Universitat Autònoma de Barcelona

2023/2024

Time series

Code: 100124
ECTS Credits: 6

Degree	Type	Year	Semester
2500149 Mathematics	OT	4	1

Contact

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Teaching groups languages

You can check it through this link. To consult the language you will need to enter the CODE of the subject.
Please note that this information is provisional until 30 November 2023.

Teachers

Anna Lopez Ratera

Prerequisites

It is advisable to have knowledge on probability, statistical inference and linear models.

Objectives and Contextualisation

This course aims to introduce students to time series models and their applications. A time series is a set of observations of a random phenomenon evolving over time (or any other ordered magnitude). Time series appear in many fields of application. Therefore, their analysis and the modelling of the underlying random phenomena are of crucial theoretical and applied importance. The ultimate goal is the modelling of the mechanism that generates the data, performing model diagnostics, and predicting future values.

Competences

- Actively demonstrate high concern for quality when defending or presenting the conclusions of one's work.
- Develop critical thinking and reasoning and know how to communicate it effectively, both in one's own languages and in a third language.
- Effectively use bibliographies and electronic resources to obtain information.
- Formulate hypotheses and devise strategies to confirm or reject them.
- Students must be capable of applying their knowledge to their work or vocation in a professional way and they should have building arguments and problem resolution skills within their area of study.

- Students must be capable of collecting and interpreting relevant data (usually within their area of study) in order to make statements that reflect social, scientific or ethical relevant issues.
- Students must be capable of communicating information, ideas, problems and solutions to both specialised and non-specialised audiences.
- Students must develop the necessary learning skills to undertake further training with a high degree of autonomy.
- Students must have and understand knowledge of an area of study built on the basis of general secondary education, and while it relies on some advanced textbooks it also includes some aspects coming from the forefront of its field of study.
- Take sex- or gender-based inequalities into consideration when operating within one's own area of knowledge.
- Use computer applications for statistical analysis, numeric and symbolic calculus, graphic display, optimisation or other purposes to experiment with Mathematics and solve problems.
- When faced with real situations of a medium level of complexity, request and analyse relevant data and information, propose and validate models using the adequate mathematical tools in order to draw final conclusions

Learning Outcomes

1. Actively demonstrate high concern for quality when defending or presenting the conclusions of one's work.
2. Characterise homogenous groups of individuals by means of multivariate analysis.
3. Data analysis.
4. Design experiments.
5. Design, program and implant statistical packages.
6. Determine the size of the sample and establish a sampling strategy for comparison of means studies.
7. Determine the size of the sample and establish a sampling strategy for proportion comparison studies.
8. Determine the size of the sample and establish a sampling strategy for special comparisons.
9. Develop critical thinking and reasoning and know how to communicate it effectively, both in one's own languages and in a third language.
10. Devise a study on the basis of multivariate and/or data mining methodologies to solve a problem that is contextualised in the experimental reality.
11. Devise predictions and scenarios.
12. Effectively use bibliographies and electronic resources to obtain information.
13. Filter and store information on digital supports.
14. Have the capacity to devise and construct models and validate the same.
15. Identify relationships or associations.
16. Identify the relevant information in order to solve a problem.
17. Identify the stages of problems that require advanced technologies.
18. Interpret results using statistical models.
19. Recognise the different types of sampling.
20. Recognise the need to employ multivariate rather than bivariate methods.
21. Represent data graphically.
22. Students must be capable of applying their knowledge to their work or vocation in a professional way and they should have building arguments and problem resolution skills within their area of study.
23. Students must be capable of collecting and interpreting relevant data (usually within their area of study) in order to make statements that reflect social, scientific or ethical relevant issues.
24. Students must be capable of communicating information, ideas, problems and solutions to both specialised and non-specialised audiences.
25. Students must develop the necessary learning skills to undertake further training with a high degree of autonomy.
26. Students must have and understand knowledge of an area of study built on the basis of general secondary education, and while it relies on some advanced textbooks it also includes some aspects coming from the forefront of its field of study.
27. Take sex- or gender-based inequalities into consideration when operating within one's own area of knowledge.
28. Use graphs to summarise multivariate data and show dynamical pictures.
29. Use multivariate data summary indexes, time series and all other advanced techniques.

30. Use quantitative thinking and reasoning.
31. Use statistical programs for different multivariate analysis methods.
32. Use statistical programs to calculate sample sizes.
33. Use statistical programs to manage databases.
34. Use statistical programs to obtain summarised indexes of study variables.
35. Validate and manage information for statistical treatment.

Content

1. Introduction. Classical analysis of time series models.
2. Stationary Processes. On the concept of stationarity, examples. Simulation.
3. Linear models. MA(q) and AR(p). Correlograms. Yule-Walker equations. The difference operator. Relationship between MA snd AR models. The autocorrelation and partial autocorrelation functions.
4. ARIMA Models. The ARMA(p,q) model. Parameter estimation: method of moments, MLE, unconditional and conditional least squares. The ARIMA(p,d,q) and SARIMA models. The Box-Jenkins method. Segmentation.
5. Diagnostic checking and Forecasting. AIC and BIC criteria. Analysis of residuals. Confidence intervals for predictions.
6. Models for non-stationary series: ARCH/GARCH, ARMA with covariates.
7. Count Time Series: The INAR models.

