```
import numpy as np
import pandas as pd
import os
```

Adjust Data

```
path ="/Users/yifuhe/Desktop/homework7"
df1=pd.read_excel(path+"/USD_UK.xls")
df2=pd.read_excel(path+"/USD_EU.xls")
df3=pd.read_excel(path+"/JP_USD.xls")
df4=pd.read_excel(path+"/SZ_USD.xls")
```

```
df_uk=pd.DataFrame(df1.iloc[10:,:].values,columns=df1.iloc[9,:].to_list())
df_eu=pd.DataFrame(df2.iloc[10:,:].values,columns=df2.iloc[9,:].to_list())
df_jp=pd.DataFrame(df3.iloc[10:,:].values,columns=df3.iloc[9,:].to_list())
df_sz=pd.DataFrame(df4.iloc[10:,:].values,columns=df4.iloc[9,:].to_list())
```

```
df_uk=df_uk.fillna(method="ffill")
df_eu=df_eu.fillna(method="ffill")
df_jp=df_jp.fillna(method="ffill")
df_sz=df_sz.fillna(method="ffill")
```

```
df_jp["DEXJPUS"]=df_jp["DEXJPUS"]**(-1)
```

```
df_sz["DEXSZUS"]=df_sz["DEXSZUS"]**(-1)
```

Question 1

Calculate rt-rt*

```
rt_uk=(df_uk.iloc[:,1]-df_uk.iloc[:,2])/1200
rt_eu=(df_eu.iloc[:,1]-df_eu.iloc[:,2])/1200
rt_jp=(df_jp.iloc[:,1]-df_jp.iloc[:,2])/1200
rt_sz=(df_sz.iloc[:,1]-df_sz.iloc[:,2])/1200
```

Calculate st

```
st_uk=[]
st_jp=[]
for i in range(8917):
    st_uk.append(np.log(df_uk.iloc[i+21,3])-np.log(df_uk.iloc[i,3]))
    st_jp.append(np.log(df_jp.iloc[i+21,3])-np.log(df_jp.iloc[i,3]))
```

```
st_eu=[]
st_sz=[]
for j in range(5525):
    st_eu.append(np.log(df_eu.iloc[j+21,3])-np.log(df_eu.iloc[j,3]))
for m in range(1281):
    st_sz.append(np.log(df_sz.iloc[m+21,3])-np.log(df_sz.iloc[m,3]))
```

```
st_uk=np.array(st_uk)
st_jp=np.array(st_jp)
st_eu=np.array(st_eu)
st_sz=np.array(st_sz)
```

Calculate excess return

```
excess_uk=[]
for i in range(8917):
    if rt_uk[i]>=0:
        excess_uk.append(rt_uk[i]-st_uk[i])
    else:
        excess_uk.append(st_uk[i]-rt_uk[i])
```

```
excess_jp=[]
for i in range(8917):
    if rt_jp[i]>=0:
        excess_jp.append(rt_jp[i]-st_jp[i])
    else:
        excess_jp.append(st_jp[i]-rt_jp[i])
```

```
excess_eu=[]
for i in range(5525):
    if rt_eu[i]>=0:
        excess_eu.append(rt_eu[i]-st_eu[i])
    else:
        excess_eu.append(st_eu[i]-rt_eu[i])
```

```
excess_sz=[]
for i in range(1281):
    if rt_sz[i]>=0:
        excess_sz.append(rt_sz[i]-st_sz[i])
    else:
        excess_sz.append(st_sz[i]-rt_sz[i])
```

```
excess_uk=np.array(excess_uk)
excess_jp=np.array(excess_jp)
excess_eu=np.array(excess_eu)
excess_sz=np.array(excess_sz)
```

```
t_uk=excess_uk.mean()/excess_uk.std()*np.sqrt(8938)
t_jp=excess_jp.mean()/excess_jp.std()*np.sqrt(8938)
t_sz=excess_sz.mean()/excess_sz.std()*np.sqrt(1302)
t_eu=excess_eu.mean()/excess_eu.std()*np.sqrt(5546)
print(t_uk)
print(t_jp)
print(t_sz)
print(t_eu)
```

```
3.9238165738425885
5.2387334329103385
3.7824255210450604
7.442595339750493
```

From the t test value, they all make a significant profit

Question2

```
import statsmodels.api as sm
x=sm.add_constant(rt_uk[21:8938])
lm=sm.OLS(st_uk,x).fit()
print(lm.summary())
t1 = (-0.3758 - 1 )/0.172
```

```
                            OLS Regression Results
==============================================================================
Dep. Variable:                      y   R-squared:                       0.001
Model:                            OLS   Adj. R-squared:                  0.000
Method:                 Least Squares   F-statistic:                     4.793
Date:                Wed, 13 May 2020   Prob (F-statistic):             0.0286
Time:                        03:56:00   Log-Likelihood:                 19246.
No. Observations:                8917   AIC:                         -3.849e+04
Df Residuals:                    8915   BIC:                         -3.847e+04
Df Model:                           1
Covariance Type:            nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
const         -0.0008      0.000     -2.265      0.024      -0.002      -0.000
0             -0.3758      0.172     -2.189      0.029      -0.712      -0.039
==============================================================================
Omnibus:                     1350.998   Durbin-Watson:                   0.091
Prob(Omnibus):                  0.000   Jarque-Bera (JB):             4106.495
Skew:                          -0.792   Prob(JB):                         0.00
Kurtosis:                       5.923   Cond. No.                         580.
==============================================================================

Warnings:
[1] Standard Errors assume that the covariance matrix of the errors is correctly
specified.
```

```
/Users/yifuhe/opt/anaconda3/lib/python3.7/site-
packages/numpy/core/fromnumeric.py:2542: FutureWarning: Method .ptp is
deprecated and will be removed in a future version. Use numpy.ptp instead.
  return ptp(axis=axis, out=out, **kwargs)
```

```
length =np.min([st_jp.shape[0],rt_jp.shape[0]])
x = sm.add_constant(rt_jp[-length:])
lm=sm.OLS(st_jp[-length:],x).fit()
print(lm.summary())
t2= (-1.0400 - 1 )/0.186
```

```
                            OLS Regression Results
==============================================================================
Dep. Variable:                      y   R-squared:                       0.003
Model:                            OLS   Adj. R-squared:                  0.003
Method:                 Least Squares   F-statistic:                     31.18
Date:                Wed, 13 May 2020   Prob (F-statistic):           2.42e-08
Time:                        03:56:00   Log-Likelihood:                 18385.
No. Observations:                8917   AIC:                         -3.677e+04
Df Residuals:                    8915   BIC:                         -3.675e+04
Df Model:                           1
Covariance Type:            nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
const          0.0033      0.000      7.116      0.000       0.002       0.004
0             -1.0400      0.186     -5.584      0.000      -1.405      -0.675
==============================================================================
Omnibus:                      435.493   Durbin-Watson:                   0.092
Prob(Omnibus):                  0.000   Jarque-Bera (JB):              815.570
Skew:                           0.372   Prob(JB):                    7.97e-178
Kurtosis:                       4.282   Cond. No.                         571.
==============================================================================

Warnings:
[1] Standard Errors assume that the covariance matrix of the errors is correctly
specified.
```

```
length =np.min([st_eu.shape[0],rt_eu.shape[0]])
x=sm.add_constant(rt_eu[-length:])
lm=sm.OLS(st_eu[-length:],x).fit()
print(lm.summary())
t3=(-1.7107 -1)/     0.322
```

```
                            OLS Regression Results
==============================================================================
Dep. Variable:                      y   R-squared:                       0.005
Model:                            OLS   Adj. R-squared:                  0.005
Method:                 Least Squares   F-statistic:                     28.25
Date:                Wed, 13 May 2020   Prob (F-statistic):           1.11e-07
```

```
Time:                        03:56:00   Log-Likelihood:                 12027.
No. Observations:                5525   AIC:                         -2.405e+04
Df Residuals:                    5523   BIC:                         -2.404e+04
Df Model:                           1
Covariance Type:            nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
const          0.0005      0.000      1.253      0.210      -0.000       0.001
0             -1.7107      0.322     -5.315      0.000      -2.342      -1.080
==============================================================================
Omnibus:                      174.615   Durbin-Watson:                   0.093
Prob(Omnibus):                  0.000   Jarque-Bera (JB):              425.175
Skew:                          -0.130   Prob(JB):                     4.72e-93
Kurtosis:                       4.334   Cond. No.                         872.
==============================================================================

Warnings:
[1] Standard Errors assume that the covariance matrix of the errors is correctly
specified.
```

```
length =np.min([st_sz.shape[0],rt_sz.shape[0]])
x=sm.add_constant(rt_sz[-length:])
lm=sm.OLS(st_sz[-length:],x).fit()
print(lm.summary())
t4 = ( 1.1655 -1)/   0.806
```

```
                            OLS Regression Results
==============================================================================
Dep. Variable:                      y   R-squared:                       0.002
Model:                            OLS   Adj. R-squared:                  0.001
Method:                 Least Squares   F-statistic:                     2.091
Date:                Wed, 13 May 2020   Prob (F-statistic):              0.148
Time:                        03:56:00   Log-Likelihood:                 3263.2
No. Observations:                1281   AIC:                            -6522.
Df Residuals:                    1279   BIC:                            -6512.
Df Model:                           1
Covariance Type:            nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
const         -0.0023      0.002     -1.521      0.129      -0.005       0.001
0              1.1655      0.806      1.446      0.148      -0.416       2.747
==============================================================================
Omnibus:                        0.929   Durbin-Watson:                   0.124
Prob(Omnibus):                  0.628   Jarque-Bera (JB):                0.819
Skew:                          -0.020   Prob(JB):                        0.664
Kurtosis:                       3.117   Cond. No.                     1.52e+03
==============================================================================

Warnings:
[1] Standard Errors assume that the covariance matrix of the errors is correctly
specified.
[2] The condition number is large, 1.52e+03. This might indicate that there are
```

```
strong multicollinearity or other numerical problems.
```

```
print("Conclusion:")
print(f"t1: {t1}")
print(f"t2: {t2}")
print(f"t3: {t3}")
print(f"t4: {t4}")
print("T1-T3 are all different from 1, t4 cannot reject the null hypothesis")
```

```
Conclusion:
t1: -7.998837209302326
t2: -10.967741935483872
t3: -8.41832298136646
t4: 0.20533498759305208
T1-T3 are all different from 1, t4 cannot reject the null hypothesis
```

Question 3

```
# defind function
from sklearn.linear_model import LinearRegression
def q3(x,y):
    length =np.min([x.shape[0],y.shape[0]])
    x=x[-length:]
    y=y[-length:]

    Y = []
    for i in range(252,len(x)):

        lm  = LinearRegression().fit(x[:i,].reshape(-1,1),y[:i,].reshape(-1,1))
        yhead = lm.predict(x[i].reshape(-1,1))

        if yhead[0,0]> x[i]:
            Y.append(y[i,]-x[i,])
        else:
            Y.append(-y[i,]+x[i,])
    return Y
```

```
eu = np.array(q3(rt_eu.values,st_eu))
jp = np.array(q3(rt_jp.values,st_jp))
sz = np.array(q3(rt_sz.values,st_sz))
uk = np.array(q3(rt_uk.values,st_uk))
```

all excess return are significant, except sz.

```
print(f"df: {len(eu)}")
print(f"t-stats_eu: {eu.mean()/eu.std()*np.sqrt(eu.shape[0])}")
print(f"df: {len(jp)}")
print(f"t-stats_jp: {jp.mean()/jp.std()*np.sqrt(jp.shape[0])}")
print(f"df: {len(sz)}")
print(f"t-stats_sz: {sz.mean()/sz.std()*np.sqrt(sz.shape[0])}")
print(f"df: {len(uk)}")
print(f"t-stats_uk: {uk.mean()/uk.std()*np.sqrt(uk.shape[0])}")
```

```
df: 5273
t-stats_eu: 7.0755861320934414
df: 8665
t-stats_jp: 10.871171983201158
df: 1029
t-stats_sz: -0.8489514369236427
df: 8665
t-stats_uk: 6.616505541210296
```

```
# load data
data = pd.read_excel(path+"/F-F_Research_Data_Factors_daily.xlsx")
name = data.iloc[3,:]
data = pd.DataFrame(data.iloc[16077:-2,:].values,columns=name)
CAPM = data["Mkt-RF"]
F3 = data.iloc[:,1:4]


data2 = pd.read_excel(path+"/F-F_Research_Data_5_Factors_2x3_daily.xlsx")
name = data2.iloc[2,1:6]
F5 = pd.DataFrame(data2.iloc[5656:,1:6].values,columns = name)
```

```
F3.head()
```

```
.dataframe tbody tr th {
    vertical-align: top;
}

.dataframe thead th {
    text-align: right;
}
```

3	Mkt-RF	SMB	HML
0	-0.63	0.84	0.38
1	0.56	-0.07	0.21
2	-0.04	0.09	0.09
3	1.38	-0.42	0.05
4	-2.16	1.4	0.3

```
F5.head(10)
```

```
.dataframe tbody tr th {
    vertical-align: top;
}

.dataframe thead th {
    text-align: right;
}
```

2	Mkt-RF	SMB	HML	RMW	CMA
0	-0.63	0.87	0.38	-0.41	0.33
1	0.56	-0.08	0.21	-0.13	0.27
2	-0.04	0.04	0.09	-0.22	-0.01
3	1.38	-0.48	0.05	-0.28	-0.01
4	-2.16	1.44	0.3	-0.09	0.15
5	-1.17	-0.8	-0.14	0.03	-0.19
6	-0.02	0.2	0.26	-0.3	0.04
7	0.28	-0.08	0.28	-0.16	0.22
8	0.01	0.41	-0.01	-0.06	0.1
9	0.79	-0.09	-0.21	-0.41	-0.54

EU

```
# EU CAPM
#eu = pd.DataFrame(eu,columns=["EU"])
length =np.min([eu.shape[0],CAPM.shape[0]])
x=sm.add_constant(CAPM[-length:])
lm=sm.OLS(eu[-length:],x.astype(float)).fit()
```

```
print(lm.summary())

# EU F3
length =np.min([eu.shape[0],F3.shape[0]])
x=sm.add_constant(F3[-length:])
lm=sm.OLS(eu[-length:],x.astype(float)).fit()
print(lm.summary())

# EU F5
length =np.min([eu.shape[0],F5.shape[0]])
x=sm.add_constant(F5[-length:])
lm=sm.OLS(eu[-length:],x.astype(float)).fit()
print(lm.summary())
```

```
                            OLS Regression Results
==============================================================================
Dep. Variable:                      y   R-squared:                       0.001
Model:                            OLS   Adj. R-squared:                  0.000
Method:                 Least Squares   F-statistic:                     3.178
Date:                Wed, 13 May 2020   Prob (F-statistic):             0.0747
Time:                        07:40:58   Log-Likelihood:                 11460.
No. Observations:                5273   AIC:                        -2.292e+04
Df Residuals:                    5271   BIC:                        -2.290e+04
Df Model:                           1
Covariance Type:            nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
const          0.0027      0.000      7.113      0.000       0.002       0.003
Mkt-RF        -0.0006      0.000     -1.783      0.075      -0.001    5.62e-05
==============================================================================
Omnibus:                      178.931   Durbin-Watson:                   0.107
Prob(Omnibus):                  0.000   Jarque-Bera (JB):              438.092
Skew:                          -0.153   Prob(JB):                     7.41e-96
Kurtosis:                       4.379   Cond. No.                         1.20
==============================================================================

Warnings:
[1] Standard Errors assume that the covariance matrix of the errors is correctly
specified.
                            OLS Regression Results
==============================================================================
Dep. Variable:                      y   R-squared:                       0.001
Model:                            OLS   Adj. R-squared:                  0.000
Method:                 Least Squares   F-statistic:                     1.628
Date:                Wed, 13 May 2020   Prob (F-statistic):              0.181
Time:                        07:40:58   Log-Likelihood:                 11461.
No. Observations:                5273   AIC:                        -2.291e+04
Df Residuals:                    5269   BIC:                        -2.289e+04
Df Model:                           3
Covariance Type:            nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
const          0.0027      0.000      7.106      0.000       0.002       0.003
Mkt-RF        -0.0006      0.000     -1.813      0.070      -0.001     4.7e-05
SMB            0.0004      0.001      0.637      0.524      -0.001       0.002
```

```
HML           -0.0006      0.001     -1.024      0.306      -0.002       0.001
==============================================================================
Omnibus:                      178.992   Durbin-Watson:                   0.108
Prob(Omnibus):                  0.000   Jarque-Bera (JB):              438.454
Skew:                          -0.153   Prob(JB):                     6.18e-96
Kurtosis:                       4.379   Cond. No.                         2.09
==============================================================================

Warnings:
[1] Standard Errors assume that the covariance matrix of the errors is correctly
specified.
                            OLS Regression Results
==============================================================================
Dep. Variable:                      y   R-squared:                       0.001
Model:                            OLS   Adj. R-squared:                  0.000
Method:                 Least Squares   F-statistic:                     1.097
Date:                Wed, 13 May 2020   Prob (F-statistic):              0.359
Time:                        07:40:58   Log-Likelihood:                 11461.
No. Observations:                5273   AIC:                         -2.291e+04
Df Residuals:                    5267   BIC:                         -2.287e+04
Df Model:                           5
Covariance Type:            nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
const          0.0027      0.000      7.059      0.000       0.002       0.003
Mkt-RF        -0.0005      0.000     -1.380      0.168      -0.001       0.000
SMB            0.0006      0.001      0.928      0.353      -0.001       0.002
HML           -0.0008      0.001     -1.197      0.231      -0.002       0.001
RMW            0.0003      0.001      0.358      0.721      -0.001       0.002
CMA            0.0003      0.001      0.248      0.804      -0.002       0.002
==============================================================================
Omnibus:                      179.205   Durbin-Watson:                   0.108
Prob(Omnibus):                  0.000   Jarque-Bera (JB):              439.557
Skew:                          -0.153   Prob(JB):                     3.56e-96
Kurtosis:                       4.381   Cond. No.                         3.83
==============================================================================

Warnings:
[1] Standard Errors assume that the covariance matrix of the errors is correctly
specified.
```

JP

```
# jp CAPM

length =np.min([jp.shape[0],CAPM.shape[0]])
x=sm.add_constant(CAPM[-length:])
lm=sm.OLS(jp[-length:],x.astype(float)).fit()
print(lm.summary())

# jp F3
length =np.min([jp.shape[0],F3.shape[0]])
x=sm.add_constant(F3[-length:])
lm=sm.OLS(jp[-length:],x.astype(float)).fit()
print(lm.summary())
```

```
# jp F5
length =np.min([jp.shape[0],F5.shape[0]])
x=sm.add_constant(F5[-length:])
lm=sm.OLS(jp[-length:],x.astype(float)).fit()
print(lm.summary())
```

```
                            OLS Regression Results
==============================================================================
Dep. Variable:                      y   R-squared:                       0.000
Model:                            OLS   Adj. R-squared:                 -0.000
Method:                 Least Squares   F-statistic:                    0.4044
Date:                Wed, 13 May 2020   Prob (F-statistic):              0.525
Time:                        07:41:59   Log-Likelihood:                 17863.
No. Observations:                8610   AIC:                         -3.572e+04
Df Residuals:                    8608   BIC:                         -3.571e+04
Df Model:                           1
Covariance Type:            nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
const          0.0034      0.000     10.514      0.000       0.003       0.004
Mkt-RF         0.0002      0.000      0.636      0.525      -0.000       0.001
==============================================================================
Omnibus:                      281.273   Durbin-Watson:                   0.109
Prob(Omnibus):                  0.000   Jarque-Bera (JB):              567.309
Skew:                          -0.228   Prob(JB):                    6.46e-124
Kurtosis:                       4.172   Cond. No.                         1.11
==============================================================================

Warnings:
[1] Standard Errors assume that the covariance matrix of the errors is correctly
specified.
                            OLS Regression Results
==============================================================================
Dep. Variable:                      y   R-squared:                       0.000
Model:                            OLS   Adj. R-squared:                 -0.000
Method:                 Least Squares   F-statistic:                    0.9892
Date:                Wed, 13 May 2020   Prob (F-statistic):              0.397
Time:                        07:41:59   Log-Likelihood:                 17865.
No. Observations:                8610   AIC:                         -3.572e+04
Df Residuals:                    8606   BIC:                         -3.569e+04
Df Model:                           3
Covariance Type:            nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
const          0.0034      0.000     10.524      0.000       0.003       0.004
Mkt-RF         0.0002      0.000      0.645      0.519      -0.000       0.001
SMB            0.0007      0.001      1.315      0.189      -0.000       0.002
HML           -0.0004      0.001     -0.746      0.455      -0.002       0.001
==============================================================================
Omnibus:                      279.028   Durbin-Watson:                   0.110
Prob(Omnibus):                  0.000   Jarque-Bera (JB):              560.475
Skew:                          -0.227   Prob(JB):                    1.97e-122
Kurtosis:                       4.164   Cond. No.                         2.05
==============================================================================
```

```
Warnings:
[1] Standard Errors assume that the covariance matrix of the errors is correctly
specified.
                            OLS Regression Results
==============================================================================
Dep. Variable:                      y   R-squared:                       0.000
Model:                            OLS   Adj. R-squared:                 -0.000
Method:                 Least Squares   F-statistic:                    0.6604
Date:                Wed, 13 May 2020   Prob (F-statistic):              0.654
Time:                        07:41:59   Log-Likelihood:                 17865.
No. Observations:                8610   AIC:                         -3.572e+04
Df Residuals:                    8604   BIC:                         -3.568e+04
Df Model:                           5
Covariance Type:            nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
const          0.0034      0.000     10.470      0.000       0.003       0.004
Mkt-RF         0.0003      0.000      0.835      0.404      -0.000       0.001
SMB            0.0007      0.001      1.167      0.243      -0.000       0.002
HML           -0.0008      0.001     -1.245      0.213      -0.002       0.000
RMW         6.377e-05      0.001      0.074      0.941      -0.002       0.002
CMA            0.0008      0.001      0.792      0.429      -0.001       0.003
==============================================================================
Omnibus:                      279.136   Durbin-Watson:                   0.110
Prob(Omnibus):                  0.000   Jarque-Bera (JB):              561.110
Skew:                          -0.227   Prob(JB):                    1.43e-122
Kurtosis:                       4.165   Cond. No.                         3.84
==============================================================================

Warnings:
[1] Standard Errors assume that the covariance matrix of the errors is correctly
specified.
```

SZ

```
# sz CAPM

length =np.min([sz.shape[0],CAPM.shape[0]])
x=sm.add_constant(CAPM[-length:])
lm=sm.OLS(sz[-length:],x.astype(float)).fit()
print(lm.summary())

# SZ F3
length =np.min([sz.shape[0],F3.shape[0]])
x=sm.add_constant(F3[-length:])
lm=sm.OLS(sz[-length:],x.astype(float)).fit()
print(lm.summary())

# SZ F5
length =np.min([sz.shape[0],F5.shape[0]])
x=sm.add_constant(F5[-length:])
lm=sm.OLS(sz[-length:],x.astype(float)).fit()
print(lm.summary())
```

```
                            OLS Regression Results
==============================================================================
Dep. Variable:                      y   R-squared:                       0.000
Model:                            OLS   Adj. R-squared:                 -0.001
Method:                 Least Squares   F-statistic:                 1.027e-05
Date:                Wed, 13 May 2020   Prob (F-statistic):              0.997
Time:                        07:42:39   Log-Likelihood:                 2712.5
No. Observations:                1029   AIC:                            -5421.
Df Residuals:                    1027   BIC:                            -5411.
Df Model:                           1
Covariance Type:            nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
const         -0.0005      0.001     -0.846      0.398      -0.002       0.001
Mkt-RF     -2.063e-06      0.001     -0.003      0.997      -0.001       0.001
==============================================================================
Omnibus:                        1.287   Durbin-Watson:                   0.172
Prob(Omnibus):                  0.525   Jarque-Bera (JB):                1.345
Skew:                           0.083   Prob(JB):                        0.511
Kurtosis:                       2.936   Cond. No.                         1.20
==============================================================================

Warnings:
[1] Standard Errors assume that the covariance matrix of the errors is correctly
specified.
                            OLS Regression Results
==============================================================================
Dep. Variable:                      y   R-squared:                       0.002
Model:                            OLS   Adj. R-squared:                 -0.001
Method:                 Least Squares   F-statistic:                    0.5486
Date:                Wed, 13 May 2020   Prob (F-statistic):              0.649
Time:                        07:42:39   Log-Likelihood:                 2713.3
No. Observations:                1029   AIC:                            -5419.
Df Residuals:                    1025   BIC:                            -5399.
Df Model:                           3
Covariance Type:            nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
const         -0.0005      0.001     -0.879      0.379      -0.002       0.001
Mkt-RF        -0.0001      0.001     -0.186      0.852      -0.001       0.001
SMB            0.0005      0.001      0.405      0.686      -0.002       0.003
HML           -0.0012      0.001     -1.212      0.226      -0.003       0.001
==============================================================================
Omnibus:                        1.115   Durbin-Watson:                   0.174
Prob(Omnibus):                  0.573   Jarque-Bera (JB):                1.176
Skew:                           0.076   Prob(JB):                        0.556
Kurtosis:                       2.934   Cond. No.                         2.09
==============================================================================

Warnings:
[1] Standard Errors assume that the covariance matrix of the errors is correctly
specified.
                            OLS Regression Results
==============================================================================
Dep. Variable:                      y   R-squared:                       0.004
Model:                            OLS   Adj. R-squared:                 -0.000
```

```
Method:                 Least Squares   F-statistic:                     0.9216
Date:                Wed, 13 May 2020   Prob (F-statistic):              0.466
Time:                        07:42:39   Log-Likelihood:                 2714.8
No. Observations:                1029   AIC:                            -5418.
Df Residuals:                    1023   BIC:                            -5388.
Df Model:                           5
Covariance Type:            nonrobust
================================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
--------------------------------------------------------------------------------
const         -0.0005      0.001     -0.917      0.359      -0.002       0.001
Mkt-RF         0.0001      0.001      0.211      0.833      -0.001       0.002
SMB            0.0007      0.001      0.645      0.519      -0.001       0.003
HML           -0.0018      0.001     -1.507      0.132      -0.004       0.001
RMW            0.0024      0.002      1.519      0.129      -0.001       0.006
CMA            0.0016      0.002      0.777      0.438      -0.002       0.006
================================================================================
Omnibus:                        1.524   Durbin-Watson:                   0.179
Prob(Omnibus):                  0.467   Jarque-Bera (JB):                1.599
Skew:                           0.083   Prob(JB):                        0.449
Kurtosis:                       2.903   Cond. No.                         4.08
================================================================================

Warnings:
[1] Standard Errors assume that the covariance matrix of the errors is correctly
specified.
```

UK

```
# UK CAPM

length =np.min([uk.shape[0],CAPM.shape[0]])
x=sm.add_constant(CAPM[-length:])
lm=sm.OLS(uk[-length:],x.astype(float)).fit()
print(lm.summary())

# UK F3
length =np.min([uk.shape[0],F3.shape[0]])
x=sm.add_constant(F3[-length:])
lm=sm.OLS(uk[-length:],x.astype(float)).fit()
print(lm.summary())

# UK F5
length =np.min([uk.shape[0],F5.shape[0]])
x=sm.add_constant(F5[-length:])
lm=sm.OLS(uk[-length:],x.astype(float)).fit()
print(lm.summary())
```

```
                            OLS Regression Results
==============================================================================
Dep. Variable:                      y   R-squared:                       0.000
Model:                            OLS   Adj. R-squared:                  0.000
Method:                 Least Squares   F-statistic:                     1.040
Date:                Wed, 13 May 2020   Prob (F-statistic):              0.308
Time:                        07:49:00   Log-Likelihood:                 18782.
```

```
No. Observations:                8610   AIC:                         -3.756e+04
Df Residuals:                    8608   BIC:                         -3.755e+04
Df Model:                           1
Covariance Type:            nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
const          0.0063      0.000     21.541      0.000       0.006       0.007
Mkt-RF         0.0003      0.000      1.020      0.308      -0.000       0.001
==============================================================================
Omnibus:                      919.546   Durbin-Watson:                   0.170
Prob(Omnibus):                  0.000   Jarque-Bera (JB):             2356.989
Skew:                           0.614   Prob(JB):                         0.00
Kurtosis:                       5.249   Cond. No.                         1.11
==============================================================================

Warnings:
[1] Standard Errors assume that the covariance matrix of the errors is correctly
specified.
                            OLS Regression Results
==============================================================================
Dep. Variable:                      y   R-squared:                       0.000
Model:                            OLS   Adj. R-squared:                 -0.000
Method:                 Least Squares   F-statistic:                    0.3595
Date:                Wed, 13 May 2020   Prob (F-statistic):              0.782
Time:                        07:49:00   Log-Likelihood:                 18782.
No. Observations:                8610   AIC:                         -3.756e+04
Df Residuals:                    8606   BIC:                         -3.753e+04
Df Model:                           3
Covariance Type:            nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
const          0.0063      0.000     21.539      0.000       0.006       0.007
Mkt-RF         0.0003      0.000      0.983      0.326      -0.000       0.001
SMB        -2.641e-05      0.001     -0.052      0.958      -0.001       0.001
HML           -0.0001      0.001     -0.195      0.846      -0.001       0.001
==============================================================================
Omnibus:                      919.171   Durbin-Watson:                   0.170
Prob(Omnibus):                  0.000   Jarque-Bera (JB):             2355.085
Skew:                           0.614   Prob(JB):                         0.00
Kurtosis:                       5.248   Cond. No.                         2.05
==============================================================================

Warnings:
[1] Standard Errors assume that the covariance matrix of the errors is correctly
specified.
                            OLS Regression Results
==============================================================================
Dep. Variable:                      y   R-squared:                       0.000
Model:                            OLS   Adj. R-squared:                 -0.000
Method:                 Least Squares   F-statistic:                    0.6663
Date:                Wed, 13 May 2020   Prob (F-statistic):              0.649
Time:                        07:49:00   Log-Likelihood:                 18783.
No. Observations:                8610   AIC:                         -3.755e+04
Df Residuals:                    8604   BIC:                         -3.751e+04
Df Model:                           5
Covariance Type:            nonrobust
```

```
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
const          0.0063      0.000     21.510      0.000       0.006       0.007
Mkt-RF         0.0002      0.000      0.658      0.511      -0.000       0.001
SMB         9.454e-05      0.001      0.175      0.861      -0.001       0.001
HML            0.0003      0.001      0.543      0.587      -0.001       0.002
RMW            0.0005      0.001      0.679      0.497      -0.001       0.002
CMA           -0.0013      0.001     -1.402      0.161      -0.003       0.001
==============================================================================
Omnibus:                      915.730   Durbin-Watson:                   0.171
Prob(Omnibus):                  0.000   Jarque-Bera (JB):             2339.835
Skew:                           0.613   Prob(JB):                         0.00
Kurtosis:                       5.240   Cond. No.                         3.84
==============================================================================

Warnings:
[1] Standard Errors assume that the covariance matrix of the errors is correctly
specified.
```

Question 4

```
# defind function
from sklearn.linear_model import LinearRegression
def q4(x,y):
    length =np.min([x.shape[0],y.shape[0]])
    x=x[-length:]
    y=y[-length:]

    Y = []
    for i in range(len(x)-252):

        lm  = LinearRegression().fit(x[i:i+251,].reshape(-1,1),y[i:i+251,].reshape(-1,1))
        yhead = lm.predict(x[i].reshape(-1,1))

        if yhead[0,0]> x[i]:
            Y.append(y[i,]-x[i,])
        else:
            Y.append(-y[i,]+x[i,])
    return Y
```

```
eu = np.array(q4(rt_eu.values,st_eu))
jp = np.array(q4(rt_jp.values,st_jp))
sz = np.array(q4(rt_sz.values,st_sz))
uk = np.array(q4(rt_uk.values,st_uk))
```

```
print(f"df: {len(eu)}")
print(f"t-stats_eu: {eu.mean()/eu.std()*np.sqrt(eu.shape[0])}")
print(f"df: {len(jp)}")
print(f"t-stats_jp: {jp.mean()/jp.std()*np.sqrt(jp.shape[0])}")
print(f"df: {len(sz)}")
print(f"t-stats_sz: {sz.mean()/sz.std()*np.sqrt(sz.shape[0])}")
print(f"df: {len(uk)}")
print(f"t-stats_uk: {uk.mean()/uk.std()*np.sqrt(uk.shape[0])}")
print("all excess return are significant!")
```

```
df: 5273
t-stats_eu: 19.33244918864757
df: 8665
t-stats_jp: 23.95469734654302
df: 1029
t-stats_sz: 6.302818243479613
df: 8665
t-stats_uk: 21.869808734119164
all excess return are significant!
```

use the same data for CAPM, F3, F5

EU

```
# EU CAPM
#eu = pd.DataFrame(eu,columns=["EU"])
length =np.min([eu.shape[0],CAPM.shape[0]])
x=sm.add_constant(CAPM[-length:])
lm=sm.OLS(eu[-length:],x.astype(float)).fit()
print(lm.summary())

# EU F3
length =np.min([eu.shape[0],F3.shape[0]])
x=sm.add_constant(F3[-length:])
lm=sm.OLS(eu[-length:],x.astype(float)).fit()
print(lm.summary())

# EU F5
length =np.min([eu.shape[0],F5.shape[0]])
x=sm.add_constant(F5[-length:])
lm=sm.OLS(eu[-length:],x.astype(float)).fit()
print(lm.summary())
```

```
                            OLS Regression Results
==============================================================================
Dep. Variable:                      y   R-squared:                       0.000
Model:                            OLS   Adj. R-squared:                  0.000
Method:                 Least Squares   F-statistic:                     1.082
Date:                Wed, 13 May 2020   Prob (F-statistic):              0.298
Time:                        07:47:40   Log-Likelihood:                 11528.
No. Observations:                5273   AIC:                        -2.305e+04
Df Residuals:                    5271   BIC:                        -2.304e+04
Df Model:                           1
Covariance Type:            nonrobust
```

```
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
const          0.0072      0.000     19.304      0.000       0.006       0.008
Mkt-RF         0.0003      0.000      1.040      0.298      -0.000       0.001
==============================================================================
Omnibus:                      207.480   Durbin-Watson:                   0.168
Prob(Omnibus):                  0.000   Jarque-Bera (JB):              516.251
Skew:                          -0.199   Prob(JB):                    7.90e-113
Kurtosis:                       4.480   Cond. No.                         1.20
==============================================================================

Warnings:
[1] Standard Errors assume that the covariance matrix of the errors is correctly
specified.
                            OLS Regression Results
==============================================================================
Dep. Variable:                      y   R-squared:                       0.000
Model:                            OLS   Adj. R-squared:                 -0.000
Method:                 Least Squares   F-statistic:                    0.7048
Date:                Wed, 13 May 2020   Prob (F-statistic):              0.549
Time:                        07:47:40   Log-Likelihood:                 11528.
No. Observations:                5273   AIC:                         -2.305e+04
Df Residuals:                    5269   BIC:                         -2.302e+04
Df Model:                           3
Covariance Type:            nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
const          0.0072      0.000     19.315      0.000       0.007       0.008
Mkt-RF         0.0004      0.000      1.126      0.260      -0.000       0.001
SMB           -0.0006      0.001     -0.971      0.332      -0.002       0.001
HML         8.116e-05      0.001      0.141      0.887      -0.001       0.001
==============================================================================
Omnibus:                      205.761   Durbin-Watson:                   0.169
Prob(Omnibus):                  0.000   Jarque-Bera (JB):              510.403
Skew:                          -0.197   Prob(JB):                    1.47e-111
Kurtosis:                       4.472   Cond. No.                         2.09
==============================================================================

Warnings:
[1] Standard Errors assume that the covariance matrix of the errors is correctly
specified.
                            OLS Regression Results
==============================================================================
Dep. Variable:                      y   R-squared:                       0.001
Model:                            OLS   Adj. R-squared:                  0.000
Method:                 Least Squares   F-statistic:                     1.509
Date:                Wed, 13 May 2020   Prob (F-statistic):              0.183
Time:                        07:47:40   Log-Likelihood:                 11531.
No. Observations:                5273   AIC:                         -2.305e+04
Df Residuals:                    5267   BIC:                         -2.301e+04
Df Model:                           5
Covariance Type:            nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
const          0.0072      0.000     19.322      0.000       0.007       0.008
```

```
Mkt-RF         0.0003      0.000      0.927      0.354      -0.000       0.001
SMB           -0.0011      0.001     -1.637      0.102      -0.002       0.000
HML           -0.0003      0.001     -0.399      0.690      -0.002       0.001
RMW           -0.0014      0.001     -1.675      0.094      -0.003       0.000
CMA            0.0019      0.001      1.801      0.072      -0.000       0.004
==============================================================================
Omnibus:                      203.612   Durbin-Watson:                   0.171
Prob(Omnibus):                  0.000   Jarque-Bera (JB):              500.740
Skew:                          -0.197   Prob(JB):                    1.84e-109
Kurtosis:                       4.457   Cond. No.                         3.83
==============================================================================

Warnings:
[1] Standard Errors assume that the covariance matrix of the errors is correctly
specified.
```

```
/Users/yifuhe/opt/anaconda3/lib/python3.7/site-packages/numpy/core/fromnumeric.py:2542:
FutureWarning: Method .ptp is deprecated and will be removed in a future version. Use
numpy.ptp instead.
  return ptp(axis=axis, out=out, **kwargs)
```

jp

```
# jp CAPM

length =np.min([jp.shape[0],CAPM.shape[0]])
x=sm.add_constant(CAPM[-length:])
lm=sm.OLS(jp[-length:],x.astype(float)).fit()
print(lm.summary())

# jp F3
length =np.min([jp.shape[0],F3.shape[0]])
x=sm.add_constant(F3[-length:])
lm=sm.OLS(jp[-length:],x.astype(float)).fit()
print(lm.summary())

# jp F5
length =np.min([jp.shape[0],F5.shape[0]])
x=sm.add_constant(F5[-length:])
lm=sm.OLS(jp[-length:],x.astype(float)).fit()
print(lm.summary())
```

```
                            OLS Regression Results
==============================================================================
Dep. Variable:                      y   R-squared:                       0.000
Model:                            OLS   Adj. R-squared:                 -0.000
Method:                 Least Squares   F-statistic:                    0.5975
Date:                Wed, 13 May 2020   Prob (F-statistic):              0.440
Time:                        07:48:07   Log-Likelihood:                 17923.
No. Observations:                8610   AIC:                        -3.584e+04
Df Residuals:                    8608   BIC:                        -3.583e+04
Df Model:                           1
Covariance Type:            nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
```

```
------------------------------------------------------------------------------
const          0.0076      0.000     23.316      0.000       0.007       0.008
Mkt-RF         0.0002      0.000      0.773      0.440      -0.000       0.001
==============================================================================
Omnibus:                      179.523   Durbin-Watson:                   0.176
Prob(Omnibus):                  0.000   Jarque-Bera (JB):              323.890
Skew:                           0.159   Prob(JB):                     4.66e-71
Kurtosis:                       3.896   Cond. No.                         1.11
==============================================================================

Warnings:
[1] Standard Errors assume that the covariance matrix of the errors is correctly
specified.
                            OLS Regression Results
==============================================================================
Dep. Variable:                      y   R-squared:                       0.000
Model:                            OLS   Adj. R-squared:                 -0.000
Method:                 Least Squares   F-statistic:                    0.9302
Date:                Wed, 13 May 2020   Prob (F-statistic):              0.425
Time:                        07:48:07   Log-Likelihood:                 17924.
No. Observations:                8610   AIC:                         -3.584e+04
Df Residuals:                    8606   BIC:                         -3.581e+04
Df Model:                           3
Covariance Type:            nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
const          0.0076      0.000     23.290      0.000       0.007       0.008
Mkt-RF         0.0003      0.000      0.909      0.363      -0.000       0.001
SMB           -0.0001      0.001     -0.224      0.823      -0.001       0.001
HML            0.0008      0.001      1.425      0.154      -0.000       0.002
==============================================================================
Omnibus:                      181.121   Durbin-Watson:                   0.176
Prob(Omnibus):                  0.000   Jarque-Bera (JB):              328.733
Skew:                           0.158   Prob(JB):                     4.13e-72
Kurtosis:                       3.903   Cond. No.                         2.05
==============================================================================

Warnings:
[1] Standard Errors assume that the covariance matrix of the errors is correctly
specified.
                            OLS Regression Results
==============================================================================
Dep. Variable:                      y   R-squared:                       0.000
Model:                            OLS   Adj. R-squared:                 -0.000
Method:                 Least Squares   F-statistic:                    0.8289
Date:                Wed, 13 May 2020   Prob (F-statistic):              0.529
Time:                        07:48:07   Log-Likelihood:                 17925.
No. Observations:                8610   AIC:                         -3.584e+04
Df Residuals:                    8604   BIC:                         -3.580e+04
Df Model:                           5
Covariance Type:            nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
const          0.0076      0.000     23.168      0.000       0.007       0.008
Mkt-RF         0.0004      0.000      1.320      0.187      -0.000       0.001
SMB            0.0002      0.001      0.343      0.732      -0.001       0.001
```

```
HML            0.0007      0.001      1.031      0.302      -0.001       0.002
RMW            0.0009      0.001      1.080      0.280      -0.001       0.003
CMA            0.0004      0.001      0.373      0.709      -0.002       0.002
==============================================================================
Omnibus:                      181.318   Durbin-Watson:                   0.176
Prob(Omnibus):                  0.000   Jarque-Bera (JB):              328.919
Skew:                           0.159   Prob(JB):                     3.77e-72
Kurtosis:                       3.903   Cond. No.                         3.84
==============================================================================

Warnings:
[1] Standard Errors assume that the covariance matrix of the errors is correctly
specified.
```

SZ

```
# sz CAPM

length =np.min([sz.shape[0],CAPM.shape[0]])
x=sm.add_constant(CAPM[-length:])
lm=sm.OLS(sz[-length:],x.astype(float)).fit()
print(lm.summary())

# SZ F3
length =np.min([sz.shape[0],F3.shape[0]])
x=sm.add_constant(F3[-length:])
lm=sm.OLS(sz[-length:],x.astype(float)).fit()
print(lm.summary())

# SZ F5
length =np.min([sz.shape[0],F5.shape[0]])
x=sm.add_constant(F5[-length:])
lm=sm.OLS(sz[-length:],x.astype(float)).fit()
print(lm.summary())
```

```
                            OLS Regression Results
==============================================================================
Dep. Variable:                      y   R-squared:                       0.001
Model:                            OLS   Adj. R-squared:                 -0.000
Method:                 Least Squares   F-statistic:                    0.5636
Date:                Wed, 13 May 2020   Prob (F-statistic):              0.453
Time:                        07:48:43   Log-Likelihood:                 2587.8
No. Observations:                1029   AIC:                            -5172.
Df Residuals:                    1027   BIC:                            -5162.
Df Model:                           1
Covariance Type:            nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
const          0.0038      0.001      6.240      0.000       0.003       0.005
Mkt-RF         0.0005      0.001      0.751      0.453      -0.001       0.002
==============================================================================
Omnibus:                        1.452   Durbin-Watson:                   0.211
Prob(Omnibus):                  0.484   Jarque-Bera (JB):                1.343
Skew:                          -0.083   Prob(JB):                        0.511
```

```
Kurtosis:                       3.062   Cond. No.                         1.20
==============================================================================

Warnings:
[1] Standard Errors assume that the covariance matrix of the errors is correctly
specified.
                            OLS Regression Results
==============================================================================
Dep. Variable:                      y   R-squared:                       0.001
Model:                            OLS   Adj. R-squared:                 -0.002
Method:                 Least Squares   F-statistic:                    0.3821
Date:                Wed, 13 May 2020   Prob (F-statistic):              0.766
Time:                        07:48:43   Log-Likelihood:                 2588.1
No. Observations:                1029   AIC:                            -5168.
Df Residuals:                    1025   BIC:                            -5148.
Df Model:                           3
Covariance Type:            nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
const          0.0038      0.001      6.259      0.000       0.003       0.005
Mkt-RF         0.0005      0.001      0.660      0.510      -0.001       0.002
SMB            0.0008      0.001      0.622      0.534      -0.002       0.003
HML            0.0005      0.001      0.451      0.652      -0.002       0.003
==============================================================================
Omnibus:                        1.482   Durbin-Watson:                   0.212
Prob(Omnibus):                  0.477   Jarque-Bera (JB):                1.372
Skew:                          -0.084   Prob(JB):                        0.504
Kurtosis:                       3.063   Cond. No.                         2.09
==============================================================================

Warnings:
[1] Standard Errors assume that the covariance matrix of the errors is correctly
specified.
                            OLS Regression Results
==============================================================================
Dep. Variable:                      y   R-squared:                       0.002
Model:                            OLS   Adj. R-squared:                 -0.003
Method:                 Least Squares   F-statistic:                    0.4375
Date:                Wed, 13 May 2020   Prob (F-statistic):              0.822
Time:                        07:48:43   Log-Likelihood:                 2588.6
No. Observations:                1029   AIC:                            -5165.
Df Residuals:                    1023   BIC:                            -5136.
Df Model:                           5
Covariance Type:            nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
const          0.0038      0.001      6.275      0.000       0.003       0.005
Mkt-RF         0.0003      0.001      0.321      0.748      -0.001       0.002
SMB            0.0008      0.001      0.671      0.503      -0.002       0.003
HML            0.0009      0.001      0.681      0.496      -0.002       0.004
RMW           -0.0012      0.002     -0.642      0.521      -0.005       0.002
CMA           -0.0016      0.002     -0.692      0.489      -0.006       0.003
==============================================================================
Omnibus:                        1.547   Durbin-Watson:                   0.213
Prob(Omnibus):                  0.461   Jarque-Bera (JB):                1.440
Skew:                          -0.087   Prob(JB):                        0.487
```

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Kurtosis:                       3.060   Cond. No.                         4.08
==============================================================================

Warnings:
[1] Standard Errors assume that the covariance matrix of the errors is correctly
specified.
```

UK

```
# UK CAPM

length =np.min([uk.shape[0],CAPM.shape[0]])
x=sm.add_constant(CAPM[-length:])
lm=sm.OLS(uk[-length:],x.astype(float)).fit()
print(lm.summary())

# UK F3
length =np.min([uk.shape[0],F3.shape[0]])
x=sm.add_constant(F3[-length:])
lm=sm.OLS(uk[-length:],x.astype(float)).fit()
print(lm.summary())

# UK F5
length =np.min([uk.shape[0],F5.shape[0]])
x=sm.add_constant(F5[-length:])
lm=sm.OLS(uk[-length:],x.astype(float)).fit()
print(lm.summary())
```

```
                            OLS Regression Results
==============================================================================
Dep. Variable:                      y   R-squared:                       0.000
Model:                            OLS   Adj. R-squared:                  0.000
Method:                 Least Squares   F-statistic:                     1.040
Date:                Wed, 13 May 2020   Prob (F-statistic):              0.308
Time:                        07:49:22   Log-Likelihood:                 18782.
No. Observations:                8610   AIC:                        -3.756e+04
Df Residuals:                    8608   BIC:                        -3.755e+04
Df Model:                           1
Covariance Type:            nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
const          0.0063      0.000     21.541      0.000       0.006       0.007
Mkt-RF         0.0003      0.000      1.020      0.308      -0.000       0.001
==============================================================================
Omnibus:                      919.546   Durbin-Watson:                   0.170
Prob(Omnibus):                  0.000   Jarque-Bera (JB):             2356.989
Skew:                           0.614   Prob(JB):                         0.00
Kurtosis:                       5.249   Cond. No.                         1.11
==============================================================================

Warnings:
[1] Standard Errors assume that the covariance matrix of the errors is correctly
specified.
                            OLS Regression Results
```

```
==============================================================================
Dep. Variable:                      y   R-squared:                       0.000
Model:                            OLS   Adj. R-squared:                 -0.000
Method:                 Least Squares   F-statistic:                    0.3595
Date:                Wed, 13 May 2020   Prob (F-statistic):              0.782
Time:                        07:49:22   Log-Likelihood:                 18782.
No. Observations:                8610   AIC:                        -3.756e+04
Df Residuals:                    8606   BIC:                        -3.753e+04
Df Model:                           3
Covariance Type:            nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
const          0.0063      0.000     21.539      0.000       0.006       0.007
Mkt-RF         0.0003      0.000      0.983      0.326      -0.000       0.001
SMB        -2.641e-05      0.001     -0.052      0.958      -0.001       0.001
HML           -0.0001      0.001     -0.195      0.846      -0.001       0.001
==============================================================================
Omnibus:                      919.171   Durbin-Watson:                   0.170
Prob(Omnibus):                  0.000   Jarque-Bera (JB):             2355.085
Skew:                           0.614   Prob(JB):                         0.00
Kurtosis:                       5.248   Cond. No.                         2.05
==============================================================================

Warnings:
[1] Standard Errors assume that the covariance matrix of the errors is correctly
specified.
                            OLS Regression Results
==============================================================================
Dep. Variable:                      y   R-squared:                       0.000
Model:                            OLS   Adj. R-squared:                 -0.000
Method:                 Least Squares   F-statistic:                    0.6663
Date:                Wed, 13 May 2020   Prob (F-statistic):              0.649
Time:                        07:49:22   Log-Likelihood:                 18783.
No. Observations:                8610   AIC:                        -3.755e+04
Df Residuals:                    8604   BIC:                        -3.751e+04
Df Model:                           5
Covariance Type:            nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
const          0.0063      0.000     21.510      0.000       0.006       0.007
Mkt-RF         0.0002      0.000      0.658      0.511      -0.000       0.001
SMB         9.454e-05      0.001      0.175      0.861      -0.001       0.001
HML            0.0003      0.001      0.543      0.587      -0.001       0.002
RMW            0.0005      0.001      0.679      0.497      -0.001       0.002
CMA           -0.0013      0.001     -1.402      0.161      -0.003       0.001
==============================================================================
Omnibus:                      915.730   Durbin-Watson:                   0.171
Prob(Omnibus):                  0.000   Jarque-Bera (JB):             2339.835
Skew:                           0.613   Prob(JB):                         0.00
Kurtosis:                       5.240   Cond. No.                         3.84
==============================================================================

Warnings:
[1] Standard Errors assume that the covariance matrix of the errors is correctly
specified.
```