FORECASTING FOR TIME SERIES

Dual Degree in Business Administration & Data and Business Analytics BBADBA SEP-2024 FTS-NBDA.3.M.A

Area Applied Mathematics

Number of sessions: 15

Academic year: 24-25

Degree course: THIRD

Number of credits: 3.0

Semester: 2º

Category: COMPULSORY

Language: English

Professor: **JUAN GARBAYO DE PABLO**

E-mail: jgarbayo@faculty.ie.edu

Juan Garbayo de Pablo is a MSc Aerospace Engineer (Universidad Politécnica de Madrid / RWTH Aachen) with a specialization in spacecraft design and graduate of Airbus' Master in Aircraft Systems (Universidad Carlos III de Madrid).

Juan's career has been focused on engineering systems of multiple industries: railroad (Deutsche Bahn AG), Aircaft (Airbus SE) and Intralogistics (Jungheinrich AG). He is currently working as a Data Scientist at Jungheinrich AG, helping transform the business model leveraging the potential of IoT to bring added value to the company and its clients.

Office Hours

Office hours will be on request. Please contact at:

jgarbayo@faculty.ie.edu

You need to **have studied in detail prior to the tutorial**.

SUBJECT DESCRIPTION

The analysis of data that have been observed at different points in time leads to new and unique problems in statistical modelling and inference. The obvious correlation introduced by the sampling of adjacent points in time can severely restrict the applicability of the many conventional statistical methods, traditionally dependent upon the assumption that these adjacent observations are independent and identically distributed (Shumway and Stoffer, 2017). Specific methods and techniques are therefore necessary to handle time series data.

The first part of the subject deals with the analysis of time series to explore the data, decompose the series, compute statistics, analyze the importance of autocorrelation, judge its stationarity... All these concepts are paramount for the second part of the course: time series forecasting, where the focus will be on building models to predict future values of a time series based on the data collected to the present.

Time series analysis and forecasting are intrinsic to econometrics, finance, business, supply chain management, climate and weather forecasting, predictive maintenance and so many more disciplines. Examples of time series data include the continuous monitoring of a person's heart rate, hourly readings of air temperature, daily closing price of a company stock, monthly rainfall data, yearly sales figures...

PREREQUISITES FOR TAKING THIS SUBJECT:

- Fundamentals of Probability and Statistics.
- Fundamentals of Data Analysis.
- Programming and Data Visualization in R.
- Time Series Analysis (time series subject from previous semester).

LEARNING OBJECTIVES

This course builds upon the course *TIme Series Analysis* from the previous semester and delves into forecasting using some of the most classic me

- Produce forecasts with Exponential Smoothing, Arima Models, Regression models and ML Algorithms such as XGBoost.
- Properly evaluate and select among such models.
- Produce aggregated forecasts with hierarchical data and deal with complex seasonality.
- Analyze complex seasonality with harmonic regression
- Analyze bi-directional relationships with Vector Autoregression
- Use of information criteria to refine time-series specific regressors.

TEACHING METHODOLOGY

IE University teaching method is defined by its collaborative, active, and applied nature. Students actively participate in the whole process to build their knowledge and sharpen their skills. Professor's main role is to lead and guide students to achieve the learning objectives of the course. This is done by engaging in a diverse range of teaching techniques and different types of learning activities such as the following:

Learning Activity	**Weighting**	**Estimated time a student should dedicate to prepare for and participate in**
Lectures	40.0 %	30.0 hours
Discussions	6.7 %	5.0 hours
Exercises in class, Asynchronous sessions, Field Work	13.3 %	10.0 hours
Group work	13.3 %	10.0 hours
Individual studying	26.7 %	20.0 hours
TOTAL	100.0 %	75.0 hours

AI POLICY

Restricted use of GenAI

In today's world, generative artificial intelligence (GenAI) is changing how we work, study and, in general, how we get things done. However, in the context of this course, the use of GenAI to carry out assignments or exams is not permitted, unless it is otherwise stated by the instructor. This use of Gwould jeopardize the students' ability to acquire fundamental knowledge or skills of this course.

