Topic 4 : Predicting the projected annual salaries for the year 2016

In [34]:

```
# Importing Libraries
import pandas as pd
import matplotlib.pyplot as plt
import warnings
warnings.filterwarnings('ignore')
import seaborn as sns
from sklearn.metrics import r2_score
import statsmodels.api as sm
import numpy as np
from sklearn import datasets, linear_model
from sklearn.metrics import mean_squared_error
```

Initial Data Cleaning:

In [ ]:

```
#Load Dataset
df = pd.read_csv("data.csv")

# Column names pre-processing
org_columns = list(df.columns)
for i in range(len(org_columns)):
    org_columns[i] = org_columns[i].replace(" ","_")
    org_columns[i] = org_columns[i].lower()
df.columns = org_columns

# Removing Special Characters
df[org_columns] = df[org_columns].replace({'\$': '', ',': '','%':''}, regex
=True)

# Typecasting All numeric columns to float
df[[ 'hourly_or_event_rate','projected_annual_salary','q1_payments',
    'q2_payments','q3_payments','q4_payments','payments_over_base_pay','%_o
ver_base_pay',
    'total_payments','base_pay','permanent_bonus_pay','longevity_bonus_pay'
,

'temporary_bonus_pay','lump_sum_pay','overtime_pay','other_pay_&_adjustments
',

'other_pay_(payroll_explorer)','average_health_cost','average_dental_cost',
'average_basic_life',
    'average_benefit_cost']] = df[[
'hourly_or_event_rate','projected_annual_salary','q1_payments',
    'q2_payments','q3_payments','q4_payments','payments_over_base_pay','%_o
ver_base_pay',
    'total_payments','base_pay','permanent_bonus_pay','longevity_bonus_pay'
,
'temporary_bonus_pay','lump_sum_pay','overtime_pay','other_pay_&_adjustments
',

'other_pay_(payroll_explorer)','average_health_cost','average_dental_cost',
'average_basic_life',
     'average_benefit_cost']].astype(float)

# Storing the cleaned dataset in a new csv file "processed_data.csv" to avo
id cleaning everytime.
df.to_csv("processed_data.csv",header=True,index=False)
```

Analysis

In [2]:

```
# Load dataset
data = pd.read_csv("processed_data.csv")
data.head()
```

Out[2]:

	row_id	year	department_title	payroll_department	record_number	job_class_title	employ
0	111391	2014	Water And Power (DWP)	NaN	1412316577	Commercial Service Representative	Full Tim
1	31732	2013	Police (LAPD)	4301.0	432728338	Police Officer I	Full Tim
2	27697	2013	Police (LAPD)	4301.0	97182506	Police Officer II	Full Tim
3	14136	2013	Harbor (Port of LA)	3201.0	950136941	Senior Security Officer	Full Tim
4	91896	2014	Public Works - Sanitation	7024.0	3230003445	Senior Clerk Typist	Full Tim

5 rows × 35 columns

In [3]:

```
# Displaying all Columns
data.columns
```

Out[3]:

```
Index(['row_id', 'year', 'department_title', 'payroll_department',
       'record_number', 'job_class_title', 'employment_type',
       'hourly_or_event_rate', 'projected_annual_salary', 'q1_payments',
       'q2_payments', 'q3_payments', 'q4_payments',
'payments_over_base_pay',
'payments_over_base_pay',
       '%_over_base_pay', 'total_payments', 'base_pay',
'permanent_bonus_pay',
       'longevity_bonus_pay', 'temporary_bonus_pay', 'lump_sum_pay',
       'overtime_pay', 'other_pay_&_adjustments',
       'other_pay_(payroll_explorer)', 'mou', 'mou_title',
'fms_department',
       'job_class', 'pay_grade', 'average_health_cost',
'average_dental_cost',
       'average_basic_life', 'average_benefit_cost', 'benefits_plan',
       'job_class_link'],
      dtype='object')
```

