Seasonal Model Identification for the Ozone Data

Segment 1
Module 10

<table>
<thead>
<tr>
<th>Year</th>
<th>Time</th>
<th>Mean</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.5</td>
<td>3.0</td>
<td>3.5</td>
<td>4.0</td>
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</table>

<table>
<thead>
<tr>
<th>Lag</th>
<th>ACF</th>
<th>PACF</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>10</td>
<td>-1</td>
<td>0.5</td>
</tr>
<tr>
<td>20</td>
<td>0.5</td>
<td>1.0</td>
</tr>
<tr>
<td>30</td>
<td>0.5</td>
<td>1.0</td>
</tr>
</tbody>
</table>

Los Angeles Ozone Data Monthly Averages 1955-1972

<table>
<thead>
<tr>
<th>Year</th>
<th>Time</th>
<th>Mean</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.5</td>
<td>1</td>
<td>1.5</td>
<td>2</td>
</tr>
</tbody>
</table>

Graphical Output from Function \( \text{iden} \) for the Log Ozone Data with No Differencing

Graphical Output from Function \( \text{iden} \) for the Log Ozone Data with No Differencing
No Transformation (Model 1) Output Part 1

Data with 1 Regular Difference

Residuals vs. Fitted Values

Model: Component 1 :: ma: 1 Component 2 :: period = 12 ndiff = 1 ma: 1 on w = pphm

Graphical Output from Function

ACF

Residual ACF

Monthly Average of Hourly Readings of Ozone on Downtown Los Angeles

Seasonal Model Estimation and Forecasting for the Ozone Data

Graphical Output from Function
Some applications:
- count for permanent or temporary changes in the process
- include regression (usually dummy variables) terms to ac-
  cess the effect of promotional events on sales
- political party in power

Time Series Intervention Modeling

\[
\frac{(g)}{1} = (g)^x
\]

\[
\ldots - z^3 z^2 z - 1 z^1 z - 1 z = \eta
\]

\[
\hat{Z}(g)^x = \hat{Z} \left( \frac{c_1 B - 1}{c_1 B - 1} \right),\theta - 1
\]

\[
\hat{Z}(\theta - 1) = \hat{Z}(\theta - 1)
\]

\[
\hat{Z}(g)^x = \hat{Z} \left( \frac{c_1 B - 1}{c_1 B - 1} \right),\theta - 1
\]

\[
\hat{Z}(\theta - 1) = \hat{Z}(\theta - 1)
\]

Model:

\[
\ldots + z^{-2} \eta z^2 \eta + 1^{-1} \eta + 1 \eta = 1 \hat{Z}
\]

\[
\hat{h}(g)^x = \hat{h} \left( \frac{c_1 B - 1}{c_1 B - 1} \right),\theta - 1
\]

\[
\hat{h}(\theta - 1) = \hat{h}(\theta - 1)
\]

Module 10

Introduction to Time Series Intervention Models

Segment 4

Module 10

Time Series Intervention Modeling (model 4) Output Part 2

Ozone data will SARIMA(0,1,1)(0,1,1) Model
Changes in the ozone process

- Starting in 1966 all new cars had to have air pollution controls.

Possible input variables for intervention analysis

- Step function beginning at time $T$
  \[ S(T, t) = \begin{cases} 0 & t < T, \\ 1 & t \geq T. \end{cases} \]

- Impulse (or pulse) function at time $T$
  \[ P(T, t) = (1 - \delta) S(T, t) - S(T, t - 1) = \begin{cases} 1 & t = T, \\ 0 & t \neq T. \end{cases} \]

- Ramp function beginning at time $T$
  \[ R(T, t) = \begin{cases} t - T + 1 & t \geq T, \\ 0 & t < T. \end{cases} \]

Exponential (percent) increase or linear ramp-up:

- If $\omega_1$ is positive, we have exponential (percent) increase or linear increase.
- If $\omega_1$ is negative, we have exponential (percent) decrease or linear decrease.