If a student is found to have used AI-generated content for any form of assessment, it will be considered academic misconduct, and the student might fail the respective assignment or the course.

Students are nonetheless encouraged to use AI to get additional explanaions of code snippets presented by the teacher in class or fr debugging purposes, but never to produce code delivered as part of solution to assignments, homework or exams. In an exam context, Gen AI is strictly forbidden.

PROGRAM

SESSION 1 (LIVE IN-PERSON)

EXPONENTIAL SMOOTHING - REVIEW AND AUTOMATED MODEL SELECTION

- Review of exponential smoothing methods
- Simple
- Trended
- Seasonal
- Akaike Information Criterion
    - Concept
    - Relationship to Model Selection

Note: it is paramount that the student is familiar with the models taught in the first part of the subject: Time Series Analysis.

Book Chapters: Forecasting Principles and Practice (see references)

SESSION 2 (LIVE IN-PERSON)

ARIMA – DATA STATIONARITY AND DIFFERENTIATION. BACKSHIFT OPERATOR.

Book Chapters: Forecasting Principles and Practice (see references section)

SESSION 3 (LIVE IN-PERSON)

ARMA Processes

- Concept of ARMA Models
- Wold's decomposition and its importance in ARIMA
- Identification of orders *p* and *q*

Book Chapters: Forecasting Principles and Practice - 3rd Edition (see references section of the syllabus).

SESSION 4 (LIVE IN-PERSON)

NON-SEASONAL ARIMA MODELS

Book Chapters: Forecasting Principles and Practice (see references)

SESSION 5 (LIVE IN-PERSON)

SEASONAL ARIMA MODELS

SESSION 6 (LIVE IN-PERSON)

PRACTICE EXERCISES

Book Chapters: Forecasting Principles and Practice (see references)

SESSION 7 (LIVE IN-PERSON)

PRACTICE EXERCISES

SESSION 8 (LIVE IN-PERSON)

MIDTERM

SESSION 9 (LIVE IN-PERSON)

REGRESSION APPLIED TO TIME SERIES (1/2)

Exercises to prepare the midterm.

SESSION 10 (LIVE IN-PERSON)

REGRESSION APPLIED TO TIME SERIES (2/2)

SESSION 11 (LIVE IN-PERSON)

FOURIER TERMS TO MODEL SEASONALITY

- Comparison against dummy variables
- Exercises

Book Chapters: Forecasting Principles and Practice; Chapter 7 (See Bibliography)

SESSION 12 (LIVE IN-PERSON)

ARIMA MODELS WITH EXTERNAL REGRESSORS

Book Chapters: Forecasting Principles and Practice (see references)

SESSION 13 (LIVE IN-PERSON)

THE PROPHET MODEL COMPARED TO ARIMA + REGRESSION MODELS

- Exercises to prepare final

SESSION 14 (LIVE IN-PERSON)

EXERCISES TO REVIEW AND PREPARE FINAL

SESSION 15 (LIVE IN-PERSON)

FINAL EXAM

EVALUATION CRITERIA

criteria	percentage	Learning Objectives	Comments
Final Exam	30 %		Final exam
Group Work	25 %		Group Assignments
Midterm	30 %		Midterm exam
Participation	15 %		Homework, participation and initial assignment on R

RE-SIT / RE-TAKE POLICY

Student with a grade lower than 3.5 in the final will have to go to the re-take regardless of whether their overall grade is higher or lower than 5.

BIBLIOGRAPHY

Compulsory

- Hyndman, R J & Athanasopoilos, G. *Forecasting Principles and Practice.* 3rd Edition. OTexts. ISBN 9780987507136 (Digital)

- Robert H Shumway, David S. Stoffer. (2019). *Time Series: A Data Analysis Approach Using R.* CRC Press. ISBN 9780367221096 (Digital)

BEHAVIOR RULES

Please, check the University's Code of Conduct here. The Program Director may provide further indications.

ATTENDANCE POLICY

Please, check the University's Attendance Policy here. The Program Director may provide further indications.

ETHICAL POLICY

Please, check the University's Ethics Code here. The Program Director may provide further indications.