UNIVERSITÀ CATTOLICA del Sacro Cuore

Applied statistics for finance

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Course aims and intended learning outcomes

The course aims at introducing statistical techniques and models widely used in Finance in general, but with particular focus on option pricing. In the course different types of options will be introduced and, for each of these, the specific complexities that modelling such derivatives entail will be analysed.

Part of the course is dedicated to the introduction of stochastic processes which can be used to model stock prices and consequently to the problem of calibration of such stochastic models from financial data using estimation methods such as maximum likelihood estimation, method of moments and least squares method.

The course will then provide an in depth overview of numerical methods for option pricing like Monte Carlo and finite difference methods. The last part of the course is dedicated to the introduction of Multi-Asset options which, being based on more than one underlying asset, generate the further issue of modelling the dependence structure between such underlying assets: for such purpose methods based on the use of a linear correlation coefficient, factor models and copulae will be introduced. The presentation of each topic will be accompanied by a demonstration on how to compute each problem through the use of the R statistical environment.

By the end of the course students are expected to be able to understand the complexities that evaluating different derivatives entail and to comprehend which model grants the most accurate results, based on the specific characteristics of the financial product that they have to evaluate. Students are also expected to be able to use R to set the specific problems and to reach numerical results.

Course content

- Random number generation and variance reduction techniques.
- Calibration and estimation of financial models from the data using method of moments, maximum likelihood estimation and least squares method.
- The main stochastic processes used to model stock prices in finance, such as the Geometric Brownian motion and Lévy processes.
- Girsanov theorem and the risk neutral transformation (Esscher transform).
- Introduction to stochastic calculus (Ito's lemma and quotient rule, multiplicative rule, Radon-Nikodym derivative, Girsanov kernel etc.) and derivation of the Black and Scholes formula and of Margrabe's formula.
- Monte Carlo methods with applications to (European, American and Multi-Asset) option pricing.
- Fast Fourier transform method with applications to European option pricing under different stochastic processes.
- Finite difference methods with applications to American option pricing.
- Multi-Asset options: how to capture the dependence between the multiple underlying assets using a linear correlation coefficient, copula methods and factor models. Both under the assumption of stock prices following a Geometric Brownian motion and Lévy processes.
- The course is highly focused on the use of the R statistical environment

Reading list

Slides and laboratory handouts will be distributed during the course and I will refer to some textbooks. These are references that are supportive information but are not required to follow:

Stefano M. Iacus (2008), Simulation and Inference for Stochastic Differential Equations with R Examples, Springer New York.
Stefano M. Iacus (2011), Option Pricing and Estimation of Financial Models with R, Wiley & Sons, Chichester.

Teaching method

Lectures with computer labs and classes.

Assessment method and criteria

Final report on real analysis for financial data.

Notes and prerequisites

Students are expected to have impeccable knowledge of basic statistics, such as discrete and continuous random variables, the main families of distributions and properties of distributions (density functions, probability mass functions, cumulative distribution functions, moment generation functions, characteristic functions etc.). They are expected to have a basic understanding of parameters' estimation methods, such as method of moments, maximum likelihood and least squares method. Basic knowledge of derivatives pricing (such as the payoff of the most common options, the Geometric Brownian motion, Ito's Lemma, Black & Scholes method and MonteCarlo simulations) is also required.