UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

COURSE SYLLABUS

Advanced Statistical Methods

2627-2-F1602M015

Learning objectives

This course aims to provide students a set of methods for the statistical study of financial phenomena. Students will acquire the ability to identify and apply the appropriate statistical tools for analyzing, describing, and forecasting financial phenomena.

Expected Learning Outcomes (Dublin Descriptors):

Knowledge and understanding
Students will learn the fundamental concepts related to the study of multivariate random variables and the use of multivariate analysis techniques to solve classification and dimensionality reduction problems.

Applying knowledge and understanding
Students will learn how to apply, using statistical software, the methodologies introduced in the course.

Making judgements
Students will develop sound autonomy in making judgements and will learn to identify the methodologically correct techniques to answer specific questions, starting from the empirical evidence provided by the data.

Communication skills
Students will learn to use statistical technical jargon and to effectively communicate the conclusions drawn from the data analyses performed.

Learning skills
The knowledge of the concepts presented in the course will provide the conceptual foundations that will allow students to independently learn more sophisticated or alternative techniques.

Contents

The course will cover the following topics:

1. Multivariate distribution models, copulas and alternative dependence measures to Pearson's linear correlation.
2. Supervised statistical learning techniques aimed at solving classification problems.
3. Unsupervised statistical learning techniques aimed at solving classification (clustering) and dimensionality reduction problems.

Detailed program

This course introduces statistical learning techniques applicable to various financial fields, such as portfolio optimization, credit risk assessment, and actuarial science. Specifically, the following topics will be covered:

1. Multivariate random variables: with particular reference to the multivariate normal distribution, elliptical distributions, and the use of copulas to construct multivariate models. Parameter estimation for multivariate models.
2. Dependence measures: linear correlation and alternative concordance measures, and tail dependence.
3. Core concepts of credit risk: the use of copulas in credit risk assessment models (specifically within the CreditMetrics framework).
4. Supervised statistical learning techniques for classification: logistic regression, linear discriminant analysis, classification trees, random forests, bagging, and boosting. Application of these techniques to estimate a debtor's probability of default PD and to forecast default events.
5. Unsupervised statistical learning techniques: clustering (hierarchical methods and k-means) and principal component analysis. Application of these techniques to portfolio optimization and other financial contexts.

Prerequisites

Students are required to possess the following prerequisite knowledge:

1. Descriptive statistics
2. Probability and univariate random variables (both discrete and continuous)
3. Core concepts of statistical inference: point estimation and estimators, confidence intervals, and hypothesis testing.

To ensure students meet these requirements, passing the Statistics course is a strict prerequisite.

Teaching methods

Lectures on theoretical concepts and practical hands-on sessions in the classroom and laboratory using R and/or Python software.
A mixed teaching approach is adopted across all lectures: traditional lecturing will alternate with interactive teaching moments, with proportions varying from time to time (depending on the topic, the specific activity, and the class interaction). Typically, the interactive component will be larger during classroom and laboratory exercises. Approximately 30% of the course will be delivered through interactive methods.

Assessment methods

The exam consists of a written test and an oral examination. The written test involves performing data analysis using the techniques introduced in class (typically 3 exercises covering 3 different methodologies) utilizing R and/or Python statistical software.
The oral exam consists of a discussion on the interpretation of the results obtained in the written test, alongside questions regarding the technical and theoretical aspects of the methods presented throughout the course.

During the course, the possibility of replacing the written exam with a data processing project will be evaluated together with the students. Also in this case, the oral exam remains mandatory.

The assessment methods, exam dates, and schedules are the same for all students (both attending and non-attending).

Textbooks and Reading Materials

James, G., Witten, D., Hastie, T., & Tibshirani, R. (2013). An introduction to statistical learning (1st ed.). Springer.
Nelsen, R. (1999) An Introduction to Copulas. Springer, New York.
Mai, Jan-Frederik, and Matthias Scherer. Financial Engineering with Copulas Explained. Palgrave Macmillan, 2014.
Teaching materials

Semester

Second semester

Teaching language

Italian

Sustainable Development Goals

QUALITY EDUCATION