Euncet Business School

centro adscrito a:

UNIVERSITAT POLITÈCNICA DE CATALUNYA BARCELONATECH

TEACHING GUIDE BLACK-SHOLES ENVIRONMENT AND DERIVATIVE INSTRUMENTS 2025-26

GENERAL DATA

Name:	Black-Scholes environment and derivative instruments
Code:	
Course:	2025-26
Titration:	Master's Degree in Financial Innovation and Fintech
Number of credits (ECTS):	5
Location in the curriculum:	1st Course, 1st Semester
Department:	
Head of department:	
Date of last revision:	March 2025
Teaching staff:	Josep Masdemont, Jordi Planagumà, Bru Martinell, Luís Ortiz

1 OVERVIEW

The subject "Black-Scholes Environment and Derivative Instruments" provides a detailed introduction to the quantitative techniques essential for understanding and valuing products in financial derivatives markets, as well as for risk management and investment optimization. The course covers everything from the fundamental concepts of forwards, options and swaps to their valuation using arbitrage principles and numerical methodology. Hedging strategies, the interaction between derivatives and spot markets, and the role of volatility in price determination are also examined.

Discrete models are presented through binomial trees and continuous models based on mathematical tools such as Brownian motion, the Itô formula and the Black-Scholes equation. In addition, numerical techniques are introduced, including Monte Carlo trees and simulations, essential for the assessment of these instruments. The course also addresses fixed income derivatives and interest rates, with a particular focus on the construction of yield curves and the valuation of bonds and futures on interest rates.

The subject also incorporates practical applications in derivatives valuation, hedging strategies and hybrid products, allowing students to develop quantitative skills to analyse and trade in complex financial markets, providing an applied approach to the modelling and analysis of derivative instruments in the current financial context.

2 OBJECTIVES

- Understand the nature and functioning of financial derivatives, including forwards, options and swaps, as well as their role in financial markets.

- Learn arbitrage principles and valuation techniques to determine the theoretical price of derivative instruments.

- Analyze hedging and arbitrage strategies, differentiating their applications in risk management and investment optimization.

- Understand the relationship between derivatives markets and spot markets, as well as the influence of volatility on price formation.

- Know discrete and continuous models for the valuation of derivatives, as well as the Black-Scholes equation and its implications.

- Know how to implement numerical methods based on binomial trees, as well as Monte Carlo simulations based on Brownian motion.

- Know how fixed income and interest rate derivatives work, including the construction of yield curves and the valuation of bonds and futures on interest rates.

- Assess the complexity of hybrid and structured products, combining derivatives with fixed income and equity assets.

- Apply quantitative tools in real financial environments to design investment strategies and risk management.

3 LEARNING OUTCOMES

At the end of the course, the student will be able to:

K2.1: Define investment and financing strategies that are efficient in terms of risk and return, taking into account the new technological and sustainability (ESG) paradigms.

K2.2: Distinguish the different financial products and markets by the levels of risk, profitability and sustainability.

S1.1: Communicate effectively orally, in writing and graphically with other people about learning, thinking and decision-making, and participate in debates, making use of interpersonal skills, such as active listening and empathy, which favour teamwork.

S2.1: Develop the capacity to contribute to innovation in new or existing business institutions and organizations, through participation in creative projects and have the ability to apply skills and knowledge on technology-based business sales, organization and development.

S3.1: Understand advanced digital technologies, so that they can be applied with a critical perspective, in diverse contexts, in academic, professional, social or personal situations.

S5.1: Plan investment portfolios, following diversification theories, fixed-income products, equities, hybrids and sustainable products that take into account returns, different levels of risk and ethical and sustainability criteria.

S5.2: Compare traditional investment systems with alternative systems such as robo-advisors, investment in EFTs, Vanguard funds and sustainable finance.

C1.1: Integrate the values of sustainability, understanding the complexity of systems, in order to undertake or promote actions that restore and maintain the health of ecosystems and improve justice, generating diverse visions for sustainable futures.

C2.1: Identify and analyse problems that require autonomous, informed and reasoned decision-making, in order to act with social responsibility, in accordance with ethical values and principles.

C3.1: Develop the capacity to assess gender and gender inequalities and to design solutions.

C6.2: Implement financial strategies that support business objectives and take into account the advances in digitalisation and new technologies that are breaking into the financial sector.

C7.2: Apply data analysis techniques, artificial intelligence, and machine learning fundamentals to analyze and predict trends in financial markets and inform decision-making in technology investment management and business finance.

We can highlight:

- Understand and apply the fundamental techniques of financial derivatives markets.
- Value forwards, options and swaps using arbitrage techniques and quantitative models.

- Analyze hedging and arbitrage strategies for financial risk management.
- Assess the relationship between derivatives and spot markets, as well as the impact of volatility on price formation.
- Implement discrete models, using binomial trees, and continuous models using Brownian motion and Monte Carlo methodologies as well as using the Black-Scholes equation in the valuation of derivatives.
- Valuing fixed income derivatives and interest rates, as well as implementing interest rate curves and analysing hedging strategies in these markets.
- Differentiate between hybrid and structured products, understanding their use in investment strategies and risk management.
- Apply quantitative tools to design financial strategies in real market environments.
- Identify opportunities and risks in the use of derivatives within portfolio management and investment optimization.

