ARCH_share

July 22, 2021

Importing packages

[61]:
```
#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

[62]:
```
#reading the file
df = pd.read_excel('C:\\Users\\rluck\\OneDrive\\share.xlsx')
df
```


[62]:
```
     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)

$$R = R^2$$

[63]:
```python
#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
```

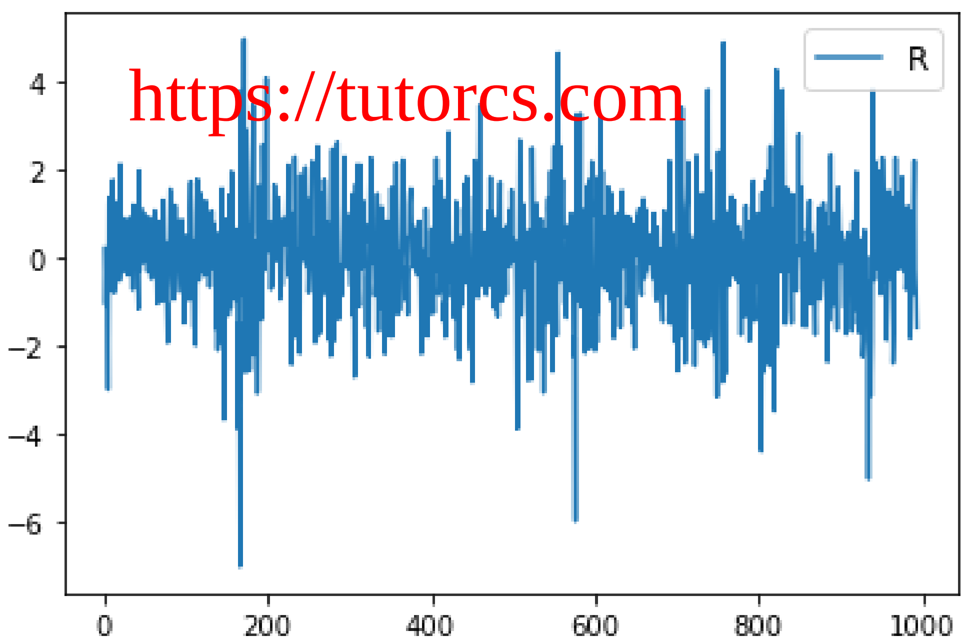
[63]:

	OBS	PRICE	[illegible]	[illegible]red
1	2	977.07	[illegible]	[illegible]256
2	3	966.58	[illegible]	[illegible]154
3	4	964.00	[illegible]	[illegible]437
4	5	956.05	[illegible]	[illegible]763
5	6	927.69	[illegible]	[illegible]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

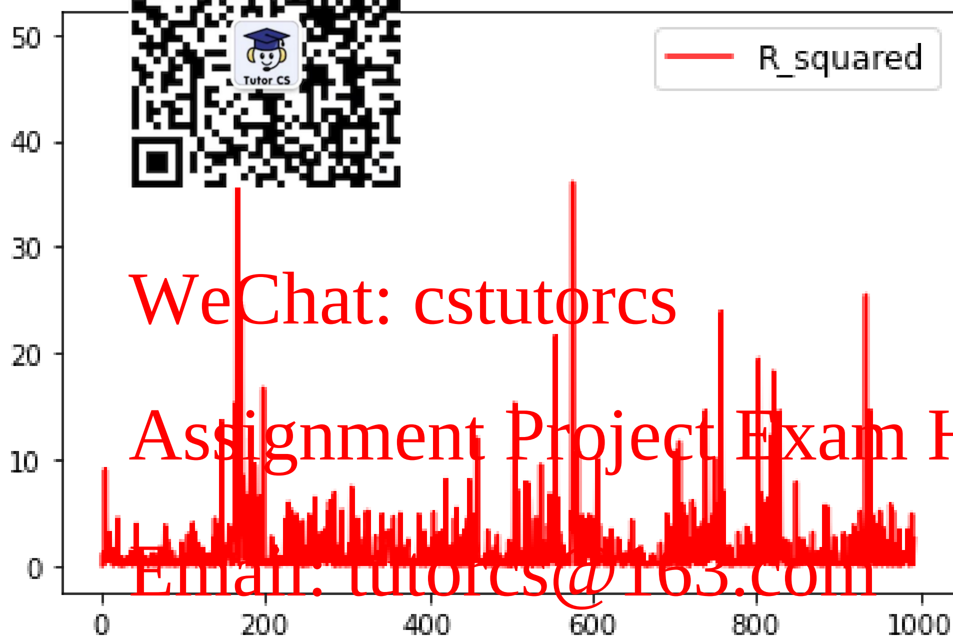
[993 rows x 4 columns]

