Quantitative Finance

Joel Hasbrouck

Topics

- What is quantitative finance?
- Where is it used? / Where are the jobs?
- Where are the courses? (and what are the courses?)

Terminology

- Quantitative finance
- Mathematical finance
- Financial engineering
- Computational finance
- All embrace/glorify/celebrate the role of "advanced" mathematics in applied finance.
  - advanced math = anything you might encounter in applied math after the freshman calculus course.
  - This includes: probability, statistics, linear algebra, differential equations, optimization, numerical analysis, artificial intelligence, etc.
  - But probably not: topology, differential geometry, advanced algebra, control theory.

FAQ: What is Stern's view of quantitative finance?

- All practical finance uses numbers. You have to be "numerate" at some basic level.
- Advanced mathematical methods are widely used in many aspects of practical finance.
- If an incoming MBA student has a technical undergraduate degree, and wishes to continue on a technical career trajectory, there are courses that would be interesting, challenging and possibly rewarding.
- But:
  - There are no well-defined career paths here.
  - There is no obvious circumscribed body of core competency.
  - There are trade-offs in becoming a specialist.

FAQ: Will quantitative finance courses help me to get/hold a job in finance?

- The trade-offs:
  - One more stat/math/finance course means one less management/marketing/accounting/etc. course.
  - While you are learning more about quantitative finance, you are learning less about other things.
  - As you learn more quantitative finance, you become more of a specialist.
- This may qualify you for some jobs; it may disqualify you for others.

FAQ: I majored in Comp. Lit. Should I go back and take undergraduate math courses?

- The gains from such study are unlikely to warrant the effort.
- Remember
  - Most (if not all) concepts in mathematical finance can be understood at levels ranging from the simple to the complex.
  - The closer you get to the customer and the customer's problems, the stronger the need to simplify and maintain a clear sense of the broad picture.

FAQ: As I enter the ranks of the finance profession, will ignorance of stochastic calculus mark me as an unworthy muggle lacking "the right stuff"?

- No. It's a big (professional) world.

The basics

- Theorem 1: Finance is an *applied* field.
  - Proof: {Journals: "finance" $\wedge$ "theoretical" $\subset$ title} $\approx \varnothing$
  - Corollary: Pure math, physics, chemistry, and molecular biology are beautiful. Finance is usually ugly.
- Theorem 2:
  {Jobs in finance: You are paid solely for solving math problems} $\approx \varnothing$
  - Proof: Just try it.
  - Corollary: Technical skills are not enough. Communication/presentation skills are crucial.
- Theorem 3:
  {Well-defined practical finance problems with closed-form solutions} $\approx \varnothing$
  - There is never a textbook answer to a finance problem (at least, not one that can be trusted). In any job you're likely to hold, you'll be paid mainly for exercising judgment. This is true in financial modeling of all sorts.

Math tools

- Basic skills
  - Probability (the mathematics of uncertainty)
  - Statistics (using data to draw inferences about parameters of probabilistic models)
  - Computer programming
    - Common analytical languages include: Matlab, C/C++, SAS, Mathematica, SQL
- Next: specific areas

Equity asset management

- Canonical problem: choose asset allocation weights to maximize expected return for a given level of risk.
- Tools
  - Time series analysis (statistics of time series) to analyze historical return data and forecast model parameters.
  - Multivariate statistics (linear regression, principal components, factor analysis) to model return dependencies
  - Constrained optimization (to determine weights)

Risk management

- Canonical problems:
  - What causes variability in the firm's income/net worth?
  - How do we measure this variability?
  - How do we hedge it?
- Tools
  - Advanced probability and statistics
  - Time series analysis (volatility forecasting)
  - Simulation methodologies

Proprietary and "stat arb" trading

- Canonical problems
  - What are the regularities in short-term asset returns?
  - How can we trade against them?
- Tools
  - Time series analysis
  - Artificial intelligence
  - Data mining
  - Advanced computer skills
    - Real time databases
    - OLAP (Online Analytic Processing)

Fixed income management

- Canonical problem: How do we maximize expected return on a bond portfolio subject to an investment objective?
- This typically involves dynamic modeling of
  - yield curve
  - prepayment behavior
  - default
- Tools
  - time series analysis
  - stochastic processes
  - optimization

Derivatives trading

- Typical problems: valuation of complex derivatives.
- Tools
  - advanced stochastic processes
  - numerical solutions to partial differential equations.

Equity trading

- Canonical problems:
  - How do we minimize the trading cost associated with portfolio management?
  - How do we design a trading system?
- Tools
  - Time series analysis *of very high-frequency data*
  - Advanced statistics
  - Dynamic optimization

Litigation support

- Typical problem
  - The management of XYZ withheld material information from SEC filings. What is the dollar amount of the damages?
- Tools
  - Statistics
  - Time series analysis

Advanced math is used less often* in . . .

- Financial statement analysis
- Taxation
- Mergers and acquisitions
- Venture capital
- Real estate

- *Note: “less often” >> “never”

FAQ: What degrees cover or span quantitative finance?

- MS in financial/computational math
  - Typically one year
  - All finance and math.
- MBA
- PhD
  - Typically five years.
  - Very specialized.
  - Can’t be justified by future salaries.

FAQ: Where might I find relevant courses?

- At Stern
  - Statistics
    - www.stern.nyu.edu/sor/dept.html
    - www.stern.nyu.edu/sor/ms_fineng.html
  - Information systems
    - www.stern.nyu.edu/is
  - Finance
    - www.stern.nyu.edu/fin/
- NYU outside of Stern
  - Courant Institute
    - www.cims.nyu.edu
    - Stochastic processes, numerical methods
  - Economics department
    - www.econ.nyu.edu
    - Econometrics

FAQ: What are some representative courses?

- Note: the following courses represent a sample of what's available. See school and departmental web pages for a full list.
- Statistics
  - Sequence based on core statistics course
    - Basic probability and statistics: *Statistics and data analysis (B01.1305)*
    - Time series analysis: *Forecasting time series data (B90.2302)*
    - *Regression and multivariate data analysis (B90.2301)*
    - *Applied stochastic processes for financial models (B90.2308)*
  - Advanced course substitutions
    - *Introduction to the theory of probability (B90.3301)*
    - *Statistical inference and regression analysis (B90.3302)*

- Finance
  - *B40.3332 Advanced Portfolio Analysis*
  - *B40.3333 Debt Instruments and Markets*
  - *B40.3335 Futures and Options*
  - *B40.3340 Advanced Futures and Options*
  - *Note: These courses do not require advanced math/stat prerequisites beyond the core. They cover areas in which advanced financial math is used.*
- Information Systems
  - *Data mining and knowledge systems B20.3336*
  - *Financial information systems B20.3350*
- Courant offerings
  - *G63.2791 DERIVATIVE SECURITIES*
  - *G63.2792 CONTINUOUS TIME FINANCE*

Final thoughts

- Whether or not you pursue quantitative finance at Stern, you will have other educational opportunities to pick up this stuff (courses, seminars, etc.) after Stern.
  - If you pursue quantitative finance as a career, you will have to keep educating yourself in order to stay current.
- Don't label yourself as a "quant"/"rocket scientist"/etc.
  - You want to be thought of as a portfolio manager / risk manager / treasurer / etc., who happens to have command of the cutting edge quantitative techniques.

