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220270 - Applied Statistics in Industrial Engineering

Coordinating unit: 205 - ESEIAAT - Terrassa School of Industrial, Aerospace and Audiovisual Engineering
Teaching unit: 715 - EIO - Department of Statistics and Operations Research
Academic year: 2019
Degree: MASTER'S DEGREE IN INDUSTRIAL ENGINEERING (Syllabus 2013). (Teaching unit Optional)
ECTS credits: 5 Teaching languages: Catalan

Teaching staff

Coordinator: Maria Albareda Sambola

Prior skills

To follow this course it is necessary to have some basic knowledge on statistics (covariance, correlation coefficient, linear regression) and on linear algebra (matrix calculus and eigenvalues and eigenvectors)

Degree competences to which the subject contributes

Specific:

1. Ability to exercise direction in organizations and departments.

2. Ability to design, develop and apply analytical methods (quantitative methods, statistical models and decision tools) for making strategic, tactical and operational decisions in organizations.
3. Ability to analyze, diagnose, design solutions and manage complex systems that integrate various resources of an organization keeping in mind the business environment.
4. Ability to apply theories and inherent principles of the organization in order to analyze complex and uncertainty situations, and make decisions using engineering tools.

Teaching methodology

The course is organized around three main activities:
Lectures
Practical sessions (exercises and laboratory sessions)
Autonomous work
In the lectures, teachers will introduce the theoretical basis of the subject, concepts, methods and results, given convenient examples to assist the understanding.
During the practical sessions, teachers will guide the students in the application of the theoretical concepts for problem solving, putting special emphasis on critical thinking skills. Exercises will be proposed to solve in and outside the classroom, in order to put the students in contact with the use of the tools developed in the lectures.
Students, on their own, should work on the supplied materials and the results of the practical sessions, in order to assimilate and fix the concepts. Professors will supply a syllabus of the course and guidelines to follow activities.

Observation: Although the materials are written in catalan, classroom sessions might be delivered in Spanish if it is needed.

Learning objectives of the subject

This course provides the student with a series of advanced statistical tools which have been developed in the area of statistics in response to industrial and managerial problems.
It is a quantitative course, where statistical tools that can be used in decision taking on the basis of collected data. In

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particular, it covers forecasting computations from data series and some multivariate analysis methods.

Study load

Total learning time: 125h	Hours large group:	30h	24.00%
	Hours small group:	15h	12.00%
	Self study:	80h	64.00%

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Content

-M1 Module. Introduction to multivariate analysis

Learning time: 8h 30m

Theory classes: 3h 30m
Self study : 5h

Description:
Multivariate statistics is quite a wide area within statistics, specialized in treating multidimensional observations. That is, it can be applied to populations where two or more characteristics are simultaneously measured. Because of its nature, its study requires certain matrix algebra skills and some basic statistics concepts, such as variance, covariance and correlations. This first introduction reviews these concepts.

Related activities:
1,2,3

Specific objectives:
Revise concepts that will be needed for following the course

M2 Module. Principal Components Analysis

Learning time: 35h

Theory classes: 7h
Laboratory classes: 6h
Self study : 22h

Description:
Principal components address the problems that arise when several variables which have been measured on a large set of individuals need to be analyzed, and the size of the database complicates an easy and efficient interpretation, whilst correlations among variables reduce the efficacy of other methods.
THe graphical representation of the variables and individuals on the space defined by the principal components allows to visualize the relationships among the variables, the similarities among individuals and the mutual assotiations.
Indeed, principal components can be seen as the projection of the individuals on a lower dimension space that minimizes the lost information.

Related activities:
1, 2, 3 and 5

Specific objectives:
Provide the student with the ability to reducer the volume of tables of quantitative data collected on a sample, without loosing much information

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M3 Module: Correspondence Analysis.

Learning time: 16h 30m

Theory classes: 5h 30m
Laboratory classes: 1h
Self study : 10h

Description:
Correspondence analysis is focused on the study of two-entry tables where individuals are classified according to two different criteria. They yield a geometric representation on a low dimensional space, which is simple and precise, and allows to visualize association between cathegories of the same classification criterion, and among both of them.

Related activities:
1, 2, 3

Specific objectives:
At the end of the course the student whould be able to identify possible relationships between the cathegories used to classify individuals in a two-entry table.

