Lab 1: Applied data science

1) *Which variables have the most explanatory power? Which have the least?*

The next method is to use pearson test to compare both variables:

```
df = pd.read_csv("trafficking_data.csv")
print pearsonr(df["persons prosecuted"],df["Adult victims"])
……and so on

person prosecuted VS adult victim:
(-0.048430976740660318, 0.54565160155960302)
child victim VS adult victim:
(-0.035024116929785513, 0.66219496601816152)
gdp VS adult victim:
(0.028646394597412601, 0.72087188051004913)
life expectancy VS adult victim:
(0.049826116824534659, 0.53412741414372966)
Female primary education VS adult victim:
(-0.10034340943285375, 0.20967825172658733)
policy index VS adult victim:
(0.063669987031620329, 0.42674651732545388)
```

where the return value is (Pearson's correlation coefficient, 2-tailed p-value). Here we understand that almost no correlation between two of them (pearson coefficient varies from -1 to 1, close to zero implies no correlation). P-value roughly indicates the probability of an uncorrelated system producing datasets that have a Pearson correlation at least as extreme as the one computed from these datasets. In addition, policy index seems to be dominant factor in predicting Adult victims.

Then we start implementing linear prediction model to try predicting each expected Y values by fixed x variables and compare the R squared value.

```
                            OLS Regression Results
==============================================================================
Dep. Variable:          Adult_victims   R-squared:                       0.106
Model:                            OLS   Adj. R-squared:                  0.089
Method:                 Least Squares   F-statistic:                     6.142
Date:                Wed, 08 Oct 2014   Prob (F-statistic):           0.000567
Time:                        18:24:05   Log-Likelihood:                -1280.2
No. Observations:                 158   AIC:                             2566.
Df Residuals:                     155   BIC:                             2576.
Df Model:                           3
=====================================================================================
                        coef    std err          t      P>|t|      [95.0% Conf. Int.]
-------------------------------------------------------------------------------------
gdp               -3.425e-12   3.06e-11     -0.112      0.911     -6.38e-11   5.7e-11
policy_index         19.3717     31.154      0.622      0.535       -42.169    80.913
life_expectancy       4.5127      8.912      0.506      0.613       -13.092    22.117
females_education    -4.4773     11.804     -0.379      0.705       -27.795    18.840
==============================================================================
Omnibus:                      198.128   Durbin-Watson:                   0.777
Prob(Omnibus):                  0.000   Jarque-Bera (JB):             5932.011
Skew:                           5.132   Prob(JB):                         0.00
Kurtosis:                      31.208   Cond. No.                     1.20e+12
==============================================================================

Warnings:
[1] The condition number is large, 1.2e+12. This might indicate that there are
strong multicollinearity or other numerical problems.
Parameters: gdp                -3.425145e-12
policy_index          1.937171e+01
life_expectancy       4.512711e+00
females_education    -4.477272e+00
dtype: float64

Warnings:
[1] The condition number is large, 1.2e+12. This might indicate that there are
strong multicollinearity or other numerical problems.
```

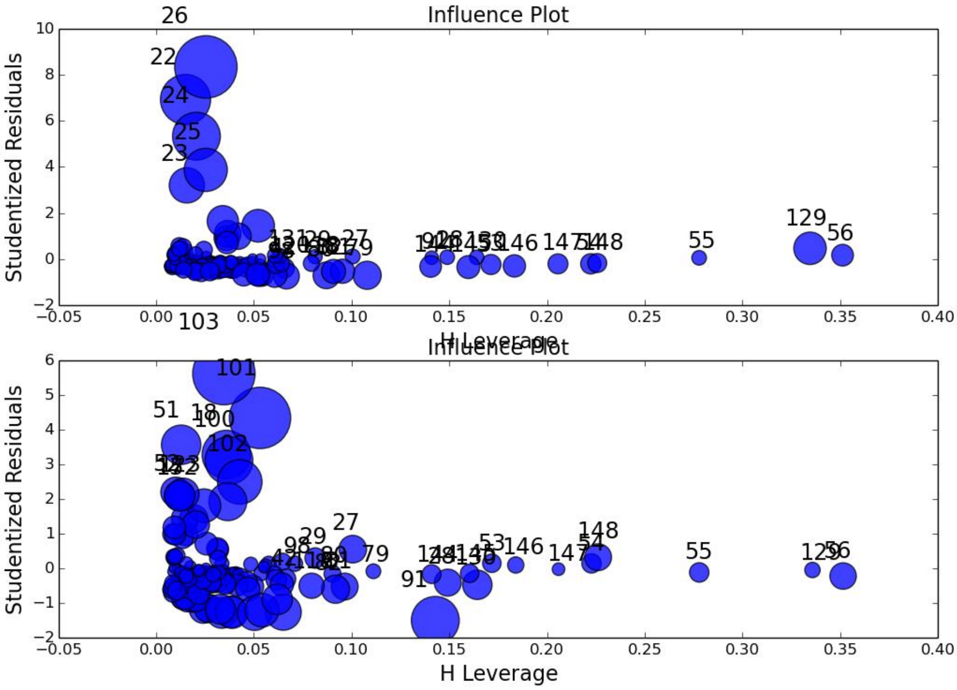
```
Parameters: gdp                 -2.586435e-12
policy_index         5.257530e+00
life_expectancy     -1.838591e+00
females_education    2.201553e+00
dtype: float64
                            OLS Regression Results
==============================================================================
Dep. Variable:     persons_prosecuted   R-squared:                       0.034
Model:                            OLS   Adj. R-squared:                  0.015
Method:                 Least Squares   F-statistic:                     1.828
Date:                Wed, 08 Oct 2014   Prob (F-statistic):              0.144
Time:                        18:24:05   Log-Likelihood:                -1510.8
No. Observations:                 158   AIC:                             3028.
Df Residuals:                     155   BIC:                             3037.
Df Model:                           3
======================================================================================
                        coef    std err          t      P>|t|      [95.0% Conf. Int.]
--------------------------------------------------------------------------------------
gdp                5.426e-12   1.32e-10      0.041      0.967     -2.55e-10  2.65e-10
policy_index        101.7509    134.108      0.759      0.449      -163.163   366.665
life_expectancy     -32.9970     38.363     -0.860      0.391      -108.779    42.785
females_education    36.2056     50.813      0.713      0.477       -64.169   136.581
==============================================================================
Omnibus:                      224.600   Durbin-Watson:                   0.538
Prob(Omnibus):                  0.000   Jarque-Bera (JB):            10002.180
Skew:                           6.162   Prob(JB):                         0.00
Kurtosis:                      39.979   Cond. No.                     1.20e+12
==============================================================================

Warnings:
[1] The condition number is large, 1.2e+12. This might indicate that there are
strong multicollinearity or other numerical problems.
Parameters: gdp                  5.425977e-12
policy_index         1.017509e+02
life_expectancy     -3.299698e+01
females_education    3.620564e+01
```

```
dtype: float64


        R^2 of results_victims 0.106242258731

        R^2 of results_prosecuted 0.0341707197668
```

From the result above we could see that R squared for adult victim is larger than results prosecuted. Therefore, we will use Adult victims as the value to predict in this assignment.

