Perspectives and Opportunities in Financial Engineering at Citi

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Perspectives on Financial Engineering

1. Cultures of Quantitative Finance
Quantitative Finance – A Combination of Cultures

In order to understand the origins of quantitative finance and to speculate intelligently on where it might be going, it is necessary to understand its three cultures.

The three cultures that contribute to Quantitative Finance are:
1. Academic Finance
2. Mathematical Sciences
3. Financial Industry

The financial industry is the domain of financial engineers

The practice of financial engineering drives the activity. It creates demand for:
- Mathematics
- Technology
- People

I describe the realm of quantitative finance in terms of the contributions of these three cultures.
What is Financial Engineering?

Financial engineering describes the application of engineering and mathematical principles to support efforts in sales, trading, and investing in financial assets.

- Financial Engineering activities include
  - Delivery, collection, and synthesis of market data
  - Development of pricing algorithms and/or implementation of those algorithms to end users
  - Risk management and P/L attribution of financial positions
  - Ad hoc pricing and hedging of tradable assets
  - Assisting in development of market strategy, particularly as regards analytic frameworks
  - Programmed trading and position monitoring

- There was no such thing when I started (in 1988)
  - Financial engineering programs are addressing the need in the financial markets for individuals who have deeper quantitative approaches to finance than occur in typical training of MBAs
  - That role used to be filled by scientists with no financial training
  - There are now many financial engineering programs
Perspectives on Financial Engineering

2. The Demand for Mathematics, Technology and People
Practice: The Demand for Mathematics

Although many financial institutions exude vast power, they are highly vulnerable because it is hard to patent financial ideas. Thus, having a stream of new ideas is critical. Financial institutions must constantly be seeking new ideas.

Some products resulting from applications of mathematics in the financial industry

- Fundamental theorems of asset pricing
- Evolution of yield curves over time
- Integrated models of interest rates, swaps, and options
- Change of numeraire and market models for interest rates
- Monte-Carlo simulations for American options
- Coherent and convex risk measures
- Correlation models and copulas
- Stochastic volatility modeling
- Lévy processes and fractional Brownian motion
- Time-series analyses and machine learning methods

Mathematicians tend to drive out those who would help them.

- Statistics began in mathematics departments and moved out
- Computer Science began in math departments and moved out
- Will Quantitative Finance move out of math departments?

Still, Mathematics are important

- Mathematicians bring rigor to the party
  - Rigor is a critical part of quantitative finance
- Rigor is not the only part
- Model building is a critical part of quantitative finance

Financial institutions must constantly be seeking new ideas. Many of these are mathematical

Often the most appropriate model does not require deep mathematics
Industry: The Demand for Technology

The volume and complexity of financial data and models drives the demand for faster and innovative technology

- The drive for technology to get a market edge goes back at least as far and the Rothschild’s use of carrier pigeons to relay news to London of Napoleon's defeat at Waterloo

  “There are three rival cable companies in London .... From 3 PM, which means 10 AM in New York, messages pour into these offices at the rate of many hundreds an hour and are flashed with inconceivable rapidity over the wires from London via Ireland and Canada to New York.... This speed in the transmission of orders enables the arbitrageur to secure his profits.”

  Samuel A. Nelson
  The ABC of Options and Arbitrage
  New York
  1904

- Today, some forms of the demand for technology are:
  - Grids of parallel computers to process simulations of correlated returns of structures backed by asset backed securities
  - Super-fast automated transaction systems to exploit price anomalies
  - Use of graphics processing units found in video games to speed up options analytics and other math-intensive applications
Industry: The Demand for People

Firms have long realized that their greatest asset is their people. Only lately are they realizing that the people that are most valuable are those with quantitative training.

