GARCH_share

uly 22, 2021

Importing package

[109]:
```
#importing packag
import statsmodels.api as sm
from statsmodels.tsa.stattools import adfuller
import pandas as pd
import numpy as np
import statsmodels.formula.api as smf
from sklearn import linear_model
import matplotlib.pyplot as plt
```


Reading Excel file saved in hard drive

[110]:
```
#reading the file
df = pd.read_excel("C:\\Users\\rtack\\OneDrive\\share.xlsx")
df
```


[110]:

	OBS	PRICE
0	1	975.04
1	2	977.07
2	3	966.58
3	4	964.00
4	5	956.05
..	…	…
989	990	1144.80
990	991	1170.35
991	992	1167.10
992	993	1158.31
993	994	1139.93

[994 rows x 2 columns]

Calculating daily returns and daily squared returns from SP500

Daily returns (R)

$$R = 100 * ln(P_t/P_{t-1})$$

Daily squared returns (R^2)

$$R = R^2$$

[111]:
```
#computing the inflation rate
df['R'] = 100*np.log(df['PRICE']/df['PRICE'].shift(1))
df['R_squared'] = df['R']**2
df = df.dropna(subset=["R"])
df
```

[111]:

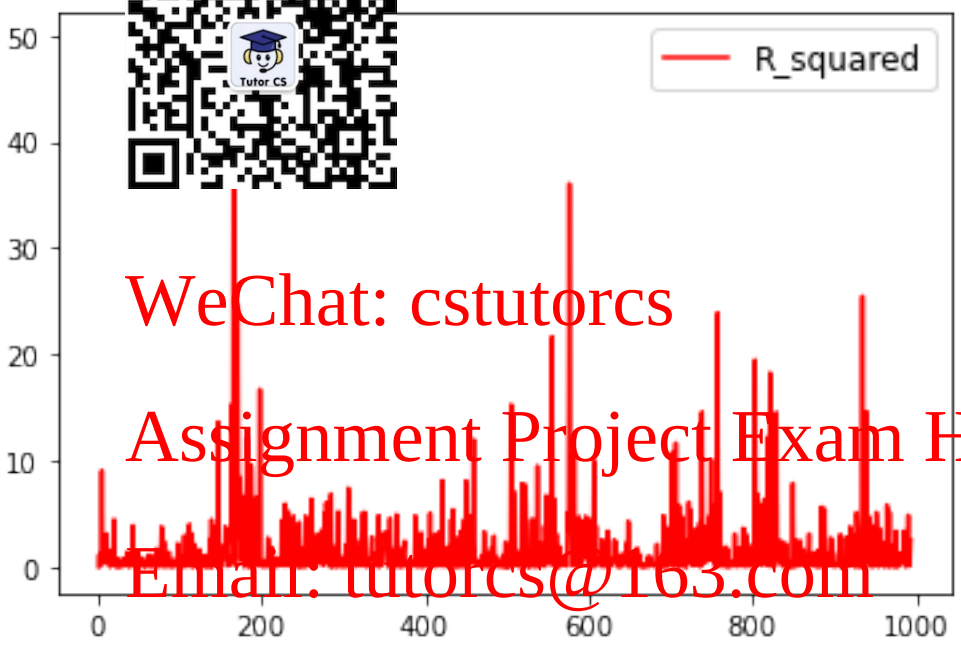
	OBS	PRICE	R	R_squared
1	2	977.07		256
2	3	966.58		154
3	4	964.00		437
4	5	956.05		763
5	6	927.69		679
..	…	…	…	…
989	990	1144.80	1.310082	1.716314
990	991	1170.35	2.207290	4.872129
991	992	1167.10	-0.278081	0.077329
992	993	1158.31	-0.755999	0.571535
993	994	1139.93	-1.599519	2.558461

[993 rows x 4 columns]

