In [33]:

```
%matplotlib inline

import numpy as np
import pandas as pd
import scipy.stats as stats
import matplotlib.pyplot as plt
import math
import random
from matplotlib import collections as matcoll
import seaborn as sns
from scipy.optimize import curve_fit
from sklearn.linear_model import LinearRegression
from pylab import *
from kapteyn import kmpfit
import pylab

import statsmodels.api as sm
from statsmodels.stats.outliers_influence import summary_table
```

In [3]:

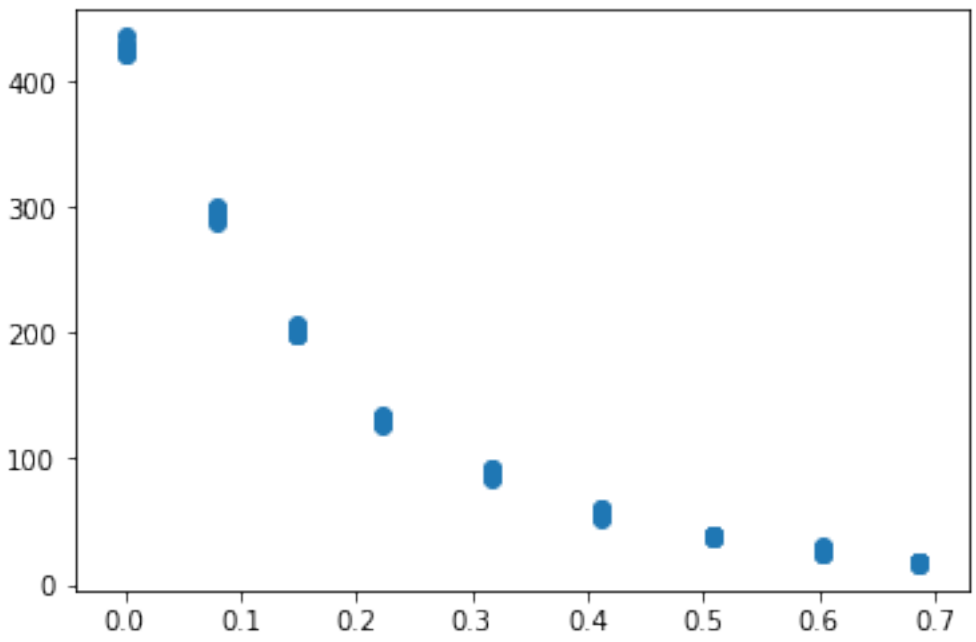
```
#Read Data into dataframe
gaugeData = pd.read_table('gauge-1wb1wa6-2gpel41.txt',delim_whitespace=Tru
```

In [4]:

```
plt.scatter(gaugeData['density'],gaugeData['gain'])
```

Out[4]:

```
<matplotlib.collections.PathCollection at 0x1a14a4e7b8>
```



In [5]:

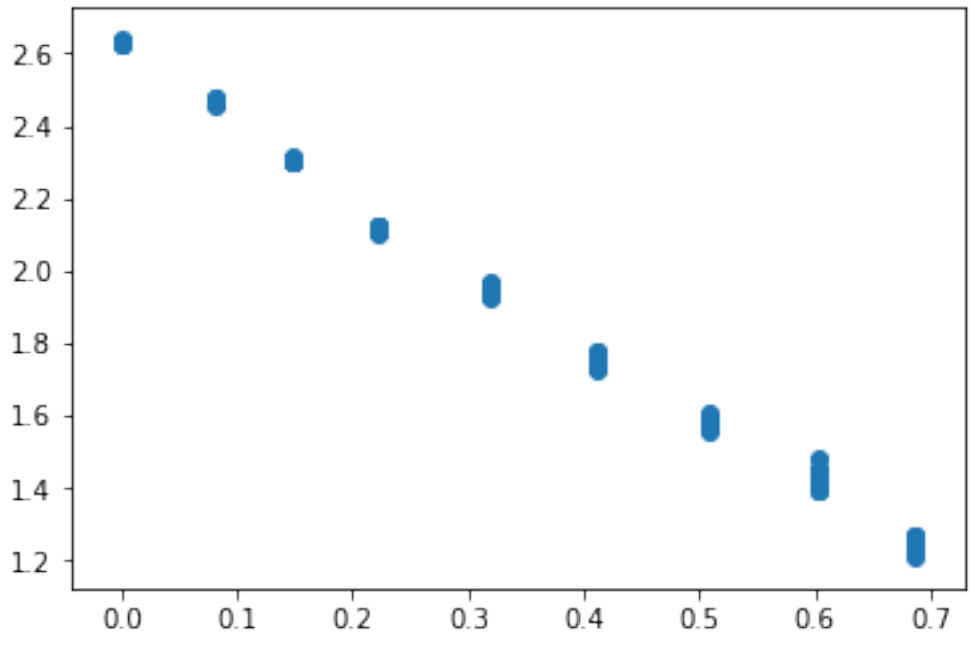
```
#Log Transformation Gain Data
gaugeData2 = gaugeData.copy(deep = True)
gaugeData2['gain'] = gaugeData2['gain'].apply(lambda x: np.log10(x))
```

