

The background of the slide is a blurred image of a financial trading interface. On the left, there are several tables of market data with columns for stock symbols, prices, and percentages. On the right, there are candlestick charts showing price movements over time. The overall theme is financial analytics and time series data.

Introduction to Time Series

THE UNIVERSITY OF CHICAGO - MASTERS IN ANALYTICS – WEEK 4

Asynchronous Agenda

Residual diagnostics

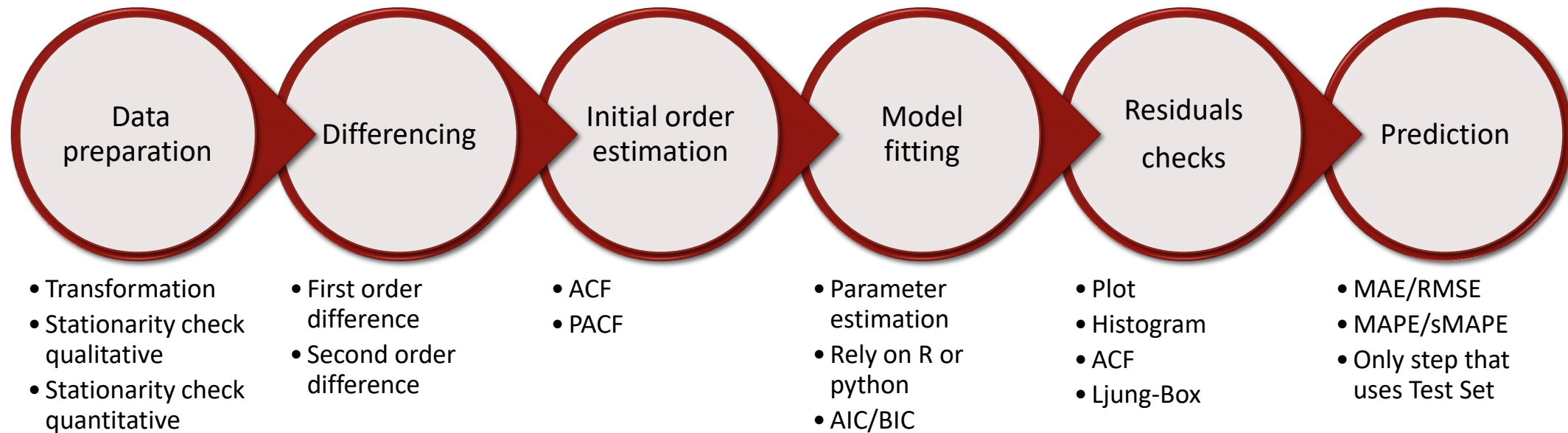
Point forecasts & intervals

Seasonal ARIMA introduction

Model diagnostics



Model identification procedure



Qualitative diagnostics

- What should residuals look like?
- Residuals plot
 - Examine mean – is it stable?
 - Variance – is it stable?
 - Outliers – how many? Is there a pattern?
- Normality
 - Histogram
- Autocorrelation
 - ACF

Quantitative diagnostics

- Autocorrelation
 - Durbin Watson
 - Box Pierce
 - Ljung Box
- Normality
 - Shapiro Wilk
 - Kolmogorov Smirnov
 - Jarque Bera
- Heteroscedasticity
 - Breusch Pagan
 - Mclead Li

Point forecasting & intervals



Point forecasts

$$(1 - \hat{\phi}_1 B - \hat{\phi}_2 B^2 - \hat{\phi}_3 B^3)(1 - B)y_t = (1 + \hat{\theta}_1 B)\varepsilon_t,$$

- Expand the ARIMA equation so that y_t is on the LHS of the equation

$$y_t = (1 + \hat{\phi}_1)y_{t-1} - (\hat{\phi}_1 - \hat{\phi}_2)y_{t-2} - (\hat{\phi}_2 - \hat{\phi}_3)y_{t-3} - \hat{\phi}_3 y_{t-4} + \varepsilon_t + \hat{\theta}_1 \varepsilon_{t-1}.$$

- Rewrite the equation by replacing t with $T+h$ (forecast horizon = 1)

$$y_{T+1} = (1 + \hat{\phi}_1)y_T - (\hat{\phi}_1 - \hat{\phi}_2)y_{T-1} - (\hat{\phi}_2 - \hat{\phi}_3)y_{T-2} - \hat{\phi}_3 y_{T-3} + \varepsilon_{T+1} + \hat{\theta}_1 \varepsilon_T.$$