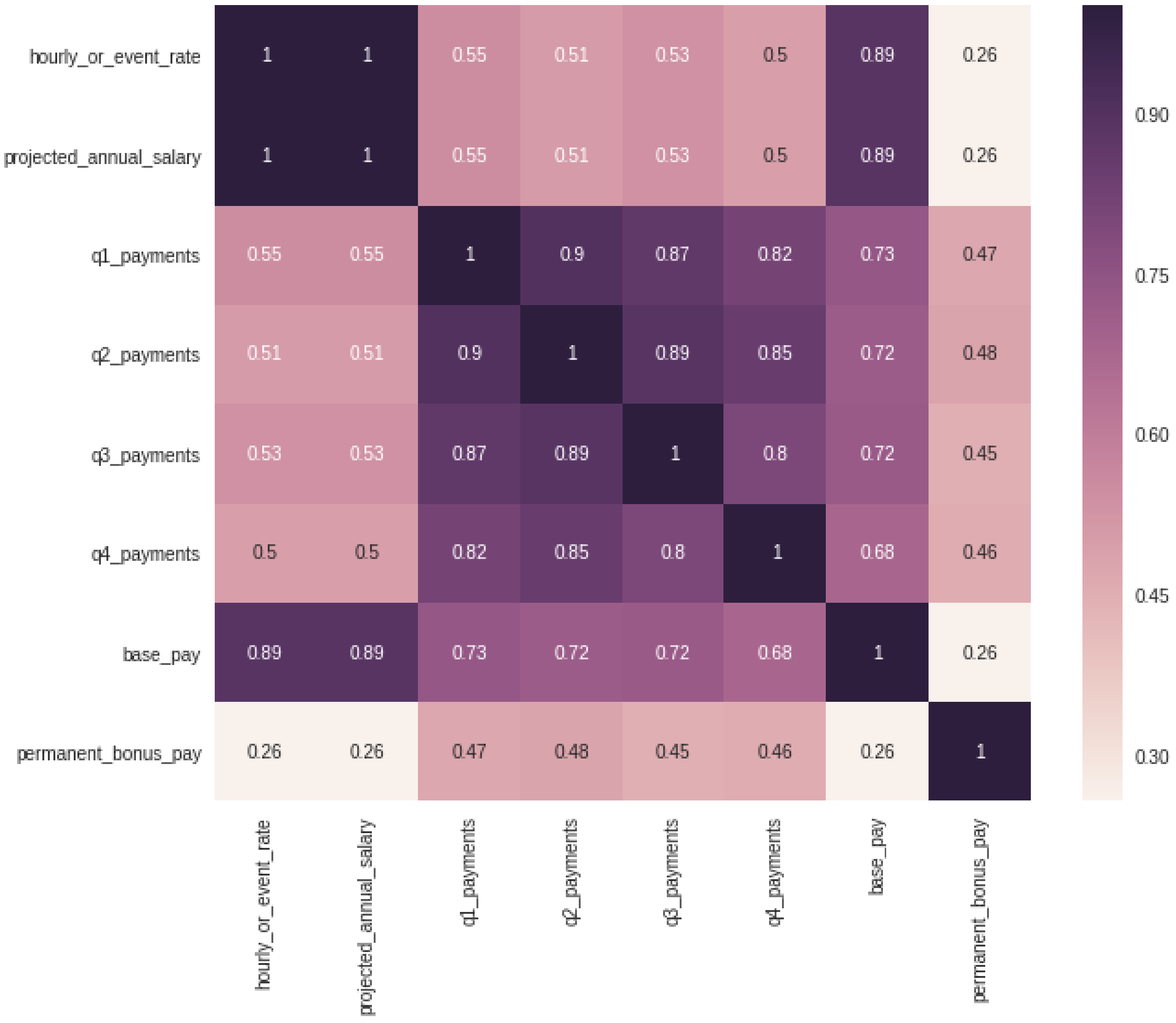
Correlation heat map plot after data cleaning

In [9]:

```
subcorr = sub_data.corr()
fig, ax = plt.subplots(figsize=(10,8))
sns.heatmap(subcorr,annot=True,ax=ax)
```

Out[9]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x7f0df93762b0>
```



In [30]:

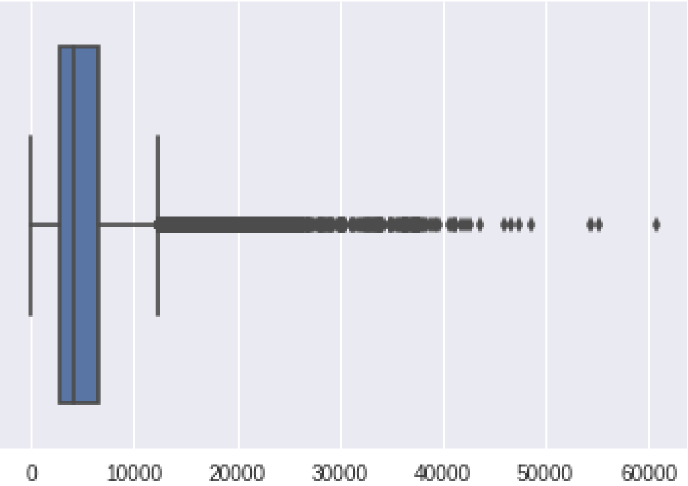
```
# Function to remove outliers
def outlier_range(x):
    x = np.array(x)
    upper_q = np.percentile(x, 75)
    lower_q = np.percentile(x, 25)
    iqr = (upper_q - lower_q) * 1.5
    acceptable_range = (lower_q - iqr, upper_q + iqr)
    return acceptable_range
```

In [11]:

