Master in Applied Econometrics and Forecasting (1st year/1st semester)

TIME SERIES ANALYSIS AND FORECASTING

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Aims and Goals

This course is offered to students with a background in statistical theory. It should be useful for graduate students in economics, business, finance, management, statistics and econometrics. The course is concerned with the building of statistical models for time series analysis and forecasting and their use in important areas of application such as Economics, Business and Finance. It will introduce case studies to be analyzed with Python and EViews. At the end of the course, students should be able to understand time series decomposition methods, exponential smoothing methods, Box-Jenkins ARMA models and their extensions, and time series forecasting.

Required Textbook

Mills, Terence (2019). *Applied Time Series Analysis: A Practical Guide to Modeling and Forecasting*, Academic Press, Elsevier, London.

Class Assignments and Topics

Class/Week 1: Introduction to Time Series and Their Empirical Features. Chapter 1 (p. 1-12)

Class/Week 2: Time Series Decomposition and Transformations. Chapter 2 (p. 13-30)

Class/Week 3: Stationarity, Autocorrelation and Partial Autocorrelation. Chapter 3 (p. 31-34)

Class/Week 4: White Noise and Autoregressive (AR) Models. Chapter 3 (p. 35-43)

Class/Week 5: Moving Average (MA) and ARMA Models. Chapter 3 (p. 36-43)

Class/Week 6: ARMA Model: Identification, Estimation, Testing and Selection. Chapter 3 (p. 43-56)

Class/Week 7: ARIMA Models for Nonstationary Time Series. Chapter 4 (p. 57-69)

Class/Week 8: Unit Root, Trend and Difference Stationary Models. Chapter 5 (p. 71-83)

Class/Week 9: Forecasting. Chapter 7 (p. 121-130)

Class/Week 10: Seasonal ARMA and ARIMA Models. Chapter 9 (p. 153-160)

Class/Week 11: Exponential Smoothing. Chapter 9 (p. 153-160)

Class/Week 12: Topics for Further Research

Supplementary Textbooks

Box, G. Jenkins, G., Reinsel, G., and Ljung. G. (2015). *Time Series Analysis: Forecasting and Control,* 5th Edition, Wiley.

Brockwell, P. and Davis, R. (2016): *Introduction to Time Series and Forecasting,* 3rd edition, Springer

Hyndman, R. e Athanasopoulos, G. (2021): *Forecasting: Principles and Practice*, 3rd edition, OTexts.com.

William W. Wei (2005). *Time Series Analysis: Univariate and Multivariate Methods*, 2nd edition, Addison-Wesley.

Assessment

The assessment of Time Series Analysis and Forecasting is based on the following components:

- **Regular assessment period:** Test (20%), Group Project (40%) and Final Exam (40%)
- **Repeated assessment period:** Appeal Exam (100%)

The **Test** is a multiple-choice question test (30 minutes). The **Final Exam** and **Appeal Exam** are written exams scheduled for two hours. The **Group Project** should be sent by e-mail to the instructor and to the assigned discussion group. A printed copy should be handed in before or at the actual group presentation.

The report (in PPT format) should have a maximum of 15 slides (ideally 10 slides), including cover, tables, figures, and table of contents. Students have exactly 20 minutes for the presentation, and we will reserve approximately 10 minutes for the discussion.

The **Group Project** will be graded both by the paper content, its final written form, and the oral presentation and discussion.

During the presentation of the **Group Project**, students must justify each step of their operations and analysis and explain the choices they made at each step and the reasons for choosing the models they have chosen. In case presenters' performances at the presentation are very uneven, different grades can be assigned to the different members of the same group. The depth and content of discussant's questions to the presenting group and subsequent discussion will also be taken into consideration for each group grade.

The objectives and focus of the case study (Group Project) are as follows:

- Choose a topic for an empirical research study in ARMA modeling and forecasting of univariate time series;
- Find sources of literature and data;
- Employ ARIMA/SARIMA methodology for modeling and forecasting the time series under study. Use the flowing steps:
    1. Plot the data. Identify any unusual observations. Understand patterns.
    2. Data transformation. If necessary, use Box-Cox transformation to stabilize the variance. If necessary, take (seasonal and non-seasonal) differences of the data until the data are stationary.
    3. Examine the ACF/PACF of the differenced data and try to determine possible candidate ARIMA/SARIMA models.
    4. Perform diagnostic checking. Plot the ACF/PACF of the residuals and do a portmanteau test (Ljung-Box test). If they do not look like "white noise", try a modified model(s).
    5. Model selection criteria. Use criteria for model selection (AIC, SBC, HQ) to search for the "best" fitted model.
    6. Forecasting. If the main purpose of a model is to forecast future values, then alternative criteria for model selection (RMSE, MAE, MAPE) can be based on forecast errors. Use the "best" forecast model to produce forecasts of the series and the associated confidence intervals of forecasts.
- Employ also exponential smoothing methods (single, Holt, Holt-Winters) and compare their forecast accuracy with ARMA/SARIMA models.
- Discuss the results and give contributions to the problem under study.

Key dates and deadlines

First class: 14-09-2022

Group Project Final Constitution: 12-10-2022

Test: 26-10-2022

Last class: 07-12-2022

Project Submission: 06-01-2023

Project Discussion: 11-01-2023

Final Exam: 11-01-2023

Appeal Exam: 1-02-2023

Software and Data Resources

Install Python with Anaconda: https://www.anaconda.com/products/individual

Some useful datasets:

https://finance.yahoo.com/commodities (Yahoo Finance)

https://datamarket.com/data/list/?q=provider:tsdl (800 time series)

https://www.msci.com/world (MSCI)

https://www.bls.gov/ (Bureau of Labour Statistics in US)

https://www.stlouisfed.org/ (Federal Reserve Bank of St. Louis)

https://www.imf.org/en/Data (IMF)

https://vincentarelbundock.github.io/Rdatasets/datasets.html (1300 datasets)

Instructor

Jorge Caiado holds a Ph.D. in Applied Mathematics for Economics and Management. He is a Professor of Data Science and Time Series Econometrics at ISEG Lisbon School of Economics and Management (University of Lisbon) and a Researcher at the Centre for Applied Mathematics and Economics. He was a visiting researcher in the Department of Statistics at University Carlos III in Madrid (Madrid, Spain) and Invited Professor at NOVA Information Management School (Lisbon, Portugal). His research in data science has led to numerous publications in scientific journals, book chapters and books. He serves as an econometric and statistical consultant and trainer for numerous companies and organizations including central banks, commercial and investment banks, bureau of statistics, transportation and logistics companies, health companies and insurance companies. He is co-founder of GlobalSolver – a deep tech company that works with AI, Machine Learning & Big Data. First Prize SICO 2007, Spanish IEEE Computational Intelligence Society. Co-inventor of the US Patent Nº US11334930B2 “Digital Method for Purchase Centralisation, Optimisation and Negotiation”.

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