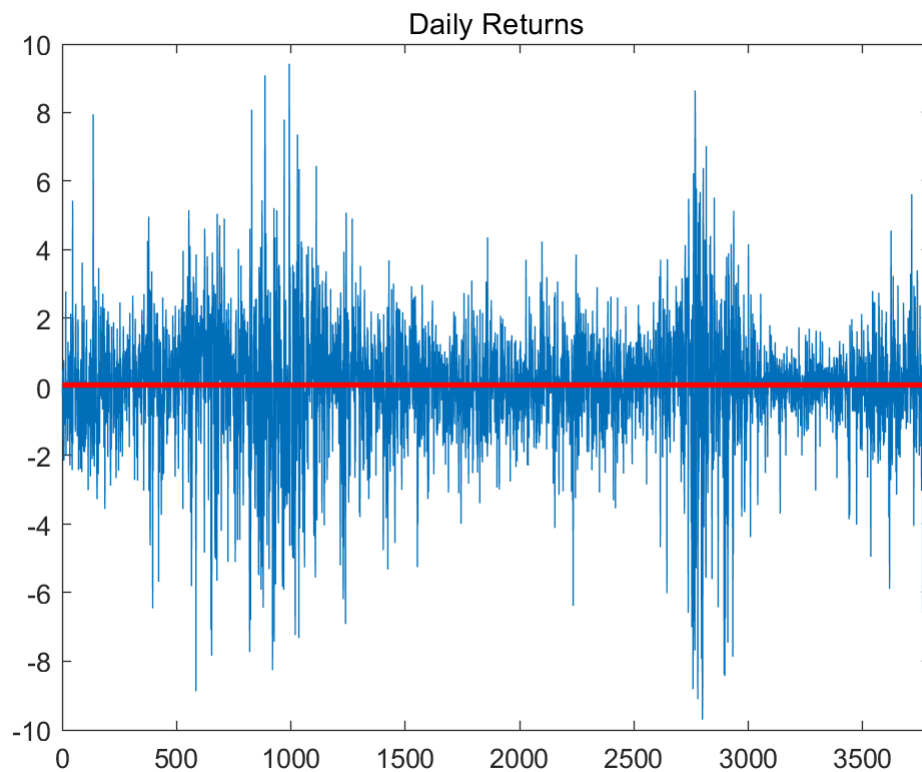


```
load data_nanas0.mat;  
r = data_nanas0(:,1);  
T = size(r,1)
```

T = 3798

```
figure  
plot(r)  
hold on  
const = ones(T).*mean(r);  
plot(const, 'r', 'LineWidth', 2)  
xlim([0,T])  
title('Daily Returns')
```



```
mean(r)
```