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

[64]:
```python
#plotting the R series
plt.plot(df['R'],label='R')
plt.legend(loc='best', fontsize='large')
plt.show()
```

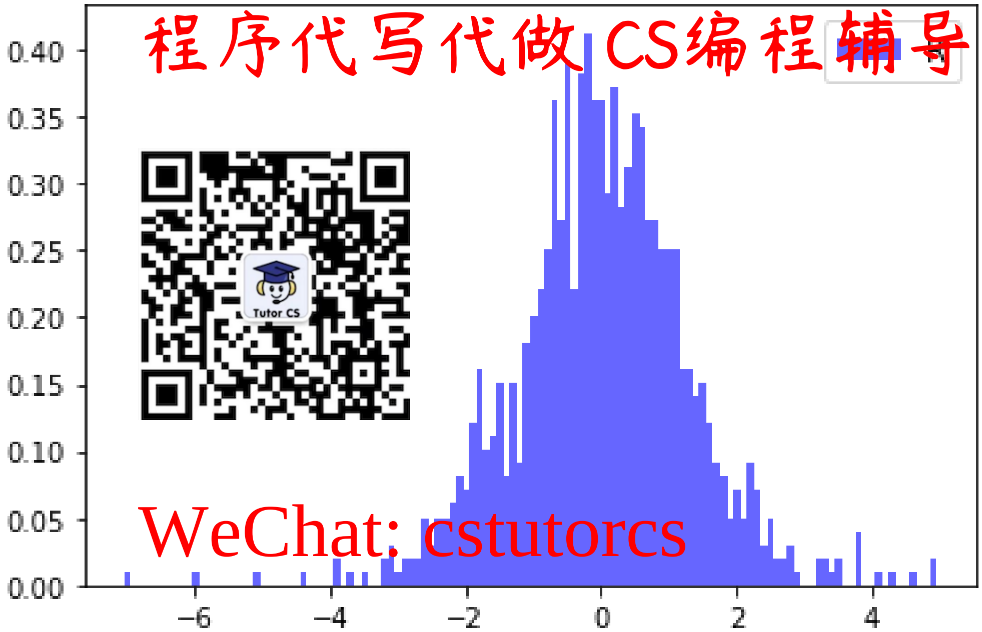


```
[65]: #plotting the R_squared series
plt.plot(df['R_squared'],label='R_squared',color='Red')
plt.legend(loc='best', fontsize='large')
plt.show()
```



Histogram and descriptive statistics


```
[66]: #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()
```



