INTRODUCTION TO QUANTITATIVE FINANCE AND FINANCIAL RISK MANAGEMENT

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EDUCATIONAL AIM

The educational aim of the course is to provide an integrated overview of the basic financial instruments (securities and derivatives), the models of asset dynamics for different risk types (Equities, Interest Rates, FX & Credit) and, finally, the key techniques of identification, measurement and management of financial risk.

The course will begin by examining the basic financial instruments and associated fundamental concepts: time value of money, interest rates and fixed income securities; Simple derivatives: Futures, Forwards and Interest Rate Swaps; Options and the Black-Scholes framework.

The discussion will continue with a brief overview of statistical measures and error metrics of different distributions. We will proceed to examine risk measures such as Value at Risk (VaR) and Expected Shortfall; the three key methodologies for VaR calculation (historical, parametric and Monte Carlo simulation), their advantages, shortfalls and limitations will be discussed extensively.

Additionally, we will examine the formalism of credit risk and the Basel II capital requirements; finally, the course will conclude with a computer lab session in which participants will gain hands-on experience with Monte Carlo simulations, and will employ such techniques to find solutions to real-world risk management problems affecting the financial sector.

Participants should have some knowledge of differential calculus and linear algebra (matrix operations). However, we will be able to review in class all mathematical background as necessary.

Familiarity with Microsoft EXCEL or a statistical programming language is also essential.

There will be two assignments throughout the course, which will count for 20% of the grade each. The final exam will consist of multiple choice questions and a computer assignment; it will count for the remaining 60% of the grade.

TENTATIVE COURSE OUTLINE

- **LECTURE 1 – Interest Rates and Fixed Income Securities**
    - Time value of money
        - Net Present Value vs. Internal Rate of Return
    - Interest rate curve
        - Term structure of interest rates
        - Spot and forward rates
    - Fixed income securities
        - Price – Yield relationship
        - Sensitivity to risk: duration and convexity
        - The Floating Rate Note and Running Present Value

- **LECTURE 2 – Derivatives: Forwards, Futures and Interest Rate Swaps**
    - Futures and forwards
        - Arbitrage, parity and the determination of the forward price
        - Valuation of forward contracts
        - Futures, Counterparty Credit Risk and margin requirements
    - Interest Rate Futures and Forward Rate Agreements (FRAs)
    - Interest rate swaps (IRS)
        - Determining the swap rate
        - Swap valuation techniques
        - Forward swap rate

- **LECTURE 3 – Derivatives: Options and the Black-Scholes framework**
    - Options
        - Definition and basic characteristics
        - Sensitivities ("Greeks")
        - Basic option formulation: the replication argument
    - Statistical distributions and models of asset dynamics
        - Geometric Brownian motion and Ito process
        - The Black – Scholes framework

- **LECTURE 4 – Introduction to Risk Management**
    - Lessons from financial disasters
    - Brief history of risk metrics and risk management techniques
        - Introduction to different metrics: Value at Risk, Expected Shortfall, Potential Future Exposure
    - Real world asset dynamics
        - Volatility estimation from market data
        - GARCH and the "volatility of volatility"

- **LECTURE 5 – VaR: Historical simulation**
    - Advantages and disadvantages
    - Error estimation techniques
    - Refinements and improvements
        - Filtered historical simulation

- **LECTURE 6 – VaR: Parametric evaluation (I)**
    - Basic formulation and Matrix notation
    - Marginal, incremental and component VaR
    - Factor loadings
        - Single factor and the Diagonal model
        - Multifactor
        - Taylor Expansion

- **LECTURE 7 – VaR: Parametric evaluation (II)**
    - Generalized factor loading formulation
        - Factor loadings for selected securities and derivatives
    - Variance – covariance matrix
        - Examples of combined portfolios of securities and derivatives
        - Imperfect hedge and minimum variance hedge
    - Introduction to Principal Component analysis (PCA)
        - PCA in the movements of interest rate curves

- **LECTURE 8 – VaR: Monte Carlo simulation**
    - Value at risk: Monte Carlo simulation
        - Production of random numbers (single variable)
        - Production of vectors of correlated random numbers
            - Cholesky decomposition and shortcut methods
        - Advantages, disadvantages and limitations of Monte Carlo simulation
    - Monte Carlo applications in finance
        - Long term market simulations
            - Potential Future Exposure, derivative counterparty risk and credit risk mitigation agreements
        - Non-linear derivatives (options)
        - Hedge effectiveness

- **LECTURE 9 – Credit risk**

    - Credit instruments and asymmetric payoffs
    - Returns of credit portfolios
    - Modeling the credit event
        - Merton model
        - Credit-metrics approach
            - Transition matrices and credit VaR
        - Single factor model in credit portfolios
            - Basel II capital charges as a limiting case of single factor approach
    - Where market and credit risk intersect: Credit Valuation Adjustment

- **LECTURE 10 – Computer Lab**

    - Time series analysis of real-world data
    - Hands-on construction of Monte Carlo simulation
        - Single variable and multi-variable Monte Carlo
    - Error identification and measurement

ADDITIONAL REFERENCE READING MATERIAL

- John Hull, *Options, Futures and Other Derivatives,* Prentice – Hall.
- Philippe Jorion, *Value at Risk*, McGraw-Hill.
- Philippe Jorion, *Financial Risk Manager Handbook*, Wiley.
- Crouhy, Galai, Mark, *Risk Management*, McGraw-Hill.