A Summer of Quantitative Analysis

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What Does A Quantitative Analyst Do?

A quant designs and implements mathematical models for the pricing of derivatives, assessment of risk, or predicting market movements.

There are several types of quant roles:
- Front Office
- Model Validating
- Research
- Developer

Who's Hiring?

- Commercial Banks
- Investment Banks
- Hedge Funds
- Software Companies
- Accountancy Firms

Morgan Stanley

• Morgan Stanley is consistently rated in the top 10 investment banks in the country based industry league tables

• Total revenue in 2013: $36 Billion

• Three branches

- Institutional Securities Group
  - Mergers and Acquisitions advising, restructurings, corporate lending
- Wealth Management
- Investment Management

What I Did

My group was a Research/ModelValidity/Development quant group

In a nutshell:

- Software Development and Usability Testing
  - Documentation
- Financial Model Reviews
- Some work Foreign Exchange

What is Risk?

There are two kind of risk

- Systemic Risk
    - Uncertainty that comes from the entire market or segment of market
    - Day-to-day fluctuations in price
    - Also called Volatility

- Unsystemic Risk
    - Uncertainty that comes from investing in a certain industry or company
    - Can be reduced with diversification

- Volatility is a measure of risk because it captures the behavior of the investment
- Volatility *is* the reason why you can make money investing

How can you calculate volatility?

A common measure of volatility is Beta, which can be calculated in two ways.

- Regression Analysis on asset returns vs. market returns
- Or with the formula
  - The returns from an asset
  - The market's return
- Used as part of the Capital Asset Pricing Model to find the expected returns of an asset

- rate of return of an investment with no risk of financial loss
  - Ex: Government bonds

What can we do with Beta?

The beta of an asset tells us how it moves with the market
- means that the price of an asset will be as volatile as the market
- \> 1 means that the price of an asset will be more volatile than the market
  - This is not necessarily a bad thing
- < 1 means that the price of an asset will be less volatile than the market

A higher beta value offers high returns, but at a higher risk

You can make the beta of a portfolio higher or lower through diversification.

Is the risk we're taking worth it?

There is a useful measure of risk-adjusted returns: the Sharpe Ratio

- return on a benchmark asset like the S&P 500
- asset return

• The greater the Sharpe Ratio, the better

• Can also be used to measure an investor's skill

- Higher returns, less risk

On Foreign Exchange

In terms of the volume of trading, the Foreign Exchange market is the largest and trades are made 24 a day except for weekends

- A change in the value of a single currency affects the entire market
  - Highly computerized trading systems

- Simplest trade is spot transaction
  - Buy or sell X amount of currency at the *current* exchange rate right now
- Forward Exchange Rate
  - Buy or sell X amount of currency at a specified exchange rate right now, but pay and deliver at a future date.

What kind of trades can I make?

An option is a contract that gives the owner the right to buy or sell an asset or instrument at a specified (strike price) on or before a specific time (the expiry date).

- American vs. European options – refers to when you can exercise an option
- A call option gives the owner the right to buy an asset/instrument and a put option gives the owner the right to sell

Long Trade

- Buy a certain quantity of an asset, hope the price goes up

Short Trade

- Borrow some quantity of an asset, sell it, hope price goes down, re-buy and give quantity back
- In theory, this can result in an infinite loss

An Example Quant Job Posting

"Successful quant candidates have traditionally been exceptionally talented students _at the top of their respective math, physics, engineering, and computer science programs_; a considerable number have also competed successfully in the United States and International Math Olympiads as well as the Putnam Competition. Members of our highly versatile technical staff possess the wide range of quantitative and programming abilities necessary to tackle challenging problems that are critical to the firm's continued success."

Education

- Undergraduate
    - Mathematics, Physics, Engineering, Computer Science
    - Minors/n^{th} Majors in Finance, Economics
- Graduate
    - MS in Mathematical Finance or any of the above
    - PhD in Mathematics, Physics, Statistics

As the Finance industry is becoming more and more mathematical, there is a high demand for qualified PhDs

Programming

- You *will* have to know how to program in order to become a quant.
- Some of the languages I saw used during the summer
  - C++, Java, Scala
  - Python, BASH, awk, sed
  - R   (MATLAB and Mathematica are good too)
  - MYSQL, SQLite
  - VBA and Excel Macros
- Linux skills are a plus
- C++ is an industry standard for implementing algorithms

Recommended Courses to Take/Audit

Mathematics

- Statistics: MAT 521-525-526
- Linear Algebra: MAT 531 and/or 532
- Differential Equations: MAT 414-517
- Numerical Analysis with Programming: MAT 581

Economics

- Basic Economics: ECN 203
- Macro/Microeconomics: ECN 302-311
- Game Theory and Economic Strategy: ECN 421
- Introduction to Money & Banking: ECN 481
- Economic Statistics and Econometric Methods: ECN 521-522

Recommended Courses (cont.)

Finance

- Essentials of Finance: FIN 301
- Investments: FIN 456
- Financial Modeling: FIN 461
- The Securities Market: FIN 465
- Financial Institutions and Portfolio Management: FIN 458
- Introduction to Derivatives: FIN

459 Computer Science

- Introduction to Computer Science: CIS 252
- Programming Languages: Theory and Practice : CIS 352
- Software Specification and Design: CIS 453
- Software Implementation: CIS 454

Getting an Internship

Financial Internships are notoriously hard to get, so it is important that you do your best to set yourself apart from the rest

- Participate in Mathematical competitions like Putnam and COMAP
- Build tools and applications that prove your quantitative/financial/programming knowledge
    - Make a mock portfolio and preforming risk analysis on it regularly
- Stay informed on current financial/economic affairs

Many firms only hire interns within specific timeframes

- Make sure to apply as early as possible
- Most hiring for larger firms only takes place through their internship programs

Quantitative Roles may not be explicitly advertised at some firms

The Interview

Interviews for quantitative roles on Wall Street can be very challenging because of the amount of technical and logic-based questions asked: Examples:

- What is the angle between hour and minute hands at 12:15?
- What are the differences between the Python and C++ programming languages?
- What is a Monte Carlo simulation?
- What is the Black-Scholes Equation?

Some firms actually have exams for quantitative positions.

Recommended Reading

Paul Wilmott on Quantitative Finance

Mathematical Finance by Nikolai Dokucahev

Introduction to Quantitative Finance – A Math Tool Kit by Robert R. Reitano

Heard on the Street: Quantitative Questions from Wall Street Interviews

Numerical Methods in Finance and Economics by Paolo Brandimarte

Learn Python The Hard Way by Zed Shaw