Introduction to Algorithmic trading

AMRANI Ilias

Université de Paris Dauphine

Paris, September, 2025

Part I

Administrative and organisational details

Lecturer

- **AMRANI Ilias**
- IT Quant - Engineer
- Education: Télécom Bretagne - M2MO
- Algo Trading Experiences: Société Générale CIB - IT Quant - Algo Trading Desk, Aplo/Sheeld-Market - Responsible of the execution services, Independant Quantitative trader
- mail: ilias.amrani@dauphine.psl.eu, amraniilias19945@gmail.com

Evaluation

- 40% Research papers group presentation, November, 20 at 13:45
- 40% Final Exam or group project, November, 27 at 13:45
- 20% 10 min Quiz at the beginning of some sessions

Main topics of the lecture

- Session 1: Lecture introduction + assessment
- Sessions 2 -> 4: Python Refresher
- Session 5: Introduction + terminology + Labs
- Session 6: Execution, Liquidation and Market impact + Labs
- Session 7: Market liquidity + Labs
- Session 8: Market making, Low, medium and High frequency trading + Labs
- Session 9: Group presentation
- Session 10: Performance and risk metrics + Graded Project or Final Exam

The drive

https://drive.google.com/drive/folders/1TbVoNG1GPPIobIDJw3Y8cJBTo_3bFP-S?usp=sharing

Software requirements

- Python: https://drive.google.com/file/d/1vOSX3CfOFAf8F9z-VHClYOO7MXu0qQJe/view?usp=drive_link
- Jupyter Notebook:https://drive.google.com/file/d/1EnYmpPuFRKSyeEmHxm4RUnE3PTNEs5Tu/view?usp=drive_link
- Pycharm:https://drive.google.com/file/d/15X_UduSF4B5SwyY7xfpRCKq1IicAojYC/view?usp=drive_link
- Git: Optionnal

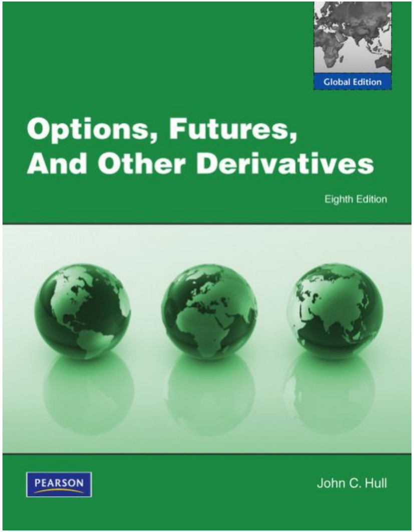
Github

https://github.com/amraniilias/BFA3-2025-2026

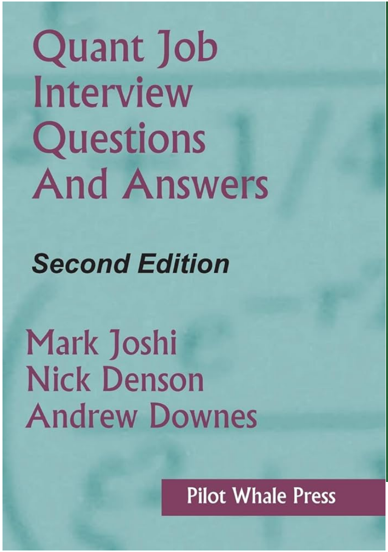
Part II

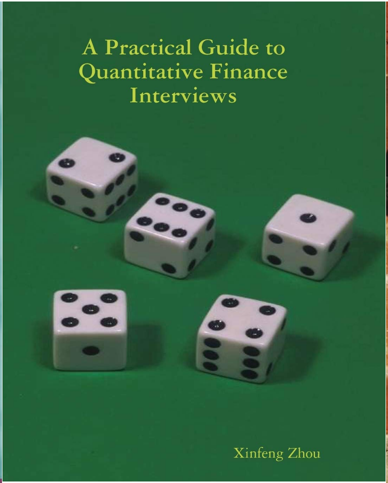
Extra

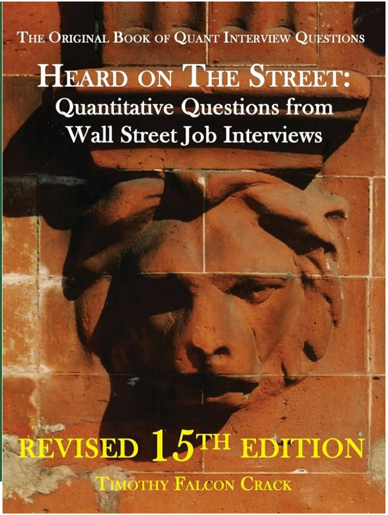
Interviews: broad finance knowledge (1/4)



