```
clear; close all;
```

Get utility functions

```
[f1,f2] = utils();
```

Open data

```matlab
path = "./Data/india_data.xlsx";
% opts = detectImportOptions(path);
T = readtable(path,"ReadRowNames",true);
data = table2array(T)';
% Finding the first NAN value and taking data upto the instance before it
cut_off = length(data(:,1));
for i = 1:length(data(:,1))
    if (sum(isnan(data(i,:))))
        cut_off = i-1;
        break;
    end
end
time = data(1:cut_off,1);
Data = data(1:cut_off,2:end);
```

Visualisation

```matlab
n = length(time);
m = length(Data(1,:));
subplot(2,1,1);
plot(time,Data(:,1));
title('CO2 emissions');
ylabel('CO2 emissions in idk'); xlabel('Year');
subplot(2,1,2);
plot(time,Data(:,2));
title('GDP');
ylabel('GDP in idk'); xlabel('Year');
```
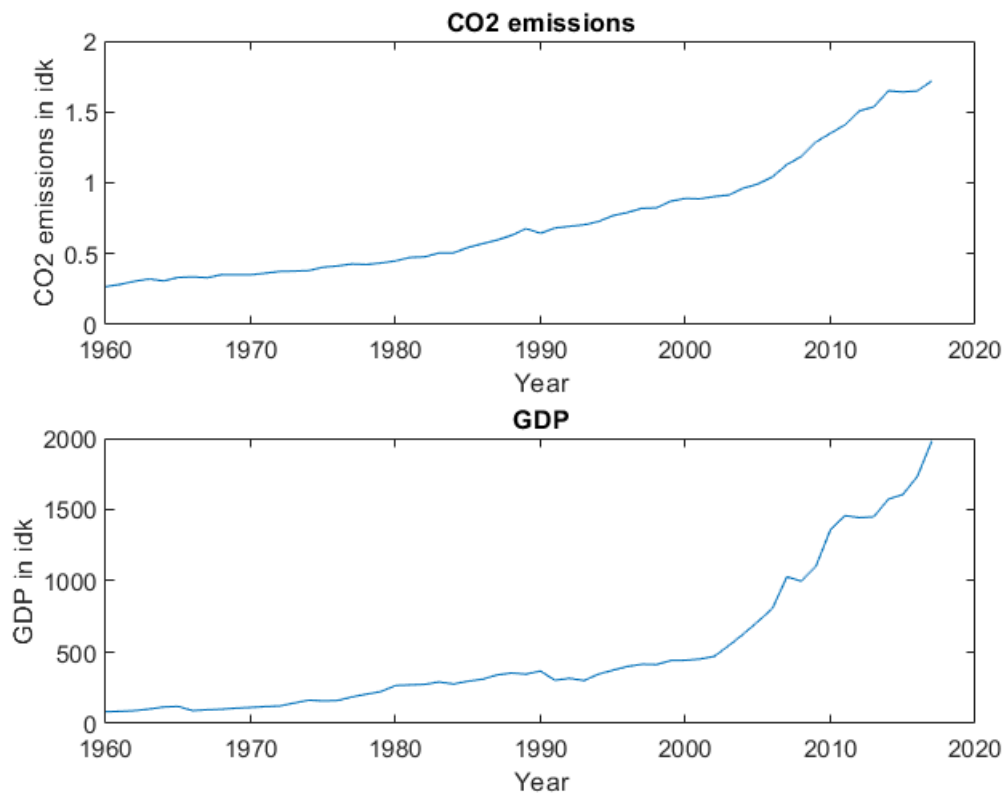
From the plot we see non stationarity of trend type (not random walk) as would be expected.

Test for integrating effects

```
results = zeros(m,2);
for i = 1:m
    [results(i,1), results(i,2)] = adftest((Data(:,i)));
end
```

Unit root test not rejected for both GDP and CO2 => has integrating effects

```
CO2 = (Data(:,1));
diff_CO2 = diff(CO2);
[hCO2,pCO2] = adftest(diff_CO2);
diff_GDP = diff(Data(:,2));
[hGDP,pGDP] = adftest(diff_GDP);
figure;
subplot(211);plot(time(2:end),diff_CO2);title("Differenced CO2");xlabel("Time");
subplot(212);plot(time(2:end),diff_GDP);title("Differenced GDP");xlabel("Time");
```