$**Plotting the time series: R and** $R^2$$

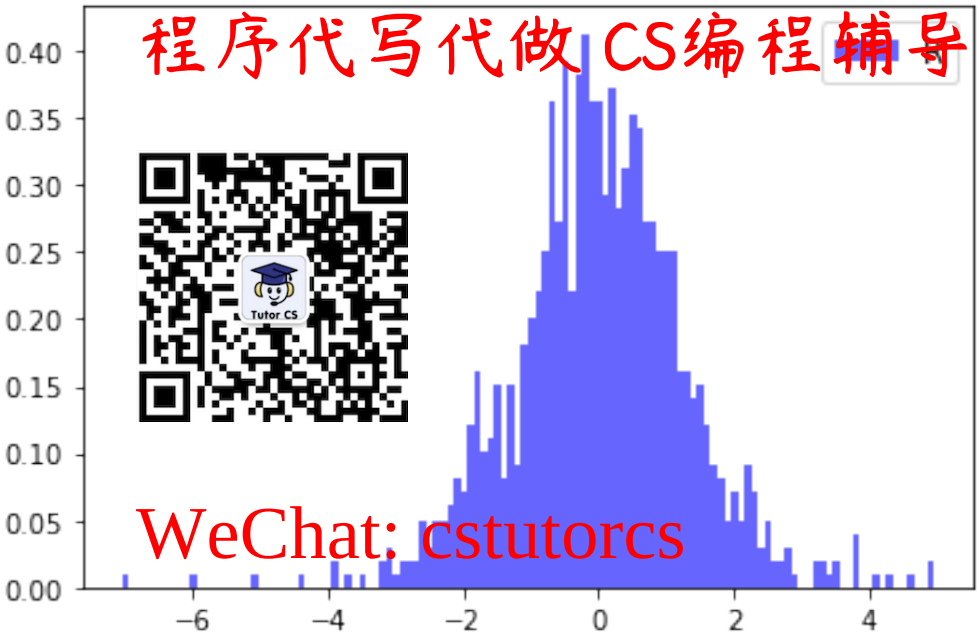
[112]:
```
#plotting the R series
plt.plot(df['R'],label='R')
plt.legend(loc='best', fontsize='large')
plt.show()
```

[113]:
```
#plotting the R_squared Series
plt.plot(df['R_squared'],label='R_squared',color='Red')
plt.legend(loc='best', fontsize='large')
plt.show()
```



Histogram and descriptive statistics

[114]:
```
#Plot histogram of R
plt.hist(df['R'],bins=120,label='R', density=True, alpha=0.6, color='b')
plt.legend(loc='best', fontsize='large')
plt.show()
```



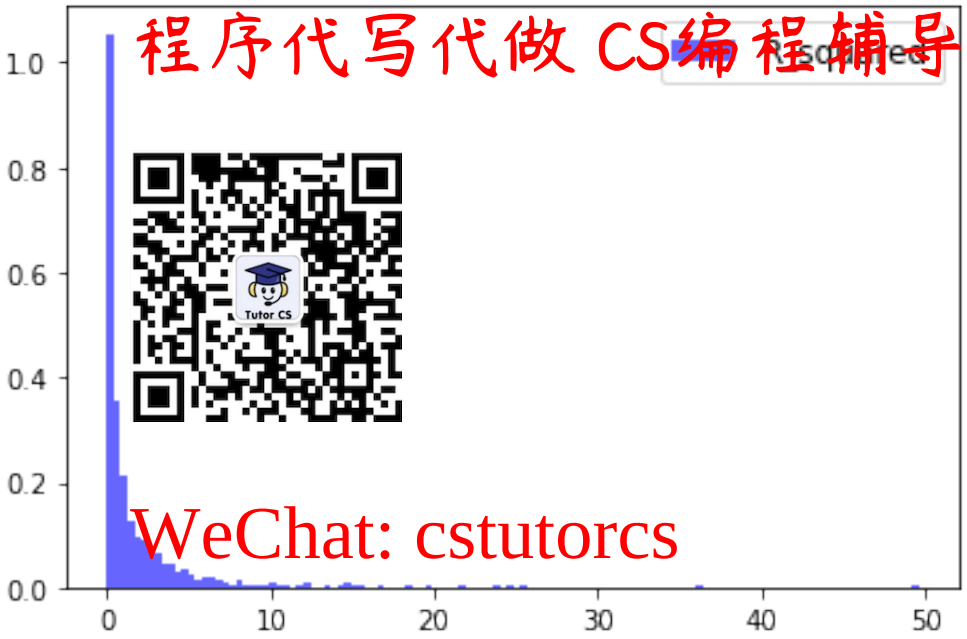
[115]:
```
from scipy import stats
stats.describe(df['R'])
```

[115]:
```
DescribeResult(nobs=993, minmax=(-7.043759037302043, 4.964596183505854),
mean=0.015734505588626 76, variance=1.6948773272 67905,
skewness=-0.14682321703 67387, kurtosis=2.016094075647234)
```

[116]:
```
stats.jarque_bera(df['R'])
```

[116]:
```
Jarque_beraResult(statistic=171.7419793855507, pvalue=0.0)
```

[117]:
```
#Plot histogram of R_squared
plt.hist(df['R_squared'],bins=120,label='R_squared', density=True, alpha=0.6,␣
↪color='b')
plt.legend(loc='best', fontsize='large')
plt.show()
```



[118]:
```
stats.describe(df['R_squared'])
```

[118]:
```
DescribeResult(nobs=993, minmax=(0.0, 49.614541375574206),
mean=1.693418576326566, variance=11.506356201573688, skewness=6.16939777089506,
kurtosis=59.64692480462559)
```

[119]:
```
stats.jarque_bera(df['R_squared'])
```

[119]:
```
Jarque_beraResult(statistic=153501.31264418407, pvalue=0.0)
```

ACF , PACF of R

[120]:
```
from statsmodels.graphics import tsaplots
fig =tsaplots.plot_acf(df['R'],lags=16)
fig =tsaplots.plot_pacf(df['R'],lags=16)
plt.show()
```

[121]:
```
# Generating the Q tables
import numpy as np
r,q,p = sm.tsa.acf(df['R'].values.squeeze(), qstat=True)
data = np.c_[range(1,41), r[1:], q, p]
table = pd.DataFr                                    ['lag', "AC", "Q", "Prob(>Q)"])
print (table.set_
```

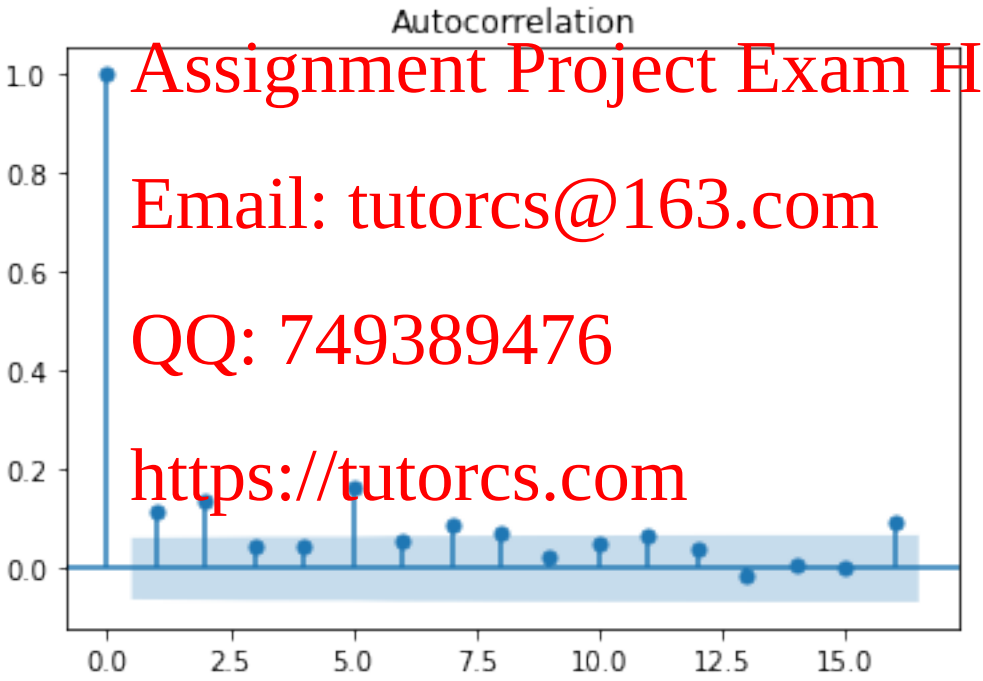

lag	AC		
1.0	0.002187	0	
2.0	-0.044549	1	
3.0	-0.042759	3	
4.0	0.036575	5.144571	0.272783
5.0	-0.068961	9.900359	0.078108
6.0	-0.019748	10.290740	0.112930
7.0	-0.001411	10.292735	0.172582
8.0	-0.019274	10.665353	0.221391
9.0	-0.019877	11.062067	0.271479
10.0	0.014334	11.268578	0.336980
11.0	-0.054077	14.210389	0.221543
12.0	0.077208	20.214671	0.063133
13.0	0.059358	23.766889	0.033343
14.0	-0.008254	23.835639	0.047960
15.0	0.039619	25.421426	0.044562
16.0	-0.040201	27.055817	0.040867
17.0	0.014268	27.261915	0.054337
18.0	-0.057071	30.561506	0.032324
19.0	0.021465	31.029898	0.040069
20.0	-0.010472	31.141257	0.053353
21.0	-0.054597	34.171259	0.034738
22.0	-0.015008	34.400460	0.044705
23.0	0.028022	35.200283	0.049681
24.0	0.036951	36.592496	0.048029
25.0	-0.033563	37.742296	0.049009
26.0	0.017079	38.040350	0.060041
27.0	0.082436	44.991090	0.016296
28.0	0.001189	44.992538	0.022101
29.0	0.017297	45.299169	0.027513
30.0	-0.000220	45.299219	0.036196
31.0	0.004336	45.318524	0.046688
32.0	-0.053556	48.267405	0.032500
33.0	-0.040998	49.997358	0.029234
34.0	-0.089707	58.288305	0.005893
35.0	-0.037434	59.733514	0.005697
36.0	0.025398	60.399493	0.006620
37.0	-0.010012	60.503099	0.008705
38.0	-0.001130	60.504421	0.011575
39.0	0.057283	63.902786	0.007182

```
40.0 -0.073371  69.484020  0.002633

C:\Users\rluck\anaconda3\lib\site-packages\statsmodels\tsa\stattools.py:657:
FutureWarning: The default number of lags is changing from 40 tomin(int(10 *
np.log10(nobs)), nobs - 1) after 0.12is released. Set the number of lags to an
integer to  silenc
  warnings.warn(
C:\Users\rluck\ana                    ckages\statsmodels\tsa\stattools.py:667:
FutureWarning: fft                    the default after the release of the 0.12
release of statsmo                    this warning, explicitly set fft=False.
  warnings.warn(
```

$ACF , PACF of $R

[122]:
```
fig =tsaplots.plot_acf(df['R_squared'],lags=16)
fig =tsaplots.plot_pacf(df['R_squared'],lags=16)
plt.show()
```