ans = 0.0573

```
[h,pValue] = adftest(r)
```

h = *logical*

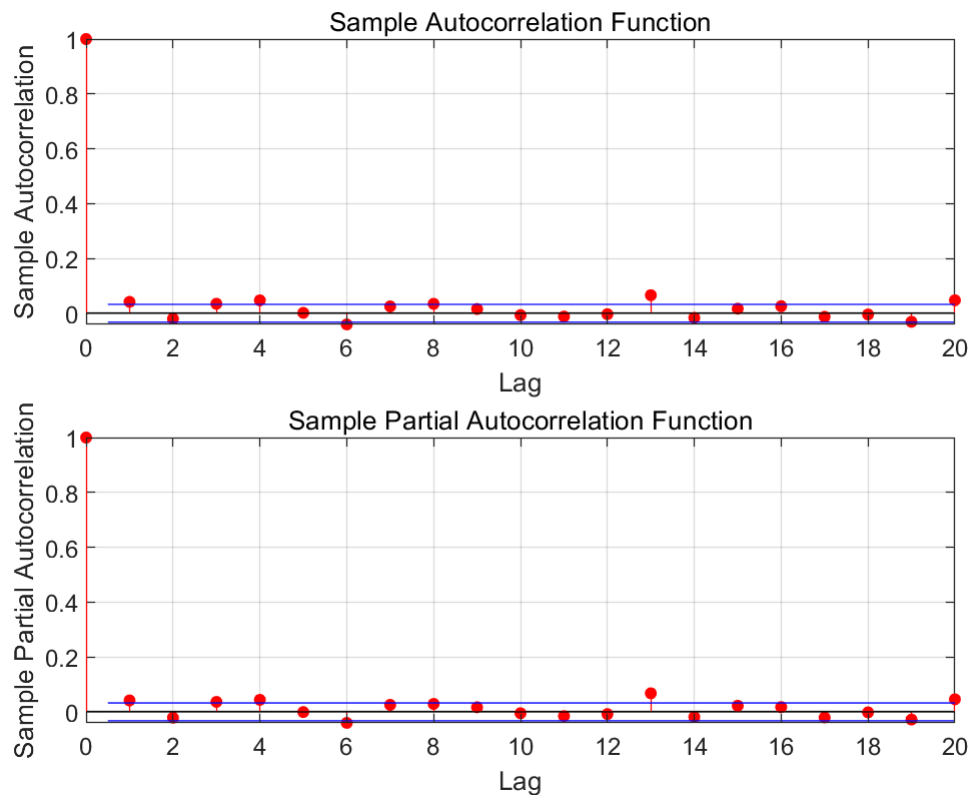
1

pValue = 1.0000e-03

```
[h,pValue] = kpsstest(r)
```

```
h = logical
    0
pValue = 0.1000
```

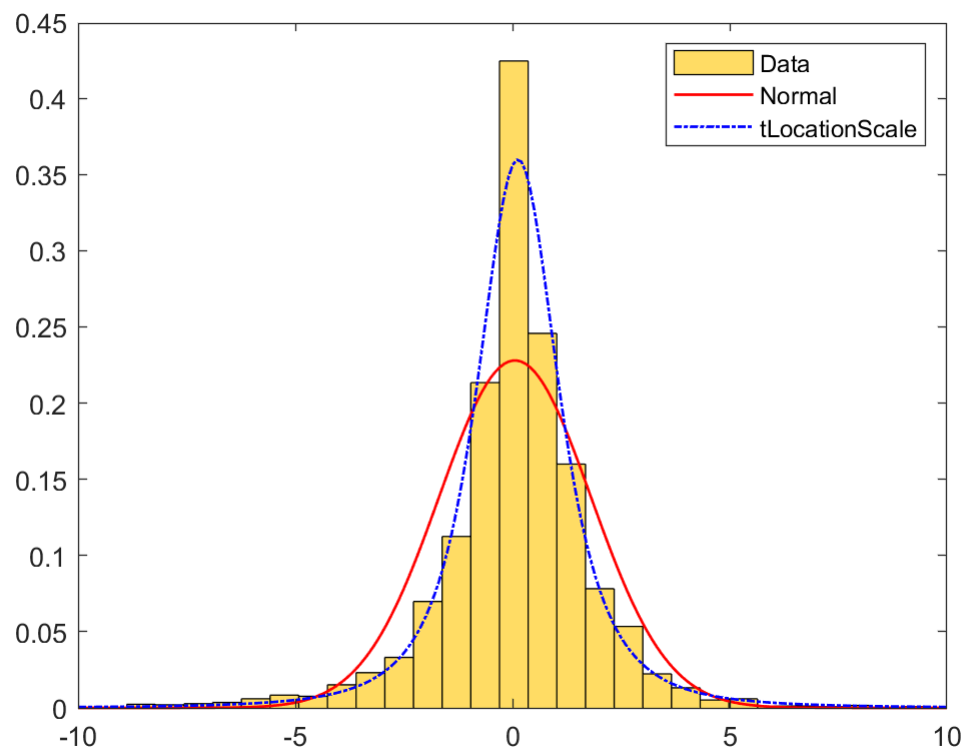
```
figure
subplot(2,1,1)
autocorr(r)
subplot(2,1,2)
parcorr(r)
```



```
pd_n = fitdist(r,'Normal');
pd_t = fitdist(r,'tLocationScale');

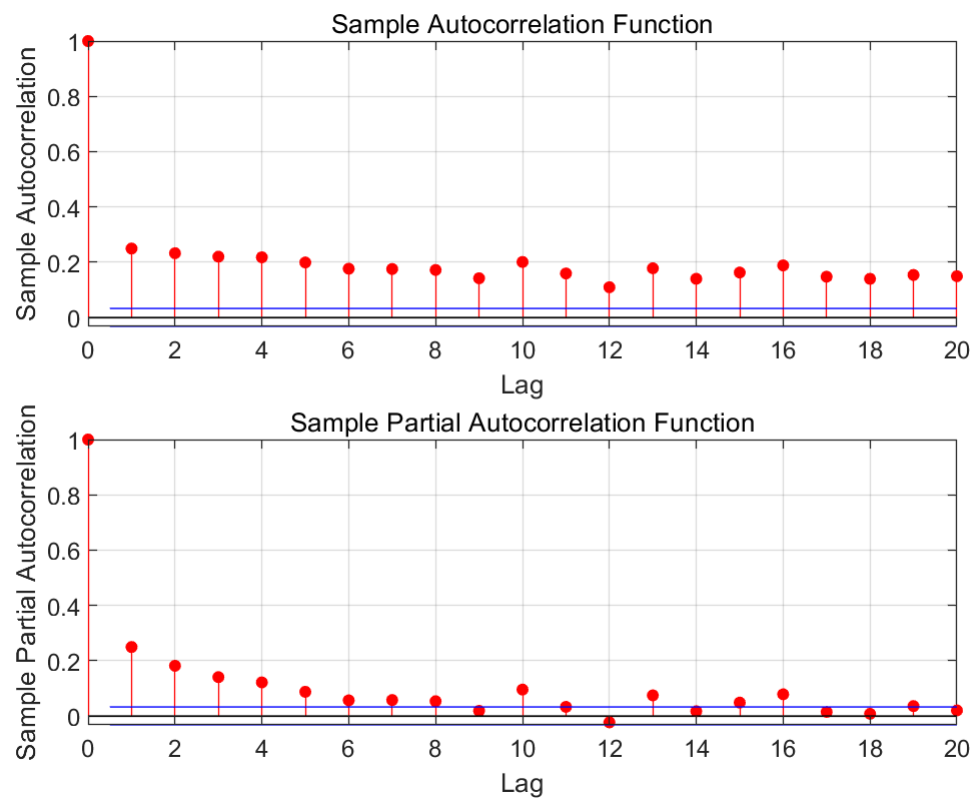
x = -10:0.1:10;
pdf_n = pdf(pd_n,x);
pdf_t = pdf(pd_t,x);
```

```
figure
histogram(r,30,'Normalization','pdf','FaceColor',[1,0.8,0]);
xlim([-10 10])
line(x,pdf_n,'LineStyle','-','Color','r','LineWidth',1)
line(x,pdf_t,'LineStyle','-','Color','b','LineWidth',1)
legend('Data','Normal','tLocationScale')
```



```
e = r - mean(r);
```

```
figure  
subplot(2,1,1)  
autocorr(e.^2)  
subplot(2,1,2)  
parcorr(e.^2)
```

