Financial engineering

Aim

This course introduces the basic derivative contracts (forward/futures contracts and options) and their use in risk management. We discuss simple pricing models, laying down the foundation for more sophisticated approaches. Emphasis is placed on numerical pricing methods and their practical implementation in MATLAB, as well as on the discussion of real-life business cases.

Content

- *Deterministic optimization*.
  - Unconstrained optimization in the differentiable case and generalization to nonsmooth optimization.
  - Constrained optimization, Lagrange multipliers, Karush-Kuhn-Tucker conditions and their economic interpretation.
  - Model building in linear, mixed-integer, and nonlinear programming.
  - Convex optimization: cones and norm cones; dual norms and dual cones.
  - Applications: financial portfolio optimization and model calibration; statistical learning.
  - Numerical optimization.
- *Stochastic optimization.*
  - Stochastic linear programming with recourse.
  - Stochastic dynamic programming and reinforcement learning.
  - Robust optimization.
  - Applications to risk measures and asset pricing.
- Financial derivatives.
  - An introduction to linear and nonlinear derivatives.
  - Option pricing by BSM.
  - Use of derivatives in risk management. Discussion of AIFS and Pine Street business cases.
- Numerical methods in financial engineering.
  - Sample path generation for stochastic processes; stochastic and deterministic approaches to discretization.
  - Option pricing by lattices and trees.
  - Option pricing and risk measurement by Monte Carlo methods.
  - Variance reduction and low-discrepancy sequences.

Bibliography

- HBS Case 205026: Hedging currency risk at AIFS
- HBS Case 201071: Pine street capital
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- P. Brandimarte. *Handbook in Monte Carlo Simulation: Applications in Financial Engineering, Risk Management, and Economics*. Wiley, 2014.
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- S. Boyd, L. Vandenberghe. *Convex Optimization*. Cambridge University Press, 2004. The book pdf can be downloaded from http://www.stanford.edu/_boyd/cvxbook/
- G. Cornuejols, R. Tütüncü. *Optimization Methods in Finance*. Cambridge University Press, 2007.
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