```
sns.boxplot(list(sub_data.permanent_bonus_pay))
```

Out[11]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x7f0dfaed5f60>
```



In [16]:

```
# Creating grouped dataset grouped by "department_title"
grouping = sub_data.groupby("department_title").mean()
grouping.head()
```

Out[16]:

	hourly_or_event_rate	projected_annual_salary	q1_payments	q2_payments
department_title				
Aging	39.530000	82538.640000	19491.600000	25373.420000
Airports (LAWA)	34.215724	71442.344038	19729.799430	22553.469378
Animal Services	30.194765	63047.649262	14727.189128	16959.803423
Building and Safety	44.698193	93324.831074	23016.762902	27122.441094
City Administrative Officer (CAO)	66.037500	137889.432500	30427.012500	35613.455000

In [31]:

```
# Function to calculate SSE
def sse_calc(actual,predicted)
def sse_calc(actual,predicted):
    sse = 0
    for i in range(len(actual)):
        sse = sse + pow((actual[i] - predicted[i]),2)
    return sse

# Function to calculate MAPE
def mape_calc(actual,predicted):
    mape = 0
    for i in range(len(actual)):
        if actual[i]!=0:
            mape += abs(actual[i]-predicted[i])/actual[i]
    mape = (mape*100)/len(actual)
    return mape
```

Linear Regression Analysis:

LR After Outlier Removal:

In [54]:

```
# Getting training data (before the year 2016)
sub_data = data[data['year']<=2015]

# Get important columns
sub_data = sub_data[['department_title','hourly_or_event_rate','projected_a
nnual_salary',
                 'q1_payments','q2_payments', 'q3_payments', 'q4_payments',
base_pay', 'permanent_bonus_pay']]

# Remove negative and Nan values
num = sub_data._get_numeric_data()
num[num < 0] = 0
sub_data = sub_data.replace(0, np.nan)
sub_data = sub_data.dropna()

# Remove outliers
cols = ['hourly_or_event_rate','projected_annual_salary','q1_payments','q2_
payments', 'q3_payments',
        'q4_payments','base_pay', 'permanent_bonus_pay']
for col in cols:
    a = outlier_range(list(sub_data[col]))
    sub_data = sub_data[(sub_data[col]>=a[0]) & (sub_data[col]<=a[1])]

# Fit Linear Regression Models
X_train = sub_data[['hourly_or_event_rate','q1_payments','q2_payments', 'q3
_payments',
        'q4_payments','base_pay', 'permanent_bonus_pay']]
Y_train = sub_data['projected_annual_salary']
regr = linear_model.LinearRegression()
regr.fit(X_train, Y_train)

print("EQUATION:")
print("Y = ("+str(regr.coef_[0])+") X1 \n   +("+str(regr.coef_[1])+") X2 \n
+("
      +str(regr.coef_[2])+") X3 \n   +("+str(regr.coef_[3])+") X4 \n   +("
      +str(regr.coef_[4])+") X5 \n   +("+str(regr.coef_[5])+") X6 \n   +("+s
tr(regr.coef_[6])+") X7 \n    +("
      +str(regr.intercept_)+")")

print("\n")

# Getting Test Data
test_data = data[data['year']>=2016]

# Grouping data
grouping = sub_data.groupby("department_title").mean()
grouping.head()

# Make predictions based on department title
y_pred = []
for index, row in test_data.iterrows():
    hourly_rate = row['hourly_or_event_rate']
    temp = grouping[grouping.index==row['department_title']]
    try:
        q1 = temp['q1_payments'][0]
        q2 = temp['q2_payments'][0]
        q3 = temp['q3_payments'][0]
        q4 = temp['q4_payments'][0]
        base = row['base_pay']
        bonus = row['permanent_bonus_pay']
        y_pred.append(regr.predict([hourly_rate,q1,q2,q3,q4,base,bonus]))
    except:
        y_pred.append(0)
        pass

# Getting actual values for error check
actual = list(test_data['projected_annual_salary'])

# Some processing required
y_pred_new = []
for i in y_pred:
    try:
        y_pred_new.append(i[0])
    except:
        y_pred_new.append(i)


y_pred_final = []
actual_final = []
for i in range(len(actual)):
    if y_pred_new[i]!=0:
        y_pred_final.append(y_pred_new[i])
        actual_final.append(actual[i])

# Computing SSE and MAPE values
print("Sample y_pred values: ",y_pred_new[45678:45690],"\n")
print("Actual values: ",actual[45678:45690],"\n")
print("SSE: ",sse_calc(actual_final,y_pred_final),"\n")
print("MAPE: ",mape_calc(actual_final,y_pred_final))
```

```
EQUATION:
Y = (2087.9555889) X1
   +(-2.33032955403e-05) X2
   +(-0.000110569938274) X3
   +(2.79917728252e-05) X4
   +(5.08891902689e-06) X5
   +(5.06891902069e-06) X5
   +(4.95806723477e-05) X6
   +(0.000131502128451) X7
   +(-0.277583954288)


Sample y_pred values:  [array([ 101744.64264821]), array([
109219.74248075]), array([ 112623.13760107]), array([ 101160.00170153]), ar
ray([ 105127.30631701]), array([ 106379.99315612]), array([
94415.74577499]), array([ 106609.84235733]), array([ 109219.701518]), array
([ 108697.64775209]), array([ 103957.88944155]), array([ 99635.74050775])]

Actual values:  [101744.59, 109232.14999999999, 112622.02,
101163.60000000001, 105134.45, 106383.60000000001, 94419.360000000001, 1066
14.85000000001, 109232.14999999999, 108701.28, 103961.52,
99639.360000000001]

SSE:  3.34062503927e+14

MAPE:  0.00594579931611
```