2) ***Remove some the outlier countries, how does this effect your model?*** -----

To get a better image on how removing outlier countries, we can observe the distribution of influential plot (H leverage VS studentized residuals). Here we remove Brazil who has unevenly distributed residual value, bigger than the standardized value of 3:



More detail summary of the coefficient can be seen here:

```
                             OLS Regression Results
==============================================================================
Dep. Variable:           Adult_victims   R-squared:                       0.024
Model:                             OLS   Adj. R-squared:                 -0.002
```

```
Method:                 Least Squares   F-statistic:                    0.9258
Date:                Wed, 08 Oct 2014   Prob (F-statistic):              0.451
Time:                        18:24:12   Log-Likelihood:                -1278.7
No. Observations:                 158   AIC:                             2567.
Df Residuals:                     153   BIC:                             2583.
Df Model:                           4
=====================================================================================
                         coef    std err          t      P>|t|      [95.0% Conf. Int.]
-------------------------------------------------------------------------------------
const               6367.3284   4201.836      1.515      0.132     -1933.778  1.47e+04
gdp                 4.989e-12   3.12e-11      0.160      0.873     -5.66e-11  6.65e-11
policy_index          16.6306     31.606      0.526      0.600       -45.810    79.071
females_education   -130.7897     84.940     -1.540      0.126      -298.596    37.017
life_expectancy        1.3003      9.139      0.142      0.887       -16.755    19.356
persons_prosecuted    -0.0182      0.019     -0.948      0.344        -0.056     0.020
child_victims         -0.6412      0.768     -0.835      0.405        -2.159     0.876
==============================================================================
Omnibus:                      191.304   Durbin-Watson:                   0.794
Prob(Omnibus):                  0.000   Jarque-Bera (JB):             5184.289
Skew:                           4.886   Prob(JB):                         0.00
Kurtosis:                      29.306   Cond. No.                     1.61e+14
==============================================================================

Warnings:
[1] The condition number is large, 1.61e+14. This might indicate that there are
strong multicollinearity or other numerical problems.
Outlier:  [22, 23, 24, 25, 26]
   country  year  persons_prosecuted  Adult_victims  child_victims  \
22  Brazil  2003                  52           5223              0
23  Brazil  2004                 130           2887              0
24  Brazil  2005                 128           4348              0
25  Brazil  2006                 117           3417              0
26  Brazil  2007                 200           5975              0

             gdp  policy_index  females_education  life_expectancy
22  5.524693e+11            10           47.71990               71
```

```
23  6.637603e+11            11          47.70676              71
24  8.821857e+11            12          47.59256              71
25  1.088917e+12            11          47.20861              71
26  1.366824e+12            11          47.20861              71
                            OLS Regression Results
==============================================================================
Dep. Variable:          Adult_victims   R-squared:                       0.153
Model:                            OLS   Adj. R-squared:                  0.130
Method:                 Least Squares   F-statistic:                     6.683
Date:                Wed, 08 Oct 2014   Prob (F-statistic):           5.68e-05
Time:                        18:24:13   Log-Likelihood:                -1037.2
No. Observations:                 153   AIC:                             2084.
Df Residuals:                     148   BIC:                             2100.
Df Model:                           4
======================================================================================
                         coef    std err          t      P>|t|      [95.0% Conf. Int.]
--------------------------------------------------------------------------------------
const              -3407.2866   1153.837     -2.953      0.004     -5687.410 -1127.163
gdp                 8.754e-12   8.38e-12      1.044      0.298     -7.81e-12  2.53e-11
policy_index          -0.3600      8.523     -0.042      0.966       -17.203    16.483
females_education     82.6792     23.400      3.533      0.001        36.438   128.920
life_expectancy       -7.1481      2.466     -2.899      0.004       -12.021    -2.275
persons_prosecuted    -0.0029      0.005     -0.555      0.580        -0.013     0.007
child_victims          0.3980      0.208      1.913      0.058        -0.013     0.809
==============================================================================
Omnibus:                       91.217   Durbin-Watson:                   0.738
Prob(Omnibus):                  0.000   Jarque-Bera (JB):              417.753
Skew:                           2.289   Prob(JB):                     1.93e-91
Kurtosis:                       9.676   Cond. No.                     1.64e+14
==============================================================================

Warnings:
[1] The condition number is large, 1.64e+14. This might indicate that there are
strong multicollinearity or other numerical problems.
```

From the summary above we could see that R squared increased from 0.024 to 0.153, showing that the model works better without outliers.

3) ***Log-scale each of the variables, how does this change your model? Does it improve the models predictive power? How can you tell?***

After scales were changed to logarithmic, we could observer that R squared increased significantly:

```
                            OLS Regression Results
==============================================================================
Dep. Variable:           Adult_victims   R-squared:                       0.153
Model:                             OLS   Adj. R-squared:                  0.130
Method:                  Least Squares   F-statistic:                     6.683
Date:                 Wed, 08 Oct 2014   Prob (F-statistic):           5.68e-05
Time:                         19:50:51   Log-Likelihood:                -1037.2
No. Observations:                  153   AIC:                             2084.
Df Residuals:                      148   BIC:                             2100.
Df Model:                            4
====================================================================================
                        coef    std err          t      P>|t|      [95.0% Conf. Int.]
------------------------------------------------------------------------------------
Intercept         -3407.2866   1153.837     -2.953      0.004     -5687.410 -1127.163
persons_prosecuted   -0.0029      0.005     -0.555      0.580        -0.013     0.007
child_victims         0.3980      0.208      1.913      0.058        -0.013     0.809
gdp                8.754e-12   8.38e-12      1.044      0.298     -7.81e-12  2.53e-11
policy_index         -0.3600      8.523     -0.042      0.966       -17.203    16.483
females_education    82.6792     23.400      3.533      0.001        36.438   128.920
life_expectancy      -7.1481      2.466     -2.899      0.004       -12.021    -2.275
==============================================================================
Omnibus:                        91.217   Durbin-Watson:                   0.738
Prob(Omnibus):                   0.000   Jarque-Bera (JB):              417.753
Skew:                            2.289   Prob(JB):                     1.93e-91
Kurtosis:                        9.676   Cond. No.                          nan
==============================================================================
Warnings:
[1] The smallest eigenvalue is -6.49e+08. This might indicate that there are
strong multicollinearity problems or that the design matrix is singular.
                            OLS Regression Results
==============================================================================
Dep. Variable:          Adult_victims   R-squared:                       0.454
Model:                            OLS   Adj. R-squared:                  0.432
Method:                 Least Squares   F-statistic:                     20.27
Date:                Wed, 08 Oct 2014   Prob (F-statistic):           3.63e-17
Time:                        19:50:51   Log-Likelihood:                -1003.6
No. Observations:                 153   AIC:                             2021.
Df Residuals:                     146   BIC:                             2042.
Df Model:                           6
========================================================================================
========
                                   coef    std err          t      P>|t|      [95.0%
Conf. Int.]
----------------------------------------------------------------------------------------
--------
Intercept                    -1.001e+04   3555.325     -2.815      0.006     -1.7e+04
-2981.212
np.log1p(persons_prosecuted)    29.3962      7.357      3.995      0.000       14.855
43.937
np.log1p(child_victims)         24.5572      7.602      3.231      0.002        9.534
39.581
np.log1p(gdp)                  -32.4480      3.509     -9.246      0.000      -39.384
-25.512
np.log1p(policy_index)          82.4559     53.638      1.537      0.126      -23.552
188.464
np.log1p(females_education)   2615.0982    911.383      2.869      0.005      813.891
4416.306
np.log1p(life_expectancy)       97.1963    137.693      0.706      0.481     -174.932
369.325
==============================================================================
Omnibus:                       68.088   Durbin-Watson:                   1.049
Prob(Omnibus):                  0.000   Jarque-Bera (JB):              198.134
```

```
Skew:                           1.820   Prob(JB):                     9.46e-44
Kurtosis:                       7.222   Cond. No.                     6.52e+03
==============================================================================

Warnings:
[1] The condition number is large, 6.52e+03. This might indicate that there are
strong multicollinearity or other numerical problems.
```

Therefore, we may conclude logarithmic conversion did improve the predictive power of this particular regression model.