In [6]:

```
1 plt.scatter(gaugeData2['density'],gaugeData2['gain'])
```

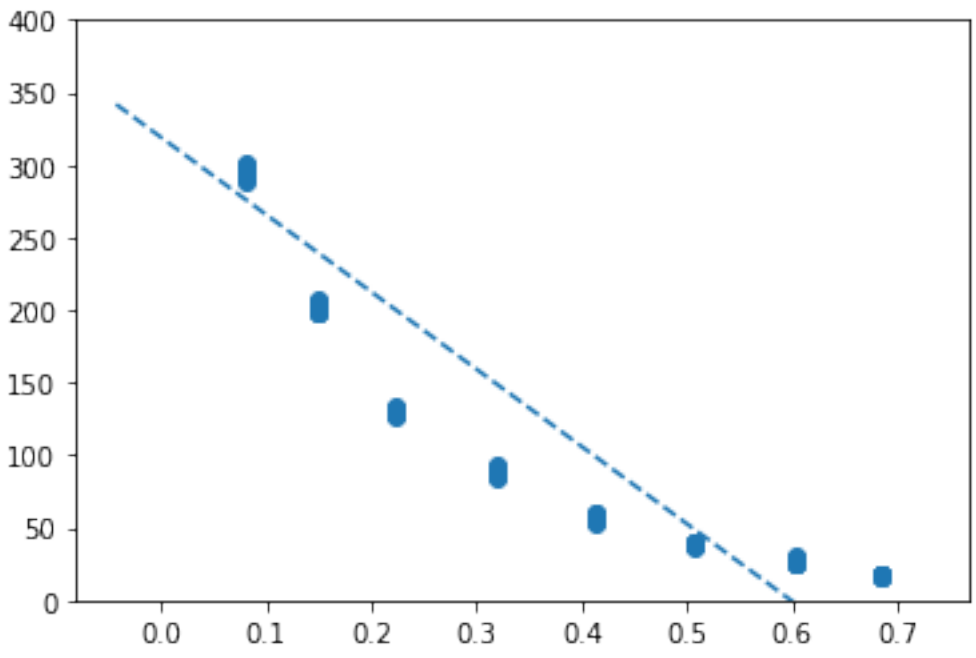
Out[6]:

```
<matplotlib.collections.PathCollection at 0x1a14ba6278>
```