Differenced CO2 / Differenced GDP
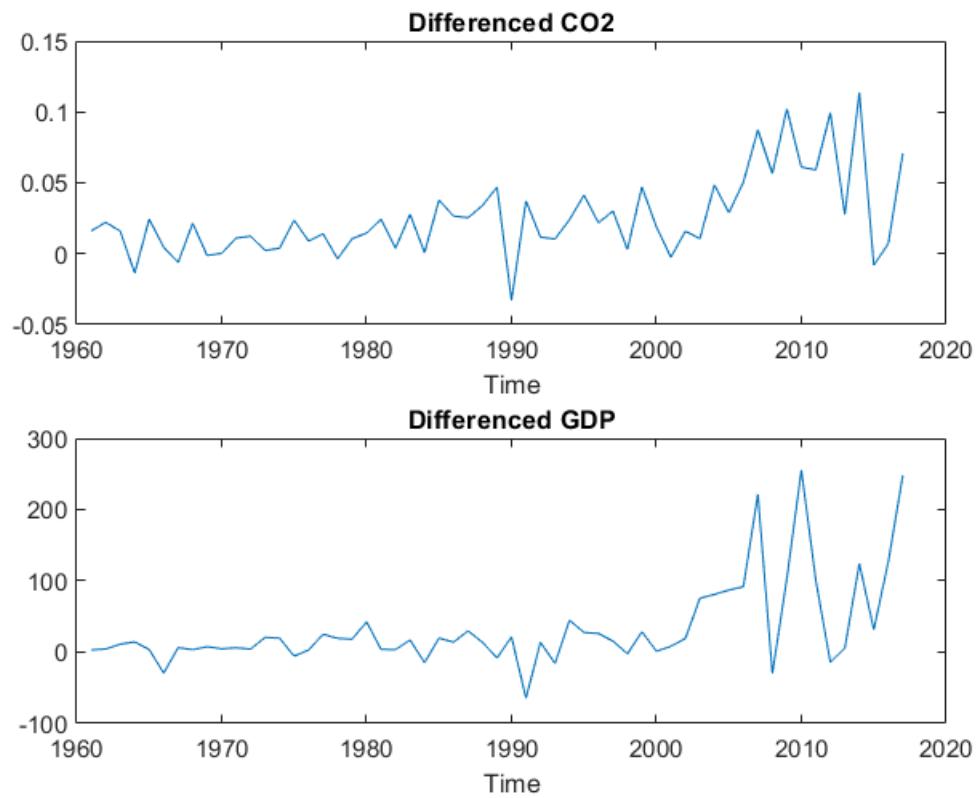
Null hypothesis rejected, the differenced series does not have any integrating effects!

ARIMA model for CO2

```
figure;
subplot(211); autocorr(diff_CO2); title('ACF diff_CO2');
subplot(212); parcorr(diff_CO2,"NumLags",30); title('PACF diff_CO2');
```

ACF diff$_c$O2

PACF diff$_c$O2
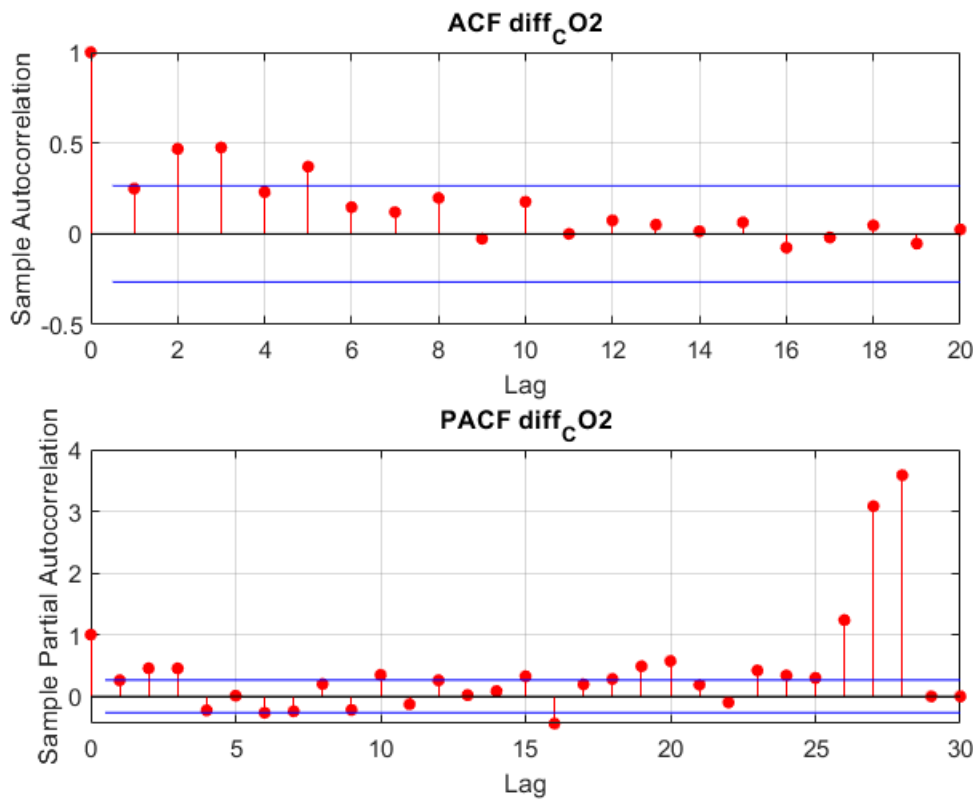
```
[est_m1,res,uf,of] = f1([1,1,1],1,CO2,0);
```