4) ***Can you think of any other modeling techniques (from class) that could be used instead of linear regression? Try using one of these and explain your results, with diagrams and if possible, a visualization as well as descriptive statistics.***

One of the other model that was discussed in the class (not lab) were polinomial. In this assignment linear, 2nd order and 3rd order of polynomial regressions were tested. It can be done by implementing formula in statsmodels OLS feature:

```
# 3-rd order polynomial
poly_3 = smf.ols(formula='Adult_victims~ 1 + persons_prosecuted + child_victims+ gdp+ policy_index+ females_education + life_expectancy+I(persons_prosecuted ** 2.0) + I(child_victims ** 2.0)+ I(gdp ** 2.0) + I(policy_index ** 2.0)+I(females_education ** 2.0) + I(life_expectancy ** 2.0)+I(persons_prosecuted ** 3.0) + I(child_victims ** 3.0)+ I(gdp ** 3.0) + I(policy_index ** 3.0)+I(females_education ** 3.0) + I(life_expectancy ** 3.0)', data=df).fit()
print poly_3.summary()
plt.plot(x, poly_3.predict(X), 'go', label='Poly n=3 $R^2$=%.2f' % poly_3.rsquared,
        alpha=0.9)
```

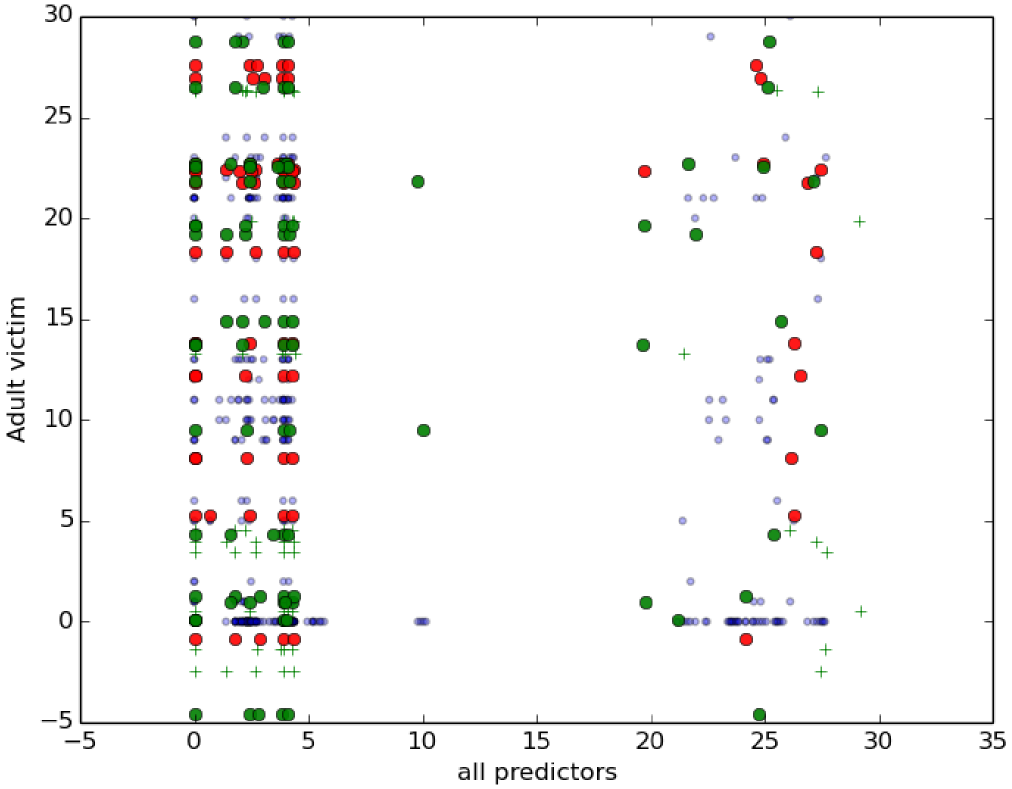
The statistic summary:

```
                            OLS Regression Results
==============================================================================
Dep. Variable:          Adult_victims   R-squared:                       0.454
Model:                            OLS   Adj. R-squared:                  0.432
Method:                 Least Squares   F-statistic:                     20.27
```

```
Date:                Wed, 08 Oct 2014   Prob (F-statistic):           3.63e-17
Time:                        22:03:28   Log-Likelihood:                -1003.6
No. Observations:                 153   AIC:                             2021.
Df Residuals:                     146   BIC:                             2042.
Df Model:                           6
======================================================================================
                         coef    std err          t      P>|t|      [95.0% Conf. Int.]
--------------------------------------------------------------------------------------
const              -1.001e+04   3555.325     -2.815      0.006      -1.7e+04 -2981.212
gdp                  -32.4480      3.509     -9.246      0.000       -39.384   -25.512
policy_index          82.4559     53.638      1.537      0.126       -23.552   188.464
females_education   2615.0982    911.383      2.869      0.005       813.891  4416.306
life_expectancy       97.1963    137.693      0.706      0.481      -174.932   369.325
persons_prosecuted    29.3962      7.357      3.995      0.000        14.855    43.937
child_victims         24.5572      7.602      3.231      0.002         9.534    39.581
==============================================================================
Omnibus:                       68.088   Durbin-Watson:                   1.049
Prob(Omnibus):                  0.000   Jarque-Bera (JB):              198.134
Skew:                           1.820   Prob(JB):                     9.46e-44
Kurtosis:                       7.222   Cond. No.                     6.52e+03
==============================================================================

Warnings:
[1] The condition number is large, 6.52e+03. This might indicate that there are
strong multicollinearity or other numerical problems.
                            OLS Regression Results
==============================================================================
Dep. Variable:          Adult_victims   R-squared:                       0.673
Model:                            OLS   Adj. R-squared:                  0.629
Method:                 Least Squares   F-statistic:                     15.29
Date:                Wed, 08 Oct 2014   Prob (F-statistic):           2.45e-24
Time:                        22:03:28   Log-Likelihood:                -964.53
No. Observations:                 153   AIC:                             1967.
Df Residuals:                     134   BIC:                             2025.
Df Model:                          18
========================================================================================
========
                                   coef    std err          t      P>|t|      [95.0%
Conf. Int.]
----------------------------------------------------------------------------------------
--------
Intercept                    -5.723e+07   1.04e+08     -0.551      0.582     -2.62e+08
1.48e+08
persons_prosecuted            -133.4874     33.380     -3.999      0.000      -199.508
-67.467
child_victims                  -15.8600     59.138     -0.268      0.789      -132.825
101.105
gdp                           -107.1898     47.483     -2.257      0.026      -201.103
-13.276
policy_index                  -637.5839    504.583     -1.264      0.209     -1635.560
360.393
females_education              4.34e+07      8e+07      0.542      0.588     -1.15e+08
2.02e+08
life_expectancy               4.193e+05    3.9e+05      1.075      0.284     -3.52e+05
1.19e+06
I(persons_prosecuted ** 2.0)    50.3547     10.252      4.912      0.000        30.079
70.631
I(child_victims ** 2.0)          8.6766     27.626      0.314      0.754       -45.962
63.315
I(gdp ** 2.0)                    3.8014      3.751      1.013      0.313        -3.618
11.221
I(policy_index ** 2.0)         601.7357    406.774      1.479      0.141      -202.792
1406.263
I(females_education ** 2.0)  -1.108e+07   2.06e+07     -0.538      0.591     -5.18e+07
2.97e+07
I(life_expectancy ** 2.0)    -9.996e+04    9.4e+04     -1.064      0.289     -2.86e+05
8.59e+04
I(persons_prosecuted ** 3.0)    -3.8735      0.737     -5.257      0.000        -5.331
-2.416
I(child_victims ** 3.0)         -0.1597      3.171     -0.050      0.960        -6.431
6.112
I(gdp ** 3.0)                   -0.0361      0.075     -0.480      0.632        -0.185
```

```
0.113
I(policy_index ** 3.0)        -131.4920     86.698     -1.517      0.132      -302.965
39.981
I(females_education ** 3.0)   9.435e+05    1.77e+06      0.534      0.594     -2.55e+06
4.44e+06
I(life_expectancy ** 3.0)     7933.6415    7540.870      1.052      0.295     -6980.886
2.28e+04
==============================================================================
Omnibus:                       69.548   Durbin-Watson:                   1.413
Prob(Omnibus):                  0.000   Jarque-Bera (JB):              283.826
Skew:                           1.678   Prob(JB):                     2.33e-62
Kurtosis:                       8.766   Cond. No.                     8.61e+10
==============================================================================

Warnings:
[1] The smallest eigenvalue is 4.91e-12. This might indicate that there are
strong multicollinearity problems or that the design matrix is singular.
```

