ANX-PR/CL/001-01

LEARNING GUIDE

SUBJECT

53000687 - Computational Statistics And Stochastic Modelling

DEGREE PROGRAMME

05BD - Master Universitario En Ingenieria De La Organizacion

ACADEMIC YEAR & SEMESTER

2022/23 - Semester 1

Index

Learning guide

1. Description

1.1. Subject details

Name of the subject	53000687 - Computational Statistics And Stochastic Modelling
No of credits	3 ECTS
Type	Optional
Academic year ot the programme	Second year
Semester of tuition	Semester 3
Tuition period	September-January
Tuition languages	English
Degree programme	05BD - Master Universitario en Ingenieria de la Organizacion
Centre	05 - Escuela Técnica Superior De Ingenieros Industriales
Academic year	2022-23

2. Faculty

2.1. Faculty members with subject teaching role

Name and surname	Office/Room	Email	Tutoring hours *
Carolina Silvia Garcia Martos (Subject coordinator)	UD Estadística	garcia.martos@upm.es	Sin horario. Concertar cita por email

* The tutoring schedule is indicative and subject to possible changes. Please check tutoring times with the faculty member in charge.

3. Prior knowledge recommended to take the subject

3.1. Recommended (passed) subjects

- AnÁlisis De Datos Para La GestiÓn

3.2. Other recommended learning outcomes

- It is needed to have a basic knowledge of R (RStudio), particularly related to Descriptive Statistics, Inference and Regression Models

- Of course, related to Descriptive Statistics, Inference and Regression Methods the student must have not only a practical knowledge but also to understand the methods and models. but

- The contents needed are those included in the course "Analisis de datos para la gestión", Guia Aprendizaje (Learning Guide) of the academic year 2021-2022. In case of doubt contact the coordinator of the course at garcia.martos@upm.es

4. Skills and learning outcomes *

4.1. Skills to be learned

CB06 - Poseer y comprender conocimientos que aporten una base u oportunidad de ser originales en el desarrollo y/o aplicación de ideas, a menudo en un contexto de investigación

CB07 - Que los estudiantes sepan aplicar los conocimientos adquiridos y su capacidad de resolución de problemas en entornos nuevos o poco conocidos dentro de contextos más amplios (o multidisciplinares) relacionados con su área de estudio

CB08 - Que los estudiantes sean capaces de integrar conocimientos y enfrentarse a la complejidad de formular juicios a partir de una información que, siendo incompleta o limitada, incluya reflexiones sobre las responsabilidades sociales y éticas vinculadas a la aplicación de sus conocimientos y juicios

CB10 - Que los estudiantes posean las habilidades de aprendizaje que les permitan continuar estudiando de un modo que habrá de ser en gran medida autodirigido o autónomo

CE01 - Conocer y aplicar técnicas y herramientas para el manejo y análisis de grandes masas de datos

CG01 - Utilizar los conocimientos científicos y tecnológicos adquiridos en sus estudios de Grado en Ingeniería como recurso a integrar en la generación de soluciones a problemas de las organizaciones, sean éstos de funcionamiento o de diseño

CG02 - Analizar situaciones estructuradas y poco estructuradas de empresas y otras organizaciones, estableciendo diagnósticos apropiados, en particular, de carácter estratégico

CG05 - Conocer las tendencias predominantes en el entorno actual de las distintas políticas funcionales (marketing, producción, logística, finanzas, recursos humanos, liderazgo...)

CG06 - Conocer y aplicar las principales tramas conceptuales (frameworks) para el desarrollo de la estrategia de una organización y la gestión de los procesos de diseño, de gestión de la información y cambio de dicha organización

CT01 - Aplica. Habilidad para aplicar conocimientos científicos, matemáticos y tecnológicos en sistemas relacionados con la práctica de la ingeniería

CT02 - Experimenta. Habilidad para diseñar y realizar experimentos así como analizar e interpretar datos

CT03 - Diseña. Habilidad para diseñar un sistema, componente o proceso que alcance los requisitos deseados teniendo en cuenta restricciones realistas tales como las económicas, medioambientales, sociales, políticas, éticas, de salud y seguridad, de fabricación y de sostenibilidad

CT04 - Trabaja en equipo. Habilidad para trabajar en equipos multidisciplinares

CT05 - Resuelve. Habilidad para identificar, formular y resolver problemas de ingeniería

CT08 - Entiende los impactos. Educación amplia necesaria para entender el impacto de las soluciones ingenieriles en un contexto social global

CT09 - Se actualiza. Reconocimiento de la necesidad y la habilidad para comprometerse al aprendizaje continuo

CT10 - Conoce. Conocimiento de los temas contemporáneos

CT11 - Usa herramientas. Habilidad para usar las técnicas, destrezas y herramientas ingenieriles modernas necesarias para la práctica de la ingeniería