The numerator $B_k$ provides a $k$-period delay in the intervention effect. With $0 \leq \delta_1 < 1$, if $\omega_1$ is positive, we have an exponential (percent) increase or linear increase effect. If $\omega_1$ is negative, we have an exponential (percent) decrease or linear decrease effect.
Look at plot of the time series realization and check times.

Fit a univariate ARIMA/SARIMA model to the data. Examine residuals, especially around the time of the external events, and their possible effect.

Unscrambled model

Dummy Variables and "Integrated" Dummy Variables

Seasonal Intervention Model for the Ozone Data

Seasonal (Preintervention Noise) Model for the Ozone

Strategy for Identifying Intervention Models
In 1960 before 1960 and between 1961 and 1966

Ozone

\[ Z_t = Z_{1955} + \theta_1 Z_{t-1} + \theta_2 Z_{t-2} + \theta_3 Z_{t-3} + \theta_4 Z_{t-4} + \theta_5 Z_{t-5} + \theta_6 Z_{t-6} + \theta_7 Z_{t-7} + \theta_8 Z_{t-8} + \theta_9 Z_{t-9} + \theta_{10} Z_{t-10} + \theta_{11} Z_{t-11} + \theta_{12} Z_{t-12} \]

All cool months after 1966
\[ Z_t = Z_t - 1 + \theta_1 Z_{t-1} + \theta_2 Z_{t-2} + \theta_3 Z_{t-3} + \theta_4 Z_{t-4} + \theta_5 Z_{t-5} + \theta_6 Z_{t-6} + \theta_7 Z_{t-7} + \theta_8 Z_{t-8} + \theta_9 Z_{t-9} + \theta_{10} Z_{t-10} + \theta_{11} Z_{t-11} + \theta_{12} Z_{t-12} \]

All warm months after 1966
\[ Z_t = Z_t - 1 + \theta_1 Z_{t-1} + \theta_2 Z_{t-2} + \theta_3 Z_{t-3} + \theta_4 Z_{t-4} + \theta_5 Z_{t-5} + \theta_6 Z_{t-6} + \theta_7 Z_{t-7} + \theta_8 Z_{t-8} + \theta_9 Z_{t-9} + \theta_{10} Z_{t-10} + \theta_{11} Z_{t-11} + \theta_{12} Z_{t-12} \]

In 1960
\[ Z_t = Z_t - 1 + \theta_1 Z_{t-1} + \theta_2 Z_{t-2} + \theta_3 Z_{t-3} + \theta_4 Z_{t-4} + \theta_5 Z_{t-5} + \theta_6 Z_{t-6} + \theta_7 Z_{t-7} + \theta_8 Z_{t-8} + \theta_9 Z_{t-9} + \theta_{10} Z_{t-10} + \theta_{11} Z_{t-11} + \theta_{12} Z_{t-12} \]

Before 1960 and between 1961 and 1966
\[ Z_t = Z_t - 1 + \theta_1 Z_{t-1} + \theta_2 Z_{t-2} + \theta_3 Z_{t-3} + \theta_4 Z_{t-4} + \theta_5 Z_{t-5} + \theta_6 Z_{t-6} + \theta_7 Z_{t-7} + \theta_8 Z_{t-8} + \theta_9 Z_{t-9} + \theta_{10} Z_{t-10} + \theta_{11} Z_{t-11} + \theta_{12} Z_{t-12} \]

Overall

Unscrambled Seasonal Intervention Models

Model: Component 1 :: ma: 1  Component 2 :: period= 12 ndiff= 1 ma: 1 on w= pphm  regr variables= ozo.xreg

No Transformation (Model 10) Part 2
Ozone SARIAMA(0,1)(0,1)2 Intervention Model

Log Transformation (Model 9) Part 2
Ozone SARIAMA(0,1)(0,1)2 Intervention Model