- S1 Module: Introduction to Time Series

Learning time: 5h

Theory classes: 2h
Self study : 3h

Description:
A Time Series is a set of observations of the same magnitude ordered along the time. The objective of this module and the following ones is to analyze a series to extract its behavioral pattern, validate its goodness of fit, and forecast, as long as possible, its future evolution. A necessary tool to achieve this objective is linear regression, which will be revised in this introduction.

Related activities:
1, 2, 4

Specific objectives:
To present the concept of Time Series, and review some concepts that will be required in the forthcomming modules

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-S2 Module: Classical decomposition of Time Series

Learning time: 11h

Theory classes: 3h
Laboratory classes: 1h
Self study : 7h

Description:
This module develops the so-called Classical Decomposition method, which decomposes the series in trend, seasonality, ciclic component, and residuals. To model the series and be able to do forecasts it is necessary to stabilize it by freeing it from the seasonal component, by means of moving averages. Once the conjuntion (aditive or multiplicative) of the components, a final model is obtained, which will allow to forecast future values.

Related activities:
1, 2, 4

Specific objectives:
Provide the student with the ability to identify additive and multiplicative series, and to model their trend and seasonality components, in order to build adequate models for each time series.

S3 Module: Time series modelling using cathecorical variables

Learning time: 15h

Theory classes: 2h
Laboratory classes: 3h
Self study : 10h

Description:
Modeling Time Series by means of cathecorical variables is a generalization of the classical decomposition method, that allows to model simultaneously the trend and the seasonality. Moreover, it dones not require deciding a priory wether the model should be additive or multiplicative. As opposite, a very general model, which includes both effects is proposed as a starting point, and it is the method itself who determines which of them are relevant in the series evolution. Thanks to this fact, the use of categorical variables in the process of time series modeling allows to overcome one of the principal limitations of classical decomposition, since it allows to build adequate models for series with a mixt behavior.

Related activities:
1, 2, 4 and 6

Specific objectives:
Provide the student the ability to model series with trend and seasonality, independently of their interaction.

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-S4 Module: Autocorrelation	Learning time: 21h Theory classes: 4h Laboratory classes: 3h Self study : 14h

Description:
This module presents the correlogram (graphical representation of the autocorrelation function). It can be used to confirm the seasonality of the series and its periodicity, as well as to determine the maximum number of allowable forecasts.

Related activities:
1, 2, 4 and 6

Specific objectives:
Give the student the necessary skills for correlogram elaboration and interpretation.

-S5 Module: Other forecasting techniques	Learning time: 13h Theory classes: 3h Laboratory classes: 1h Self study : 9h

Description:
This module develops some methods based on exponential smoothing which can be applied, in particular, to model series that do not present a stable trend along the data collection period, or for which not much information is available.
It also contains brief overview of Box Jenkis methodology.

Related activities:
1, 2, 4.

Specific objectives:
Overview other techniques that become useful to work with series that do not present a strong structure given by a trend and a seasonality

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Planning of activities

Activity 1: Large group sessions/Theory and exercises

Hours: 67h
Theory classes: 27h
Self study: 40h

Description:
Attendance to the theory and practice sessions, and previous and subsequent training.

Support materials:
Documentation made available through Atenea
Course bibliography

Specific objectives:
Transfer the necessary knowledge for a correct interpretation of the contents developed in the large group sessions.
Solving of exercises, and discussion on any doubts that might arise in relation to the course contents.
Generic competences training.

Activity 2: Practice sessions

Hours: 19h
Laboratory classes: 7h
Self study: 12h

Description:
Attendance to the practical sessions, and previous and subsequent preparation.
During these sessions the problem will guide the students through the solution of practical problems, encouraging the discussion among all attendants.

Support materials:
Notes and exercise sheets provided through Atenea

Activity 3: Partial exam

Hours: 5h
Theory classes: 1h
Self study: 4h

Description:
Individual and writen exam concerning the contents of modules M1, M2 and M3

Support materials:
Statement of the partial exam.
Students can use all their notes, and the material made avalilable trhough Atenea. Bibliography is also allowed.

Descriptions of the assignments due and their relation to the assessment:
The deliverable will be the exam sheed with marked answers.
It represents 40% of the final course mark

Specific objectives:
The exam should prove that the student has acquired and fixed the concepts, principles and basic foundings related with modules M1, M2 and M3.