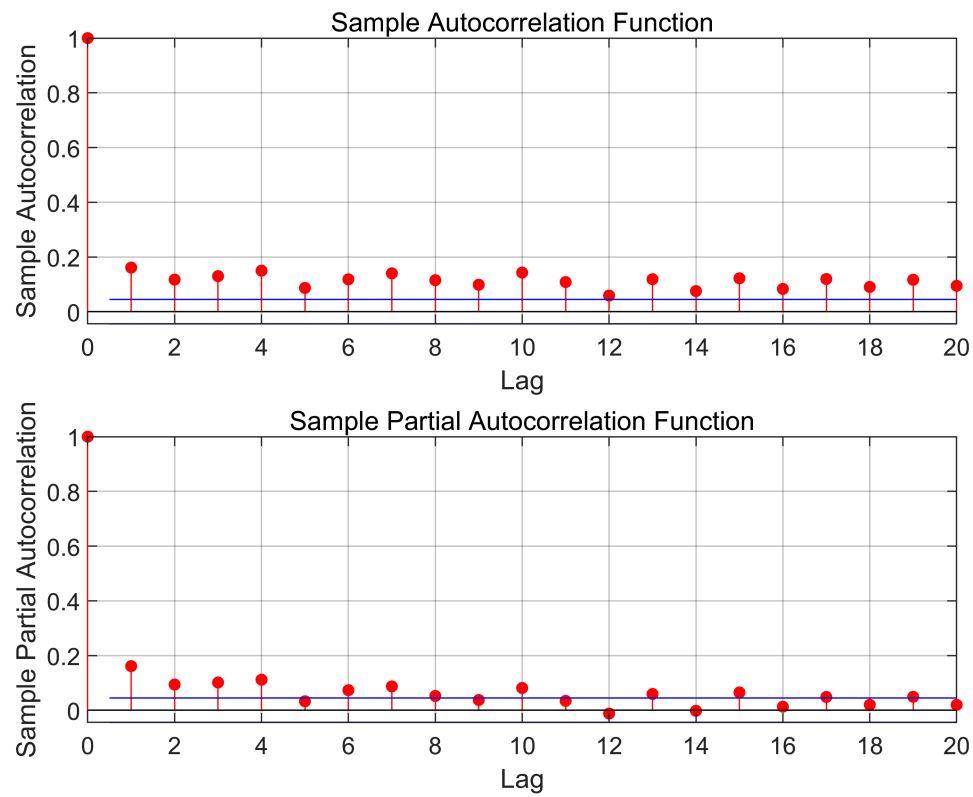


```
len = 2000
```

```
len = 2000
```

```
e = r(1:len) - mean(r(1:len));
```

```
figure
subplot(2,1,1)
autocorr(e.^2)
subplot(2,1,2)
parcorr(e.^2)
```

