Mathématical finance speciality

ECTS credits
8 credits

Semester
Spring

Presentation

Prerequisites

* Content of the course unit Finance in the DDEFi track (see syllabus)
* Probabillity at Master level (1st year): theory of probability and it is recommended to have knowledge about stochastics processes in discrete or continuous time.

Learning objectives

* Apply stochastic calculus to price financial products such as options.
* Learn the standard models used in mathematical finance.
* Know the basic data science models and their usage

Description of the programme

This course unit consists of three courses (of 24 hours each): Stochastic calculus, Interest rate models, and Volatility modeling, 24h each and is complemented by the third part of the data project (9 hours course and 12 hours project) devoted to models and their validation.

Stochastic calculus

1. Gaussian variable and stochastic processes
2. Brownian motions
3. Stochastic integration and semi-martingales
4. Stochastic differential equations
5. Parabolic partial differential equations and semigroups
6. Measure change and Girsanov theoremIntroduction to financial mathematics

Interest rate models

1. A Mathematical Toolkit

2. Interest rates, swaps and options
3. One-factor Short-Rates Models
4. Two-factor Short-Rates Models
5. The Health-Jarrow-Morton (HJM) Model
6. The change of numeraire
7. Derivatives Pricing under the Libor Market Model

Volatility models

1. Elementary financial mathematics notions
2. PDE: Black Scholes and risk neutral measure
3. Dupire's local volatility: advantages and drawbacks
4. Stochastic volatility (Heston and SABR)
5. Tutorial: discretization of the Heston's model

Data science projects. Part 3: Models and validation

1. Projects and models
   i. The Bias-Variance tradeoff
   ii. Feature Selection
   iii. Feature Engineering
   iv. Defining a metric
2. Models and applications
   i. Regressions (linear, polynomial, penalized et logistic)
   ii. Decision trees (random forest and gradient boosting)
3. Focus on Natural Language Processing (NLP)

Generic central skills and knowledge targeted in the discipline

* Understand stochastic calculus and know how to apply its main results
* Know how to apply stochastic methods to price financial products
* Understand the mathematical contexts under which the classical financial mathematics models hold
* Know and understand the relevance and limits of financial mathematics models
* Understand the impact of volatility on the profit and losses of a hedged position
* Know how to build numerical methods for pricing financial products
* Know how to use data science models (Natural Language Processing in particular) in business projects.

How knowledge is tested

* Stochastic calculus (written exam): 25%
* Interest rate models (project): 25%

* Volatility models (project): 25%
* Data project (project): 25%

Bibliography

Stochastic calculus

* Evans, L. (2010). An Introduction to Stochastic Differential Equation. American Mathematical Society.
* Le Gall, J.-F. (2006). Intégration, Probabilités et Processus Aléatoires. Ecole Normale Supérieure de Paris

Interest rate models

* Brigo, D., & Mercurio, F. (2007). Interest rate models-theory and practice: with smile, inflation and credit. Springer Science & Business Media
* Privault, N. (2012). An elementary introduction to stochastic interest rate modeling. World Scientific.

Volatility models

* El Karoui, N. (2004) Couverture des risques dans les marchés financiers. Ecole Polytechnique

Data science projects

* Zeng, A and Casari, A. Feature Engineering for Machine Learning. O'Reilly Media.
* Müller, A. and Guido, S. Introduction to Machine Learning with Python. O'Reilly Media.

Teaching team

* Stochastic calculus: Sébastien Darses (Aix-Marseille Université)
* Interest rate models: Abderrahim Ben Jazia (RSM Paris)
* Volatility models: Ismail Akil (Morgan Stanley)
* Data science projects: Alexandre Chirié et Maxilimilen Défourné (Mantiks)

Sustainable Development Goal

Partnerships for the goals

Total des heures **100h**

CM	Master class	81h
PJ		19h