# Mathematical and statistical methods for decision-making

## Prof. Michele Longo (mathematics module), Prof. Davide Zurlo (statistics module)

***COURSE AIMS and INTENDED learning outcomes***

The main aim of this two-module course (mathematics and statistics), is to introduce students to the basic mathematical and statistical methods and techniques needed to describe, analyze and solve economic, statistical and financial problems. The presentation of the topics will have the dual purpose of providing a general theoretical preparation and of suggesting and analyzing concrete applications.

At the end of the course students should:

1. have acquired the theoretical concepts presented during the course and be able to solve theoretical problems and exercises,
2. be able to represent and analyze with the mathematical and statistical language presented in the course real world situations, especially in the economic, statistical and financial fields,
3. have developed good learning skills that allow for more advanced studies to be undertaken with greater autonomy.

***COURSE CONTENT***

The course is divided in two modules:

***Mathematics module.*** (Prof. Michele Longo)*.*

*Linear algebra*. The vector space RN. Subspaces. Linear dependence and independence. Basis and dimension. Inner product and norm. Linear functions. Eigenvalues and eigenvectors. Quadratic forms.

*Differential calculus for function of several variable and optimization*. Overview on differential calculus for several variable. The chain rule for the derivative of composite functions. Implicit functions. Concave/convex functions. Unconstrained and constrained optimization. Comparative statics and the envelope theorem.

*Elements of probability* *theory*. Probability spaces. Conditional probability and Bayes rule. Uniform spaces and basic combinatorial basic formulas. Discrete and continuous random variable. Cumulative distribution function and density. Mean, variance and covariance.

*Choices under uncertainty*. Lotteries. Preferences on lotteries. von-Neumann-Morgenstern axiomatization. Expected utility. Attitude towards risk. Certainty equivalent and risk premium. Absolute and relative coefficient of risk aversion. First and second order stochastic dominance. Insurance contracts. Portfolio choice. The mean-variance model and introduction to CAPM.

***Statistics module*** (Prof Davide Zurlo).

*Software R*. Introduction to the use of software for statistical analysis R

*Linear regression*. Recalls of simple and multiple linear regression analysis. Least-squares estimator Analysis of residuals. Heteroschedasticity. Generalized least-squares estimator. Use of dichotomous explanatory variables.

*Regression with time series data* Introduction to time series data. Autocorrelation. Autoregressive models. Models with distributed lags. ARDL models.

*Regressions with qualitative dependent* variables logit and probit models for binary dependent variables, multinomial logit models for multiple choice dependent variables.

***READING LIST***

***Mathematics module***

Lecture notes available on the e-learning platform Blackboard. Further readings are:

1. Bianchi, M., G. Messineo, *Appunti di matematica per l’analisi economica*, Giappichelli, 2021.
2. Baldi, P., *Introduzione alla probabilità con elementi di statistica*, McGraw-Hill, 2003.
3. Huang, C., Litzenberger, R., *Foundations of Financial Economics*, Prentice Hall, 1998.

***Statistics module***

Lecture notes available on the e-learning platform Blackboard. Further readings are:

1. Carter Hill, Griffiths, W.E., Lim G.C., *Principles of Econometrics*, Wiley, 2018.

***TEACHING METHOD***

Face-to-face lectures.

***ASSESSMENT METHOD AND CRITERIA***

Written examination, one for each module, where students are required to answer theory questions and solve numerical problems. Furthermore, for the statistics module there is an additional examination which consist in estimating a statistical model using R.

The two examination modules may be taken during different sessions, providing they are in the same academic year, otherwise the pass result will no longer be deemed valid.

Further information regarding the examination will be provided at the beginning of the course and posted on the *Blackboard* platform.

***NOTES AND PREREQUISITES***

Knowledge of the contents of the basic courses in Calculus and Statistics of a three-year degree course in economics is useful for successful attendance of the course.

The first six weeks of the course will be devoted to the mathematics module, the following six, after the mid-term tests, will be devoted to statistics.

The online *Blackboard* platform will be used to distribute course material, announce marks and provide information regarding the course.

***TEACHER OFFICE HOURS***

Michele Longo receives students, upon request for an appointment via e-mail, in person, on Mondays at 11.00 a.m. at office 553 (3rd floor), or, remotely, by agreeing on the timetable.

Davide Zurlo receives students, upon request for an appointment via e-mail, in person, on Wednesday, at the end of the lesson, or, remotely, by agreeing on the timetable.