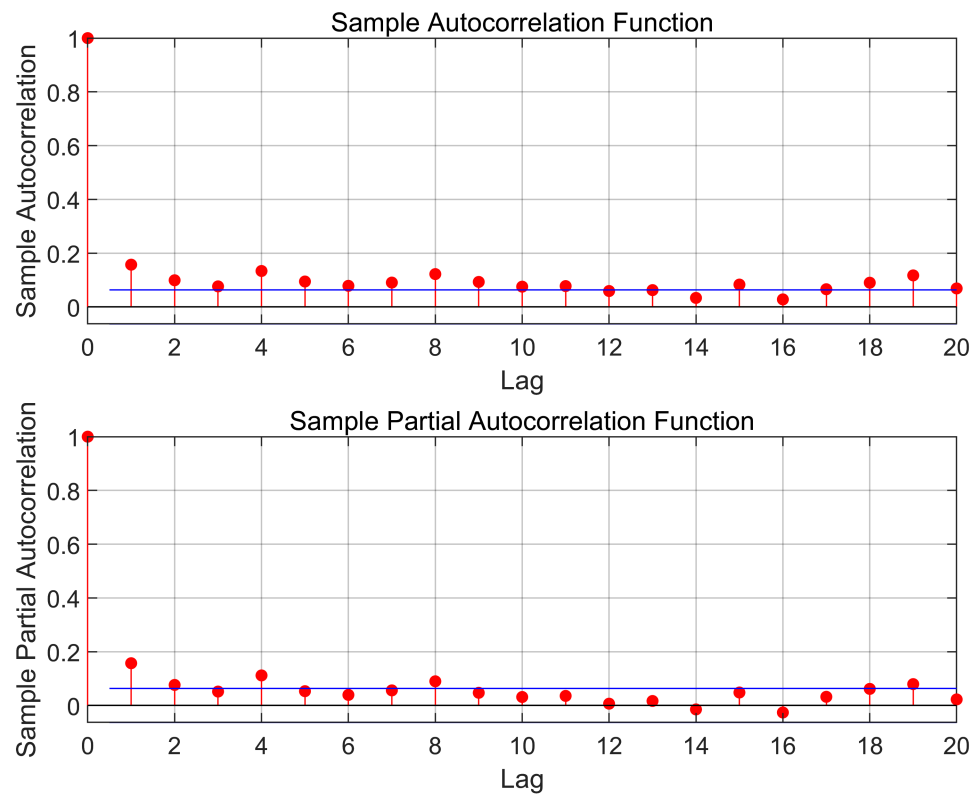


```
len = 1000
```

```
len = 1000
```

```
e = r(1:len) - mean(r(1:len));
```

```
figure  
subplot(2,1,1)  
autocorr(e.^2)  
subplot(2,1,2)  
parcorr(e.^2)
```

