

# Time Series Analysis

## Lecture 4

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Mixed Autoregressive Moving Average (ARMA) Models

Autoregressive Integrated Moving Average (ARIMA) Models

Seasonal ARIMA (SARIMA) Models

# Review the Steps to Build ARIMA Time Series Models

# Recall the General Steps to Analyze a Time Series

1. Based on the interaction of theory, subject matter expertise, and practice, consider a useful class of models.
2. Collect and cleanse the data.
3. Conduct exploratory time series data analysis (ETSDA) by plotting the series, and examine the main patterns and atypical observations of the graph, after collecting and “cleaning” the data :
  - Trend
  - The fluctuation around a trend
    - Seasonal variation (or seasonality)
    - Cyclical variation (that does not appear to be seasonal variation)
  - Sharp change in behavior (i.e., structural change or jumps)
  - Outliers
4. **Examine and (statistically) test whether the series is stationary (when applying a stationary model).**

## General Steps to Analyze a Time Series (2)

5. **If the series is not stationary, transform the series to a stationary series, because the time series models covered in this course apply only to stationary or integrated times series. Common transformation techniques include trend removal (i.e., detrending), seasonality removal, logarithmic, and difference transformation.**
6. Model the transformed series with a stationary or integrated time series model.
7. Examine the validity of the model's underlying assumptions.
  - This is an important step, because if the model's underlying assumptions are not satisfied, one should not proceed to conducting statistical inference and forecasting.
8. Among the valid models, choose the one that perform “best” according to some pre-specified metrics.
9. Once a (statistically) valid model is chosen, conduct statistical inference and/or forecasting, if the underlying statistical assumptions are all satisfied.

# Modeling Procedure of ARIMA Models

When estimating an ARMA model using a time series, we will use the following general steps:

1. Plot the data, and identify the key dynamics and any unusual observations.
2. If necessary, transform the data (using a Box-Cox transformation) to stabilize the variance.
3. If the data are nonstationary: Take first differences of the data until the data are stationary.
4. Examine the ACF/PACF: Is an  $AR(p)$  or  $MA(q)$  model appropriate?
5. Try your chosen model(s), and use the AICc to search for a better model.
6. Conduct diagnostic testing and formal model assumption testing:
  - Check the residuals on the chosen model by plotting the ACF of the residuals, and doing a portmanteau test of the residuals. If they do not look like white noise, the model need to be respecified, reestimated, and retested.
7. Once the hypothesis that the residuals follow a white noise process cannot be rejected, the model can be used for forecasting.

Note: One could attempt to write an algorithm to automate steps 3–5.

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