CT12 - Es bilingüe. Capacidad de trabajar en un entorno bilingüe (inglés/español)

4.2. Learning outcomes

RA1 - Elegir y aplicar técnicas de análisis exploratorios de grandes bases de datos

RA3 - Elegir y aplicar técnicas de predicción para variables cuantitativas y cualitativas

RA47 - Enumerar, seleccionar y aplicar herramientas y metodologías para la explotación de datos mediante modelos

RA48 - Identificar y aplicar modelos estadísticos de predicción en el funcionamiento diario de una empresa eléctrica

RA71 - RA1 - Elegir y aplicar técnicas de análisis exploratorios de grandes bases de datos

RA76 - RA6 - Formalizar, implementar y explotar modelos no deterministas

RA6 - Formalizar, implementar y explotar modelos no deterministas

RA73 - RA3 - Elegir y aplicar técnicas de predicción para variables cuantitativas y cualitativas

RA2 - Elegir y aplicar técnicas de modelado de grandes bases de datos

RA74 - RA47 - Enumerar, seleccionar y aplicar herramientas y metodologías para la explotación de datos mediante modelos

RA75 - RA48 - Identificar y aplicar modelos estadísticos de predicción en el funcionamiento diario de una empresa eléctrica

RA72 - RA2 - Elegir y aplicar técnicas de modelado de grandes bases de datos

* The Learning Guides should reflect the Skills and Learning Outcomes in the same way as indicated in the Degree Verification Memory. For this reason, they have not been translated into English and appear in Spanish.

5. Brief description of the subject and syllabus

5.1. Brief description of the subject

This course is mainly focused on the analysis, modelling and forecasting of time-dependent data. There are many examples of time series: electricity prices in liberalized markets, Industrial Production Indexes in the EU countries, CO2 emmission prices or unemployment rates, among many others. We will firstly rgo through main concepts of univariate time series (Autocorrelation and Partial Autocorrelation Function, ACF and PACF, respectively, stationary processes such that AR, MA and ARMAs) and then revise nonstationary processes (ARIMAs) and go deeply into Seasonal ARIMA models. This is all focused on modelling and forecasting the conditional mean (i.e., modelling and forecasting the same variable for which we have the historical data) in the univariate framework (a single variable evolving over time, or several ones but not accounting for their multivariate relationship).

Then we will move to volatility models (conditionally heteroskedastic models) where the main issue is to model and forecast the volatility and to use that for improving the computation of forecasting intervals.

Finally we will move to the multivariate framework: VARIMA models will be studied.

The approach will be practical, with extensive use of the R an open-source package for the analysis of real-data examples.

Significant attention will be devoted to, by means of statistical inference, quantification of uncertainty, which is an essential added value of Statistics for decision-making processes under uncertainty.

OUTLINE:

1) Univariate Time Series Models.

1a. ACF and PACF

1b. Stationary time series (AR, MA and ARMA models)

1c. ARIMA models.

1d. Seasonal ARIMA models.

2. Conditional Heteroskedasticity and volatility models

2a. ARCH and GARCH models (will be covered in detail, theoretically and practically with real data sets).

2b. SV models (Just main characteristics and differences between SV models and GARCH).

3. Introduction to Multivariate Time Series Models

5.2. Syllabus

1. Univariate Time Series Models
    1.1. ACF and PACF
    1.2. AR, MA and ARMA models
    1.3. ARIMA models
    1.4. Seasonal ARIMA models
2. Conditional Heteroskedasticity and volatility models
    2.1. ARCH and GARCH models
    2.2. SV models
3. Multivariate Time Series Models

6. Schedule

6.1. Subject schedule*

Week	Classroom activities	Laboratory activities	Distant / On-line	Assessment activities
1	**Introduction to univariate time series models. ACF and PACF. Stationary models (AR, MA, ARMA).** Duration: 02:00 Lecture			
2	**Introduction to univariate time series models. ACF and PACF. Stationary models (AR, MA, ARMA).** Duration: 02:00 Laboratory assignments			
3	**Practical examples on AR, MA and ARMA models** Duration: 00:00 Laboratory assignments			
4	**ARIMA models** Duration: 01:00 Lecture	**ARIMA models** Duration: 01:00 Cooperative activities		
5	**Seasonal ARIMA models** Duration: 02:00 Lecture			
6		**Seasonal ARIMA models and review on univariate models** Duration: 02:00 Problem-solving class		
7				**Presentations on Seasonal ARIMA models (groups of 2 or 3 students depending on the total number of students enrolled)** Group presentation Continuous assessment and final examination Presential Duration: 02:00
8	**The concepts of Volatility modelling and Conditional Heteroskedasticity. Introduction of the different models available (ARCH and GARCH and SV models)** Duration: 02:00 Lecture			
9	**ARCH models** Duration: 01:00 Lecture	**GARCH models** Duration: 01:00 Lecture		