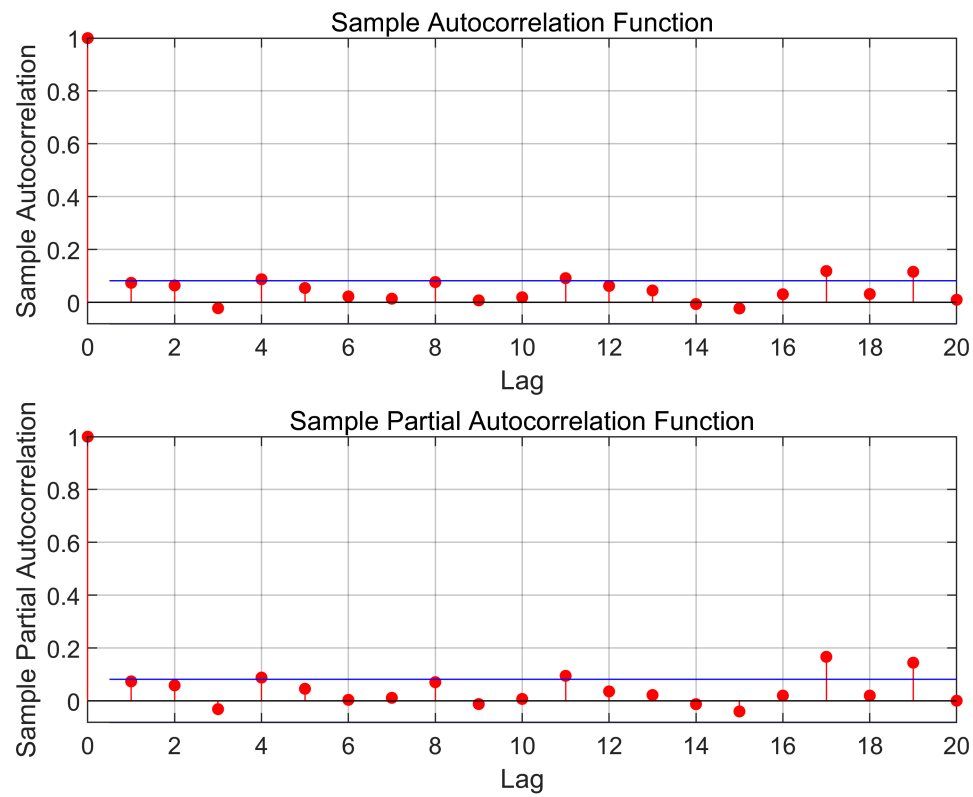


```
len = 600
```

```
len = 600
```

```
e = r(1:len) - mean(r(1:len));
```

```
figure
subplot(2,1,1)
autocorr(e.^2)
subplot(2,1,2)
parcorr(e.^2)
```

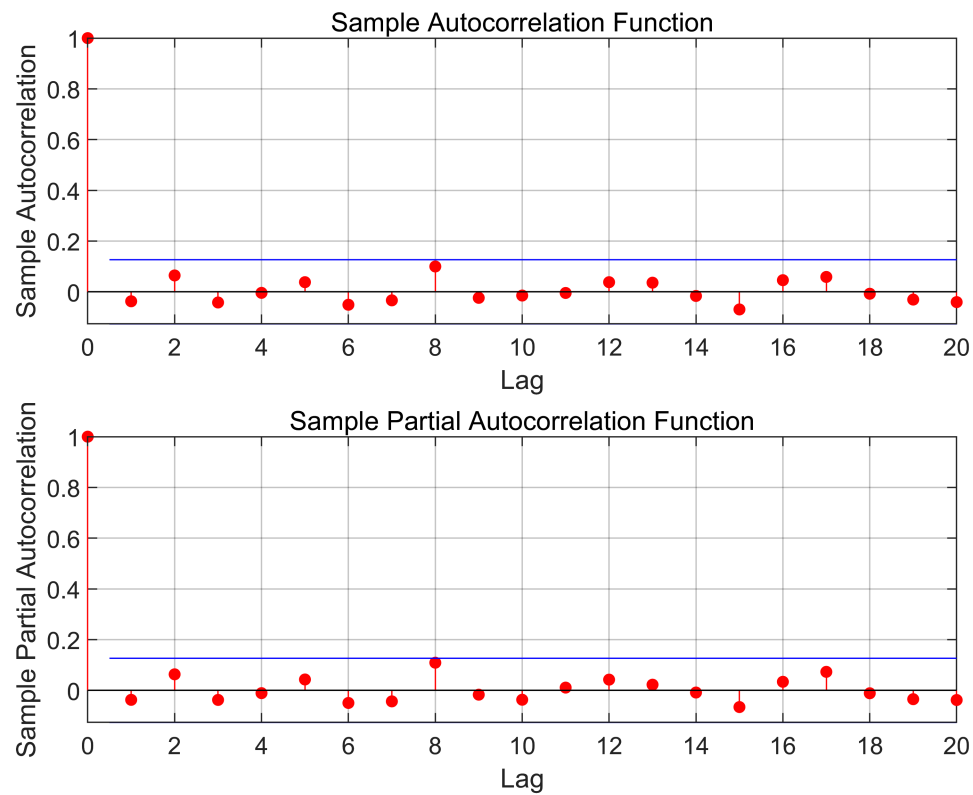


```
len = 250
```

```
len = 250
```

```
e = r(1:len) - mean(r(1:len));
```

```
figure
subplot(2,1,1)
autocorr(e.^2)
subplot(2,1,2)
parcorr(e.^2)
```



```
Mdl = garch(1,1);
EstMdl = estimate(Mdl,r,'Display','off');
summarize(EstMdl);
```

#### GARCH(1,1) Conditional Variance Model (Gaussian Distribution)

Effective Sample Size: 3798  
Number of Estimated Parameters: 3  
LogLikelihood: -6919.95  
AIC: 13845.9  
BIC: 13864.6