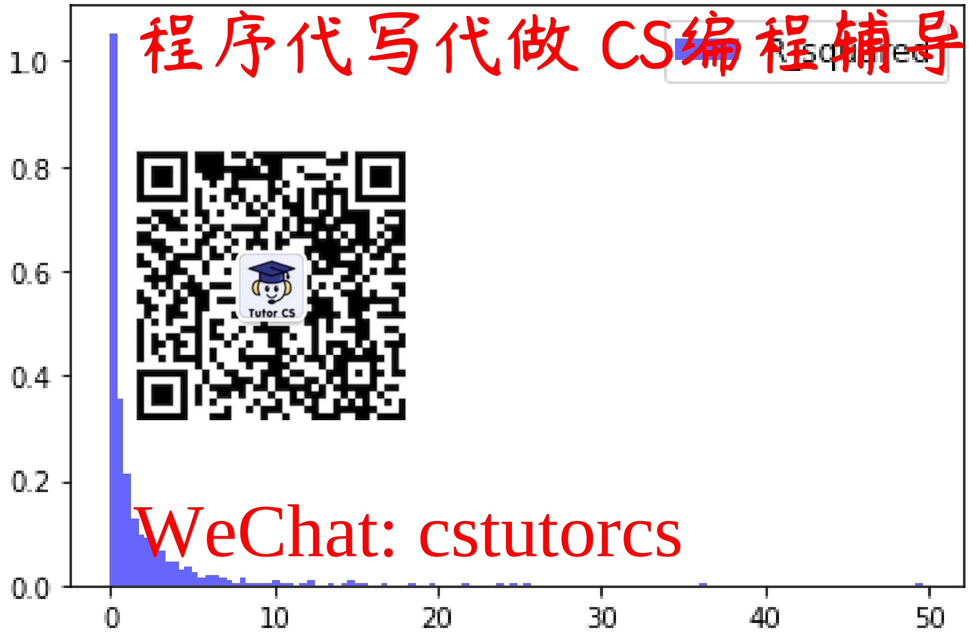
[67]:
```python
from scipy import stats
stats.describe(df['R'])
```

[67]:
```
DescribeResult(nobs=993, minmax=(-7.043759037302043, 4.964596183505854),
mean=0.01573450555862576, variance=1.694877327267905,
skewness=-0.1468232170367387, kurtosis=2.016094075647234)
```

[68]:
```python
stats.jarque_bera(df['R'])
```

[68]:
```
Jarque_beraResult(statistic=171.7419793855507, pvalue=0.0)
```

[69]:
```python
#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()
```



[70]:
```
stats.describe(df['R_squared'])
```

[70]:
```
DescribeResult(nobs=993, minmax=(0.0, 49.614541375574206),
mean=1.693418576326566, variance=11.506356201573688, skewness=6.16939777089506,
kurtosis=59.64692480462559)
```

[71]:
```
stats.jarque_bera(df['R_squared'])
```

[71]:
```
Jarque_beraResult(statistic=153501.31264418407, pvalue=0.0)
```

ACF , PACF of R

[72]:
```
from statsmodels.graphics import tsaplots
fig =tsaplots.plot_acf(df['R'],lags=16)
fig =tsaplots.plot_pacf(df['R'],lags=16)
plt.show()
```


Autocorrelation
1.0
0.8
0.6
0.4
0.2
0.0
0.0
2.5
5.0
7.5
10.0
12.5
15.0


Partial Autocorrelation
1.0
0.8
0.6
0.4
0.2
0.0
0.0
2.5
5.0
7.5
10.0
12.5
15.0

[73]:
```python
# 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[illegible]['lag', "AC", "Q", "Prob(>Q)"])
print (table.set_[illegible]
```

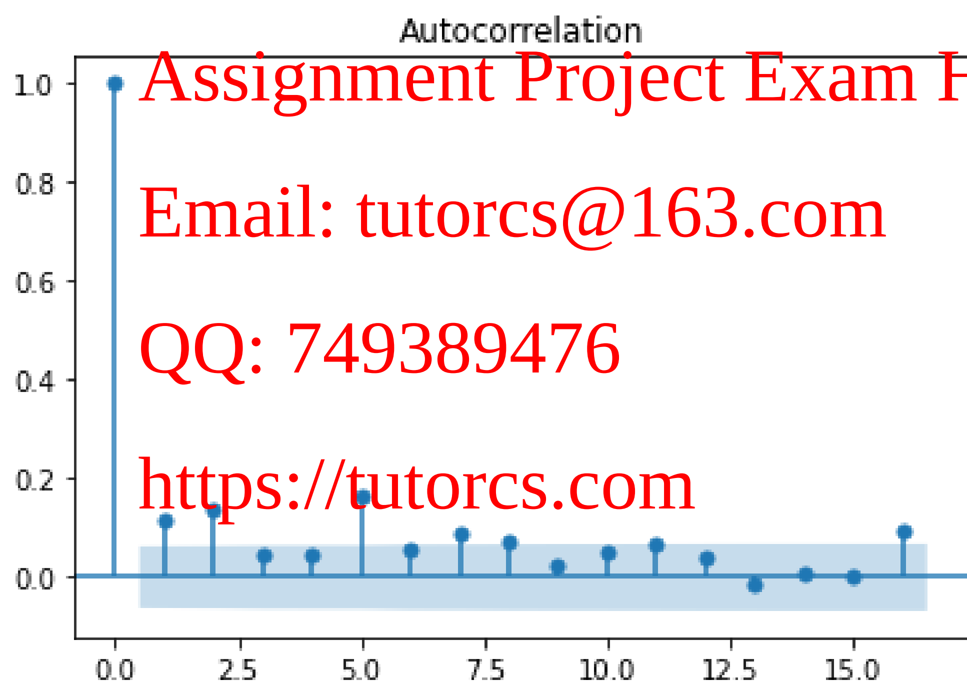
```
            AC
lag
1.0    0.002187   0[illegible]
2.0   -0.044549   1[illegible]
3.0   -0.042759   3[illegible]
4.0    0.036575   5.144571  0.272783
5.0   -0.068961   9.900359  0.078108
6.0   -0.019748  10.290740  0.112930
7.0   -0.001411  10.292735  0.172582
8.0   -0.019274  10.665353  0.221391
9.0   -0.019877  11.062067  0.271479
10.0   0.014334  11.268578  0.336980
11.0  -0.054077  14.210889  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  30.562506  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

[74]:
```
fig =tsaplots.plot_acf(df['R_squared'],lags=16)
fig =tsaplots.plot_pacf(df['R_squared'],lags=16)
plt.show()
```

[75]:
```python
# 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'))
```

lag	AC	Q	Prob(>Q)
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  103.898575  4.253523e-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  136.004633  4.128389e-15
32.0  0.079173  142.449347  6.937586e-16
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  148.749640  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(
```

ARCH(5)

[76]:
```python
from arch import arch_model
```

[77]:
```python
dt = df['R']
model = arch_model(dt,mean ='Constant', vol ='ARCH', q=5)
x_5 =model.fit(update_freq=0)
x_5
```

```
Optimization terminated successfully    (Exit mode 0)
            Current function value: 1664.047869085027
            Iterations: 5
            Function evaluations: 28
            Gradient evaluations: 5
```

[77]:
```
                     Constant Mean - ARCH Model Results
==============================================================================
Dep. Variable:                      R   R-squared:                       0.000
Mean Model:             Constant Mean   Adj. R-squared:                  0.000
Vol Model:                       ARCH   Log-Likelihood:               -1664.05
Distribution:                      al   AIC:                           3334.10
Method:                            od   BIC:                           3348.80
                                        No. Observations:                  993
Date:                              21   Df Residuals:                      992
Time:                              12   Df Model:                            1
                               an Model
============================================================================
                 coef    std err          t      P>|t|     95.0% Conf. Int.
----------------------------------------------------------------------------
mu             0.0293  4.132e-02      0.709      0.478 [-5.170e-02,  0.110]
                              Volatility Model
============================================================================
                 coef    std err          t      P>|t|     95.0% Conf. Int.
----------------------------------------------------------------------------
omega          1.5288      0.104     14.654  1.263e-48     [  1.324,  1.733]
alpha[1]       0.0963  4.954e-02      1.944  5.194e-02 [-8.088e-04,  0.193]
============================================================================

Covariance estimator: robust
ARCHModelResult, id: 0x21914bdbe20
```


[78]:
```python
#Aligning AIC, BIC from Python with Stata's AIC, BIC
n =993
name = ['AIC_stata','BIC_stata']
stata=[x_5.aic/n,x_5.bic/n]
lzip(name, stata)
```

