different regression models
# Basic Model, Top10perc and Outstate are regressors
OLS1 = smf.ols('palumni ~ Top10perc + Outstate', data=raw0).fit()

# Same as above, but adding Private to the regressors
OLS2 = smf.ols('palumni ~ Top10perc + Outstate + Private', data=raw0).fit()

# Same as above, but adding Apps to the regressors
OLS3 = smf.ols('palumni ~ Top10perc + Outstate + Private + Apps', data=raw0).
↪fit()

# Introducing an interaction term between Top10perc and Outstate
OLS4 = smf.ols('palumni ~ Top10perc + Outstate + Top10perc:Outstate',␣
↪data=raw0).fit()

# Adding Expend to the regressors from Model 2
OLS5 = smf.ols('palumni ~ Top10perc + Outstate + Private + Expend', data=raw0).
↪fit()
```

[19]:
```python
# Number 2

from statsmodels.iolib.summary2 import summary_col

info_dict={'BIC' : lambda x: x.bic,
    'No. observations' : lambda x: f"{int(x.nobs)}"}

# Building table with each regression result
results_table = summary_col(results=[OLS1, OLS2, OLS3, OLS4, OLS5],
```

```
                               float_format='%0.2f',
                               stars = True,
                               model_names=['Model 1', 'Model 2', 'Model 3',␣
 ↪'Model 4', 'Model 5'],
                               regressor_order=['Intercept', 'Top10perc',␣
 ↪'Outstate', 'Private',
                                                 'Personal', 'Expend', 'Top10perc:
 ↪Outstate'])

results_table.add_title('OLS Regressions for Percent of Alumni')

print(results_table)
```

```
           OLS Regressions for Percent of Alumni
===========================================================
                   Model 1 Model 2 Model 3  Model 4 Model 5
-----------------------------------------------------------
Intercept          4.28*** 3.74*** 5.23***  3.99**  3.76***
                   (1.00)  (0.99)  (1.02)   (1.90)  (0.99)
Top10perc          0.14*** 0.17*** 0.21***  0.15**  0.18***
                   (0.02)  (0.02)  (0.03)   (0.06)  (0.03)
Outstate           0.00*** 0.00*** 0.00***  0.00*** 0.00***
                   (0.00)  (0.00)  (0.00)   (0.00)  (0.00)
Private                    5.50*** 2.77**           5.45***
                           (0.97)  (1.12)           (0.98)
Expend                                              -0.00
                                                    (0.00)
Top10perc:Outstate                          -0.00
                                            (0.00)
Apps                               -0.00***
                                   (0.00)
R-squared          0.35    0.37    0.39     0.35    0.37
R-squared Adj.     0.35    0.37    0.39     0.35    0.37
===========================================================
Standard errors in parentheses.
* p<.1, ** p<.05, ***p<.01
```

[ ]: