6 ECTS

15F020

Pricing Financial Derivatives

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Introduction

This course gives an introduction to one of the branches of finance that requires advanced quantitative techniques which is derivatives pricing. Taking observed market prices as input we will introduce and use the mathematical tool of stochastic calculus to obtain the corresponding value of derivatives of the stock. The fundamental theorem of arbitrage-free pricing is one of the key theorems while the Black-Scholes formula is one of the key models. We will also see how this theory extends to stochastic interest rates.

Objectives

The main purpose of this course is to introduce the machinery of stochastic calculus and show how it can be applied to solve the problem of pricing and hedging financial derivatives on continuous and discrete time models, such as options, futures and forwards contracts. By the end of the course, students will have good knowledge of how these products work, how are they used, how are they priced and how financial institutions hedge their risks when they trade the products.

Required Background Knowledge

The students are expected to have taken during their studies a basic Probability and Statistics course. Therefore, we expect them to be familiar with the basic concepts of Probability such as probability space, random variables, distribution of a random variable and common discrete and continuous distributions such as Normal, Poisson etc., and expectations. However, all these concepts will be revised during the course.

Learning Outcomes

By the end of the course, the students will be able to use the machinery of stochastic calculus, and be capable to evaluate the price of current financial derivatives and construct the hedging portfolio. Practitioners from banks will be invited to give seminars to students.

Methodology

Slides containing all the material will be exposed in class and completed with explanations in the white board. There will b list of exercises for each chapter that will be solved during the TA sessions.

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Evaluation

Homework assignments (30%) and final exam (70%). There will be 3 homework assignments, that will contain numerical exercises to be done using Matlab, that will essentially be simulations of stochastic processes and prices, and some theoretical exercises. The homework assignments are done in groups of 2 or 3 students. Each homework will count as 10% of the final grade. The final exam will contain theoretical exercises similar to those handled during the TA classes.

Course contents

Chapter I: Introduction to probability and discrete-time financial models: Discrete-time martingales, Cox-Ross and Rubinstein model.

Chapter II: Stochastic calculus for financial models: Brownian motion, Itô's integral, Itô's formula, Stochastic differential equations, Feynman-Kac formula, Black and Scholes model, Girsanov's theorem, risk-neutral measure, martingale representation theorem.

Chapter III: Pricing and hedging derivatives in continuous time: Arbitrage pricing and hedging theory, fundamental theorems of asset pricing, pricing vanilla and exotic options, computation of greeks, numerical methods.

Chapter IV: Interest rate continuous-time models: Change of numeraire, forward and futures, term-structure models, affine term structures, forward rate models, Heath-Jarrow-Morton model, LIBOR market models, caps and caplets pricing, interest rate swaps.

Specify a description, materials and cases that will be worked in class:

Session	Title, materials and cases
1	Introduction and Probability basics
2	Discrete-time martingales and Binomial model
3	Portfolio strategies and arbitrage in discrete-time
4	Pricing and hedging under the Binomial model
5	Continuous-time stochastic processes and martingales
6	Brownian motion
7-8	Stochastic Itô's calculus
9	Portfolio strategies and arbitrage in continuous-time
10	Pricing and hedging under the Black-Scholes model
11	The fundamental equation of hedge pricing
12	Examples of option pricing
13	Greeks and Delta hedging

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14	Pricing and hedging exotic options
15	Pricing coupon bonds
16	Affine short rate models
17	Forward rate models
18	Libor market models
19	Pricing caps and caplets
20	Pricing swaps

Bibliography

Shreve S.E. Stochastic Calculus for Finance I and II, Springer Finance Textbook, 2004
Björk, T. Arbitrage Theory in Continuous Time, Oxford Finance Series, 2009.

Professor's Biography

Eulalia Nualart has a Tenured Associate Professor position at the Department of Economics of the University Pompeu Fabra since 2012. Before she had a permanent research and teaching position at the Department of Mathematics of the University of Paris 13, after doing a PostDoc at the University of Paris 6, with a research fellowship from the National Swiss Foundation. She earned her PhD in Probability from the École Polytechnique Fédérale de Lausanne in 2002. She broadly works in the field of stochastic analysis and its applications to stochastic differential equations and stochastic partial differential equations.