Therefore, we may conclude the best regression model is the one with highest R squared value, which is 3rd order of polynomial. In the following graphs, red is the 2nd order, green dots are the 3rd order polynomial, and plus sign shows regular linear regression.



5) ***Think about how this model might be improved by adding more data. Then add this data to the model and test your hypothesis. What did you find. Provide descriptive statistics and visualizations as well as a few paragraphs explaining how you chose what data you did and why.***

Testing model achieved from the test training datasets and apply the same model to new unemployment rate data sets:

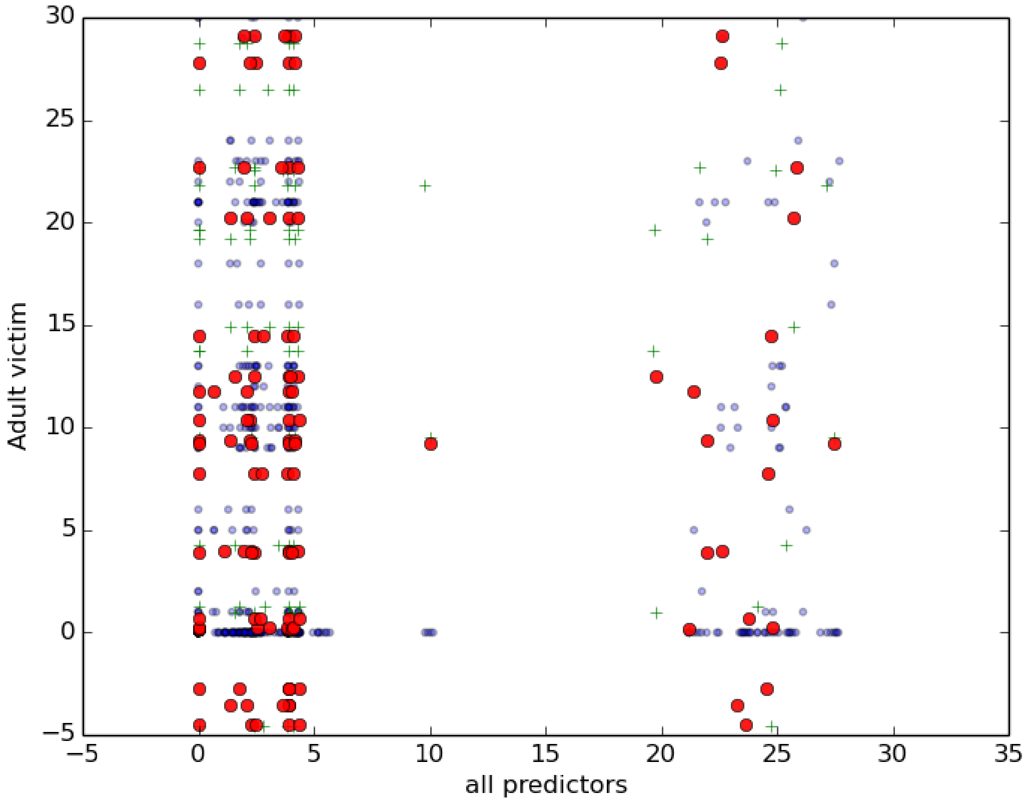
```
                            OLS Regression Results
==============================================================================
Dep. Variable:          Adult_victims   R-squared:                       0.673
Model:                            OLS   Adj. R-squared:                  0.629
Method:                 Least Squares   F-statistic:                     15.29
```

```
Date:                Wed, 08 Oct 2014   Prob (F-statistic):           2.45e-24
Time:                        22:31:41   Log-Likelihood:                -964.53
No. Observations:                 153   AIC:                             1967.
Df Residuals:                     134   BIC:                             2025.
Df Model:                          18
========================================================================================
========
                                   coef    std err          t      P>|t|      [95.0%
Conf. Int.]
----------------------------------------------------------------------------------------
--------
Intercept                    -5.723e+07   1.04e+08     -0.551      0.582     -2.62e+08
1.48e+08
persons_prosecuted            -133.4874     33.380     -3.999      0.000      -199.508
-67.467
child_victims                  -15.8600     59.138     -0.268      0.789      -132.825
101.105
gdp                           -107.1898     47.483     -2.257      0.026      -201.103
-13.276
policy_index                  -637.5839    504.583     -1.264      0.209     -1635.560
360.393
females_education              4.34e+07      8e+07      0.542      0.588     -1.15e+08
2.02e+08
life_expectancy               4.193e+05    3.9e+05      1.075      0.284     -3.52e+05
1.19e+06
I(persons_prosecuted ** 2.0)    50.3547     10.252      4.912      0.000        30.079
70.631
I(child_victims ** 2.0)          8.6766     27.626      0.314      0.754       -45.962
63.315
I(gdp ** 2.0)                    3.8014      3.751      1.013      0.313        -3.618
11.221
I(policy_index ** 2.0)         601.7357    406.774      1.479      0.141      -202.792
1406.263
I(females_education ** 2.0)  -1.108e+07   2.06e+07     -0.538      0.591     -5.18e+07
2.97e+07
I(life_expectancy ** 2.0)    -9.996e+04    9.4e+04     -1.064      0.289     -2.86e+05
```

```
8.59e+04
I(persons_prosecuted ** 3.0)    -3.8735      0.737     -5.257      0.000        -5.331
-2.416
I(child_victims ** 3.0)         -0.1597      3.171     -0.050      0.960        -6.431
6.112
I(gdp ** 3.0)                   -0.0361      0.075     -0.480      0.632        -0.185
0.113
I(policy_index ** 3.0)        -131.4920     86.698     -1.517      0.132      -302.965
39.981
I(females_education ** 3.0)   9.435e+05   1.77e+06      0.534      0.594     -2.55e+06
4.44e+06
I(life_expectancy ** 3.0)     7933.6417   7540.870      1.052      0.295     -6980.886
2.28e+04
==============================================================================
Omnibus:                       69.548   Durbin-Watson:                   1.413
Prob(Omnibus):                  0.000   Jarque-Bera (JB):              283.826
Skew:                           1.678   Prob(JB):                     2.33e-62
Kurtosis:                       8.766   Cond. No.                          nan
==============================================================================

Warnings:
[1] The smallest eigenvalue is -5.15e-12. This might indicate that there are
strong multicollinearity problems or that the design matrix is singular.
                            OLS Regression Results