[78]:
```
[('AIC_stata', 3.357598930684848), ('BIC_stata', 3.3724047635067365)]
```

ARCH Test

[79]:
```python
from statsmodels.stats.diagnostic import het_arch
from statsmodels.compat import lzip
res = het_arch(dt.values, nlags=5)
name =['lm','lm_pval','fval','f_pval']
lzip(name,res)
```

[79]:
```
[('lm', 52.586810853630816),
 ('lm_pval', 4.0887029149590036e-10),
 ('fval', 11.041163168843253),
 ('f_pval', 2.3131694315533897e-10)]
```

ARCH Test of Standardised Residuals

[80]:
```
std_resid = x_5.resid/x_5.conditional_volatility
res = het_arch(std_resid,nlags=5)
name =['lm','lm_pval','fval','f_pval']
lzip(name,res)
```


[80]:
```
[('lm', 44.616547[illegible]
 ('lm_pval', 1.73[illegible]),
 ('fval', 9.28857[illegible]
 ('f_pval', 1.176[illegible]]
```

Histogram of Resid[illegible]

[81]:
```
#Historgram of residuals
resid = x_5.resid
plt.hist(resid,bins=120,label='Resid', density=True, alpha=0.6, color='b')
plt.legend(loc='best', fontsize='large')
plt.show()
```


[82]:
```
stats.describe(resid)
```

[82]:
```
DescribeResult(nobs=993, minmax=(-7.073049296466991, 4.9353059243409065),
mean=-0.013555753606322416, variance=1.694877827267905,
skewness=-0.1468232170367387, kurtosis=2.016094075647234)
```

[83]:
```
stats.jarque_bera(resid)
```

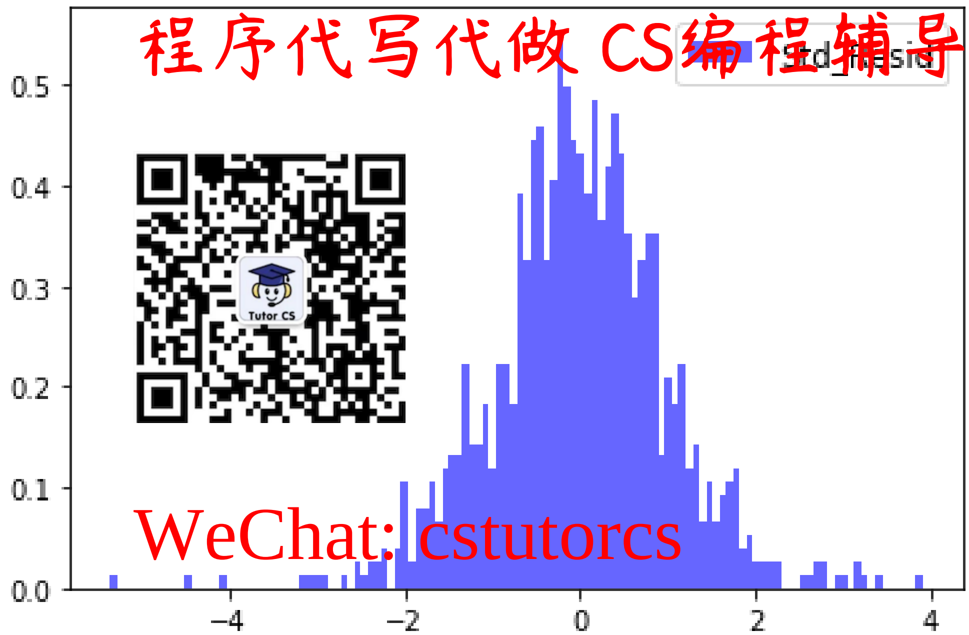
[83]: Jarque_beraResult(statistic=171.7419793855507, pvalue=0.0)

ACF , PACF of Squared Residuals

[84]:
```
fig =tsaplots.plot_acf(resid**2,lags=16)
fig =tsaplots.plo[illegible]gs=16)
plt.show()
```

