CSSS/POLS 512 - Time Series and Panel Data Methods

Lab 3: Modeling Stationary Time Series

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Preview

- Estimating and interpreting ARMA models.
- Model selection
  - In-sample fit
  - Out-of-sample fit via CV
- Prediction and Visualization
Maximum Likelihood Estimation

1. Express the joint probability of the data using the chosen probability distribution (i.e. the likelihood of data given parameters)

2. Take a logarithm and transform the product of probabilities to the sum of log-probabilities (because $\sum$ is easier for optimization than $\prod$)

3. Substitute the linear predictor $\mu = X\beta$ (sometimes we call it “systematic component”)
MLE-ARMA

\[ \mathcal{L}(\beta, \phi_1 | y, X) = -\frac{1}{2} \log \left( \frac{\sigma^2}{1 - \phi_1^2} \right) - \frac{\left( y_1 - \frac{x_1 \beta}{1 - \phi_1} \right)^2}{2 \sigma^2} \]

\[ - \frac{T - 1}{2} \log \sigma^2 - \sum_{T=2}^{T} \frac{(y_t - x_t \beta - \phi_1 y_{t-1})^2}{2 \sigma^2} \]
Model selection

- In-sample fit: AIC, MSE, RMSE, and MAE.
- Cross-validation:
  - Expanding Window CV
  - Rolling Window CV.
Cross-validation

Figure 1: Hold Out Cross-Validation
Cross-validation

Figure 2: $K$-fold Cross-Validation
Expanding Window

Expanding Window Scheme

Periods

Iterations

Dropped

Train

Test

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Rolling/sliding Window Scheme

Periods
Iterations
Dropped
Train
Test

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Model selection

- We will look on how to program a function for time-series CV.
  - We will use arimaCV() from Chris’s code.

- We will estimate several models and choose the best fitted.
  - We will compare least squares with MLE-arima.

- Finally, we will do prediction and visualization.
Model selection: time-series CV

Cross-validation of accident deaths models

Mean Absolute Error

Periods Forward

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Model selection: time-series CV

Predicted effect of reversing seat belt law

Time
Deaths
1000 1500 2000 2500 3000
Let’s get started!

Please, open the file Lab3.Rmd.