[123]:
```
# Generating the Q tables
import numpy as np
r,q,p = sm.tsa.acf(df['R_squared'].values.squeeze(), qstat=True)
data = np.c_[range(1,41), r[1:], q, p]
table = pd.DataFrame(data, columns=['lag', "AC", "Q", "Prob(>Q)"])
print (table.set_index('lag'))
```

```
            AC          Q      Prob(>Q)
lag
1.0   0.116401   13.495026  2.391966e-04
2.0   0.137366   32.307886  9.647874e-08
3.0   0.045022   34.330823  1.686854e-07
4.0   0.043314   36.205092  2.625763e-07
5.0   0.163064   62.795866  3.208813e-12
6.0   0.055033   65.827678  2.922824e-12
7.0   0.088429   73.663464  2.678057e-13
8.0   0.072519   78.938732  7.992968e-14
9.0   0.026248   79.630526  1.913609e-13
10.0  0.051198   82.265203  1.803486e-13
11.0  0.065028   86.519895  7.988149e-14
12.0  0.041676   88.269223  1.067025e-13
13.0 -0.014482   88.480668  2.726470e-13
14.0  0.010197   88.585610  7.015944e-13
15.0  0.001769   88.588769  1.817136e-12
16.0  0.091960   97.140862  1.186384e-13
```

```
17.0  0.036990   98.525997  1.667347e-13
18.0  0.072813  103.898573  4.253525e-14
19.0  0.076362  109.813725  8.627403e-15
20.0  0.020351  110.234269  1.780030e-14
21.0  0.110912  12[illegible]e-16
22.0  0.050038  12[illegible]e-16
23.0 -0.001192  12[illegible]e-16
24.0  0.044396  12[illegible]e-16
25.0  0.003592  12[illegible]e-15
26.0  0.028843  12[illegible]e-15
27.0  0.082465  13[illegible]e-16
28.0  0.026399  13[illegible]e-16
29.0 -0.004892  135.854381  9.184485e-16
30.0 -0.007907  135.918535  1.972095e-15
31.0  0.009156  136.004638  4.128389e-15
32.0  0.079173  142.449347  6.937586e-15
33.0  0.006087  142.487482  1.465969e-15
34.0 -0.039022  144.056309  1.678684e-15
35.0 -0.018729  144.418079  3.052000e-15
36.0 -0.038257  145.929177  3.521024e-15
37.0 -0.025003  146.575300  5.624595e-15
38.0 -0.043604  148.542369  5.383179e-15
39.0 -0.014147  148.774640  9.993128e-15
40.0 -0.042500  150.622304  9.812920e-15
```

```
C:\Users\rluck\anaconda3\lib\site-packages\statsmodels\tsa\stattools.py:657:
FutureWarning: The default number of lags is changing from 40 tomin(int(10 *
np.log10(nobs)), nobs - 1) after 0.12is released. Set the number of lags to an
integer to  silence this warning.
  warnings.warn(
C:\Users\rluck\anaconda3\lib\site-packages\statsmodels\tsa\stattools.py:667:
FutureWarning: fft=True will become the default after the release of the 0.12
release of statsmodels. To suppress this warning, explicitly set fft=False.
  warnings.warn(
```

GARCH(1,1)

[124]:
```
from arch import arch_model
```

[125]:
```
dt = df['R']
model = arch_model(dt,mean ='Constant', vol ='GARCH', p=1, q=1)
x_1 =model.fit(update_freq=0)
x_1
```

```
Optimization terminated successfully    (Exit mode 0)
            Current function value: 1634.7774950799287
            Iterations: 13
            Function evaluations: 76
            Gradient evaluations: 13
```

[125]:

```
                     Constant Mean - GARCH Model Results
==============================================================================
Dep. Variable:                      R   R-squared:                       0.000
Mean Model:             Constant Mean   Adj. R-squared:                  0.000
Vol Model:                      GARCH   Log-Likelihood:               -1634.78
Distribution:                      al   AIC:                           3277.55
Method:                            od   BIC:                           3297.16
                                        No. Observations:                  993
Date:                              21   Df Residuals:                      992
Time:                              10   Df Model:                            1
                               an Model
===========================================================================
                 coef    std err          t      P>|t|     95.0% Conf. Int.
---------------------------------------------------------------------------
mu             0.0416  3.828e-02      1.087      0.277 [-3.340e-02,  0.117]
                              Volatility Model
==========================================================================
                 coef    std err          t      P>|t|    95.0% Conf. Int.
--------------------------------------------------------------------------
omega          0.0739  3.549e-02      2.084  3.719e-02 [4.388e-03,  0.143]
alpha[1]       0.0803  2.587e-02      3.104  1.911e-03 [2.960e-02,  0.131]
beta[1]        0.8774  3.539e-02     24.796 1.002e-135   [  0.808,  0.947]
==========================================================================

Covariance estimator: robust
ARCHModelResult, id: 0x1af9210cd60
```


$\sigma_t^2 = 0.0739 + 0.0803 * \epsilon_{t-1} + 0.8774 * \sigma_{t-1}$

$r_t = 0.0416 + \epsilon_t$

ARCH Test

[126]:

```python
from statsmodels.stats.diagnostic import het_arch
from statsmodels.compat import lzip
```

ARCH Test of Standardised Residuals

[127]:

```python
std_resid = x_1.resid/x_1.conditional_volatility
res = het_arch(std_resid, nlags=5)
name =['lm','lm_pval','fval','f_pval']
lzip(name,res)
```

