Introduction to Quantitative Methods in Finance

The Erdös Institute

Summer 2025

Course Information

- **Instructor:** Thomas Polstra
- **Email:** thomaspolstra@gmail.com
- **Office Hours:** Wednesday 12:00-1:00 central time.
- **Class Dates:** May 13, 15, 20, 22, 27, 29 , June 3, 5, 10, 12, 17, 19
- **Class Time:** 1:00-2:30 central time

Course Overview

The Introduction to Quantitative Methods in Finance course is designed to provide participants with a solid grasp of fundamental probabilistic techniques applied in financial markets. With a specific focus on Black-Scholes modeling of European options, the course capitalizes on the availability of closed-form solutions for European option expected values. This facet not only facilitates the evaluation of model predictions but also underscores the practical relevance of the concepts covered.

Course Description

This course delves into the application of mathematical principles in the domain of finance through Python.

The curriculum commences with an overview of probability theory and probabilistic measurement techniques. Moving forward, the course delves into the mathematical foundation of stock movements as Brownian motions. The concept of volatility is examined, enabling participants to model and predict market fluctuations.

The course then shifts its focus to option trading, covering European options and introducing the Black-Scholes model. Risk management of option strategies are introduced through the study of the Greeks – delta, gamma, theta, vega, and rho – which quantify option price sensitivity. The technique of delta hedging is thoroughly dissected as a means to manage risk exposure in practical trading scenarios and to create expected profit distributions that are more favorable to the investor and reduce a portfolio's risk.

Monte Carlo simulation is introduced as a tool for option pricing and risk assessment. Participants will be introduced to how to utilize this computational method effectively and efficiently through vectorized code, with an additional emphasis on control variates to enhance accuracy. The course proceeds to explore binomial trees as an approach for option pricing and decision-making. Participants will learn about backtesting strategies using historical data to validate a strategy's efficacy.

This course is tailored for individuals transitioning to roles within quantitative finance and offers a pragmatic blend of theoretical insights and hands-on problem-solving exercises through Python. It equips participants with introductory methods used in financial markets.

Student Learning Outcomes

By the end of this course, students will be able to:

- Use probabilistic to predict stock movement volatility using historical data.
- Use volatility predictions to evaluate a portfolio's value at risk and to price European option contracts using Monte-Carlo and binomial tree methodology.
- Create accurate European option price predictions by enhancing Monte-Carlo simulations through the use of control variates. Accuracy will be measured against closed-form solutions to option contracts provided by Black-Scholes option pricing equations.
- Adjust Monte-Carlo simulations of European contracts for the purpose of pricing more complicated option contracts whose expected value does not have a closed form solutions. Such option contracts may include American, Asian, lookback, and barrier option contracts.
- Develop hedging strategies which minimize risk and improve expected profit distributions of an option investment strategy.
- Backtest a trading strategy using historical stock prices.

Course Project

There will be regular assignments throughout the course. At the end of the course, you will submit certain assignments to receive a certificate of completion.

Course Topics

1. Probability Theory and Probabilistic Methodology

2. Times Series and Stock Movements
3. Volatility and Value at Risk
4. European Options and a Black-Scholes World
5. Delta Hedging
6. Monte-Carlo Simulations, Expected Profit Distributions, and Control Variates

Disclaimer

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