ECON 4115/5115

Chapter 5. The Forecaster’s Toolbox

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- Forecasting workflow:
  - Data preparation
  - Plot the data
  - Define the forecasting model
  - Estimate the model
  - Check the model’s in-sample performance
  - Produce forecasts

- Some simple forecasting methods:
  - Average method
  - Naïve method
  - Seasonal naïve method

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- Fitted values and residuals (in-sample):
  - Fitted values: $\hat{y}_{t|t-1}$
  - Residuals: $e_t = y_t - \hat{y}_{t|t-1}$
- Residual diagnostics
  - Two most important features: residuals should be mean zero and white noise
- Prediction intervals
  - Based on probability distributions
  - One-step and multi-step prediction intervals: $\hat{y}_{T+h|T} \pm c \cdot \hat{\sigma}_h$

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- Forecasting using transformations:
  - Box-Cox transformation can be used to make variation and/or seasonality constant.
  - Box-Cox transformation: $w_t = \begin{cases} log(y_t) \text{ if } \lambda = 0 \\ \left(y_t^{\lambda} - 1\right)/\lambda \text{ otherwise} \end{cases}$
  - Reverse Box-Cox transformation: $y_t = \begin{cases} exp(w_t) \text{ if } \lambda = 0 \\ (\lambda w_t + 1)^{1/\lambda} \text{ otherwise} \end{cases}$
  - The *fable* package will automatically produce confidence intervals.
  - The back-transformed forecast confidence interval may be asymmetric.

- Forecasting using decompositions
  - The *decomposition_model*() function can be a useful forecasting tool.
  - The seasonal, trend and remainder components can be forecasted separately.
  - The forecasts are then added (or multiplied) together to produce the final forecast.

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- Evaluating forecasting accuracy
  - The size of the residuals are not always a great indicator of forecasting accuracy.
  - Over-fitting can reduce in-sample residuals, but won't always improve forecasting.
  - It's better to check the out-of-sample forecasting accuracy.
  - Textbook terminology:
    - "training" data = "in-sample" data
    - "test" data = "out-of-sample" data
  - The *filter*() and *slice*() functions can help split the sample.
  - Residuals vs. Forecast Errors
    - Residuals: $e_t = y_t - \hat{y}_{t|t-1}$
    - Forecast errors: $e_{T+h} = y_{T+h} - \hat{y}_{T+h|T}$

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- Scale-dependent accuracy measures:
  - Mean absolute error (MAE): $\text{mean}(|e_t|)$
  - Root mean squared error (RMSE): $\sqrt{\text{mean}(e_t^2)}$
- Scale-independent accuracy measures:
  - Mean absolute percentage error (MAPE): $\text{mean}(|100e_t/y_t|)$
  - Symmetric MAPE (sMAPE)
  - Mean absolute scaled errors (MASE), where

$$\text{MASE} = \text{mean}(|q_j|), q_j = \frac{e_j}{\frac{1}{T-m}\sum_{t=m+1}^{T}|y_t - y_{t-m}|}$$

- The *accuracy*() function will calculate the RMSE, MAE, MAPE & MASE.