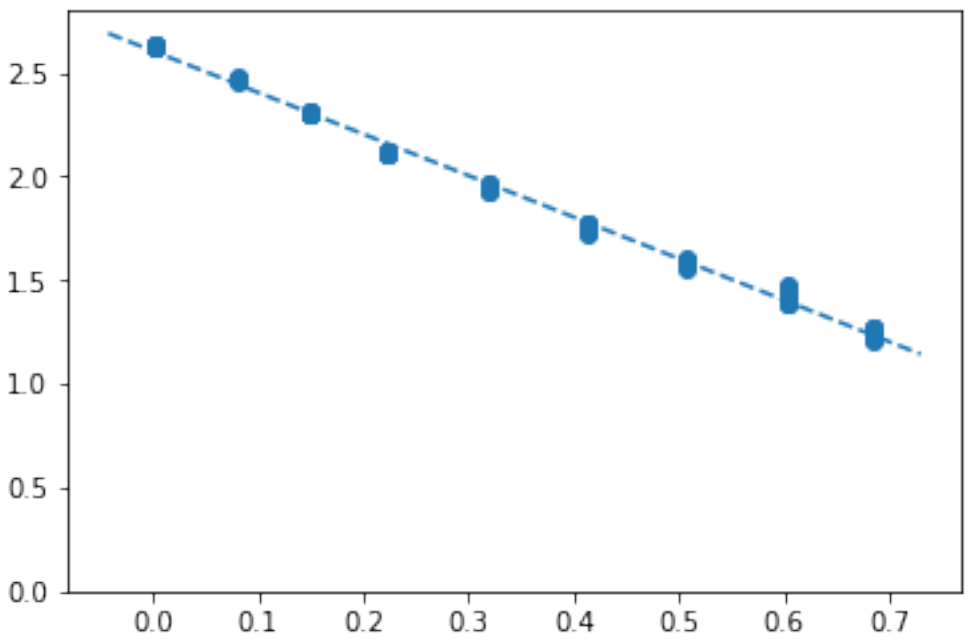
In [7]:

```
#Data plotted with least squares line
def line(x, m, b):
    return m*x + b
M,B = curve_fit(line, gaugeData['density'], gaugeData['gain'])[0]
def abline(slope, intercept):
    axes = plt.gca()
    x_vals = np.array(axes.get_xlim())
    y_vals = intercept + slope * x_vals
    plt.plot(x_vals, y_vals, '--')
plt.scatter(gaugeData['density'],gaugeData['gain'])
plt.ylim(0,400)
abline(M,B)
```



In [8]:

```
#Data plotted with least squares line
def line(x, m, b):
    return m*x + b
M2,B2 = curve_fit(line, gaugeData2['density'], gaugeData2['gain'])[0]
def abline(slope, intercept):
    axes = plt.gca()
    x_vals = np.array(axes.get_xlim())
    y_vals = intercept + slope * x_vals
    plt.plot(x_vals, y_vals, '--')
plt.scatter(gaugeData2['density'],gaugeData2['gain'])
plt.ylim(0,2.8)
abline(M2,B2)
```

