

Lecture 5: Monte Carlo Methods and Applications

Lecture 5 Outline: Monte Carlo Methods and Applications

1. Introduction to Continuous Random Variables

- Brief recap of key concepts: continuous vs. discrete random variables, the normal distribution.

2. Lognormal Distribution

- Introduce the lognormal distribution, emphasizing its application in modeling stock prices.
- **Practical Exercise in R:** Simulate and visualize lognormal distributions and stock prices.

3. Monte Carlo Methods and Applications

- **Monte Carlo Simulation Basics:**
 - Introduce the concept of Monte Carlo simulations and their use cases in finance.
 - **R Example:** Simulate portfolio returns and estimate risk metrics (e.g., Value at Risk).
- **Optimizing Monte Carlo Simulations in R:**
 - Introduce key R tools and techniques for speeding up code:
 - * Vectorization.
 - * Parallel processing (e.g., using `future` package).
 - * Efficient data handling with `data.table`.
 - **Hands-on Exercise:** Compare a simple brute-force Monte Carlo simulation with an optimized version.

4. Risk Management Applications

- **Value at Risk (VaR):**
 - Expand on VaR calculations and their assumptions.
 - Discuss handling deviations from normality (e.g., fat tails, alternative distributions).
 - **Case Study:** Use Monte Carlo simulations to estimate VaR for a stock portfolio.

5. Estimation Issues and Real-World Data

- **Statistical Estimation Challenges:**
 - Discuss estimating expected returns, variance, and covariance from data.
 - Address practical issues like statistical noise.
 - **R Exercise:** Estimation techniques with real-world stock return data.

6. R Programming: Efficiency and Documentation

- **Optimizing Code in Practice:**
 - Introduce best practices for writing efficient and maintainable R code.
 - Tools for documenting code (**Roxygen2**), version control, and team collaboration.
 - **Exercise:** Develop a small, well-documented R function related to Monte Carlo simulations.

7. References and Further Study

- Allocate time at the end for additional resources, textbooks, and suggestions for further study in financial modeling and risk management.