[127]:

```
[('lm', 7.752512201608933),
 ('lm_pval', 0.17041295778563273),
 ('fval', 1.5532744693033598),
 ('f_pval', 0.17070402835943274)]
```

Histogram of Standardised Residuals

[128]:
```
#Historgram of std_residuals
plt.hist(std_resid,bins=120,label='Std_Resid', density=True,alpha=0.5,
 ↪color='b')
plt.legend(loc='best', fontsize='large')
plt.show()
```

[129]:
```
stats.describe(std_resid)
```

[129]:
```
DescribeResult(nobs=993, minmax=(-4.689477005914575, 3.0469323127109766),
mean=-0.0369034521982772 6, variance=1.0012324803805681,
skewness=-0.36830787195222925, kurtosis=1.3412718740326568)
```

[130]:
```
stats.jarque_bera(std_resid)
```

[130]:
```
Jarque_beraResult(statistic=96.88423763663839, pvalue=0.0)
```

ACF , PACF of Std Residuals

[131]:
```
fig =tsaplots.plot_acf(std_resid,lags=16)
fig =tsaplots.plot_pacf(std_resid,lags=16)
plt.show()
```

Choosing the GARCH lags

[132]:
```
#running the GARCH(2,1) , (1,2)and (2,2)
model_2 = arch_model(dt,mean ='Constant', vol ='GARCH', p=2,q=1)
model_3 = arch_model(dt,mean ='Constant', vol ='GARCH', p=1,q=2)
model_4 = arch_model(dt,mean ='Constant', vol ='GARCH', p=2,q=2)
x_2= model_2.fit(
x_3= model_3.fit(
x_4= model_4.fit(
```

```
Optimization termi                    (Exit mode 0)
            Curren                    1634.3777875970884
            Iterat
            Functi
            Gradient evaluations: 14
Optimization terminated successfully    (Exit mode 0)
            Current function value: 1634.7774955255713
            Iterations: 13
            Function evaluations: 88
            Gradient evaluations: 13
Optimization terminated successfully    (Exit mode 0)
            Current function value: 1632.9634703263373
            Iterations: 11
            Function evaluations: 91
            Gradient evaluations: 11
```

[133]:
```
#Computing the AIC  (AIC_stata= AIC_Python/ no of obs)
n = 993
aic=[x_1.aic/n,x_2.aic/n,x_3.aic/n,x_4.aic/n]
bic= [x_1.bic/n,x_2.bic/n,x_3.bic/n,x_4.bic/n]
name =['GARCH_1,1','GARCH_2,1','GARCH_1,2','GARCH_2,2']
lzip(name,aic, bic)
```

[133]:
```
[('GARCH_1,1', 3.3006596074117396, 3.3204007178409247),
 ('GARCH_2,1', 3.3018686557846695, 3.326545043821151),
 ('GARCH_1,2', 3.3026737070001437, 3.3273500950366253),
 ('GARCH_2,2', 3.301034179912059, 3.3306458455558365)]
```

Plotting the comparative chart

[134]:
```
#ARCH(5) model defined as x_5 model
model = arch_model(df['R'],mean ='Constant', vol ='ARCH', p=5)
x_5 =model.fit(update_freq=0)
```

```
Optimization terminated successfully    (Exit mode 0)
            Current function value: 1639.433689366865
            Iterations: 15
            Function evaluations: 135
            Gradient evaluations: 15
```

[135]:
```
#defining the ARCH (5)'s conditional volatility
dt_1 = x_5.conditional_volatility
```

[136]:
```
#defining the GARCH(1,1)'s conditional volatility.
#x_1 is defined th GARCH(1,1) beforehand
dt_2 = x_1.condit
```

[137]:
```
#Deriving the abs
dta = np.abs(df['
```

[138]:
```
#Plotting the cur
dta.plot(figsize=          ua',label='R_abs')
dt_1.plot(figsize=(12,5),color='r', label='ARCH_5')
dt_2.plot(figsize=(12,5),color='b',label ='GARCH_1,1')
plt.title('GARCH_1,1 Conditional Volatility', size=15)
plt.legend(loc='best', fontsize='large')
plt.show()
```

[ ]: