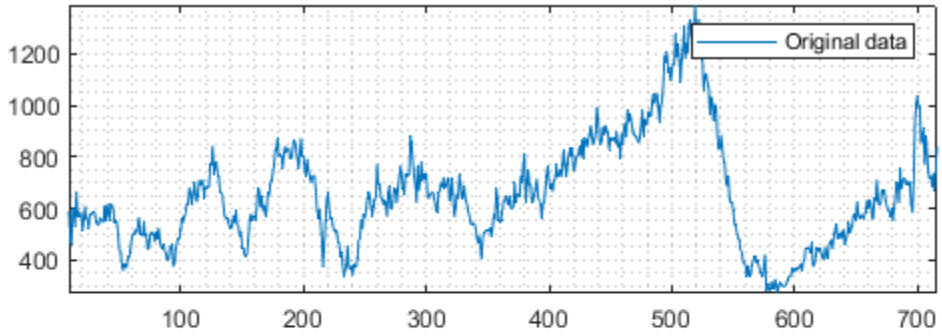
Exercise 1

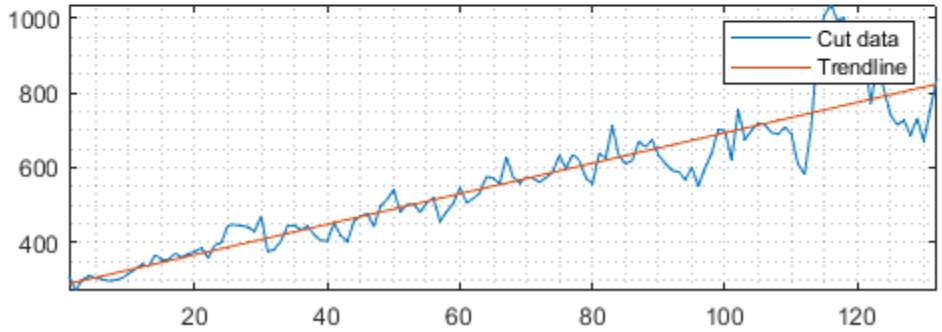
```
clearvars
close all
clc

data=readmatrix("SeriesReport-202212160449-V.xlsx");
data=data(1:end-12,2);
% Remove last year because it isn't full data

subplot(2,1,1)
plot(data),axis tight
legend("Original data")
grid minor

Data=data(end-11*12+1:end);
% We have a large drop towards the end so we cut the data from there

subplot(2,1,2)
plot(Data),axis tight,hold on

% We can see a clear upwards trend with the data also there is clear
% seasonality because it is monthly data

X=[ones(length(Data),1) [1:length(Data)]'];
Y=Data;
b=X\Y

% Now we can calculate the trendline and see the trend.

trendline=X*b;
plot(trendline)
legend("Cut data","Trendline")
grid minor

dData=Data-trendline;
% Detrend the data

p=12;

for i=1:p
    SI(i) = mean(dData(i:p:end));
end
SI
S=repmat(SI',[11 1]);
% Repeat the plot for 11 years

figure(2)
plot(dData,"b"),hold on
plot(S,"r"),axis tight
legend("Detrended data","Seasonal index"),hold off
grid minor
```

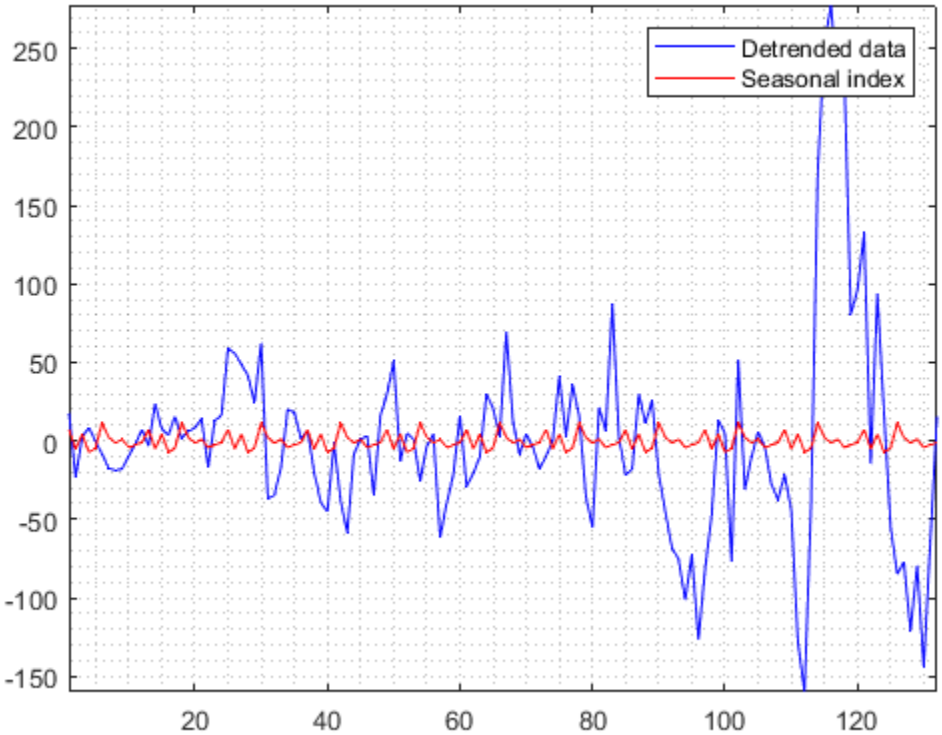
```
I=dData-S;
% Calculate the irregular part

figure(3)
subplot(2,1,1)
plot(I),axis tight
grid minor
legend("Irregular part of the data")

h=kpsstest(I)
% Test isn't good so we difference the data
Id=diff(I);

subplot(2,1,2)
plot(dData,"b"),hold on
plot(Id,"r"),axis tight,hold off,grid minor
legend("Detrended data","Differenced irregular data")

h=kpsstest(Id)
% Now the test is good

figure(4)
subplot(2,1,1)
autocorr(Id,11)
subplot(2,1,2)
parcorr(Id,11)
% Auto correlation and partial correlation shows that points are inside the
% significant levels

% Forecasting trendline

Xf=[ones(p,1),(length(Data)+1:length(Data)+p)'];
Tf=Xf*b;

Mf=Tf+SI';

figure(5)
plot(Data,"b"),hold on
plot(length(Data):length(Data)+p-1,Mf,"r")
legend("Original data","Forecast data"),hold off,grid minor

% Arma
Models=[];
% Looking at the ACF and PACF plots I would think the smallest value is
% somewhere around 10 so lets loop from 7 to 11
for i=7:11
    for j=7:11
        M=armax(Id,[i j]);
        a=aic(M);
        Models=[Models; i j a];
    end
end
m=find(Models(:,end)==min(Models(:,end)));
```

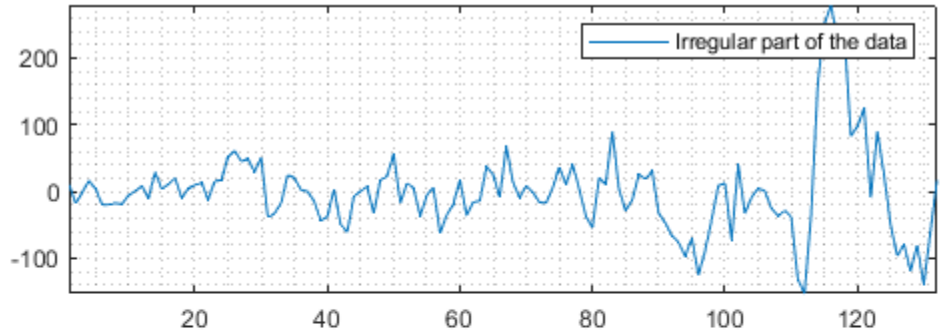
```
Models(m,:)

ar=Models(m,1);
ma=Models(m,2);

ModelFit=armax(Id,[ar ma]);

Idf=forecast(ModelFit,Id,p);

% Forecast for irregular data
figure(6)
subplot(2,1,1)
plot(Id,"b"),hold on
plot(length(Id):length(Id)+p-1,Idf,"r"),axis tight,hold off,grid minor
legend("Differenced irregular data","Forecast for the irregular data")

Xf=(length(Data)+1:length(Data)+p)';

% Forecast for whole data
If(1)=I(end)+Idf(1);
for i=2:p
    If(i)=If(i-1)+Idf(i);
end

Forecast=Tf+SI'+If';
Forecast,format shortG

subplot(2,1,2)
plot(Data,"b"),hold on
plot(length(Data):length(Data)+p-1,Forecast,"r"),grid minor
legend("Original data","Forecast")


b =

       285.14
       4.0787


SI =

  Columns 1 through 6

       7.1526      -5.1988       4.2679      -7.2654      -4.6168
11.577

  Columns 7 through 12

       2.1349      -1.3075       1.0684      -4.2831      -2.4527
-1.0768


h =
```

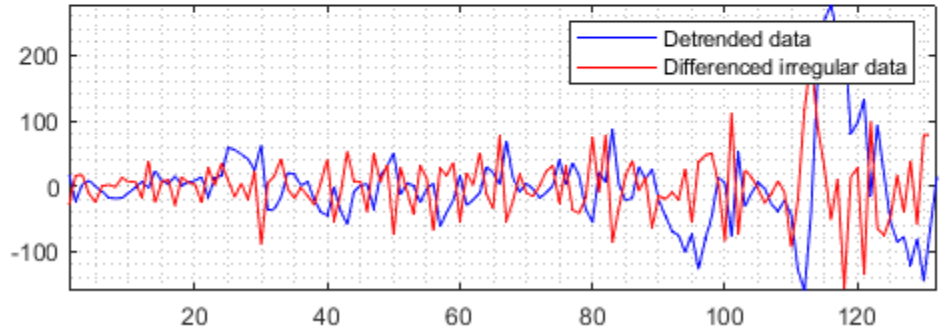
```
  logical

   1


h =

  logical

   0


ans =

          10           9      7.6081


Forecast =

       789.65
        820.5
       841.78
       798.14
       824.74
       837.19
        852.5
       863.71
       809.23
        873.7
       881.81
       833.31
```

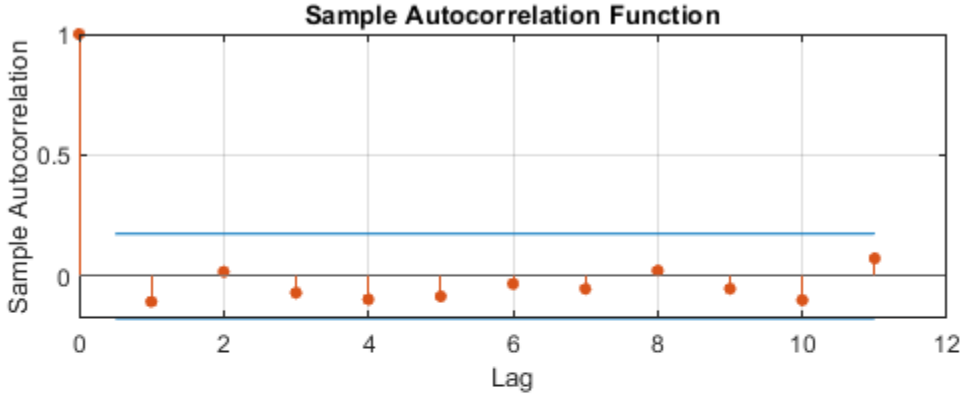

Original data
1200
1000
800
600
400
100
200
300
400
500
600
700

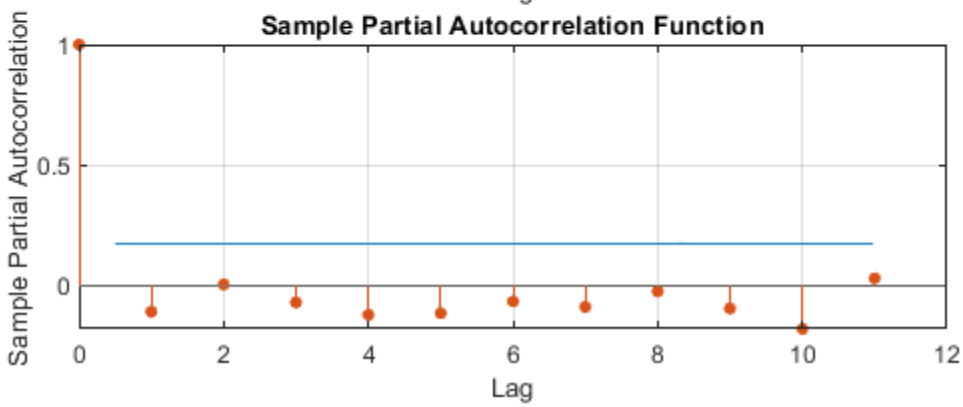

Cut data
Trendline
1000
800
600
400
20
40
60
80
100
120

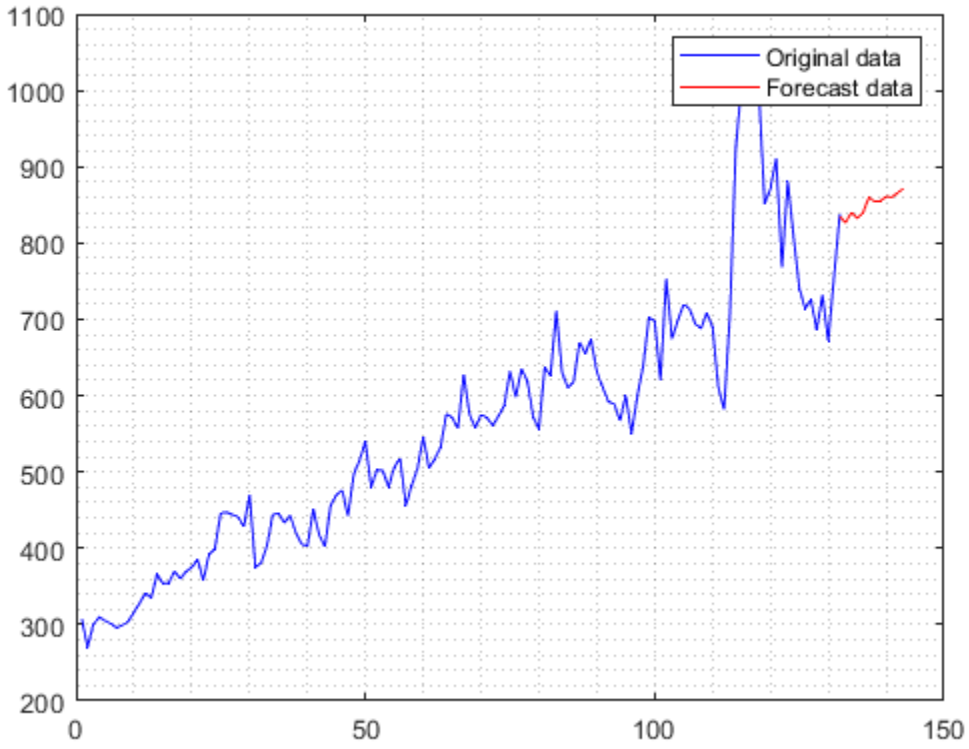

Detrended data
Seasonal index
250
200
150
100
50
0
-50
-100
-150
20
40
60
80
100
120

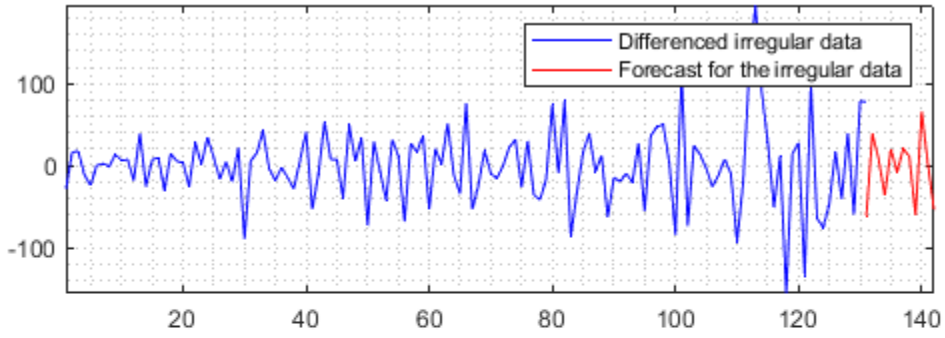

Irregular part of the data
200
100
0
-100
20
40
60
80
100
120

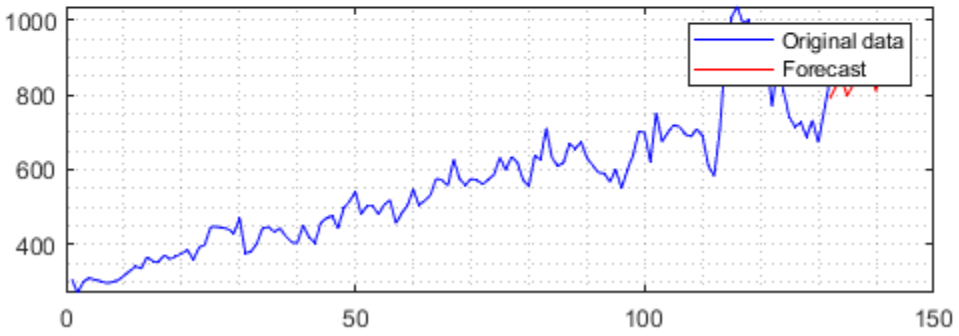

Detrended data
Differenced irregular data
200
100
0
-100
20
40
60
80
100
120


Sample Autocorrelation Function
Sample Autocorrelation
1
0.5
0
0
2
4
6
8
10
12
Lag


Sample Partial Autocorrelation Function
Sample Partial Autocorrelation
1
0.5
0
0
2
4
6
8
10
12
Lag


Original data
Forecast data
1100
1000
900
800
700
600
500
400
300
200
0
50
100
150


Differenced irregular data
Forecast for the irregular data
100
0
-100
20
40
60
80
100
120
140


Original data
Forecast
1000
800
600
400
0
50
100
150

Exercise 2

```
clearvars
close all
clc

data=readmatrix("SeriesReport-202212190329-V.xlsx");
data=data(1:end-12,2);
% Remove the first year and the last year of data because they aren't full
% So we have 81 years of data

subplot(2,1,1)
plot(data),axis tight,grid minor
legend("Original data")

Data=data(end-13*12+1:end);
% We have a large drop towards the end so we cut the data from there

subplot(2,1,2)
plot(Data),axis tight,hold on

X=[ones(length(Data),1) [1:length(Data)]'];
Y=Data;
b=X\Y
% Now we can calculate the trendline and see the trend.

trendline=X*b;
plot(trendline)
legend("Cut data","Trendline")
grid minor

dData=Data-trendline;
% Detrend the data

p=12;
for i=1:p
    SI(i) = mean(dData(i:p:end));
end
SI
S=repmat(SI',[13 1]);
% Repeat the plot for 13 years

figure(2)
plot(dData,"b"),hold on
plot(S,"r"),axis tight
legend("Detrended data","Seasonal index"),hold off,grid minor

I=dData-S;
% Calculate the irregular part

figure(3)
subplot(2,1,1)
plot(I),axis tight,grid minor
```

```
legend("Irregular part of the data")

h=kpsstest(I)
% Test isn't good so we difference the data
Id=diff(I);

subplot(2,1,2)
plot(dData,"b"),hold on
plot(Id,"r"),axis tight,hold off,grid minor
legend("Detrended data","Differenced irregular data")

h=kpsstest(Id)
% Now the test is good

figure(4)
subplot(2,1,1)
autocorr(Id,13)
subplot(2,1,2)
parcorr(Id,13)
% Auto correlation and partial correlation aren't the greatest.

% Forecasting
% Forecasting the trendline

Xf=[ones(p,1) (length(Data)+1:length(Data)+p)'];
Tf=Xf*b;

Mf=Tf+SI';

figure(5)
plot(data,"b"),hold on
plot(length(data):length(data)+p-1,Mf,"r")
legend("Original data","Forecast","Location","best"),hold off,grid minor

% Arma
Models=[];
for i=0:4
    for j=0:4
        M=armax(Id,[i j]);
        a=aic(M);
        Models=[Models; i j a];
    end
end
m=find(Models(:,end)==min(Models(:,end)));
Models(m,:)

ar=Models(m,1);
ma=Models(m,2);

ModelFit=armax(Id,[ar ma]);

Idf=forecast(ModelFit,Id,p);

% Forecast for irregular data
```

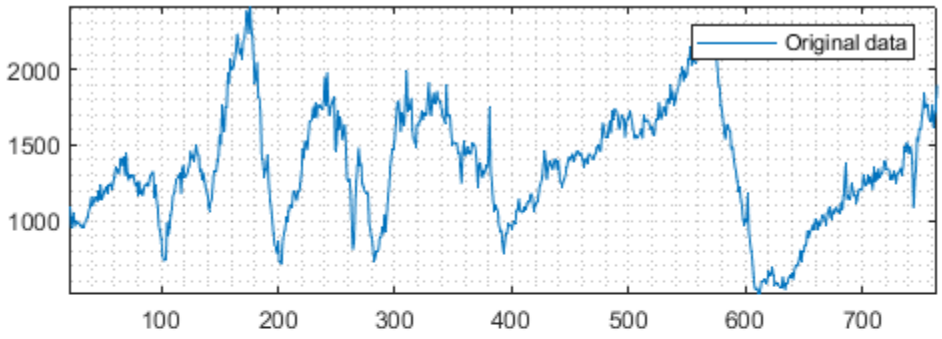
```
figure(6)
subplot(2,1,1)
plot(Id,"b"),hold on
plot(length(Id):length(Id)+p-1,Idf,"r"),axis tight,hold off,grid minor
legend("Differenced irregular data","Forecast for the irregular data")

Xf=(length(Data)+1:length(Data)+p)';

% Forecast for whole data
If(1)=I(end)+Idf(1);
for i=2:p
    If(i)=If(i-1)+Idf(i);
end

Forecast=Tf+SI'+If';
Forecast
format shortG

subplot(2,1,2)
plot(Data,"b"),hold on
plot(length(Data):length(Data)+p-1,Forecast,"r")
legend("Original data","Forecast","Location","best")
```

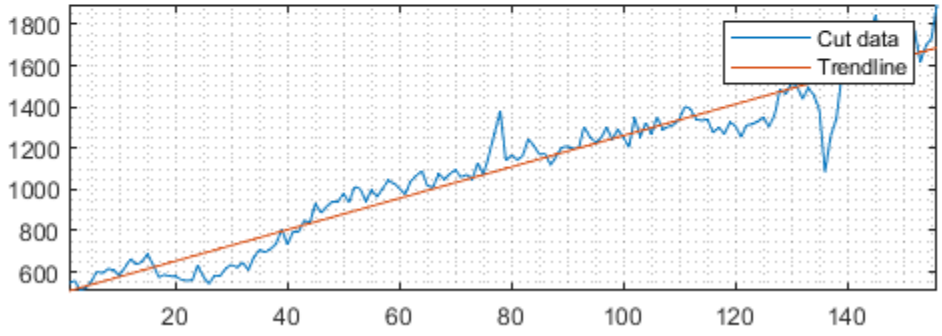
```
b =

       501.13
       7.6021


SI =

  Columns 1 through 6

       6.1451       5.6968       1.5562      -23.661      -18.571
-6.3271

  Columns 7 through 12

      -8.0062        1.007      -1.7489       5.1874       13.354
25.368


h =

  logical

   1


h =

  logical
```

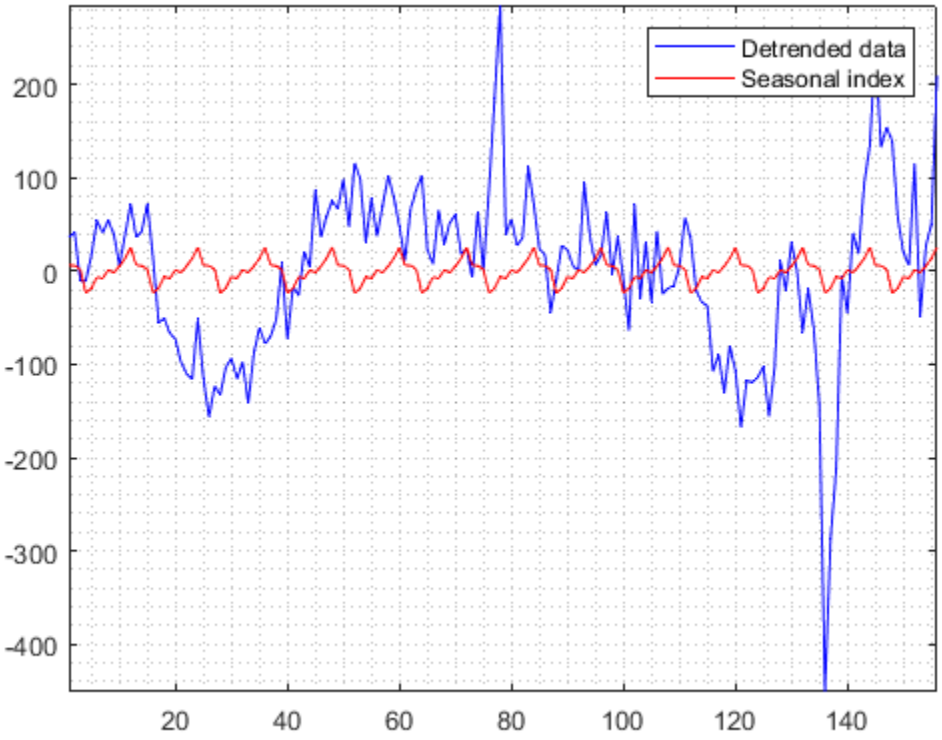
```
    0
```

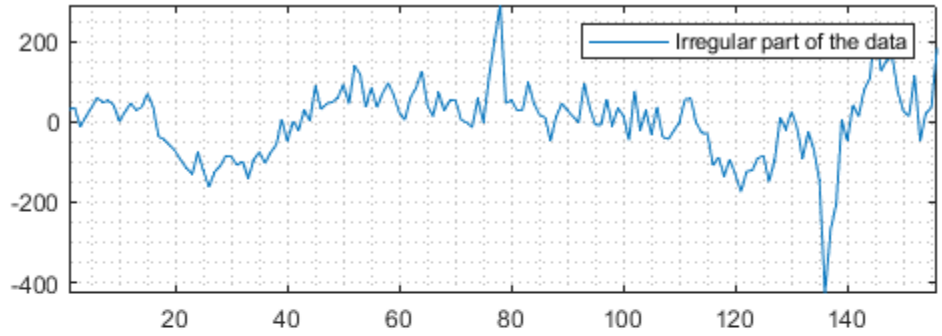
```
ans =

            3             3        8.1729
```

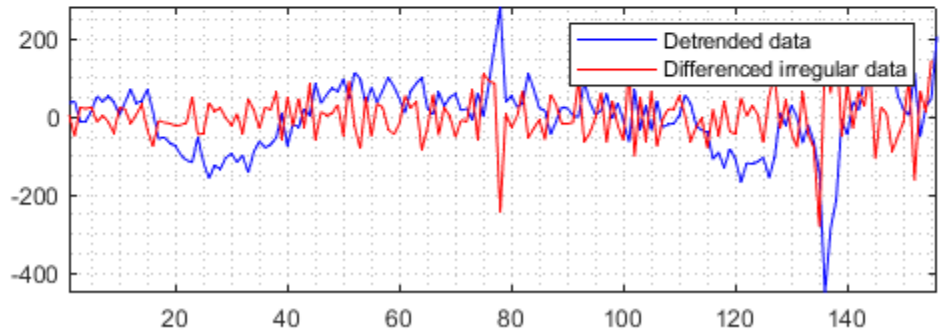
```
Forecast =

        1798.7
        1840.2
        1776.3
        1788.9
        1750.1
        1794.3
        1762.6
          1797
        1775.9
        1801.7
        1801.5
        1826.2
```

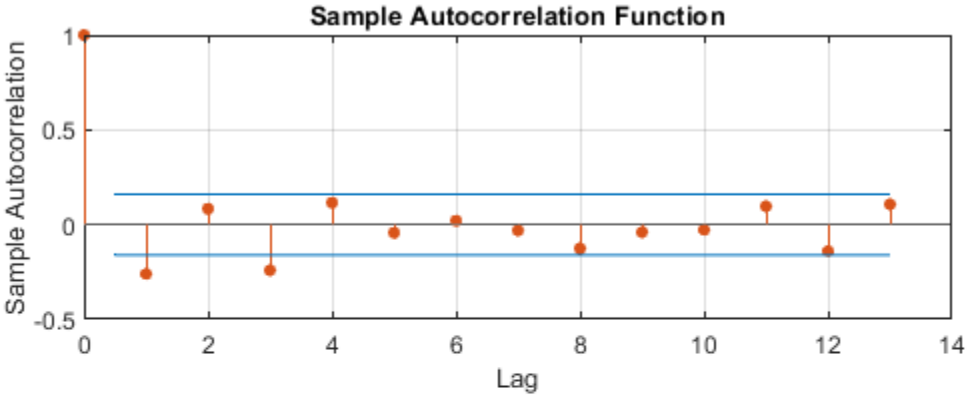


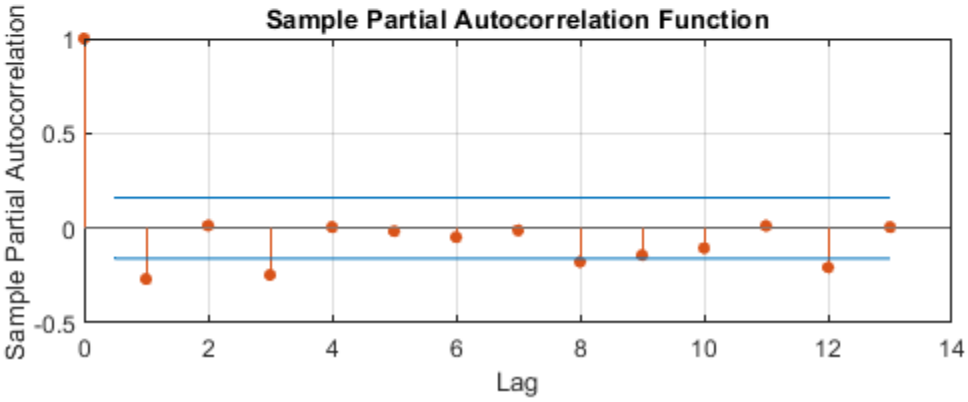


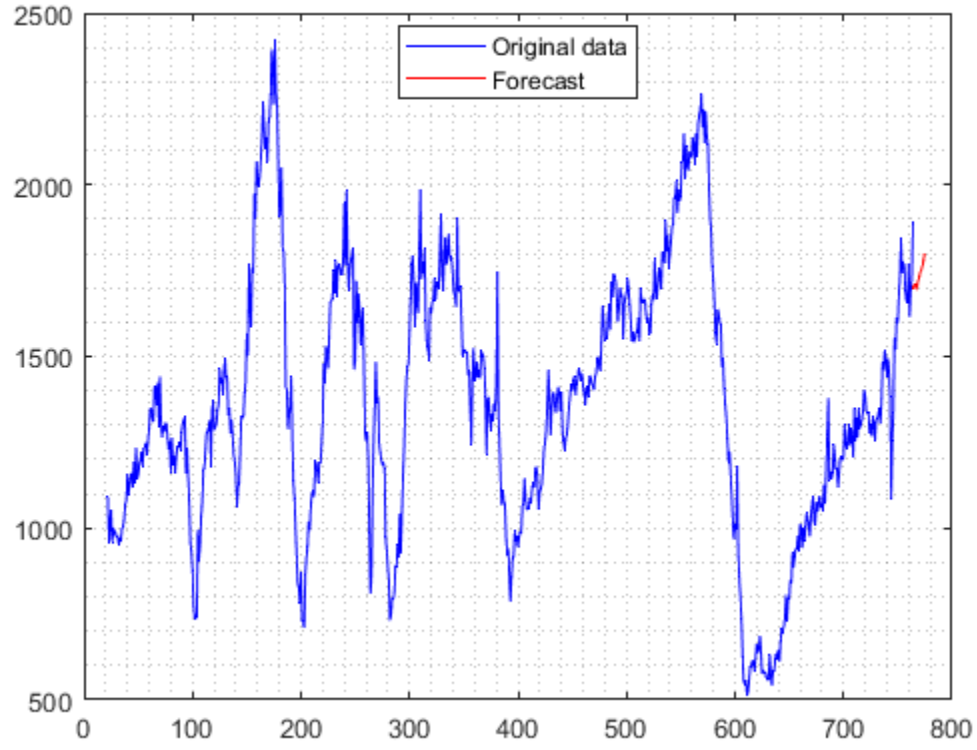

Detrended data
Seasonal index
200
100
0
-100
-200
-300
-400
20
40
60
80
100
120
140

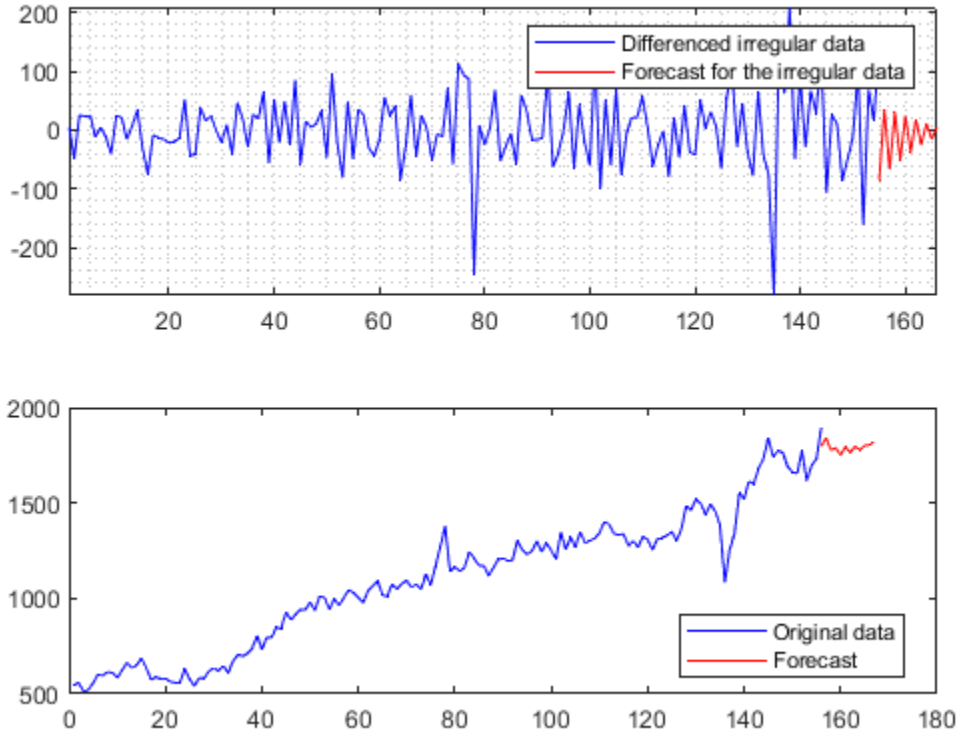

Irregular part of the data
200
0
-200
-400
20
40
60
80
100
120
140


Detrended data
Differenced irregular data
200
0
-200
-400
20
40
60
80
100
120
140


Sample Autocorrelation Function
Sample Autocorrelation
1
0.5
0
-0.5
0
2
4
6
8
10
12
14
Lag


Sample Partial Autocorrelation Function
Sample Partial Autocorrelation
1
0.5
0
-0.5
0
2
4
6
8
10
12
14
Lag


Original data
Forecast
2500
2000
1500
1000
500
0
100
200
300
400
500
600
700
800



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