	Value	StandardError	TStatistic	PValue
Constant	0.012984	0.0021595	6.0126	1.826e-09
GARCH{1}	0.94878	0.0032412	292.73	0
ARCH{1}	0.047558	0.0033996	13.989	1.8134e-44

```
v = infer(EstMdl,r);
res = (r-EstMdl.Offset)./sqrt(v);

figure
subplot(2,2,1)
plot(res)
xlim([0,T])
```

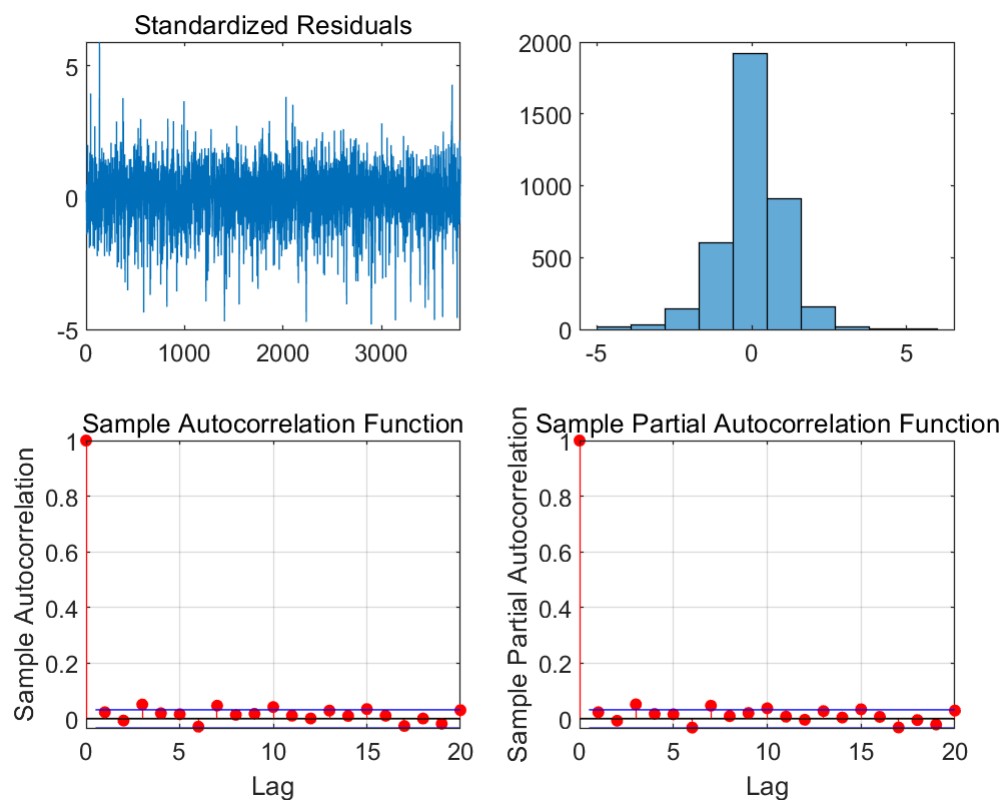


```
title('Standardized Residuals')
```

```
subplot(2,2,2)
histogram(res,10)
```

```
subplot(2,2,3)
autocorr(res)
```

```
subplot(2,2,4)
parcorr(res)
```



```
Mdl = garch(1,1);
opts = optimset('fmincon');
opts.Algorithm = 'interior-point';
EstMdl = estimate(Mdl,r,'options',opts,'Display','off');
summarize(EstMdl);
```

#### GARCH(1,1) Conditional Variance Model (Gaussian Distribution)

Effective Sample Size: 3798  
Number of Estimated Parameters: 3  
LogLikelihood: -6919.95  
AIC: 13845.9  
BIC: 13864.6

	Value	StandardError	TStatistic	PValue
Constant	0.012984	0.0021595	6.0126	1.8256e-09

GARCH{1}	0.94878	0.0032412	292.73	0
ARCH{1}	0.047558	0.0033996	13.989	1.8136e-44

```
Mdl = garch('GARCHLags',1,'ARCHLags',1,'Offset',NaN);
opts = optimset('fmincon');
opts.Algorithm = 'interior-point';
EstMdl = estimate(Mdl,r,'options',opts,'Display','off');
summarize(EstMdl);
```

#### GARCH(1,1) Conditional Variance Model with Offset (Gaussian Distribution)

Effective Sample Size: 3798  
Number of Estimated Parameters: 4  
LogLikelihood: -6917.76  
AIC: 13843.5  
BIC: 13868.5