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Activity 4: Final exam	Hours: 10h Theory classes: 2h Self study: 8h

Description:
Individual and written test concerning the contents of modules S1, S2, S2, S4 and S5

Support materials:
Statement of the final exam.
Students can use all their notes, and the material made avalilable trhough Atenea. Bibliography is also allowed.

Descriptions of the assignments due and their relation to the assessment:
The deliverable will be the exam sheed with marked answers.
It represents 40% of the final course mark

Specific objectives:
The test must prove that the student has adquired and fixed the concepts, principles and basic fundaments related with modules S1, S2, S3, S4 and S5.

Activity 5: Multivariate analysis project	Hours: 12h Laboratory classes: 4h Self study: 8h

Description:
Individual project on the practical application of the contents of module M2.
In this project the student will have to perform a principal components analysi of a data set provided by the professor, using a worksheet.

Support materials:
Course notes, project sketch and assigned dataset.
Worksheet prepared as a support for the development of the project.

Descriptions of the assignments due and their relation to the assessment:
The deliverable will be a report on the application of principal components analysis on the assigned data set, that the student must hand it within the prespecifided time window.
This task represents 10% of the final course mark

Specific objectives:
This project must prove that the student is able to apply correctly the tools developed in module M2, and use the obtained results to raise reasonable conclusions.

(ENG) ACTIVITAT 6: PRÀCTICA DE SÈRIES TEMPORALS	Hours: 12h Laboratory classes: 4h Self study: 8h

Description:
Individual project.
Practical application of the contents of modules S3 and S4 to a particular dataset.

Support materials:
Course notes, project sketch and individual dataset

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Descriptions of the assignments due and their relation to the assessment:
The deliverable will be the report of the application of the necessary tools to the assigned dataset, and must be handed it withn the specified time window.
This task represents 10% of the final course mark

Specific objectives:
The report must prove that the student is able to study the data of his/her assigned dataset, model their behavior, give an interpretation of the obtained model, and compute the allowable forecasts.

Qualification system

The final mark of the course depends on the following evaluation activities:
- Activity 3 (partial exam), weight: 40%
- Activity 4 (final exam), weight: 40%
- Activity 5, weight: 10%
- Activity 6, weight: 10%

Any student who cannot attend to the midterm exam (activity 3) or that wants to improve the obtained grade, will have the opportunity to improve that grade by taking an additional written exam that will take place the same day as the final exam (activity 4). The grade obtained in this test will range between 0 and 10, and will replace that of the midterm exam in case it is higher.

For those students who meet the requirements and submit to the reevaluation examination, the grade of the reevaluation exam will replace the grades of all the on-site written evaluation acts (tests, midterm and final exams) and the grades obtained during the course for lab practices, works, projects and presentations will be kept.
If the final grade after reevaluation is lower than 5.0, it will replace the initial one only if it is higher. If the final grade after reevaluation is greater or equal to 5.0, the final grade of the subject will be pass 5.0.

Regulations for carrying out activities

All evaluation activities (3, 4, 5 and 6) will be written, and performed individually.

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Bibliography

Basic:

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Albareda, M.; Algaba, I.; Pepió, M. Series temporales y previsiones. Barcelona: Omnia Science, 2013. ISBN 9788494062469.

Complementary:

Johnson, R.A.; Wichern, D.W. Applied multivariate statistical analysis. 6th ed. Englewood Cliffs, N.J: Prentice-Hall, cop. 2007. ISBN 9780131877153.

Everitt, Brian. An R and S-PLUS companion to multivariate analysis [on line]. London: Springer, cop. 2005 [Consultation: 07/07/2017]. Available on: <http://dx.doi.org/10.1007/b138954>. ISBN 1852338822.

Makridakis, S.G.; Wheelwright, S.C.; Hyndman, R.J. Forecasting: methods and applications. 3rd ed. New York [etc.]: John Wiley & Sons, cop. 1998. ISBN 0471532339.

Diebold, Francis X. Elementos de pronósticos. México [etc.]: International Thomson, cop. 1999. ISBN 9687529741.

Others resources:

Course notes, exercises, videos and quizzes available in Atenea (in catalan)