==============================================================================
Dep. Variable:          Adult_victims   R-squared:                       0.673
Model:                            OLS   Adj. R-squared:                  0.621
Method:                 Least Squares   F-statistic:                     12.85
Date:                Wed, 08 Oct 2014   Prob (F-statistic):           1.26e-22
Time:                        22:31:42   Log-Likelihood:                -964.38
No. Observations:                 153   AIC:                             1973.
Df Residuals:                     131   BIC:                             2039.
Df Model:                          21
==========================================================================================
========
                                  coef    std err          t      P>|t|      [95.0%
Conf. Int.]

------------------------------------------------------------------------------------------

--------

Intercept                    -5.783e+07    1.05e+08     -0.550      0.583     -2.66e+08

1.5e+08

persons_prosecuted            -132.5277      33.867     -3.913      0.000      -199.525

-65.530

child_victims                  -14.3127      59.915     -0.239      0.812      -132.839

104.214

gdp                           -108.7413      48.593     -2.238      0.027      -204.870

-12.612

policy_index                  -651.9263     511.092     -1.276      0.204     -1662.988

359.135

females_education             4.389e+07    8.11e+07      0.541      0.589     -1.16e+08

2.04e+08

life_expectancy               4.045e+05    3.95e+05      1.023      0.308     -3.78e+05

1.19e+06

new_data                        -0.1280      19.341     -0.007      0.995       -38.389

38.133

I(persons_prosecuted ** 2.0)    50.3116      10.404      4.836      0.000        29.729

70.894

I(child_victims ** 2.0)          7.8654      28.000      0.281      0.779       -47.524

63.255

I(gdp ** 2.0)                    3.9073       3.825      1.021      0.309        -3.660

11.474

I(policy_index ** 2.0)         611.7667     411.725      1.486      0.140      -202.724

1426.257

I(females_education ** 2.0)  -1.121e+07    2.09e+07     -0.537      0.592     -5.25e+07

3.01e+07

I(life_expectancy ** 2.0)    -9.637e+04    9.52e+04     -1.012      0.313     -2.85e+05

9.2e+04

I(new_data ** 2.0)              -5.8822      12.764     -0.461      0.646       -31.132

19.368

I(persons_prosecuted ** 3.0)    -3.8810       0.748     -5.189      0.000        -5.361

-2.401

I(child_victims ** 3.0)         -0.0741       3.213     -0.023      0.982        -6.430
```

```
6.282
I(gdp ** 3.0)                  -0.0383      0.077     -0.500      0.618       -0.190
0.113
I(policy_index ** 3.0)       -133.3417     87.717     -1.520      0.131     -306.866
40.183
I(females_education ** 3.0)   9.544e+05   1.79e+06      0.533      0.595     -2.59e+06
4.5e+06
I(life_expectancy ** 3.0)     7644.0742   7642.478      1.000      0.319    -7474.570
2.28e+04
I(new_data ** 3.0)               1.0261      6.075      0.169      0.866      -10.991
13.044
==============================================================================
Omnibus:                       68.626   Durbin-Watson:                   1.420
Prob(Omnibus):                  0.000   Jarque-Bera (JB):              281.148
Skew:                           1.650   Prob(JB):                     8.90e-62
Kurtosis:                       8.763   Cond. No.                          nan
==============================================================================

Warnings:
[1] The smallest eigenvalue is -1.37e-11. This might indicate that there are
strong multicollinearity problems or that the design matrix is singular.
```

For initial testing random numbers was used to test whether the model consistently maintain the R squared given the polynomial effect. We could conclude that adding random variables to this model does not significantly change the R squared.



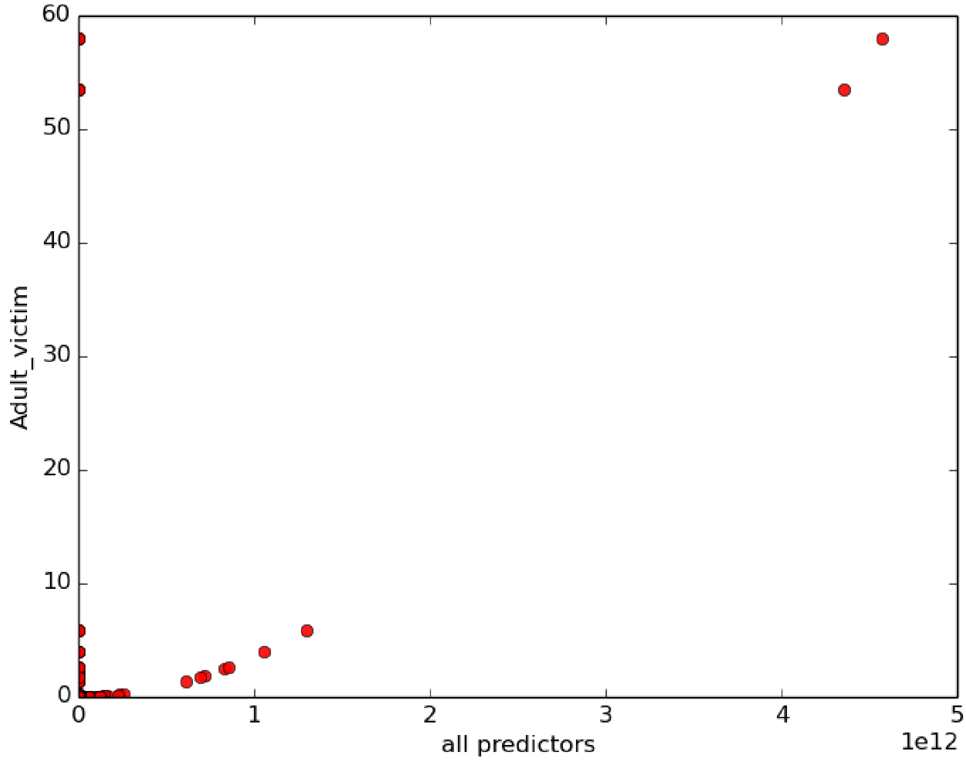
6) ***Using the model and data discussed in class predict how many cases a set of "new countries" would have (data to be provided in a separate csv file) Provide visualizations and a few paragraphs explaining your results.***