4 CONTENTS

TOPIC 1. Introduction to Financial Derivatives and Arbitrage

Specific learning outcomes:

- Differentiate and describe the main derivative instruments by understanding their characteristics and markets.
- Apply basic strategies with options and assess the complexity of derivative products.
- Calculate implied volatility and perform basic options valuations using arbitrage concepts and elementary numerical implementations**.**

Contents

1.1. Definition and examples of derivatives: Forwards, Options and Swaps.
1.2. Characteristics and markets of derivatives.
1.3. Relationship between derivatives and spot markets.
1.4. Basic strategies with options and complexity of the products.
1.5. Concept of arbitration and valuations.
1.6. Implied volatility and option prices.
1.7. Basic numerical implementations.

TOPIC 2. Discrete Models and Trees

Specific learning outcomes:

- Understand the probabilistic foundations associated with derivatives valuation.
- Implement binomial trees for the evaluation of options.

Contents

2.1. Probabilistic foundations. Hope neutral risk.
2.2. Binomial branch and binomial trees.
2.3. Numerical applications. Valuations of vanilla, barrier and American options.

TOPIC 3. Continuous Models

Specific learning outcomes:

- Acquire basic notions of stochastic calculus and understand Itô's formula .
- Understand the derivatives valuation process and the meaning of the Black-Scholes equation.
- Evaluate theoretical prices of options using Monte Carlo.

Contents

3.1. Brownian motion, stochastic calculus and Itô's formula.
3.2. Price modelling.
3.3. Self-funded portfolio and valuation formula.
3.4. The Black-Scholes equation.
3.5. Monte Carlo methods and numerical assessments.

TOPIC 4. Fixed income instruments and interest rate derivatives

Specific learning outcomes:

- Understand the construction and application of interest rate curves and their use in the valuation of financial instruments.
- Analyze the characteristics and valuation methods of bonds and RF instruments.
- Evaluate the operation of interest rate derivatives.

Contents

4.1. Introduction to interest rate curves and discount factors.
4.2. Bonds: rating and characteristics.
4.3. Futures and options on bonds and interest rates.

TOPIC 5. Valuations and practical applications

Specific learning outcomes:

- Apply methods to extract and construct interest rate curves.
- Valuing and calculating zero-coupon rates from interest rate derivatives.
- Analyze hybrid products.
- Apply hedging strategies.

Contents

5.1. Methods for extracting interest rate curves from market data.
5.2. Valuation and calculation of zero-coupon rates with interest rate derivatives.
5.3. Hybrid and structured products: combination of derivatives and fixed/variable income.
5.4. Hedging strategies and practical applications.

5 METHODOLOGY

The methodology is based on participatory lectures complemented by the reading in advance of the different topics of the material previously published on the virtual campus. With the practices in class and the work at home, it is expected to reaffirm the concepts and procedures that have been presented in class.

The subject combines:

- Theoretical sessions with analysis of current case studies.
- Practical workshops on market analysis and financial products.

6 EVALUATION

In accordance with the Bologna Plan, the model rewards the constant and continuous effort of students.

40% of the grade is obtained from the continuous evaluation of the directed activities and the remaining 60% from the final face-to-face exam. The final exam has two sittings.

Distribution of continuous assessment (60%):

- Individual practical work: 40%
- Group project of specific content analysis: 40%
- Participation in discussions and case studies: 20%

Final exam (40%):

The exam will evaluate all units with the following approximate weighting:
- Topic 1: 20%
- Topic 2: 20%
- Item 3: 20%
- Item 4: 20%
- Item 5: 20%

7 BIBLIOGRAPHY

Basic:

- Baxter, M. y Rennie, A. (1996). *Financial Calculus: An Introduction to Derivative Pricing*. Cambridge University Press.
- D Brigo, Counterparty Credit Risk, Collateral and Funding: With Pricing Cases For All Asset Classes: (The Wiley Finance Series)
- Hull, J. C. (2017). *Options, Futures, and Other Derivatives* (10ª ed.). Pearson.
- Rouah, F. D. (2021). *Black-Scholes and Beyond: Option Pricing Models*. Wiley
- P Jorion Financial Risk Manager Handbook
- Robert E. Brooks, Don M. Chance (2024) , Foundations of the Pricing of Financial Derivatives: Theory and Analysis

Complementary:

- Schreve, S. (2005). *Stochastic Calculus for Finance I: The Binomial Asset Pricing Model*. Springer Finance.

- Schreve, S. (2004). *Stochastic Calculus for Finance II: Continuous-Time Models*. Springer Finance.
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Digital Resources:

- Bank for International Settlements (www.bis.org)
- Bloomberg Terminal (institutional access)
- ECB Statistical Data Warehouse (sdw.ecb.europa.eu)
- FRED Economic Data (fred.stlouisfed.org)
- International Monetary Fund (www.imf.org)
- The Financial Times (www.ft.com)
- World Economic Forum - Financial and Monetary Systems (www.weforum.org)