LR Without Removing Outliers:

In [55]:

```
sub_data = data[data['year']<=2015]

sub_data = sub_data[['department_title','hourly_or_event_rate','projected_a
nnual_salary',
                  'q1_payments','q2_payments', 'q3_payments', 'q4_payments',
base_pay', 'permanent_bonus_pay']]

num = sub_data._get_numeric_data()
num[num < 0] = 0
sub_data = sub_data.replace(0, np.nan)

sub_data = sub_data.dropna()

X_train = sub_data[['hourly_or_event_rate','q1_payments','q2_payments', 'q3
_payments',
        'q4_payments','base_pay', 'permanent_bonus_pay']]
Y_train = sub_data['projected_annual_salary']
regr = linear_model.LinearRegression()
regr.fit(X_train, Y_train)

print("EQUATION:")
print("Y = ("+str(regr.coef_[0])+") X1 \n   +("+str(regr.coef_[1])+") X2 \n
+("
      +str(regr.coef_[2])+") X3 \n   +("+str(regr.coef_[3])+") X4 \n   +("
      +str(regr.coef_[4])+") X5 \n   +("+str(regr.coef_[5])+") X6 \n   +("+s
tr(regr.coef_[6])+") X7 \n   +("
      +str(regr.intercept_)+")")

print("\n")

test_data = data[data['year']>=2016]

grouping = sub_data.groupby("department_title").mean()
grouping.head()
```

```python
y_pred = []
for index, row in test_data.iterrows():
    hourly_rate = row['hourly_or_event_rate']
    temp = grouping[grouping.index==row['department_title']]
    try:
        q1 = temp['q1_payments'][0]
        q2 = temp['q2_payments'][0]
        q3 = temp['q3_payments'][0]
        q4 = temp['q4_payments'][0]
        base = row['base_pay']
        bonus = row['permanent_bonus_pay']
        y_pred.append(regr.predict([hourly_rate,q1,q2,q3,q4,base,bonus]))
    except:
        y_pred.append(0)
        pass

actual = list(test_data['projected_annual_salary'])

y_pred_new = []
for i in y_pred:
    try:
        y_pred_new.append(i[0])
    except:
        y_pred_new.append(i)


y_pred_final = []
actual_final = []
for i in range(len(actual)):
    if y_pred_new[i]!=0:
        y_pred_final.append(y_pred_new[i])
        actual_final.append(actual[i])

print("Sample y_pred values: ",y_pred_new[45678:45690],"\n")
print("Actual values: ",actual[45678:45690],"\n")
print("SSE: ",sse_calc(actual_final,y_pred_final),"\n")
print("MAPE: ",mape_calc(actual_final,y_pred_final))
```

```
EQUATION:
Y = (2087.95843567) X1
   +(-8.32457489418e-07) X2
   +(-6.16673171992e-05) X3
   +(-1.7606948914e-06) X4
   +(-1.69306018756e-05) X5
   +(3.87900977875e-05) X6
   +(7.11038600324e-05) X7
   +(0.282607471134)



Sample y_pred values:  [array([ 101745.37802558]), array([
109220.42231126]), array([ 112623.79208949]), array([ 101160.76362904]), ar
ray([ 105127.96585061]), array([ 106380.72291417]), array([
94416.55607372]), array([ 106610.48784421]), array([ 109220.39206726]), arr
ay([ 108698.35813183]), array([ 103958.63363821]), array([
99636.51162823])]

Actual values:  [101744.59, 109232.14999999999, 112622.02,
101163.60000000001, 105134.45, 106383.60000000001, 94419.360000000001, 1066
14.85000000001, 109232.14999999999, 108701.28, 103961.52,
14.0500000001, 109232.14999999999, 100701.20, 103901.52,
99639.360000000001]

SSE:  3.3406373765e+14

MAPE:  0.0050039252221
```

