UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

SYLLABUS DEL CORSO

Computational Finance and Financial Econometrics

2627-2-F8206B026-F8206B026-2

Learning objectives

A statistician specializing in finance must master not only the theoretical aspects of the discipline but also develop computational and data-analytic skills to apply the theory to data.

The objective of this module is to illustrate the typical features (stylized facts) of financial data and the statistical/econometric models that effectively capture these features, and to make students familiar with the fundamental aspects of computational finance, such as Monte Carlo pricing and dynamic portfolio construction, which allow them to become operational in many real-world situations.

The Computational Finance and Financial Econometrics module completes the statistical and financial training of students in the Insurance and Financial Markets (MAF) track, making the acquired or ongoing theoretical knowledge operational.

The course belongs to the Applied Statistics learning area and contributes to the program's (CdS) educational goals by providing solid knowledge of statistical methodology with a particular focus on computational aspects in the financial field.

Upon completion of the module, the expected learning outcomes are as follows, structured according to the Dublin Descriptors (DdD).

Knowledge and understanding (DdD 1): Students will know the stylized facts of financial data, uni- and multivariate volatility models, estimation methods for large covariance matrices to build optimal portfolios, and the principles of Monte Carlo simulation for derivative pricing.

Applying knowledge and understanding (DdD 2): Students will be able to use the R language at an advanced level to implement complex algorithms and solve real-world financial problems through coding.

Making judgements (DdD 3): Students will be able to critically analyze the results of econometric models, assessing their accuracy and consistency with respect to the stated objectives

Communication skills (DdD 4): Students will acquire the ability to communicate analysis results to industry experts using appropriate technical language.

Learning skills (DdD 5): Students will develop the skills necessary to independently explore new models and computational procedures essential for professional roles such as financial statisticians and data analysts
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Contents

Advanced R.

Working with financial data and assessing their empirical properties.

Uni- and multivariate GARCH models for portfolio management and derivative pricing.

Estimating large covariance matrices with applications to portfolio management.

Monte Carlo simulation for derivative pricing.

Detailed program

- Advanced R
- Definition of the main financial assets and contracts
- Stylized facts of financial prices and returns
- Univariate GARCH models
- Multivariate GARCH models
- Large covariance matrix estimation
- Monte Carlo and Bootstrap
- Simulation of univariate (geometric) Brownian motions
- Simulation of multivariate (geometric) Brownian motions
- Using the fundamental theorem of asset pricing for approximating the value of derivative contracts
- Possible extensions (GARCH asset pricing, jump-diffusion, yield curve)

Prerequisites

Working knowledge of R, matrix algebra, descriptive, inferential, multivariate statistics, and time series analysis.

Teaching methods

All lessons take place in a computer laboratory. Theoretical topics are immediately illustrated through practical examples by writing R code to solve real financial problems. Lessons are accompanied by exercises based on real-world data and problems.

Lab sessions last two or three hours, for a total of 42 hours. The instructor actively involves students in implementing solutions in the R language, which operationalize the theoretical concepts covered in this module and in the Mathematical Finance and Risk Management courses.

In accordance with the teaching taxonomy, approximately 50% of the hours (21 hours) consist of **Delivery-based teaching** (explanation of methods and procedures) and the remaining 50% (21 hours) consist of **Interactive teaching** (joint code development to solve the proposed quantitative financial problems).

No remote teaching is provided.
The course is taught in **English**.

Assessment methods

The exam takes place in a computer laboratory, where students are required to solve a real-world problem by writing R code. The exam, usually held immediately after the Risk Management exam, lasts one hour and should preferably, but not necessarily, be taken in the same exam session as Risk Management (preparing both modules together enhances your learning of the subject). If one of the two modules is not passed, the grade for the passed module will be retained until the other module is successfully completed.

Numerous past exam papers and, occasionally, their solutions are made available on the module's e-learning page. There is no oral exam, except upon the student's request solely for the purpose of discussing errors made during the computer-based test.

The final grade for Risk Management M is calculated as the rounded arithmetic mean of the grades for Risk Management and Computational Finance and Financial Econometrics.

Assessed skills: financial problem-solving through the implementation of statistical methods and code writing (R).

Evaluation and grading criteria: the exam paper requires students to apply econometric techniques and provide pricing for complex financial contracts. Both parts carry equal weight in the final assessment.

In-itinere tests: There are no mid-term tests; however, the instructor may invite attending students to solve optional problems at home, which may lead to an increase in the final grade.

Textbooks and Reading Materials

- Lecturer's notes available in the e-learning platform.
- Wickham (2015) *Advanced R*. CRC Press. First 7 chapters. Available also on-line: http://adv-r.had.co.nz/
- Remillard (2013) *Statistical Methods for Financial Engineering*, Chapman and Hall/CRC. https://doi.org/10.1201/b14285
- Iacus (2008) *Simulation and Inference for Stochastic Differential Equations: With R Examples*. Springer. Only the first chapter. The volume can be downloaded under unimib network at https://link.springer.com/

Semester

2nd term (November - January). Notice that we adopt a four terms organization of the academic year.

Teaching language

English

Sustainable Development Goals

QUALITY EDUCATION | DECENT WORK AND ECONOMIC GROWTH | INDUSTRY, INNOVATION AND INFRASTRUCTURE