Interviews Not only for quants (2/4)







Interviews: Buy side classics (3/4)

https://www.tradermath.org/

Interviews: Coding games (4/4)

https://leetcode.com/

Modeling in a nutshell

- **Problem Statement**
- **Axioms & Foundations** (probability, statistics, no-arbitrage)
- **Assumptions**
- **Model Specification**
- **Consequences & Results**
- **Limitations**
- **Extensions & Generalizations**

Problem Statement

Definition

Precisely formulate the question, objective, inputs, outputs, horizon, and success criteria. Clarify what will be optimized, predicted, or priced and which metrics will judge performance.

Black–Scholes example

Goal: determine the fair value at time $t = 0$ of a European call with strike K and maturity T on an underlying with spot S_0, continuously compounded risk-free rate r (and dividend yield q, if any).
Success criteria: a price consistent with no-arbitrage and a replicating trading strategy.

Axioms & Foundations

Definition

State the mathematical and economic principles: probability space $(\Omega, \mathcal{F}, \mathbb{P})$, filtration, Brownian motion, Itô calculus; market primitives; and no-arbitrage and market completeness under a risk-neutral measure $\mathbb{Q}$.

Black–Scholes example

Foundations: frictionless trading, continuous time, self-financing strategies, no-arbitrage; existence of $\mathbb{Q}$ such that discounted asset prices are martingales. Under $\mathbb{P}$,

$$dS_t = (\mu - q)\, S_t\, dt + \sigma S_t\, dW_t^{\mathbb{P}},$$

with constant $\sigma > 0$ and r (and dividend yield q).

Assumptions

Definition

List idealizations used to make the model tractable (distributional forms, independence, stationarity, constancy of parameters, market frictions ignored, trading frequency, information set).

Black–Scholes example

Assumptions: continuous trading; no transaction costs or bid–ask spreads; unlimited shorting and borrowing at rate r; lognormal S_t with *constant* volatility σ; no default or jumps; European exercise only; continuous dividend yield q (possibly $q = 0$).

Model Specification

Definition

Write the equations, parameters, and outputs explicitly; identify the measure (physical $\mathbb{P}$ or risk-neutral $\mathbb{Q}$); specify boundary/terminal conditions and the quantities to compute.

Black–Scholes example

Dynamics (under $\mathbb{Q}$): $dS_t = (r-q)S_t\,dt + \sigma S_t\,dW_t^{\mathbb{Q}}$.
Valuation target: call price $C(S,t)$ with terminal payoff $C(S,T) = (S-K)^+$.
PDE:

$$\partial_t C + \tfrac{1}{2}\sigma^2 S^2\,\partial_{SS} C + (r-q)S\,\partial_S C - r\,C = 0, \quad C(S,T) = (S-K)^+.$$

Equivalent risk-neutral expectation:

$$C_0 = e^{-rT}\,\mathbb{E}^{\mathbb{Q}}\big[(S_T-K)^+\big].$$

Consequences & Results

Definition

Derive prices, hedges, or policies implied by the model; obtain closed forms, numerical schemes, and calibration relationships; state theorems and corollaries that follow from the structure.

Black–Scholes example

Closed-form price (with dividend yield q):

$$C_0 = S_0 e^{-qT} N(d_1) - K e^{-rT} N(d_2), \quad d_1 = \frac{\ln(S_0/K) + (r - q + \frac{1}{2}\sigma^2)T}{\sigma\sqrt{T}}, \quad d_2 = d_1 - \sigma\sqrt{T}.$$

Hedging implication: delta $\Delta = \partial C/\partial S = e^{-qT} N(d_1)$ gives a replicating strategy.

Limitations

Definition

Identify mismatches with reality, regimes where assumptions fail, sensitivity to parameters, estimation error, numerical instability, and data/market frictions.

Black–Scholes example

Key issues: volatility is not constant (volatility smiles/skews); jumps and fat tails; discrete re-hedging and transaction costs; liquidity/market impact ignored; stochastic interest rates or dividends; model is European-only (no early exercise).

Extensions & Generalizations

Definition

Relax assumptions or enrich structure to improve realism while balancing tractability: new state variables, stochastic parameters, alternative dynamics, or market frictions.

Black–Scholes example

Examples: local volatility (Dupire) for smiles; stochastic volatility (Heston) for dynamics of σ_t; Merton jump-diffusion for jumps; transaction-cost models (e.g., Leland) or optimal execution; stochastic rates; American options via free-boundary PDEs; hybrid equity–rates–FX models.

Knowledge test