Note that new.csv does not have Adult victim, child victim and people prosecution value, and to get the expected value, we recalculate the model using the same number of x variables (fields) as the new sets. Note that the model predictive power decreased dramatically because it is used against different set of x values (this time all other expected values such as persons prosecuted):

```
                            OLS Regression Results
==============================================================================
Dep. Variable:           Adult_victims   R-squared:                      -0.315
Model:                             OLS   Adj. R-squared:                 -0.315
```

```
Method:                 Least Squares   F-statistic:                      -inf
Date:                Thu, 09 Oct 2014   Prob (F-statistic):                nan
Time:                        00:17:07   Log-Likelihood:                -1070.9
No. Observations:                 153   AIC:                             2144.
Df Residuals:                     152   BIC:                             2147.
Df Model:                           0
========================================================================================
=======
                                  coef    std err          t      P>|t|      [95.0% Conf.
Int.]
----------------------------------------------------------------------------------------
-------
Intercept                    7.208e-48   1.28e-47      0.563      0.574     -1.81e-47
3.25e-47
gdp                         -3.066e-37   5.44e-37     -0.563      0.574     -1.38e-36
7.69e-37
policy_index                -2.808e-74   6.99e-74     -0.402      0.688     -1.66e-73
1.1e-73
females_education            3.482e-46   6.18e-46      0.563      0.574     -8.73e-46
1.57e-45
life_expectancy              4.694e-46   8.34e-46      0.563      0.574     -1.18e-45
2.12e-45
I(gdp ** 2.0)                3.778e-24   6.71e-24      0.563      0.574     -9.48e-24
1.7e-23
I(policy_index ** 2.0)       6.994e-46   1.24e-45      0.563      0.574     -1.75e-45
3.15e-45
I(females_education ** 2.0)  1.683e-44   2.99e-44      0.563      0.574     -4.22e-44
7.59e-44
I(life_expectancy ** 2.0)      3.1e-44   5.51e-44      0.563      0.574     -7.78e-44
1.4e-43
I(gdp ** 3.0)               -2.197e-37   5.47e-37     -0.402      0.688      -1.3e-36
8.61e-37
I(policy_index ** 3.0)        7.37e-45   1.31e-44      0.563      0.574     -1.85e-44
3.32e-44
I(females_education ** 3.0)  8.132e-43   1.44e-42      0.563      0.574     -2.04e-42
3.67e-42
```

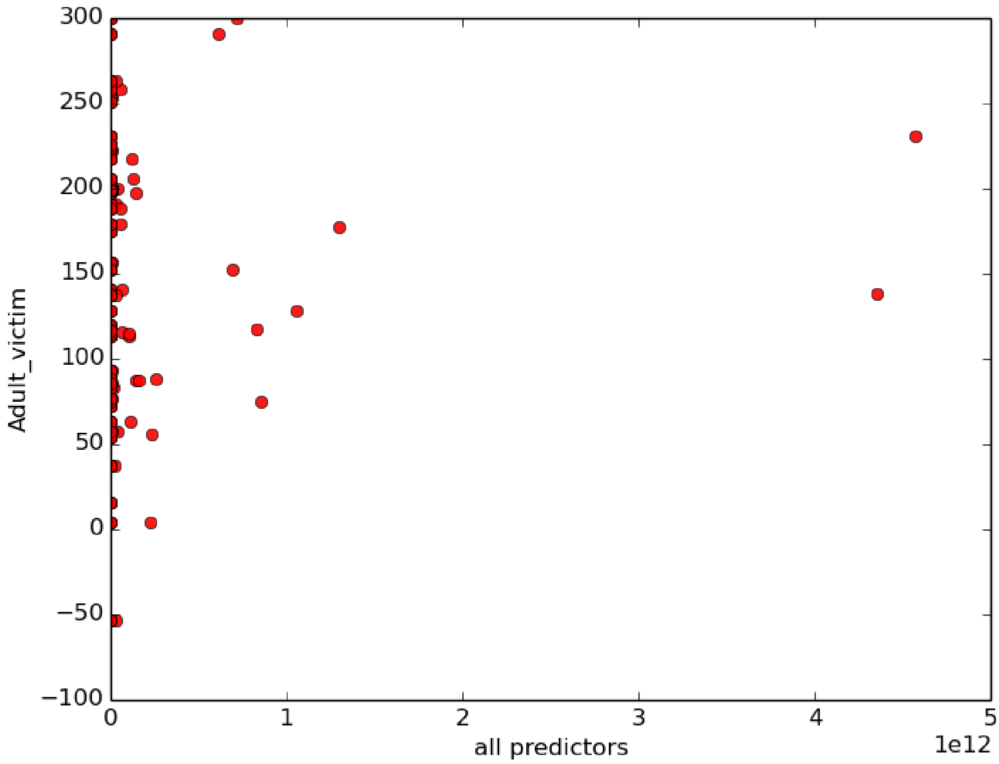
```
I(life_expectancy ** 3.0)     2.075e-42    3.69e-42       0.563       0.574      -5.21e-42

9.36e-42

==============================================================================

Omnibus:                      110.367   Durbin-Watson:                   0.569

Prob(Omnibus):                  0.000   Jarque-Bera (JB):              656.897

Skew:                           2.782   Prob(JB):                    2.27e-143

Kurtosis:                      11.490   Cond. No.                          nan

==============================================================================


Warnings:

[1] The smallest eigenvalue is -0.028. This might indicate that there are

strong multicollinearity problems or that the design matrix is singular.
```



7) ***Try other models discussed from class. What do these models predict and how do they differ from the linear regression model?***

In this problem I used weighted least squares, to get the statistic summary as follows:

```
                            WLS Regression Results
==============================================================================
Dep. Variable:          Adult_victims   R-squared:                       0.128
Model:                            WLS   Adj. R-squared:                  0.116
Method:                 Least Squares   F-statistic:                     11.02
Date:                Thu, 09 Oct 2014   Prob (F-statistic):           3.44e-05
Time:                        01:13:24   Log-Likelihood:                -654.63
No. Observations:                 153   AIC:                             1315.
Df Residuals:                     150   BIC:                             1324.
Df Model:                           2
=====================================================================================
                        coef    std err          t      P>|t|      [95.0% Conf. Int.]
-------------------------------------------------------------------------------------
const             -2951.2832   1089.960     -2.708      0.008     -5104.940  -797.626
gdp                8.351e-12   8.44e-12      0.989      0.324     -8.33e-12   2.5e-11
policy_index          0.9748      8.546      0.114      0.909       -15.912    17.861
females_education    74.1763     22.284      3.329      0.001        30.146   118.207
life_expectancy      -7.8345      2.436     -3.217      0.002       -12.647    -3.022
==============================================================================
Omnibus:                       88.244   Durbin-Watson:                   0.797
Prob(Omnibus):                  0.000   Jarque-Bera (JB):              379.683
Skew:                           2.229   Prob(JB):                     3.57e-83
Kurtosis:                       9.299   Cond. No.                     1.54e+14
==============================================================================

Warnings:
[1] The condition number is large, 1.54e+14. This might indicate that there are
strong multicollinearity or other numerical problems.
```



This prediction

The WLS is capable of resulting higher R squared value compared to the previous 3rd order polynomial model, but not as good as the original linier model.

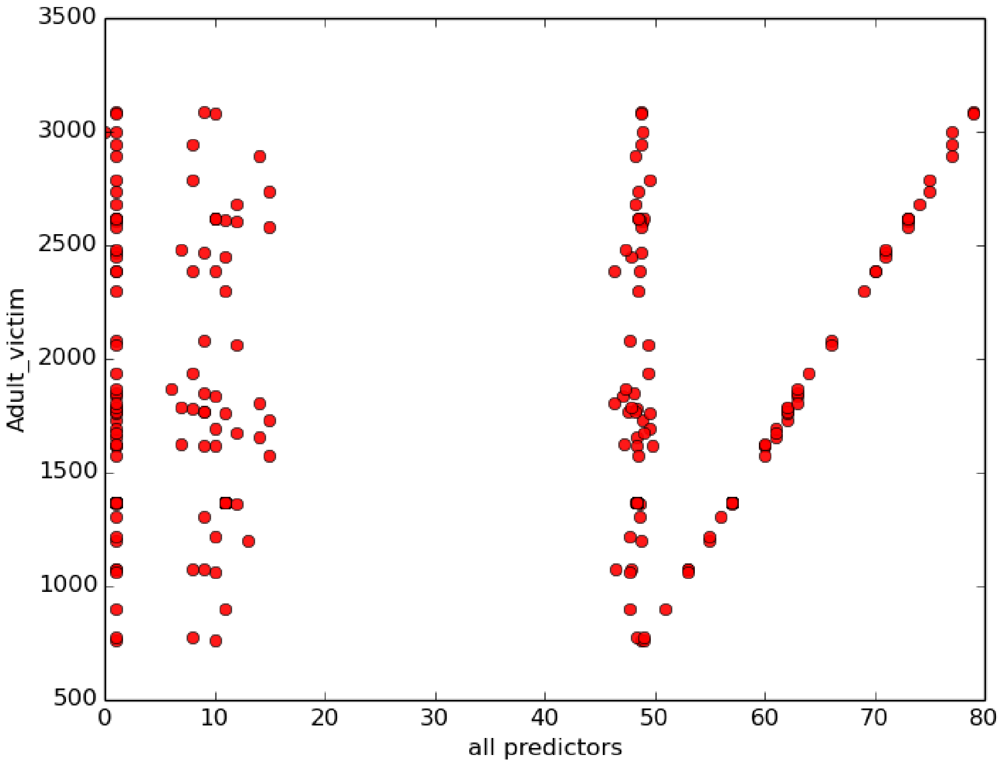
8) ***Now remove the variables with the least explanatory power. Does your linear regression improve compared to the other models? Does it do worse? Why? Please provide visuals and a few paragraphs of explanation***

From the summary we could see that gdb has the least explanatory power since it has smallest coefficient:

```
                            WLS Regression Results
==============================================================================
Dep. Variable:          Adult_victims   R-squared:                       0.122
Model:                            WLS   Adj. R-squared:                  0.105
Method:                 Least Squares   F-statistic:                     6.925
Date:                Thu, 09 Oct 2014   Prob (F-statistic):           0.000214
```

```
Time:                        01:22:09   Log-Likelihood:                -655.12
No. Observations:                 153   AIC:                             1318.
Df Residuals:                     149   BIC:                             1330.
Df Model:                           3
=====================================================================================
                        coef    std err          t      P>|t|      [95.0% Conf. Int.]
-------------------------------------------------------------------------------------
const             -3161.9193   1076.032     -2.939      0.004     -5288.172 -1035.667
policy_index          4.1584      7.969      0.522      0.603       -11.589    19.906
females_education    77.4102     22.188      3.489      0.001        33.566   121.255
life_expectancy      -7.3936      2.410     -3.067      0.003       -12.157    -2.631
==============================================================================
Omnibus:                       87.565   Durbin-Watson:                   0.798
Prob(Omnibus):                  0.000   Jarque-Bera (JB):              373.048
Skew:                           2.213   Prob(JB):                     9.85e-82
Kurtosis:                       9.239   Cond. No.                     4.99e+03
==============================================================================

Warnings:
[1] The condition number is large, 4.99e+03. This might indicate that there are
strong multicollinearity or other numerical problems.
```

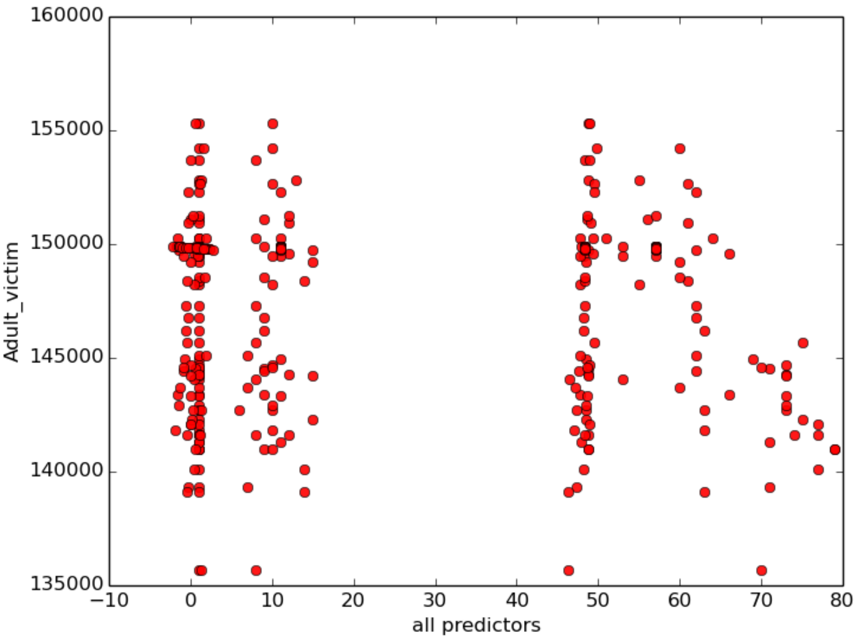
From here we know that WLS gives relatively equal predictive power compared to last result since we only omitted the variable that does not have significant effect to the whole model.