10		**ARCH and GARCH models** Duration: 02:00 Problem-solving class		
11				**Presentation on volatility models (using RStudio and analyzing real datasets).** Group presentation Continuous assessment and final examination Presential Duration: 02:00
12	**Multivariate models. Introduction and VARIMA models** Duration: 02:00 Lecture			
13		**VARIMA models with the package MTS in R** Duration: 02:00 Problem-solving class		
14	**An Introduction to dimensionality reduction techniques in the context of multivariate time series** Duration: 02:00 Lecture			
15				**Exam including the content of all the course (the 3 modules or blocks of content). This is the Examen ordinario, date given at the POD of the ETSII-UPM.** Written test Continuous assessment and final examination Presential Duration: 02:30
16				
17				

Depending on the programme study plan, total values will be calculated according to the ECTS credit unit as 26/27 hours of student face-to-face contact and independent study time.

* The schedule is based on an a priori planning of the subject; it might be modified during the academic year, especially considering the COVID19 evolution.

7. Activities and assessment criteria

7.1. Assessment activities

7.1.1. Assessment

Week	Description	Modality	Type	Duration	Weight	Minimum grade	Evaluated skills
7	Presentations on Seasonal ARIMA models (groups of 2 or 3 students depending on the total number of students enrolled)	Group presentation	Face-to-face	02:00	15%	5 / 10	CT10 CT11 CG02 CG06 CT05 CE01 CT02 CB06 CT04 CB10 CG05 CT01 CT08 CT12 CG01 CT09 CB08 CB07 CT03
11	Presentation on volatility models (using RStudio and analyzing real datasets).	Group presentation	Face-to-face	02:00	15%	5 / 10	CT11 CT05 CE01 CT02 CT01 CT12 CG01 CB08 CB07
15	Exam including the content of all the course (the 3 modules or blocks of content). This is the Examen ordinario, date given at the POD of the ETSII-UPM.	Written test	Face-to-face	02:30	70%	4 / 10	CT11 CG02 CT05 CE01 CT02 CB06 CB10 CG05 CT01 CT12 CG01 CB07

7.1.2. Global examination

Week	Description	Modality	Type	Duration	Weight	Minimum grade	Evaluated skills
7	Presentations on Seasonal ARIMA models (groups of 2 or 3 students depending on the total number of students enrolled)	Group presentation	Face-to-face	02:00	15%	5 / 10	CT10 CT11 CG02 CG06 CT05 CE01 CT02 CB06 CT04 CB10 CG05 CT01 CT08 CT12 CG01 CT09 CB08 CB07 CT03
11	Presentation on volatility models (using RStudio and analyzing real datasets).	Group presentation	Face-to-face	02:00	15%	5 / 10	CT11 CT05 CE01 CT02 CT01 CT12 CG01 CB08 CB07
15	Exam including the content of all the course (the 3 modules or blocks of content). This is the Examen ordinario, date given at the POD of the ETSII-UPM.	Written test	Face-to-face	02:30	70%	4 / 10	CT11 CG02 CT05 CE01 CT02 CB06 CB10 CG05 CT01 CT12 CG01 CB07

7.1.3. Referred (re-sit) examination

Description	Modality	Type	Duration	Weight	Minimum grade	Evaluated skills
exam covering all the course content	Written test	Face-to-face	03:00	90%	4 / 10	CT11 CG02 CT05 CE01 CT02 CB06 CB10 CG05 CT01 CT12 CG01 CB07

7.2. Assessment criteria

The group projects on ARIMA models and volatility models are mandatory to be able to pass the course.

In the final exam (Examen Ordinario) all the content of the course will be included. There will be 3 exercises, each one focused on each module of content. 70% of the final mark will be this exam, 30% the group projects (15% each one).

In the "Extraordinary exam" all the content of the course will be included. There will be 3 exercises, each one focused on each module of content. 90% of the final mark will be this exam, 10% the group projects (5% each one).

8. Teaching resources

8.1. Teaching resources for the subject

Name	Type	Notes
Material developed by Carolina García-Martos, slides and R code	Others	
"Time Series Analysis and Its Applications with R Examples" by Robert H. Shumway and David S. Stoffer. 2017, Springer.	Bibliography	
"Analysis of Financial Time Series", by Ruey Tsay., 2010, Wiley.	Bibliography	
Statistical Learning for Big Dependent Data, by Daniel Peña and Ruey Tsay. 2021, Wiley.	Bibliography	Bibliografía complementaria.