- At Citi, the proportion of “quants” to MBAs in our Associate Training program has been growing every year since 2001 (when I started recruiting)
  - My first year, we hired 2 “quants”, this year 9 (in this market)
  - The MBA hiring for 2009, decreased by 50% - “quants” rose slightly
  - For 2010, I will hire 10 full-time associates and 10 summer interns

- Citi’s two-year analyst program hired five non-economics/business majors in 2001. For our 2010 class, we will hire 20
  - The “hybrid” program started in 2005
    - One year in research / strategy
    - Second year in trading (small number in research / strategy)

- The first Masters programs in quantitative finance started less than 15 years ago (NYU and Columbia)

- There are about 75 quant finance programs worldwide, so that roughly 2,000 quant finance students graduate annually

Financial Industry: The Demand for People

Although there are now more people trained in quantitative finance, “What is the likelihood that they find jobs in today’s markets?”

- Hiring was off for 2009, but will **INCREASE** this year
  - There are two less investment banks and skilled people have been out of work
  - However, with the recovery, I am seeing the beginnings of a “hiring frenzy”

- Also, there are areas where demand for quants has been growing steadily
  - China
  - Hong Kong
  - Singapore
  - Middle East
  - India

- Regulation generates quant finance jobs
  - Jobs will be created in both industry and government
  - There will be more of that coming!

- Insurance and accounting firms are hiring more quants
Industry: Its Relationship to Academia

In many ways, goals of academics and financial practitioners can be at odds, but academia provides the human talent for the practice of finance.

<table>
<thead>
<tr>
<th>Banks</th>
<th>Academia</th>
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</thead>
<tbody>
<tr>
<td>• Banks exist to make money, not to prove theorems</td>
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</tr>
<tr>
<td>– Problems with no economic objective or perceived use are of little interest to banks</td>
<td></td>
</tr>
<tr>
<td>• Banks must do something “now” even if there is little theoretical justification</td>
<td></td>
</tr>
<tr>
<td>– Markets are incomplete, data is sparse and hedging is discontinuous</td>
<td></td>
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<tr>
<td>– A bank creates a product or buys an asset and it must be risk-managed now</td>
<td></td>
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<tr>
<td>– Products often emerge before the ability to understand their risks</td>
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<tr>
<td>• Academia exists to do research and train researchers</td>
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<tr>
<td>– Not necessarily interested in training practitioners</td>
<td></td>
</tr>
<tr>
<td>– Are able to make assumptions not upheld in the “real” world</td>
<td></td>
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<tr>
<td>• A problem need not have a practical application to be of interest</td>
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<tr>
<td>– Academics are interested in the development of consistent formal systems</td>
<td></td>
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<tr>
<td>– Complete solutions to problems are desired, often requiring years of research</td>
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</tbody>
</table>
Mathematics is the language used by finance academics to express insights about finance. Rigorous mathematics is not the method used to derive them.

- Mathematics is the language used by finance academics to express insights about finance
  - Rigorous mathematics is not the method used to derive them
  - “Proofs” go in the appendix

- Mathematicians cannot afford to dismiss the heuristic arguments of their colleagues in finance

- Academic finance is a discipline that takes years to master
  - Its own language
  - Its own important questions
  - Its own criteria for assessment

- The criteria for success in academic finance is not dependent on its practical benefits
  - . . . , but it can help – many successful academics have produced research useful for practitioners
Academic Finance and Mathematics

Mathematicians cannot afford to dismiss the heuristic arguments of their colleagues in finance if their work is to be relevant.

Finance faculty can help mathematicians avoid the trap of continuing to develop methods for pricing ever more exotic options and complex products.

Finance faculty can also help potential practitioners by training them as “problem solvers”

Some important areas for research (in practice):

- Market microstructure and order book transparency.
- Equilibrium prices and incomplete markets.
- Role of information in market movements.
- Liquidity.
- Credit models and correlated defaults.
- Energy and commodities.
- Asset management.
- Macroeconomic variables.
- Loan Pricing.
- Algorithmic Trading.
Quantitative Finance and the Effects of the Financial Crisis

3. Where are We Going? Quants in a Post-Crisis World
Overview of the Crisis

I want to consider the practice of quantitative finance, including financial engineering, in light of the most severe economic crisis since the Great Depression of the 1930s.

• The financial crisis that began in the summer of 2007 has become the deepest, broadest and one of the longest since the Great Depression
  – More than third of the major global financial institutions have seen their stock prices plummet by more than one third

• Bank failures or “near-bank failures” have triggered unprecedented public rescues in several countries in the face of obvious systemic risks
  – US financial institutions have reported over $300 billion of losses and have felt compelled to raise over $200 billion to replenish their depleted capital
  – Their equity market capitalization (using the S&P 500 financial sector) has plummeted by about $1.3 trillion — about five times the gross losses and twenty times the net losses after recapitalization — since peaking in May 2007

• The five largest U.S. investment houses have failed, lost their independence, or become commercial banks under the supervision of the Federal Reserve

• Innovations in Fed liquidity supply have occurred more rapidly and in greater degree than at any time since the Great Depression
The Current Crisis (cont.)

- Financial markets became a mess and the excesses of the finance industry dragged down the economy

- Investors seeking above average returns in low-rate environment bought extremely complicated instruments
  - Mortgage-backed securities with payoffs depended on hundreds or thousands of mortgages
  - Many of these securities received investment-grade ratings, and their returns were significantly greater than investing in a comparably rated bond
  - The law that higher risk means higher expected return seemed to have been repealed

- The practice of ratings arbitrage, getting a better-than-merited rating and selling securities based on that rating, was born.
  - Much of the quant work on CDO desks involved constructing portfolios that would generate the highest yields to equity tranche investors for a given target credit rating
It is Easy to Blame the Quants . . .

To prevent a recurrence of financial crises, some call for a return to a simpler time, before derivative securities and the quants who analyze them—a time when investors bought stocks and bonds and little else.

- It is easy under these circumstances to point an accusing finger at the "quants" on Wall Street.

- Without the quants, the complicated mortgage-backed securities that fueled the housing bubble and led to the freezing of credit might not have been created.
  - The models used by the quants determine the prices of those securities.
  - They also underlie the strategies of traders and risk managers of those securities.

- Without this guidance of quants, the banks might not have touched these products in the first place.
  - It really wasn’t the quants that led the “charge” into structured products.
  - It was the capital markets focused individuals who ran the product businesses.
    - These were almost never run by quants.
    - Quant involvement in those businesses was often viewed as a nuisance.
. . ., But, Don’t Blame the Quants

Before the collapse, many quants (myself included) believed that the level of complexity in the securitized products markets had exceeded the limitations of their models, but in most banks, the quants are not the decision makers.

- The quants knew that the models were faulty and that the structured securities were marketed questionably.
  - But in most banks, the quants are not the decision-makers.
  - When quants issue warnings that stand in the way of profits, they are quickly brushed aside.

- There was also evidence of no-documentation mortgage applications and a network of unscrupulous mortgage originators were taking advantage of the securitization process.

- Regardless of what some may wish, we will not revert to a simpler time before derivative securities; that simpler time never existed.
  - Options have been traded since the 17th century--and even before that, in ancient times, by some accounts.

- The quants did not create derivative securities.
  - They were created by investment bankers and lawyers.
Where Are We Going?

Although prediction is risky, despite the current financial progress, the demand for financial engineers is increasing, not decreasing

- Firms are realizing that the current crisis is not the failure of quantitative methods, but the failure to develop and apply them

- Firms will increasingly be run at the highest levels by quantitatively trained individuals (this is true at Citi)

- This will fuel continued demand in industry for:
  - Academic research on problems in finance
  - Students of financial engineering
  - Faculty to join banks as researchers, traders, and risk managers

- The massive number of “successful” financial applications that are currently running in financial institutions ensures the continuing demand for quantitative people
  - Even if further development ceases, their will still be demand for quants to service existing systems
  - However, an extreme amount of quantitative development and innovation continues to take place
  - Also, the specter of increased regulation will drive the demand for quants
Is a Simpler Financial System the Answer?

When a bridge collapses, no one demands the abolition of civil engineering. We can’t and won’t go back to a cash economy.