	Value	StandardError	TStatistic	PValue
Constant	0.013393	0.002163	6.192	5.9418e-10
GARCH{1}	0.94824	0.0032367	292.96	0
ARCH{1}	0.04797	0.0033919	14.143	2.0754e-45
Offset	0.044188	0.020544	2.1508	0.031488

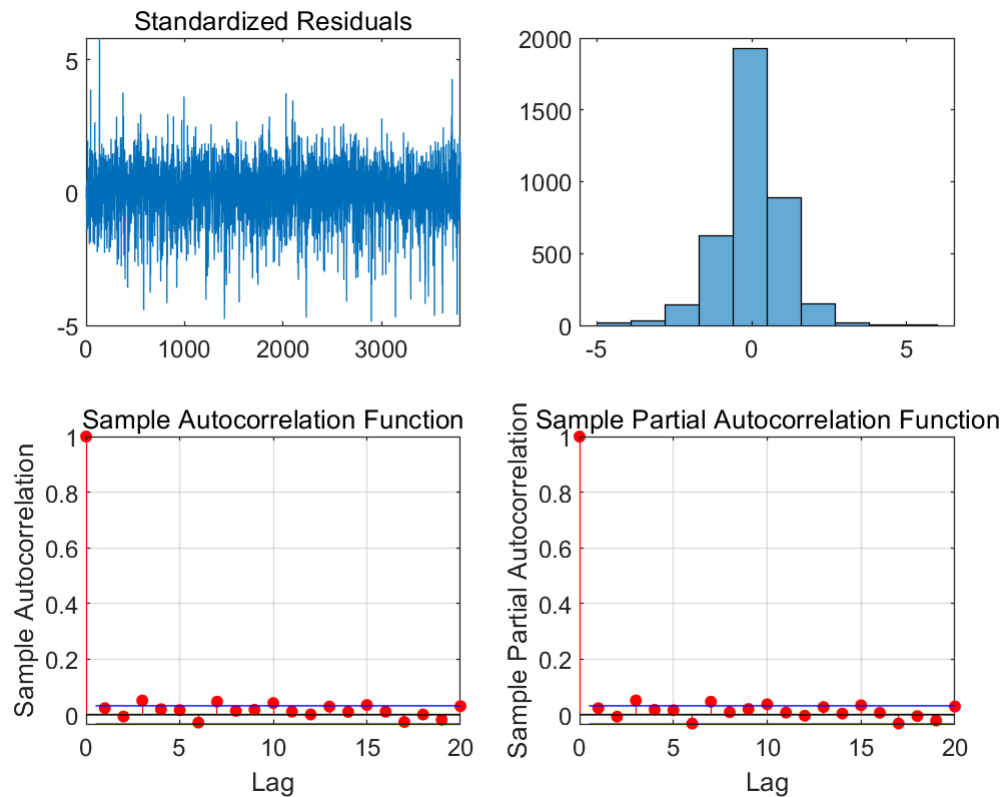
```
v = infer(EstMdl,r);
res = (r-EstMdl.Offset)./sqrt(v);

figure
subplot(2,2,1)
plot(res)
xlim([0,T])
title('Standardized Residuals')

subplot(2,2,2)
histogram(res,10)

subplot(2,2,3)
autocorr(res)

subplot(2,2,4)
parcorr(res)
```



```
h1 = lbqtest(res)
```

```
h1 = logical
      1
```

```
h2 = lbqtest(res.^2)
```

```
h2 = logical
      0
```

```
h3 = archtest(res)
```

```
h3 = logical
      0
```

```
Mdl = garch('Offset',NaN,'GARCHLags',1,'ARCLags',1);
[EstMdl,~,logL] = estimate(Mdl,r);
```

GARCH(1,1) Conditional Variance Model with Offset (Gaussian Distribution):

	Value	StandardError	TStatistic	PValue
Constant	0.01339	0.0021627	6.1913	5.9676e-10
GARCH{1}	0.94824	0.0032365	292.98	0
ARCH{1}	0.047968	0.0033917	14.143	2.0726e-45
Offset	0.044187	0.020544	2.1508	0.031492

```
Mdl2 = garch(1,1);
[EstMdl2,~,logL2] = estimate(Mdl2,r);
```

GARCH(1,1) Conditional Variance Model (Gaussian Distribution):