- On the RHS, replace future observations with their forecasts, future errors with zero and past errors with the corresponding residuals

$$\hat{y}_{T+1|T} = (1 + \hat{\phi}_1)y_T - (\hat{\phi}_1 - \hat{\phi}_2)y_{T-1} - (\hat{\phi}_2 - \hat{\phi}_3)y_{T-2} - \hat{\phi}_3 y_{T-3} + \hat{\theta}_1 e_T.$$

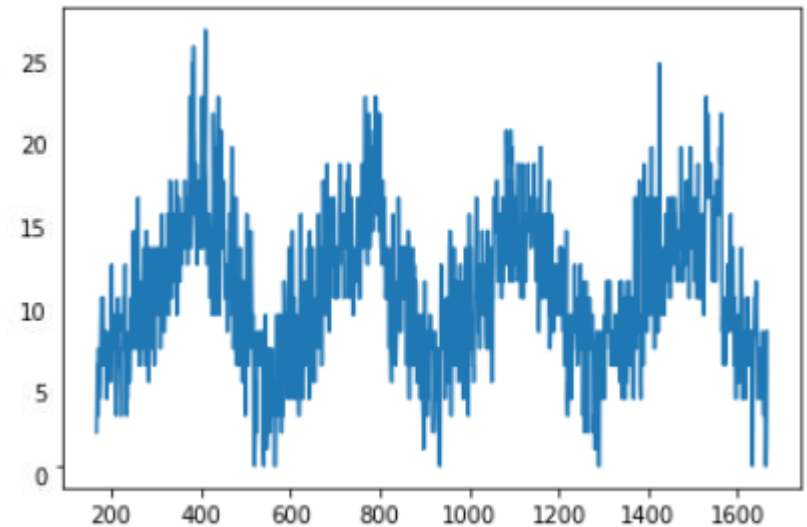
Prediction intervals

- Prediction intervals are useful in giving the user a likely band for our predictions
- The interval is given by a 95% prediction interval based on the standard deviation of the residuals
- These intervals are based on assumptions that the residuals are uncorrelated and normally distributed
 - If this is violated, then the prediction intervals may be incorrect
- Intervals widen as the forecast horizon increases

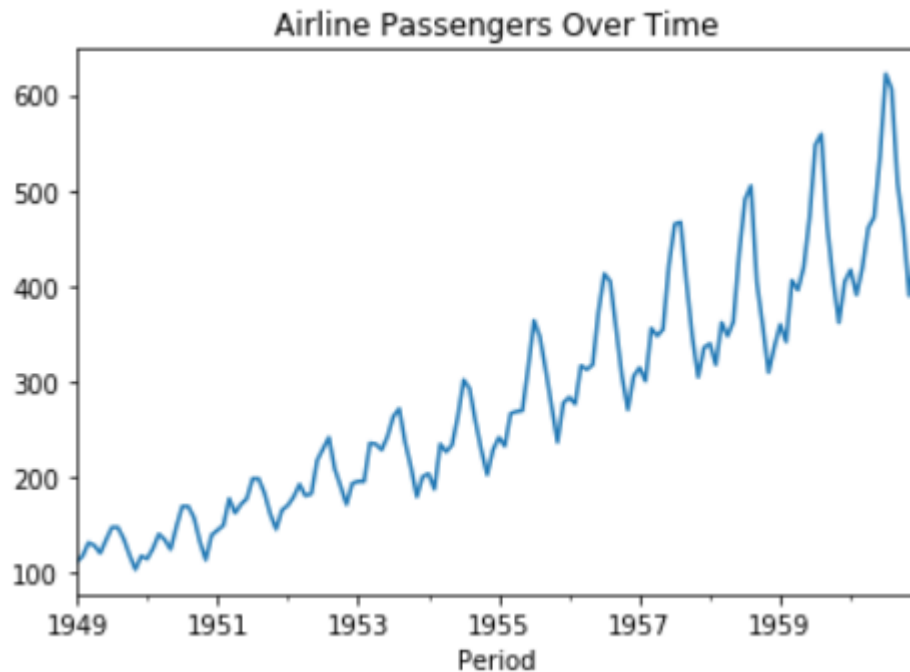
SARIMA

Seasonality

- Seasonality is a repeating pattern within a year
- Ice cream sales in a day
- What is the pattern that we see?



Seasonal Arima



$$ARIMA(p, d, q)(P, D, Q)m$$

Non-seasonal Seasonal

- Lowercase notation for non-seasonal parts
- Uppercase notation for seasonal parts
- m is the seasonal period
 - quarterly: $m = 4$
 - monthly: $m = 12$

Appendix

A thin, dark vertical line is positioned to the right of the word 'Appendix', extending from the top of the word down to the bottom of the page.