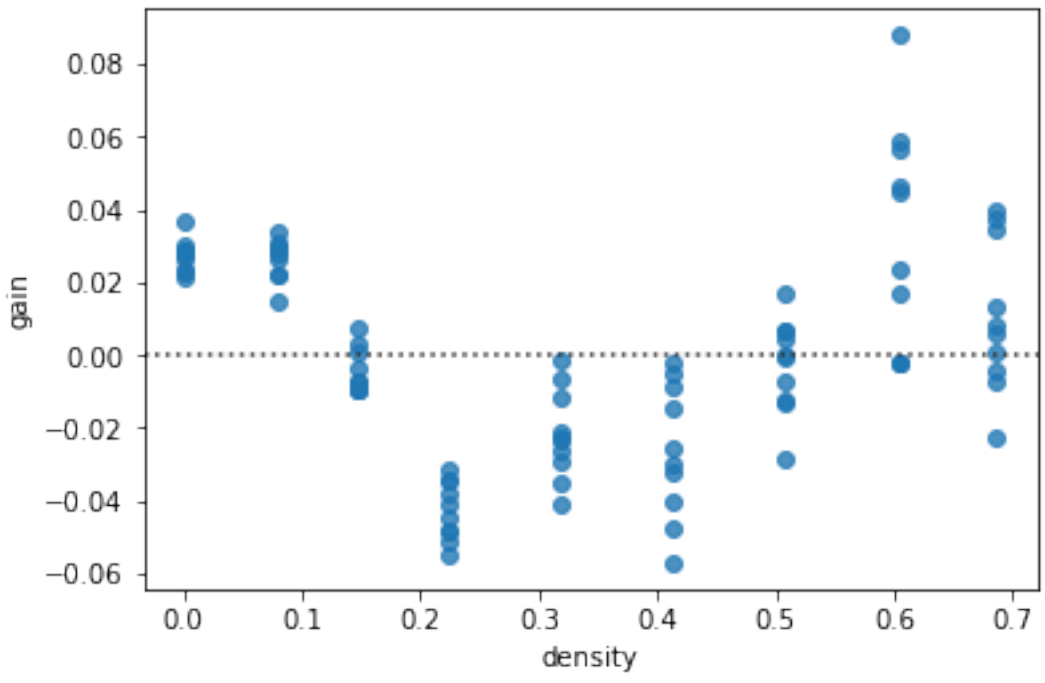


In [9]:

```
#log transformed residuals
sns.residplot(gaugeData2['density'],gaugeData2['gain'])
```

Out[9]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x1a151e9710>
```

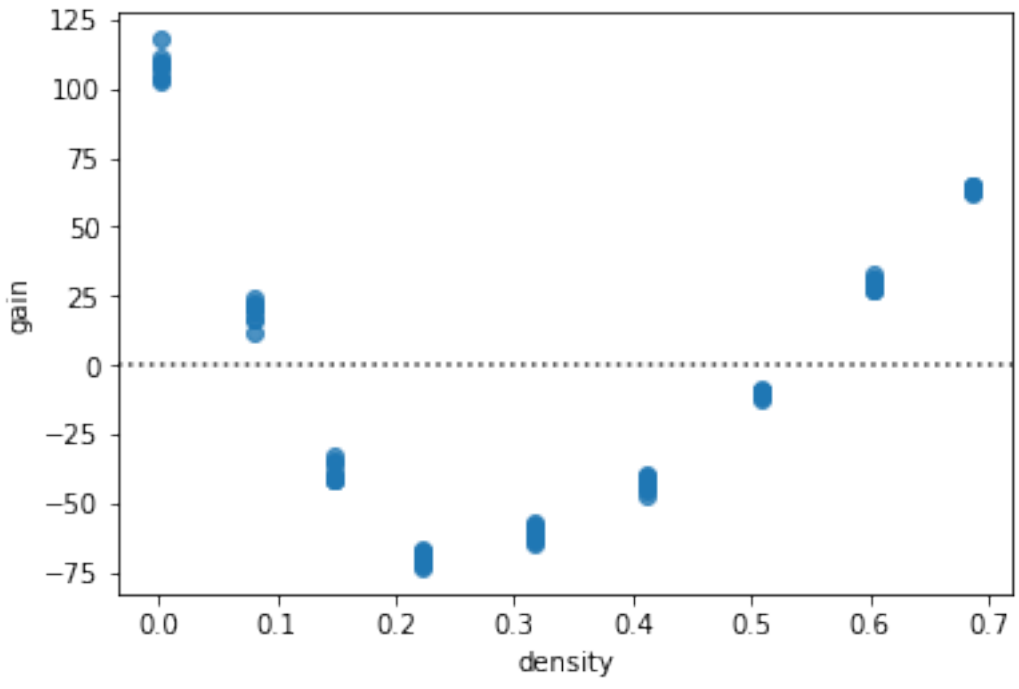


In [10]:

```
#Original Data Residuals
sns.residplot(gaugeData['density'],gaugeData['gain'])
```

Out[10]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x1a152db278>
```



In [11]:

```
np.correlate(gaugeData['density'],gaugeData['gain'])
```

Out[11]:

```
array([ 1824.5634])
```

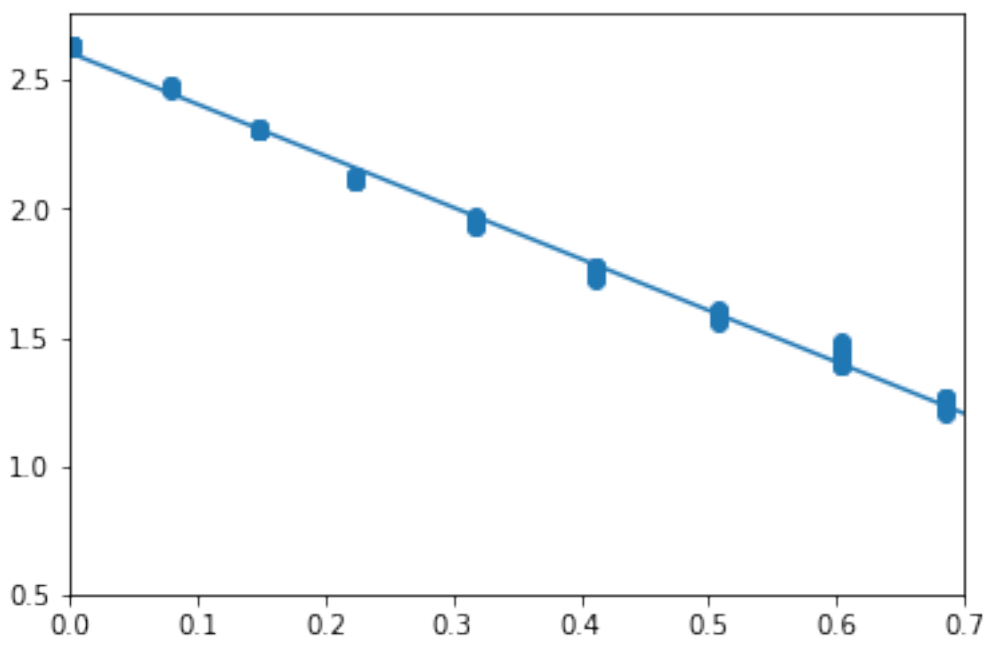
In [35]:

```
#Different Model:
model2 = LinearRegression(fit_intercept=True)

model2.fit(gaugeData2['density'][:, np.newaxis], gaugeData2['gain'])

xfit = np.linspace(0, 1, 10)
yfit = model2.predict(xfit[:, np.newaxis])

plt.scatter(gaugeData2['density'], gaugeData2['gain'])
plt.xlim(0,0.7)
plt.plot(xfit, yfit);
```



In [28]:

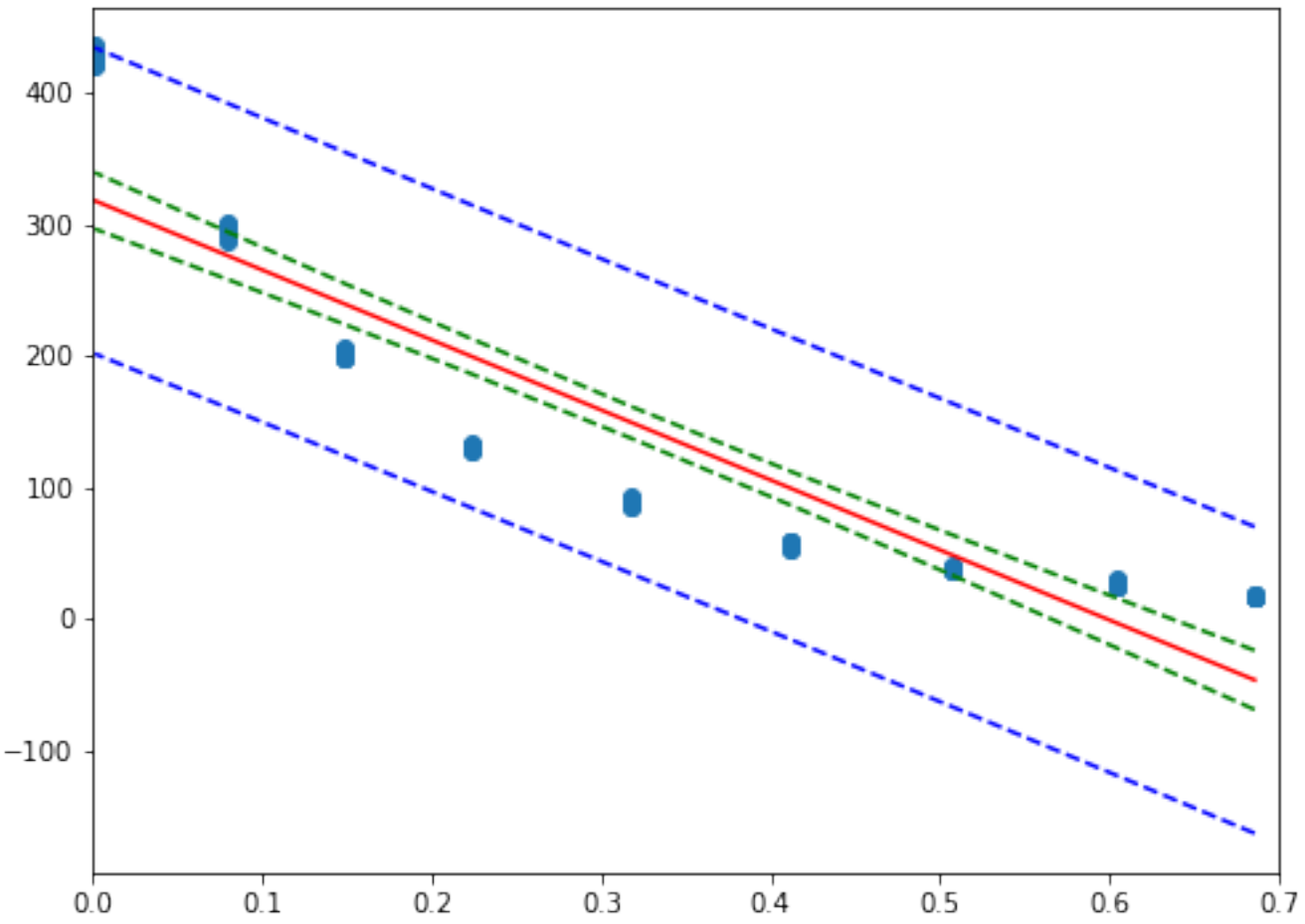
```
x = gaugeData['density']
y = gaugeData['gain']

X = sm.add_constant(x)
res = sm.OLS(y, X).fit()

```

```
st, data, ss2 = summary_table(res, alpha=0.05)
fitvalues = data[:,2]
predict_mean_se  = data[:,3]
predict_mean_l, predict_mean_u = data[:,4:6].T
predict_l, predict_u = data[:,6:8].T

fig, ax = plt.subplots(figsize=(8,6))
ax.plot(x, y, 'o', label="data")
ax.plot(X, fitvalues, 'r-', label='OLS')
ax.plot(X, predict_l, 'b--')
ax.plot(X, predict_u, 'b--')
ax.plot(X, predict_mean_l, 'g--')
ax.plot(X, predict_mean_u, 'g--')
plt.xlim(0,0.7)
plt.show()
```



In [148]:

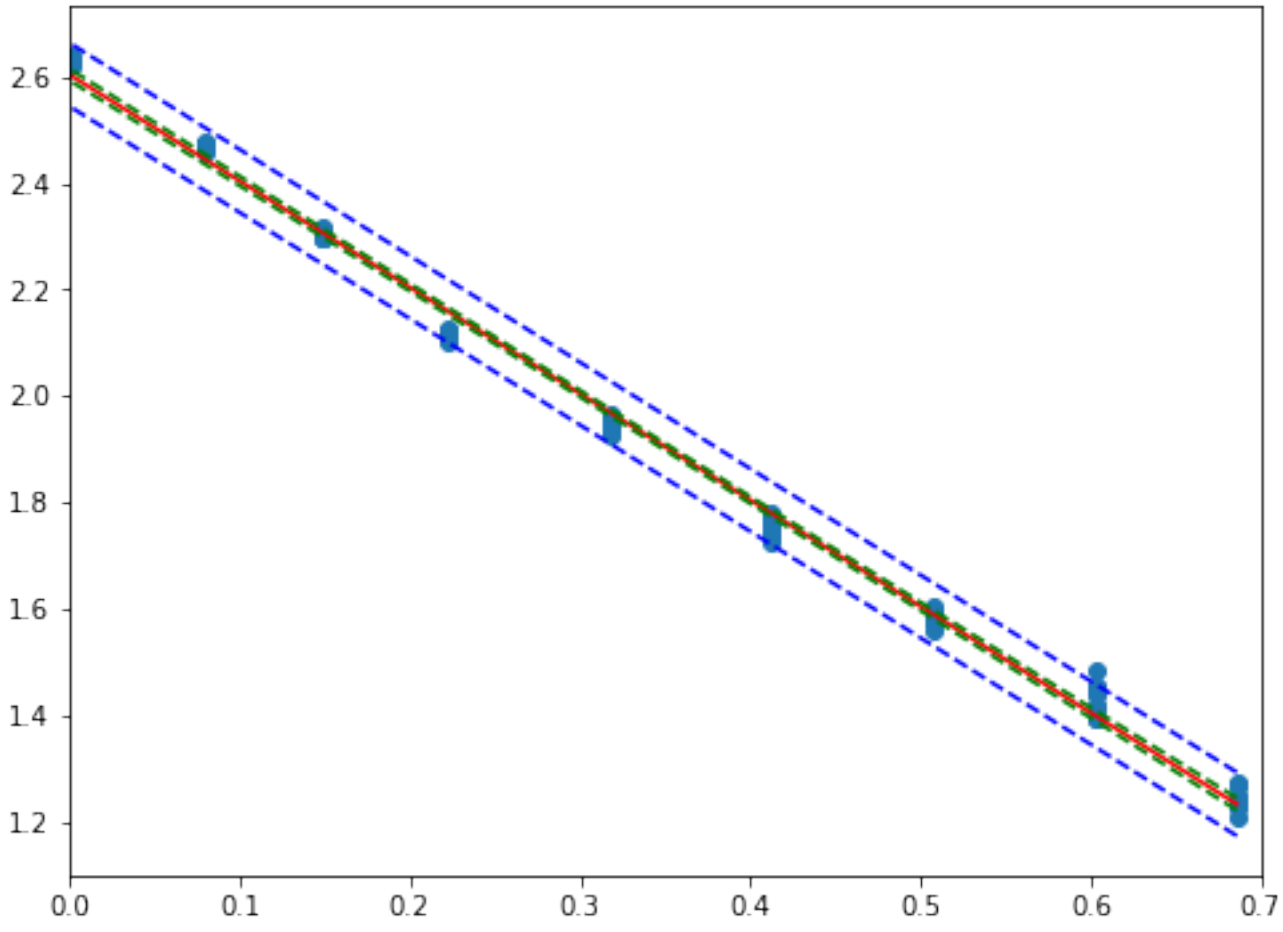
```
x = gaugeData2['density']
y = gaugeData2['gain']

X = sm.add_constant(x)
```

```
res = sm.OLS(y, X).fit()

st, data, ss2 = summary_table(res, alpha=0.05)
fitvalues = data[:,2]
predict_mean_se  = data[:,3]
predict_mean_l, predict_mean_u = data[:,4:6].T
predict_l, predict_u = data[:,6:8].T

fig, ax = plt.subplots(figsize=(8,6))
ax.plot(x, y, 'o')
ax.plot(X, fitvalues, 'r-')
ax.plot(X, predict_l, 'b--')
ax.plot(X, predict_u, 'b--')
ax.plot(X, predict_mean_l, 'g--')
ax.plot(X, predict_mean_u, 'g--')
plt.xlim(0,0.7)
plt.show()
```



In [161]:

```
# Cross Validation with
std_error = 10**.0138181
def cross_validate(density):
    sumGain = (gaugeData2.gain[gaugeData2.density == density].sum())
    lenGain = len(gaugeData2.gain[gaugeData2.density == density])
    meanGain = sumGain/lenGain
    nDF = gaugeData2[gaugeData2.density != density]
    M3,B3 = curve_fit(line, nDF['density'], nDF['gain'])[0]
    yr = M3*density + B3
    xr = (np.log(38.6) - B3)/M3
    return xr
```