	Value	StandardError	TStatistic	PValue
Constant	0.012984	0.0021595	6.0126	1.826e-09
GARCH{1}	0.94878	0.0032412	292.73	0
ARCH{1}	0.047558	0.0033996	13.989	1.8134e-44

```
[h,p] = lratiotest(logL,logL2,1)
```

```
h = Logical
    1
p = 0.0364
```

```
Mdl = garch('GARCHLags',1,'ARCHLags',1,'Offset',NaN);
Mdl.Distribution = "t";
opts = optimset('fmincon');
opts.Algorithm = 'interior-point';
EstMdl = estimate(Mdl,r,'options',opts,'Display','off');
summarize(EstMdl);
```

GARCH(1,1) Conditional Variance Model with Offset (t Distribution)

```
Effective Sample Size: 3798
Number of Estimated Parameters: 5
LogLikelihood: -6754.19
AIC: 13518.4
BIC: 13549.6
```

	Value	StandardError	TStatistic	PValue
Constant	0.014499	0.0049254	2.9436	0.0032437
GARCH{1}	0.9402	0.006837	137.52	0
ARCH{1}	0.059797	0.0080027	7.4721	7.8926e-14
DoF	4.2584	0.35012	12.163	4.908e-34
Offset	0.096197	0.018906	5.0883	3.6132e-07

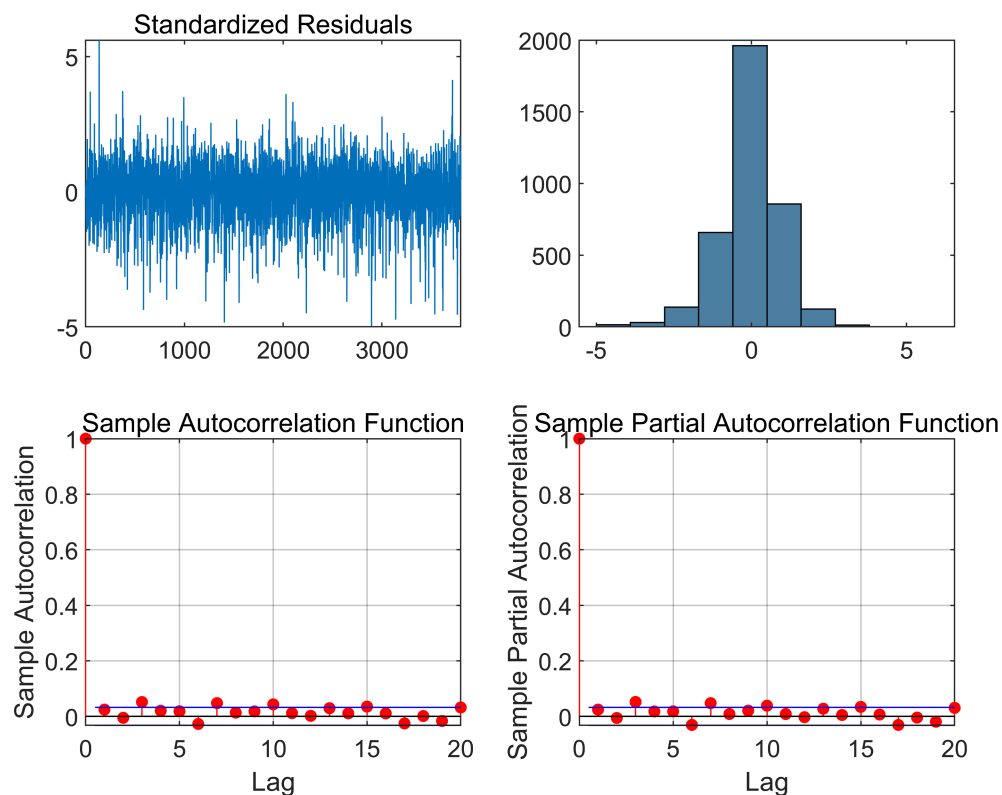
```
v = infer(EstMdl,r);
res = (r-EstMdl.Offset)./sqrt(v);
```

```
figure
subplot(2,2,1)
plot(res)
xlim([0,T])
title('Standardized Residuals')
```

```
subplot(2,2,2)
histogram(res,10)
```

```
subplot(2,2,3)
autocorr(res)
```

```
subplot(2,2,4)
parcorr(res)
```



```
% v = infer(EstMdl,r);
% res = (r-EstMdl.Offset)./sqrt(v);
%
% figure
% plot(v)
% xlim([0,T])
% title('Inferred Conditional Variances')
%
% figure
% plot(sqrt(v))
% xlim([0,T])
%
% vR = [];
% for i=1:(T/22-2)
%     vR = [vR;std(r(22*(i-1)+1:22*i))];
% end
%
% figure
% plot(vR)
% xlim([0,size(vR,1)])
```