9) ***Now add in the extra data you found. Does your linear regression improved compared to the other models? Does it do worse? Why? Please provide visuals and a few paragraphs of explanation***

By adding unemployment variable it could be seen that the R squared and adjusted Rsquared does add up the value of R squared from 0.122 to 0.124.

```
                            WLS Regression Results
==============================================================================
Dep. Variable:           Adult_victims   R-squared:                       0.124
Model:                             WLS   Adj. R-squared:                  0.101
Method:                  Least Squares   F-statistic:                     5.254
Date:                 Thu, 09 Oct 2014   Prob (F-statistic):           0.000551
Time:                         11:24:36   Log-Likelihood:                -654.95
No. Observations:                  153   AIC:                             1320.
Df Residuals:                      148   BIC:                             1335.
Df Model:                            4
=====================================================================================
                         coef    std err          t      P>|t|      [95.0% Conf. Int.]
-------------------------------------------------------------------------------------
const              -1.324e+04   4281.373     -3.092      0.002      -2.17e+04 -4777.917
policy_index          59.0554     64.946      0.909      0.365        -69.286   187.397
females_education   3918.4535   1097.999      3.569      0.000       1748.673  6088.234
life_expectancy     -473.9677    153.584     -3.086      0.002       -777.469  -170.466
unemployment         -27.6415     31.278     -0.884      0.378        -89.450    34.167
==============================================================================
Omnibus:                       87.335   Durbin-Watson:                   0.798
Prob(Omnibus):                  0.000   Jarque-Bera (JB):              370.310
Skew:                           2.208   Prob(JB):                     3.88e-81
Kurtosis:                       9.212   Cond. No.                     1.63e+03
==============================================================================

Warnings:
[1] The condition number is large, 1.63e+03. This might indicate that there are
strong multicollinearity or other numerical problems.
```



http://www.internetworldstats.com/

http://data.worldbank.org/indicator/IT.NET.USER.P2/countries

--sources of internet usage

http://www.internetlivestats.com/internet-users/

--number of connected devices

10) ***download (or scrape) data from the above websites.***

Downloaded from the website into CSV then run scripts to add to adding into main csv.

11) ***How much explanatory power does the model gain by adding the amount of internet penetration in a given country? How much does adding the total number of connected devices add?***

We would like to know how much the know the explanatory power the model gain, so we run a multivariate linear regression:

```
                            OLS Regression Results
==============================================================================
Dep. Variable:          Adult_victims   R-squared:                       0.153
Model:                            OLS   Adj. R-squared:                  0.130
Method:                 Least Squares   F-statistic:                     6.683
Date:                Thu, 09 Oct 2014   Prob (F-statistic):           5.68e-05
Time:                        09:51:59   Log-Likelihood:                -1037.2
No. Observations:                 153   AIC:                             2084.
Df Residuals:                     148   BIC:                             2100.
Df Model:                           4
======================================================================================
                         coef    std err          t      P>|t|      [95.0% Conf. Int.]
--------------------------------------------------------------------------------------
const              -3407.2646   1153.837     -2.953      0.004     -5687.387 -1127.142
gdp                 8.744e-12   8.37e-12      1.044      0.298      -7.8e-12  2.53e-11
policy_index          -0.3599      8.523     -0.042      0.966       -17.203    16.483
females_education     82.6786     23.400      3.533      0.001        36.437   128.920
life_expectancy       -7.1480      2.466     -2.899      0.004       -12.021    -2.275
persons_prosecuted    -0.0029      0.005     -0.555      0.580        -0.013     0.007
child_victims          0.3980      0.208      1.913      0.058        -0.013     0.809
==============================================================================
Omnibus:                       91.217   Durbin-Watson:                   0.738
Prob(Omnibus):                  0.000   Jarque-Bera (JB):              417.756
Skew:                           2.289   Prob(JB):                     1.93e-91
Kurtosis:                       9.676   Cond. No.                     1.64e+14
==============================================================================

Warnings:
[1] The condition number is large, 1.64e+14. This might indicate that there are
strong multicollinearity or other numerical problems.
                            OLS Regression Results
==============================================================================
Dep. Variable:          Adult_victims   R-squared:                       0.164
Model:                            OLS   Adj. R-squared:                  0.135
Method:                 Least Squares   F-statistic:                     5.760
Date:                Thu, 09 Oct 2014   Prob (F-statistic):           6.94e-05
Time:                        09:51:59   Log-Likelihood:                -1036.3
No. Observations:                 153   AIC:                             2085.
Df Residuals:                     147   BIC:                             2103.
Df Model:                           5
======================================================================================
                         coef    std err          t      P>|t|      [95.0% Conf. Int.]
--------------------------------------------------------------------------------------
const              -3437.2616   1150.537     -2.988      0.003     -5710.992 -1163.532
gdp                 1.536e-11   9.63e-12      1.595      0.113     -3.67e-12  3.44e-11
policy_index          -0.3827      8.497     -0.045      0.964       -17.175    16.410
females_education     80.6406     23.376      3.450      0.001        34.445   126.836
life_expectancy       -4.7612      3.006     -1.584      0.115       -10.702     1.180
persons_prosecuted    -0.0039      0.005     -0.746      0.457        -0.014     0.006
child_victims          0.3724      0.208      1.788      0.076        -0.039     0.784
internet_penet        -1.8272      1.324     -1.380      0.170        -4.445     0.790
==============================================================================
Omnibus:                       90.949   Durbin-Watson:                   0.747
Prob(Omnibus):                  0.000   Jarque-Bera (JB):              417.275
Skew:                           2.279   Prob(JB):                     2.45e-91
Kurtosis:                       9.684   Cond. No.                     1.64e+14
==============================================================================
Warnings:
[1] The condition number is large, 1.64e+14. This might indicate that there are
strong multicollinearity or other numerical problems.
                            OLS Regression Results
==============================================================================
Dep. Variable:          Adult_victims   R-squared:                       0.156
Model:                            OLS   Adj. R-squared:                  0.127
Method:                 Least Squares   F-statistic:                     5.435
Date:                Thu, 09 Oct 2014   Prob (F-statistic):           0.000128
Time:                        09:51:59   Log-Likelihood:                -1037.0
No. Observations:                 153   AIC:                             2086.
Df Residuals:                     147   BIC:                             2104.
Df Model:                           5
======================================================================================
                         coef    std err          t      P>|t|      [95.0% Conf. Int.]
--------------------------------------------------------------------------------------
const              -3556.1615   1173.716     -3.030      0.003     -5875.698 -1236.625
gdp                -9.496e-12   2.65e-11     -0.359      0.720     -6.18e-11  4.28e-11
policy_index          -1.1579      8.607     -0.135      0.893       -18.168    15.852
females_education     85.7290     23.811      3.600      0.000        38.674   132.784
life_expectancy       -7.1508      2.470     -2.895      0.004       -12.032    -2.269
persons_prosecuted    -0.0114      0.013     -0.888      0.376        -0.037     0.014
child_victims          0.4081      0.209      1.954      0.053        -0.005     0.821
connected_dev       8.891e-07   1.22e-06      0.726      0.469     -1.53e-06  3.31e-06
==============================================================================
Omnibus:                       92.312   Durbin-Watson:                   0.741
Prob(Omnibus):                  0.000   Jarque-Bera (JB):              433.177
Skew:                           2.310   Prob(JB):                     8.65e-95
Kurtosis:                       9.826   Cond. No.                     1.67e+14
==============================================================================

Warnings:
[1] The condition number is large, 1.67e+14. This might indicate that there are
strong multicollinearity or other numerical problems.
```

Similarly, this shows that internet penetration was the only additional variable that has positive correlation to adult victim. We could observe that by adding internet penetration variable to the model from 0.153 to 0.164.

12) ***Can you give an explanation of why or why not this does not add to the model's explanatory power? Is there another variable you might take away that is related to these variables?***

The pearson test was conducted and resulted in the following:

```
Internet penetration VS adult victim:
(-0.17378602791144523, 0.03168508364587453)
Connected device VS adult victim:
(-0.023572270737661622, 0.77241153794652262)
```

As Pearson correlation coefficient varies from -1 to 1, close to zero implies no correlation). This explained that the number of internet penetration have higher correlation to the object that we are interested in observing, Adult value.