Methodology

During the theoretical lessons (2 H/week) the fundamental results will be presented, and computer exercises will be developed. During the lab hours (with laptop) students will solve real data problems. The programing language used is R.

Annotation: Within the schedule set by the centre or degree programme, 15 minutes of one class will be reserved for students to evaluate their lecturers and their courses or modules through questionnaires.

Activities

Title	Hours	ECTS	Learning Outcomes
Type: Directed			
Practical sessions	26	1.04	27, 3, 14, 2, 1, 13, 9, 8, 6, 7, 5, 4, 11, 28, 32, 29, 16, 17, 15, 18, 30, 10, 26, 25, 24, 22, 23, 19, 20, 21, 12, 31, 33, 34, 35
Theoretical sessions	26	1.04	27, 3, 14, 2, 1, 13, 9, 8, 6, 7, 5, 4, 11, 28, 32, 29, 16, 17, 15, 18, 30, 10, 26, 25, 24, 22, 23, 19, 20, 21, 12, 31, 33, 34, 35
Type: Autonomous			
Personal work	60	2.4	27, 3, 14, 2, 1, 13, 9, 8, 6, 7, 5, 4, 11, 28, 32, 29, 16, 17, 15, 18, 30, 10, 26, 25, 24, 22, 23, 19, 20, 21, 12, 31, 33, 34, 35
Real data	25	1	27, 3, 14, 2, 1, 13, 9, 8, 6, 7, 5, 4, 11, 28, 32, 29, 16, 17, 15, 18, 30, 10, 26, 25, 24,

analysis	22, 23, 19, 20, 21, 12, 31, 33, 34, 35

Assessment

The subject will be assessed with assignments (exercise assignments, problem checks and/or practicals) and 2 exams. To obtain the weighted grade of continuous assessment you must have a minimum of 3/10 in each of the parts.
Students who have opted for the single assessment modality will have to complete an assessment that will consist of a theory exam, a problem test and the delivery of the first and last practical reports of the course. Assessment of submissions may require an assessment interview with the teacher. The student's grade will be the weighted average of the three previous activities, where the exam will account for 45% of the grade, the test 45% and the assignments 10%.
If the final grade does not reach 5/10, the student has another opportunity to pass the subject through the remedial exam that will be held on the date set by the degree coordinator. In this test you can recover 70% of the grade corresponding to the theory and the problems. The part of internships is not refundable.

Assessment Activities

Title	Weighting	Hours	ECTS	Learning Outcomes
Final Exam	0,4	3	0.12	27, 3, 14, 2, 1, 13, 9, 8, 6, 7, 5, 4, 11, 28, 32, 29, 16, 17, 15, 18, 30, 10, 26, 25, 24, 22, 23, 19, 20, 21, 12, 31, 33, 34, 35
Homework (exercises and computer activities)	0,3	8	0.32	27, 3, 14, 2, 1, 13, 9, 8, 6, 7, 5, 4, 11, 28, 32, 29, 16, 17, 15, 18, 30, 10, 26, 25, 24, 22, 23, 19, 20, 21, 12, 31, 33, 34, 35
Mid-term exam	0,3	2	0.08	27, 3, 14, 2, 1, 13, 9, 8, 6, 7, 5, 4, 11, 28, 32, 29, 16, 17, 15, 18, 30, 10, 26, 25, 24, 22, 23, 19, 20, 21, 12, 31, 33, 34, 35

Bibliography

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2. Brockwell, P.J. and Davis, R.A. (2002). *Introduction to Time Series and Forecasting*. 2nd edit. Springer. https://cataleg.uab.cat/iii/encore/record/C__Rb1671241__Sa%3A%28Brockwell%29%20t%3A%28time%2
3. Cryer, J.D. and Chan, K.S. (2008). *Time Series Analysis with Applications to R*. 2nd. edit. Springer. https://cataleg.uab.cat/iii/encore/record/C__Rb2027637__Sa%3A%28Cryer%29%20t%3A%28time%20ser
4. Peña, R.D. *A course in time series analysis*. https://onlinelibrary-wiley-com.are.uab.cat/doi/book/10.1002/9781118032978
5. Peña, D., Tiao, G.C., and Tsay, R.S. (2001). A Course in Time Series Analysis. John Wiley & Sons, Inc. https://onlinelibrary-wiley-com.are.uab.cat/doi/book/10.1002/9781118032978
6. Shumway, R.H. and Stoffer, D.S. (2011) *Time Series Analysis and its Applications.* 3rd. edit. Springer. https://cataleg.uab.cat/iii/encore/record/C__Rb1784344__Sa%3A%28shumway%29%20t%3A%28time%2
7. Tsay., R.S. (2010). *Analysis of Financial Time Series*, 3rd Edition, Wiley.

Software

R Core Team. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/.

We shall use several R libraries, including forecast, TSA, TSeries, quantmod, fgarch, tscount.