Lecture 24

Using the Augmented Dickey-Fuller Test to Determine Whether to Difference Data or Not

There are three separate cases of interest to us:

Case 1

Slow-turning around zero value \( (H_0) \) versus Fast-turning around zero value \( (H_1) \)

\[ X_t \] Slow turning

\[ X_t \] fast turning

Difference Data: I(1) \( (H_0) \)

Don't Difference Data: I(0) \( (H_1) \)
Case 2

Slow-turning Around Non-Zero Value (H₀) versus Fast-turning Around Non-Zero Value (H₁)

\[ X_t \] slow-turning

\[ X_t \] Fast-turning

Difference Data: I(1) (H₀)

Don’t Difference Data: I(0) (H₁)

Case 3

Slow-turning Around Trend (H₀) versus Fast-turning Around Trend (H₁)

\[ X_t \] slow-turning around trend

\[ X_t \] quickly turning around trend

Difference Data: I(1) (H₀)

Trend stationary Data: Detrend it (H₁)
These various cases are demonstrated in class using the data generated by the SAS program Learn Unit Root, sas and the unit root test software available in EViews. Also see the EViews program fertil13.wfl for unit root tests on the data there. The ADF tests for the GFR and PE variables in fertil13.wfl are reproduced below.

For the test equations for the ADF tests of the various cases see my Word file “Time Series Regression Notes” posted on the web.
Augmented Dickey-Fuller Unit Root Test on GFR

Null Hypothesis: GFR has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 4 (Automatic based on SIC, MAXLAG=11)

<table>
<thead>
<tr>
<th>t-Statistic</th>
<th>Prob.*</th>
</tr>
</thead>
<tbody>
<tr>
<td>-1.882944</td>
<td>0.0523</td>
</tr>
</tbody>
</table>

Test critical values:
- 1% level: -4.100935
- 5% level: -3.478305
- 10% level: -3.165788


Augmented Dickey-Fuller Test Equation
Dependent Variable: D(GFR)
Method: Least Squares
Date: 11/26/04 Time: 15:08
Sample (adjusted): 672
Included observations: 67 after adjusting endpoints

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Std. Error</th>
<th>t-Statistic</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>GFR(-1)</td>
<td>-0.057197</td>
<td>0.030377</td>
<td>-1.882944</td>
<td>0.0546</td>
</tr>
<tr>
<td>D(GFR(-1))</td>
<td>0.383102</td>
<td>0.123401</td>
<td>3.042958</td>
<td>0.0046</td>
</tr>
<tr>
<td>D(GFR(-2))</td>
<td>-0.200330</td>
<td>0.130360</td>
<td>-1.535748</td>
<td>0.1286</td>
</tr>
<tr>
<td>D(GFR(-3))</td>
<td>0.224158</td>
<td>0.128581</td>
<td>1.743304</td>
<td>0.0864</td>
</tr>
<tr>
<td>D(GFR(-4))</td>
<td>0.221310</td>
<td>0.126433</td>
<td>1.764365</td>
<td>0.0828</td>
</tr>
<tr>
<td>C</td>
<td>6.602764</td>
<td>3.573233</td>
<td>1.805725</td>
<td>0.0749</td>
</tr>
<tr>
<td>@TREND(1)</td>
<td>-0.025612</td>
<td>0.030693</td>
<td>-0.812000</td>
<td>0.4154</td>
</tr>
</tbody>
</table>

R-squared 0.256517 Mean dependent var -0.029851
Adjusted R-squared 0.192168 S.D. dependent var 4.396679
S.E. of regression 3.948965 Akaike info criterion 5.683391
Sum squared resid 935.6563 Schwarz criterion 5.913732
Log likelihood -183.3936 F-statistic 3.450198
Durbin-Watson stat 2.115648 Prob(F-statistic) 0.005401

Case 3
Data is slowly turning annual downward trend

Accept H₀: Data needs to be differenced (i.e. has "unit root")
Augmented Dickey-Fuller Unit Root Test on PE

Null Hypothesis: PE has a unit root.
Exogenous: Constant
Lag Length: 1 (Automatic based on SIC, MAXLAG=11)

<table>
<thead>
<tr>
<th>Test</th>
<th>t-Statistic</th>
<th>Prob.*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Augmented Dickey-Fuller test statistic</td>
<td>-1.871395</td>
<td>0.3438</td>
</tr>
<tr>
<td>Test critical values:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1% level</td>
<td>-3.527046</td>
<td></td>
</tr>
<tr>
<td>5% level</td>
<td>-2.903566</td>
<td></td>
</tr>
<tr>
<td>10% level</td>
<td>-2.589227</td>
<td></td>
</tr>
</tbody>
</table>


Augmented Dickey-Fuller Test Equation
Dependent Variable: D(PE)
Method: Least Squares
Date: 11/28/04  Time: 15:09
Sample (adjusted): 372
Included observations: 70 after adjusting endpoints

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Std. Error</th>
<th>t-Statistic</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>PE(-1)</td>
<td>-0.059278</td>
<td>0.031578</td>
<td>-1.871395</td>
<td>0.0657</td>
</tr>
<tr>
<td>D(PE(-1))</td>
<td>0.245315</td>
<td>0.116383</td>
<td>2.142193</td>
<td>0.0358</td>
</tr>
<tr>
<td>C</td>
<td>0.519772</td>
<td>0.827148</td>
<td>1.008075</td>
<td>0.3151</td>
</tr>
</tbody>
</table>

R-squared: 0.101219  Mean dependent var: 1.198641
Adjusted R-squared: 0.074390  S.D. dependent var: 17.91103
S.E. of regression: 17.23282  Akaike info criterion: 8.657342
Sum squared resid: 19899.99   Schwarz criterion: 8.569784
Log likelihood: -297.0697    F-statistic: 3.772721
Durbin-Watson stat: 1.986803  Prob(F-statistic): 0.028016

**Case 2**

Data is slow turning around a non-zero value.

Accept \( H_0 \): Data needs to be differenced.