Histogram of Standardised Residuals

[85]:
```
#Historgram of std residuals
plt.hist(std_resid,bins=120,label='Std Resid', density=True, alpha=0.6,␣
 ↪color='b')
plt.legend(loc='best', fontsize='large')
plt.show()
```



[86]:
```
stats.describe(std_resid)
```

[86]:
```
DescribeResult(nobs=993, minmax=(-5.343797790419605, 3.8965888804733484),
mean=-0.014086543542439298, variance=1.0008098057706427,
skewness=-0.17614610401990488, kurtosis=1.8124982770599578)
```

[87]:
```
stats.jarque_bera(std_resid)
```

[87]:
```
Jarque_beraResult(statistic=141.05812439839767, pvalue=0.0)
```

ACF , PACF of Squared Std Residuals

[88]:
```
fig =tsaplots.plot_acf(std_resid**2,lags=16)
fig =tsaplots.plot_pacf(std_resid**2,lags=16)
plt.show()
```

Choosing the ARCH lags

```
[89]: #Running ARCH from p=1 to p =9
model_1 = arch_model(dt,mean ='Constant', vol ='ARCH', p=1)
model_2 = arch_model(dt,mean ='Constant', vol ='ARCH', p=2)
model_3 = arch_model(dt,mean ='Constant', vol ='ARCH', p=3)
model_4 = arch_model(dt,mean ='Constant', vol ='ARCH', p=4)
model_5 = arch_model(dt,mean ='Constant', vol ='ARCH', p=5)
model_6 = arch_model(dt,mean ='Constant', vol ='ARCH', p=6)
model_7 = arch_model(dt,mean ='Constant', vol ='ARCH', p=7)
model_8 = arch_model(dt,mean ='Constant', vol ='ARCH', p=8)
model_9 = arch_model(dt,mean ='Constant', vol ='ARCH', p=9)
x_1= model_1.fit(update_freq=0)
x_2= model_2.fit(update_freq=0)
x_3= model_3.fit(update_freq=0)
x_4= model_4.fit(update_freq=0)
x_5= model_5.fit(update_freq=0)
x_6= model_6.fit(update_freq=0)
x_7= model_7.fit(update_freq=0)
x_8= model_8.fit(update_freq=0)
x_9= model_9.fit(update_freq=0)
```

```
Optimization terminated successfully    (Exit mode 0)
            Current function value: 1664.047869085027
            Iterations: 5
            Function evaluations: 28
            Gradient evaluations: 5
Optimization terminated successfully    (Exit mode 0)
            Current function value: 1651.3667967409056
            Iterations: 8
            Function evaluations: 49
            Gradient evaluations: 8
Optimization terminated successfully    (Exit mode 0)
            Current function value: 1650.803109203952
            Iterations: 12
            Function evaluations: 83
            Gradient evaluations: 12
Optimization terminated successfully    (Exit mode 0)
            Current function value: 1645.3224422301862
            Iterations: 13
            Function evaluations: 104
            Gradient evaluations: 13
Optimization terminated successfully    (Exit mode 0)
            Current function value: 1639.433689366865
            Iterations: 15
            Function evaluations: 135
            Gradient evaluations: 15
Optimization terminated successfully    (Exit mode 0)
            Current function value: 1638.5159772755142
            Iterations: 15
```

```
                        Function evaluations: 153
                        Gradient evaluations: 15
Optimization terminated successfully    (Exit mode 0)
                        Current function value: 1635.51431460451
                        Iterations: [illegible]
                        Function evaluations: [illegible]0
                        Gradient evaluations: [illegible]5
Optimization terminated successfully    (Exit mode 0)
                        Current function value: 1631.19776764798
                        Iterations: [illegible]
                        Function evaluations: [illegible]9
                        Gradient evaluations: [illegible]
Optimization terminated successfully    (Exit mode 0)
                        Current function value: 1631.1128849200488
                        Iterations: 20
                        Function evaluations: 264
                        Gradient evaluations: 20
```