LR Without Hourly Rate and Without Outlier Removal:

In [56]:

```
sub_data = data[data['year']<=2015]

sub_data = sub_data[['department_title','hourly_or_event_rate','projected_annual_salary',
                     'q1_payments','q2_payments', 'q3_payments', 'q4_payments', 'base_pay', 'permanent_bonus_pay']]

num = sub_data._get_numeric_data()
num[num < 0] = 0
sub_data = sub_data.replace(0, np.nan)

sub_data = sub_data.dropna()

X_train = sub_data[['q1_payments','q2_payments', 'q3_payments',
         'q4_payments','base_pay', 'permanent_bonus_pay']]
Y_train = sub_data['projected_annual_salary']
regr = linear_model.LinearRegression()
regr.fit(X_train, Y_train)

print("EQUATION:")
print("Y = ("+str(regr.coef_[0])+") X1 \n   +("+str(regr.coef_[1])+") X2 \n   +("
      +str(regr.coef_[2])+") X3 \n   +("+str(regr.coef_[3])+") X4 \n   +("
      +str(regr.coef_[4])+") X5 \n   +("+str(regr.coef_[5])+") X6 \n   +("
      +str(regr.intercept_)+")")

print("\n")

test_data = data[data['year']>=2016]

grouping = sub_data.groupby("department_title").mean()
grouping.head()

y_pred = []
for index, row in test_data.iterrows():
    #hourly_rate = row['hourly_or_event_rate']
    temp = grouping[grouping.index==row['department_title']]
    try:
        q1 = temp['q1_payments'][0]
        q2 = temp['q2_payments'][0]
        q3 = temp['q3_payments'][0]
        q4 = temp['q4_payments'][0]
        base = row['base_pay']
        bonus = row['permanent_bonus_pay']
        y_pred.append(regr.predict([q1,q2,q3,q4,base,bonus]))
    except:
        y_pred.append(0)
        pass
```

```
actual = list(test_data['projected_annual_salary'])

y_pred_new = []
for i in y_pred:
    try:
        y_pred_new.append(i[0])
    except:
        y_pred_new.append(i)


y_pred_final = []
actual_final = []
for i in range(len(actual)):
    if y_pred_new[i]!=0:
        y_pred_final.append(y_pred_new[i])
        actual_final.append(actual[i])

print("Sample y_pred values: ",y_pred_new[45678:45690],"\n")
print("Actual values: ",actual[45678:45690],"\n")
print("SSE: ",sse_calc(actual_final,y_pred_final),"\n")
print("MAPE: ",mape_calc(actual_final,y_pred_final))
```

```
EQUATION:
Y = (-0.0646171018905) X1
   +(-0.57198421168) X2
   +(-0.131859288872) X3
   +(-0.119818158993) X4
   +(1.15839125661) X5
   +(0.761316040418) X6
   +(12196.9674162)


Sample y_pred values:  [18259.715853941067, 22054.942767709967,
20952.670809027597, 19724.070914138058, 19291.212420996515,
20883.409166432095, 17664.45445341093, 21554.746705561542,
21229.075000639274, 20180.703957203652, 19225.187512776167,
18442.560309150515]

Actual values:  [101744.59, 109232.14999999999, 112622.02,
101163.60000000001, 105134.45, 106383.60000000001, 94419.360000000001, 1066
14.85000000001, 109232.14999999999, 108701.28, 103961.52,
99639.360000000001]

SSE:  4.43162403004e+14

MAPE:  75.3577163886
```

LR Without Hourly Rate and After Outlier Removal:

In [57]:

```
sub_data = data[data['year']<=2015]

sub_data = sub_data[['department_title','hourly_or_event_rate','projected_a
nnual_salary',
                  'q1_payments','q2_payments', 'q3_payments', 'q4_payments',
base_pay', 'permanent_bonus_pay']]
```

```
num = sub_data._get_numeric_data()
num[num < 0] = 0
sub_data = sub_data.replace(0, np.nan)

sub_data = sub_data.dropna()

cols = ['projected_annual_salary','q1_payments','q2_payments',
'q3_payments', 'q4_payments','base_pay',
        'permanent_bonus_pay']

for col in cols:
    a = outlier_range(list(sub_data[col]))
    sub_data = sub_data[(sub_data[col]>=a[0]) & (sub_data[col]<=a[1])]

X_train = sub_data[['q1_payments','q2_payments', 'q3_payments',
        'q4_payments','base_pay', 'permanent_bonus_pay']]
Y_train = sub_data['projected_annual_salary']
regr = linear_model.LinearRegression()
regr.fit(X_train, Y_train)

print("EQUATION:")
print("Y = ("+str(regr.coef_[0])+") X1 \n   +("+str(regr.coef_[1])+") X2 \n
+("
      +str(regr.coef_[2])+") X3 \n   +("+str(regr.coef_[3])+") X4 \n   +("
      +str(regr.coef_[4])+") X5 \n   +("+str(regr.coef_[5])+") X6 \n   +("
      +str(regr.intercept_)+")")

print("\n")

test_data = data[data['year']>=2016]

grouping = sub_data.groupby("department_title").mean()
grouping.head()

y_pred = []
for index, row in test_data.iterrows():
    #hourly_rate = row['hourly_or_event_rate']
    temp = grouping[grouping.index==row['department_title']]
    try:
        q1 = temp['q1_payments'][0]
        q2 = temp['q2_payments'][0]
        q3 = temp['q3_payments'][0]
        q4 = temp['q4_payments'][0]
        base = row['base_pay']
        bonus = row['permanent_bonus_pay']
        y_pred.append(regr.predict([q1,q2,q3,q4,base,bonus]))
    except:
        y_pred.append(0)
        pass

actual = list(test_data['projected_annual_salary'])

y_pred_new = []
for i in y_pred:
    try:
        y_pred_new.append(i[0])
    except:
        y_pred_new.append(i)
```

```
y_pred_final = []
actual_final = []
for i in range(len(actual)):
    if y_pred_new[i]!=0:
        y_pred_final.append(y_pred_new[i])
        actual_final.append(actual[i])

print("Sample y_pred values: ",y_pred_new[45678:45690],"\n")
print("Actual values: ",actual[45678:45690],"\n")
print("SSE: ",sse_calc(actual_final,y_pred_final),"\n")
print("MAPE: ",mape_calc(actual_final,y_pred_final))
```

```
EQUATION:
Y = (-0.0491338647445) X1
   +(-0.610095446354) X2
   +(-0.141796933542) X3
   +(-0.123414560125) X4
   +(1.17521595853) X5
   +(1.09026747871) X6
   +(10067.7982651)


Sample y_pred values:  [16802.802117803447, 20834.354373719172,
19956.104974111891, 18043.993932884659, 18271.777277355111,
19390.053160164676, 15725.579565529961, 20538.267400893317,
19978.447881408851, 18850.584653377518, 17694.065014876636,
16747.844090590635]

Actual values:  [101744.59, 109232.14999999999, 112622.02,
101163.60000000001, 105134.45, 106383.60000000001, 94419.360000000001, 1066
14.85000000001, 109232.14999999999, 108701.28, 103961.52,
99639.360000000001]

SSE:  4.4696506761e+14

MAPE:  77.1702293405
```

LR with only hourly rate:

In [58]:

```
sub_data = data[data['year']<=2015]

sub_data = sub_data[['department_title','hourly_or_event_rate','projected_a
nnual_salary',
                    'q1_payments','q2_payments', 'q3_payments', 'q4_payments',
base_pay', 'permanent_bonus_pay']]

num = sub_data._get_numeric_data()
num[num < 0] = 0
sub_data = sub_data.replace(0, np.nan)

sub_data = sub_data.dropna()

cols = ['hourly_or_event_rate']

for col in cols:
    a = outlier_range(list(sub_data[col]))
    sub_data = sub_data[(sub_data[col]>=a[0]) & (sub_data[col]<=a[1])]

X_train = sub_data[['hourly_or_event_rate']]
Y_train = sub_data['projected_annual_salary']
regr = linear_model.LinearRegression()
regr.fit(X_train, Y_train)

print("EQUATION:")
print("Y = ("+str(regr.coef_[0])+") X1 \n   +("
      +str(regr.intercept_)+")")

print("\n")

test_data = data[data['year']>=2016]

grouping = sub_data.groupby("department_title").mean()
grouping.head()

y_pred = []
for index, row in test_data.iterrows():
    hourly_rate = row['hourly_or_event_rate']
    try:
        y_pred.append(regr.predict([hourly_rate]))
    except:
        y_pred.append(0)
        pass

actual = list(test_data['projected_annual_salary'])

y_pred_new = []
for i in y_pred:
    try:
        y_pred_new.append(i[0])
    except:
        y_pred_new.append(i)


y_pred_final = []
actual_final = []
for i in range(len(actual)):
    if y_pred_new[i]!=0:
        y_pred_final.append(y_pred_new[i])
        actual_final.append(actual[i])

print("Sample y_pred values: ",y_pred_new[45678:45690],"\n")
print("Actual values: ",actual[45678:45690],"\n")
print("SSE: ",sse_calc(actual_final,y_pred_final),"\n")
print("MAPE: ",mape_calc(actual_final,y_pred_final))
```

```
EQUATION:
Y = (2088.00107249) X1
   +(-0.149279120145)


Sample y_pred values:  [101748.14298310412, 109223.18682260266,
112626.6285707542, 101163.50268280816, 105130.70472053083,
106383.5053640222, 94419.259218679596, 106613.18548199562,
109223.18682260266, 108701.18655448125, 103961.42411993888,
99639.2618998936521
```

```
Actual values:  [101744.59, 109232.14999999999, 112622.02,
101163.60000000001, 105134.45, 106383.60000000001, 94419.360000000001, 1066
14.85000000001, 109232.14999999999, 108701.28, 103961.52,
99639.360000000001]

SSE:  3.69391967039e+14

MAPE:  0.00254609815919
```

LR without Hourly and Quarters:

In [59]:

```
sub_data = data[data['year']<=2015]

sub_data = sub_data[['department_title','hourly_or_event_rate','projected_a
nnual_salary',
                 'q1_payments','q2_payments', 'q3_payments', 'q4_payments',
base_pay', 'permanent_bonus_pay']]

num = sub_data._get_numeric_data()
num[num < 0] = 0
sub_data = sub_data.replace(0, np.nan)

sub_data = sub_data.dropna()

cols = ['projected_annual_salary','base_pay', 'permanent_bonus_pay']

for col in cols:
    a = outlier_range(list(sub_data[col]))
    sub_data = sub_data[(sub_data[col]>=a[0]) & (sub_data[col]<=a[1])]

X_train = sub_data[['base_pay', 'permanent_bonus_pay']]
Y_train = sub_data['projected_annual_salary']
regr = linear_model.LinearRegression()
regr.fit(X_train, Y_train)

print("EQUATION:")
print("Y = ("+str(regr.coef_[0])+") X1 \n   +("+str(regr.coef_[1])+") X2 \n
+("
      +str(regr.intercept_)+")")

print("\n")

test_data = data[data['year']>=2016]

grouping = sub_data.groupby("department_title").mean()
grouping.head()

y_pred = []
for index, row in test_data.iterrows():
    temp = grouping[grouping.index==row['department_title']]
    try:
        base = row['base_pay']
        bonus = row['permanent_bonus_pay']
        y_pred.append(regr.predict([base,bonus]))
    except:
        y_pred.append(0)
        pass

actual = list(test_data['projected_annual_salary'])

y_pred_new = []
for i in y_pred:
    try:
        y_pred_new.append(i[0])
    except:
        y_pred_new.append(i)


y_pred_final = []
actual_final = []
for i in range(len(actual)):
    if y_pred_new[i]!=0:
        y_pred_final.append(y_pred_new[i])
        actual_final.append(actual[i])

print("Sample y_pred values: ",y_pred_new[45678:45690],"\n")
print("Actual values: ",actual[45678:45690],"\n")
print("SSE: ",sse_calc(actual_final,y_pred_final),"\n")
print("MAPE: ",mape_calc(actual_final,y_pred_final))
```

```
EQUATION:
Y = (0.876379765085) X1
   +(0.372226902725) X2
   +(13623.7659792)


Sample y_pred values:  [35836.444497365606, 38591.582427140958,
37603.817170692164, 37100.963212515453, 36346.033590843581,
37869.177564730708, 35689.459525070983, 38077.684799395465,
37978.337603660533, 37226.382813597898, 36623.420832470729,
36128.890800612746]

Actual values:  [101744.59, 109232.14999999999, 112622.02,
101163.60000000001, 105134.45, 106383.60000000001, 94419.360000000001, 1066
14.85000000001, 109232.14999999999, 108701.28, 103961.52,
99639.360000000001]

SSE:  2.64883842839e+14

MAPE:  51.1246410746
```

