Mathematical Finance and Complex derivatives

MAE, Module 4, 2020-2021

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Course information

Course Website: https://my.nes.ru

Instructor's Office Hours: by assignment

TAs: Margarita Shiian

Course description

The course can be considered as a continuation of a Derivative course with the goal to provide training in financial mathematics, pricing complex derivatives and numerical methods. The first part of the course is the theoretical introduction to stochastic calculus and asset pricing based on equivalent martingale measure approach. The second part is various applications for complex derivatives and structured products pricing. The material is mostly based on Hull "Options, Futures, and Other Derivatives" textbook (the second part of the book).

Course requirements, grading, and attendance policies

Prerequisites:

1. Derivatives
2. Probability theory

Grading:

Homework 1	**20%**
Homework 2	**20%**
Project	**60%**

Software and tools: Jupyter notebook, Python

Course contents

- Stochastic calculus
  - Stochastic and Diffusion processes
  - Ito's Stochastic Calculus
  - The Feynman-Kac formula

- Equivalent Martingale Measure
  - Market price of the risk
  - Choice of numeraire
  - Girsanov theorem
  - Siegel's paradox
  - Multi asset case

- Multi-asset derivatives
  - Modelling correlation between financial assets
  - Quanto. Application: Hedging risk exposure of oil company

- Monte Carlo (MC) simulation
  - Principles of Monte Carlo
  - Pricing Derivatives by MC
  - Variance Reduction
  - Applications: Derivatives pricing

- Path-dependent options on one asset
  - Asian options
  - Barrier options

- Option on futures

- Models beyond Black-Scholes
  - Local volatility
  - Stochastic volatility
  - Models with jumps

- Fixed income Structured Products
  - Callable and putable bonds. Black's model.
  - Fixed Income structured notes. Range accrual and Step-up notes

- Credit Risk
  - Modeling Credit Risk. Default Probabilities.
  - Credit derivatives. Credit Default swap (CDS). Credit Linked note (CLN).
  - Modeling default correlations: the Gaussian Copula Model. First to default baskets.

- Interest rate models
  - Short rate models
  - LIBOR models
  - Interest rate derivatives

- Structured products (SP)
  - Capital protected
  - Yield enhancement
  - Exotic

Description of course methodology

- Lectures
- Homeworks

Sample tasks for course evaluation

Called Bond:
Consider a 5-year fixed rate bond with principle of $100 and coupon 4% per year payable semiannually. This bond is callable at 2-year time with a strike price of $100. Assuming that the quoted volatility for the forward yield over a period from 2 to 5 years is 20% and flat yield curve at 4% compounded continuously, compute the current price of the above callable bond.

Course materials

Textbooks and materials

- Lecture notes
- John Hull, “Options, Futures, and Other Derivatives”

Academic integrity policy

Cheating, plagiarism, and any other violations of academic ethics at NES are not tolerated.