[90]:

```python
#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,x_5.aic/n,x_6.aic/n,x_7.aic/n,x_8.
 ↪aic/n,x_9.aic/n]
bic= [x_1.bic/n,x_2.bic/n,x_3.bic/n,x_4.bic/n,x_5.bic/n,x_6.bic/n,x_7.bic/n,x_8.
 ↪bic/n,x_9.bic/n]
name␣
 ↪=['ARCH_1','ARCH_2','ARCH_3','ARCH_4','ARCH_5','ARCH_6','ARCH_7','ARCH_8','ARCH_9']
lzip(name,aic, bic)
```


[90]:

```
[('ARCH_1', 3.357598930684848, 3.3724047635067365),
 ('ARCH_2', 3.334072098168994, 3.3538132085981793),
 ('ARCH_3', 3.3349508745296115, 3.3596271262566093),
 ('ARCH_4', 3.325926369043678, 3.3555380346874557),
 ('ARCH_5', 3.316079938301843, 3.350626881552917),
 ('ARCH_6', 3.3162456742709248, 3.3557278951292946),
 ('ARCH_7', 3.31221412810576, 3.3566316265714264),
 ('ARCH_8', 3.305534275222518, 3.35488705129548),
 ('ARCH_9', 3.3073774117221526, 3.361665465402411)]
```

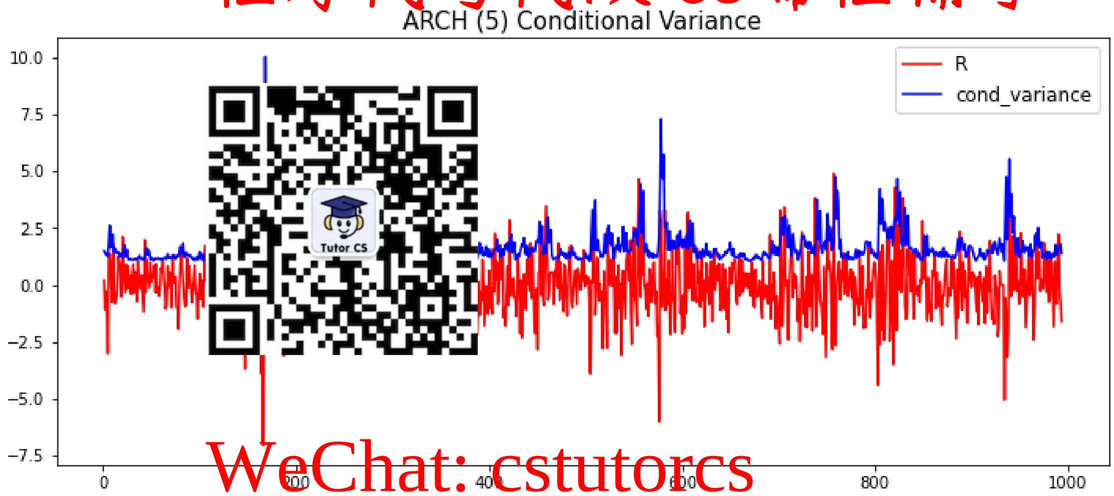

[91]:

```python
#Defining Conditional_Variance as squared conditional volatility from ARCH(5)␣
 ↪which was defined as x_5 beforehand
conditional_variance = x_5.conditional_volatility**2
```

[92]:

```python
#Plotting the R and Conditional Variance from ARCH(5)
dt.plot(figsize=(12,5), color ='red',label ='R')
conditional_variance.plot(figsize=(12,5),color='blue',label='cond_variance')
plt.title('ARCH (5) Conditional Variance', size=15)
plt.legend(loc='best', fontsize='large')
```

```
plt.show()
```



ARCH (5) Conditional Variance
R
cond_variance
10.0
7.5
5.0
2.5
0.0
−2.5
−5.0
−7.5
0
200
400
600
800
1000


```
[ ]:
```