ARIMA(1,1,1) Model (Gaussian Distribution):

	Value	StandardError	TStatistic	PValue
Constant	0.0012076	0.0018292	0.66015	0.50915
AR{1}	0.98093	0.062976	15.576	1.057e-54
MA{1}	-0.83351	0.13358	-6.2396	4.3879e-10
Variance	0.00059875	8.779e-05	6.8202	9.0912e-12

Whiteness Test for Residuals results
  0

  0.5008

Residuals are white! so no underfitting. All coefficients except constant term are significant.

```
[est_m2,res2,uf2,of2] = f1([1,1,1],0,CO2,0);
```

Warning: Upper bound constraints are active; standard errors may be inaccurate.

ARIMA(1,1,1) Model (Gaussian Distribution):

	Value	StandardError	TStatistic	PValue
Constant	0	0	NaN	NaN
AR{1}	1	0.031197	32.054	1.9014e-225
MA{1}	-0.80292	0.10952	-7.3311	2.2829e-13
Variance	0.00061695	9.0215e-05	6.8386	7.9943e-12

4

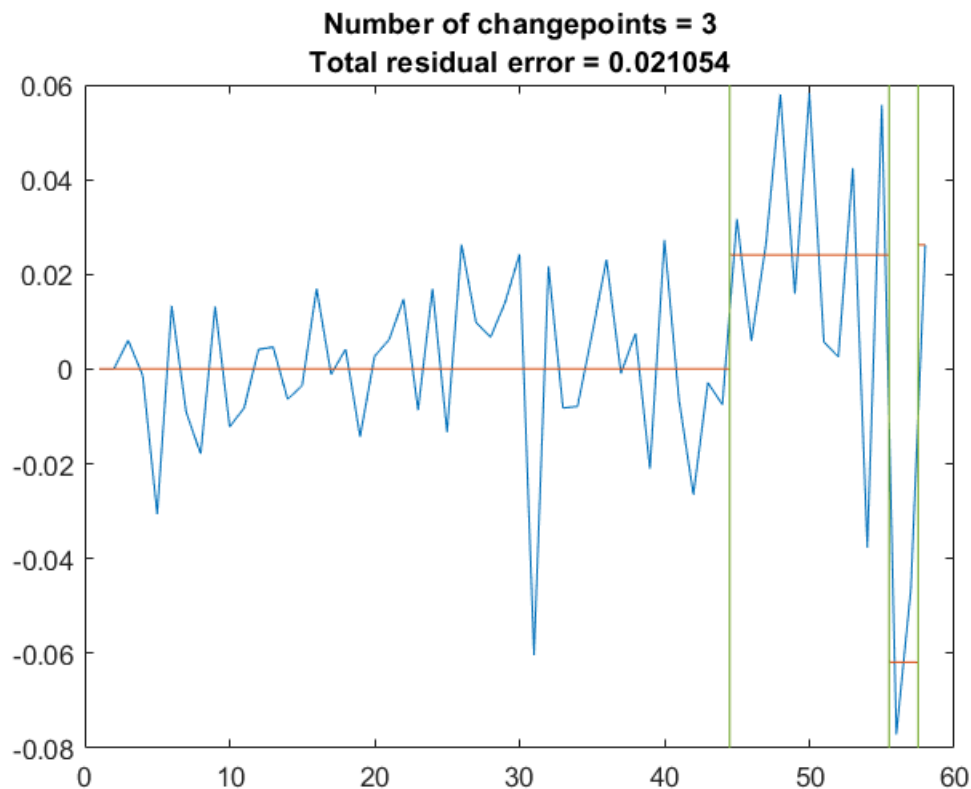```
Whiteness Test for Residuals results
    0

    0.4353
```

Neither underfit nor overfit!

## CO2 Change points

We find approximately where the mean changes using findchangepts and also observe visually to detect variance/mean changes

```
figure;findchangepts(res2,'MaxNumChanges',3);
```


Number of changepoints = 3
Total residual error = 0.021054

```
ipt = findchangepts(res2,'MaxNumChanges',3);
fspec = 'Variance before the first change point = %f \n Variance in the second region %f';
fprintf(fspec,var(res2(1:ipt(1))),var(res2(ipt(1):ipt(2))));
```

```
Variance before the first change point = 0.000292
 Variance in the second region 0.001647
```

```
% third region variance ignored because the region is too small
all_pts = [ipt; 31];
% 31 included because it has a huge dip
% Noting down the years
cpts_year = time(all_pts);
```

Visualise Gini coeff