

Introduction to Quantitative Methods in Finance

Introduction to Quantitative Methods in Finance

Key concepts, tools, and applications for financial analysis and decision-making

1. What Are Quantitative Methods?

Aspect	Description
Definition	Use of mathematical, statistical, and computational techniques to model financial phenomena and support investment decisions.
Goal	Turn raw data into actionable insights: pricing, risk measurement, portfolio construction, forecasting, and strategy evaluation.
Typical Users	Financial analysts, risk managers, traders, portfolio managers, researchers, and fintech developers.

2. Core Building Blocks

2.1 Mathematics

Topic	Relevance in Finance
Calculus (differentiation & integration)	Deriving price sensitivities (Greeks), continuous-time models, optimal control.
Linear Algebra	Portfolio optimization, factor models, principal component analysis (PCA).
Probability Theory	Modeling uncertain outcomes, stochastic processes, risk measures.

2.2 Statistics & Econometrics

Technique	Typical Application
Descriptive statistics	Summarize returns, volatility, skewness, kurtosis.
Hypothesis testing	Validate trading signals, assess model performance.
Regression analysis	Estimate factor exposures, CAPM, Fama-French models.

Introduction to Quantitative Methods in Finance

Technique	Typical Application
Time-series analysis (ARIMA, GARCH)	Forecast returns & volatility, model conditional heteroskedasticity.
Panel data methods	Analyze cross-sectional and time dimensions simultaneously.

2.3 Computational Tools

Tool	Why It Matters
Programming languages (Python, R, MATLAB, Julia)	Rapid prototyping, data handling, numerical solvers.
Numerical libraries (NumPy, pandas, SciPy, statsmodels)	Efficient matrix operations, statistical functions.
Optimization solvers (CVXPY, Gurobi, CPLEX)	Solve large-scale portfolio and risk-budgeting problems.
Monte-Carlo simulation	Evaluate complex derivatives, assess tail risk, value-at-risk (VaR).
Machine learning frameworks (scikit-learn, TensorFlow, PyTorch)	Pattern recognition, predictive modeling, algorithmic trading.

3. Fundamental Quantitative Models

Model	Core Idea	Typical Use
Mean-Variance Optimization (Markowitz)	Minimize portfolio variance for a target expected return.	Asset allocation, efficient frontier construction.
Capital Asset Pricing Model (CAPM)	Expected return = risk-free + β · (market premium).	Estimating cost of equity, benchmarking.
Multi-Factor Models (Fama-French, Carhart)	Returns explained by several systematic factors (size, value, momentum, etc.).	Performance attribution, risk budgeting.
Black-Scholes-Merton (BSM) Option Pricing	Closed-form solution for European options under log-normal dynamics.	Pricing vanilla options, implied volatility extraction.
Binomial & Trinomial Trees	Discrete-time lattice for option valuation and early exercise features.	American options, convertible bonds.

Introduction to Quantitative Methods in

Model

Core Idea

Typical Use

Interest Rate Models

(Vasicek, CIR, Hull-White)

Finance
Stochastic evolution of short rates.

Bond pricing, interest rate derivatives.

Credit Risk Models (Merton,

Jarrow-Turnbull)

Default modeled