LR withour hourly after outlier, train on 2013, test on 2014

In [60]:

```
sub_data = data[data['year']<=2013]

sub_data = sub_data[['department_title','hourly_or_event_rate','projected_a
nnual_salary',
                     'q1_payments','q2_payments', 'q3_payments', 'q4_payments',
base_pay', 'permanent_bonus_pay']]
```

```
num = sub_data._get_numeric_data()
num[num < 0] = 0
sub_data = sub_data.replace(0, np.nan)

sub_data = sub_data.dropna()

cols = ['projected_annual_salary','q1_payments','q2_payments',
'q3_payments', 'q4_payments','base_pay',
        'permanent_bonus_pay']

for col in cols:
    a = outlier_range(list(sub_data[col]))
    sub_data = sub_data[(sub_data[col]>=a[0]) & (sub_data[col]<=a[1])]

X_train = sub_data[['q1_payments','q2_payments', 'q3_payments',
        'q4_payments','base_pay', 'permanent_bonus_pay']]
Y_train = sub_data['projected_annual_salary']
regr = linear_model.LinearRegression()
regr.fit(X_train, Y_train)

print("EQUATION:")
print("Y = ("+str(regr.coef_[0])+") X1 \n   +("+str(regr.coef_[1])+") X2 \n
+("
      +str(regr.coef_[2])+") X3 \n   +("+str(regr.coef_[3])+") X4 \n   +("
      +str(regr.coef_[4])+") X5 \n   +("+str(regr.coef_[5])+") X6 \n   +("
      +str(regr.intercept_)+")")

print("\n")

test_data = data[data['year']==2016]

grouping = sub_data.groupby("department_title").mean()
grouping.head()

y_pred = []
for index, row in test_data.iterrows():
    temp = grouping[grouping.index==row['department_title']]
    try:
        q1 = temp['q1_payments'][0]
        q2 = temp['q2_payments'][0]
        q3 = temp['q3_payments'][0]
        q4 = temp['q4_payments'][0]
        base = row['base_pay']
        bonus = row['permanent_bonus_pay']
        y_pred.append(regr.predict([q1,q2,q3,q4,base,bonus]))
    except:
        y_pred.append(0)
        pass

actual = list(test_data['projected_annual_salary'])

y_pred_new = []
for i in y_pred:
    try:
        y_pred_new.append(i[0])
    except:
        y_pred_new.append(i)


y_pred_final = []
```

```
actual_final = []
for i in range(len(actual)):
    if y_pred_new[i]!=0:
        y_pred_final.append(y_pred_new[i])
        actual_final.append(actual[i])

print("Sample y_pred values: ",y_pred[45678:45690],"\n")
print("Actual values: ",actual[45678:45690],"\n")
print("SSE: ",sse_calc(actual_final,y_pred_final),"\n")
print("MAPE: ",mape_calc(actual_final,y_pred_final))
```

```
EQUATION:
Y = (-0.150308391937) X1
   +(-0.42589371165) X2
   +(-0.480398962221) X3
   +(-0.248572396115) X4
   +(1.28663695382) X5
   +(1.2011862233) X6
   +(7945.80402898)


Sample y_pred values:  [array([ 10500.34998873]), array([ 14918.43399766]),
array([ 13962.62069754]), array([ 11853.41138044]), array([
12118.63363428]), array([ 13331.12466338]), array([ 9309.75340233]), array(
[ 14599.29655577]), array([ 13980.95127614]), array([ 12744.62987898]), arr
ay([ 11474.01663473]), array([ 10434.4693232])]

Actual values:  [101744.59, 109232.14999999999, 112622.02,
101163.60000000001, 105134.45, 106383.60000000001, 94419.360000000001, 1066
14.85000000001, 109232.14999999999, 108701.28, 103961.52,
99639.360000000001]

SSE:  3.88723081267e+14

MAPE:  86.4476597726
```