• Laying the blame on the quants misses the point
  — If faulty financial engineering is to blame, the solution is better — not less — quantitative models
  — It is preposterous to replace current sophisticated tools with inferior and less efficient ones
  — Instead, the models need to be rebuilt and re-engineered and the obstacles overcome

• There are very good reasons for the existence of derivative securities — even mortgage-backed securities (MBS)
  — Potential homeowners need investors to fund their mortgages
  — Without MBS how can the two come together?
    ▪ The Savings and Loan system was a major provider of mortgages
    ▪ Its collapse in the 1980s cost the US Treasury (via the FDIC) $120 billion to make depositors whole
    ▪ The S&L model will not attract funds from foreign investors – we can’t go back

• Energy trading did not disappear with the demise of Enron, and neither will mortgage-backed securities after this fiasco
Derivatives and Securitized Products will Survive

Derivatives and securitized products will continue to exist because these instruments serve an economic purpose.

- Firms use derivative securities to hedge against risk
  - International firms hedge currency risk with FX derivatives
  - Airlines hedge fuel risk with energy derivatives
  - Insurance companies use derivatives to hedge against actuarial risk

- The quants did not create derivative securities. They help to
  - Understand them
  - Price them
  - Hedge them
  - Risk manage them

- The quants know better than anyone how their models can fail
  - To avoid repeating the current crisis, banks must measure and control all our risks,
  - including the risk that our models give incorrect results

The way out of our present dilemma is not to blame the quants. Banks must instead hire good ones --- and listen to them.
Opportunities in Financial Engineering at Citi

1. Hiring Outlook for 2010 and How to Apply
# Outlook for Financial Engineers - 2010

Although, the situation in 2009 was the most difficult I have seen, it was still relatively better for quants. The situation has improved greatly for 2010.

<table>
<thead>
<tr>
<th>Good News</th>
<th>Bad News</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Relative demand for financial engineers grows every year</td>
<td>• Competition is stiff</td>
</tr>
<tr>
<td>• Markets continue to become more quantitatively driven</td>
<td></td>
</tr>
<tr>
<td>• Trading desks are turning to financial engineers to fill jobs previously filled by MBAs</td>
<td></td>
</tr>
<tr>
<td>• Knowledge set of MFEs is perceived favorably for research/strategy position</td>
<td></td>
</tr>
<tr>
<td>• Talented people are rarely out of work for long, even in difficult periods</td>
<td>• There are two fewer investment banks than there were at the start of 2008</td>
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<td></td>
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<td></td>
<td></td>
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<tr>
<td></td>
<td>• Internships are becoming increasingly important</td>
</tr>
</tbody>
</table>
How and When Do I Apply?

APPLY EARLY: Apply between early September and January in the academic year prior to when you would like to start work or to have the internship

• The height of our (and our competitors) recruiting season is has moved earlier; we are typically finished by the end of January

• To find out more about our programs, please visit our website at http://www.oncampus.citi.com

• We ask that all applicants use our online system
  – Go to our recruiting website at www.citi.gtios.com
  – Apply under the Associate-level heading for jobs in the INSITUTIONAL CLIENTS GROUP for either our FULL TIME ASSOCIATE or SUMMER ASSOCIATE program in MARKETS QUANT ANALYSIS

• If you have questions, please contact Sarah Beamish at sarah.j.beamish@citi.com or (212) 816-4343
Opportunities in Financial Engineering at Citi

2. Career Choices: Role and Firm
Sorting Out Your Career Objectives

It is important to know that the hiring process is one of matching one’s skills and temperament to the particular needs of the employer and vice versa.

It is useful if you know what type of job is best suited to your skills and personality.

<table>
<thead>
<tr>
<th>What type of firm?</th>
<th>What kind of role?</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Buy Side</td>
<td>• Quant</td>
</tr>
<tr>
<td>• Sell Side</td>
<td>• Strategist</td>
</tr>
<tr>
<td>• Consulting / Project Oriented</td>
<td>• Trader / Structurer</td>
</tr>
<tr>
<td></td>
<td>• Technologist</td>
</tr>
</tbody>
</table>

All of you are talented or you would not be here.

However, not all people are suited for all jobs.

Knowing your skills (and limitations) will make your job search more efficient and save disappointment.

Internships are particularly useful in helping to shape career goals.
### “Buy Side” vs “Sell Side” Firm

There are two main types of firm: sell side and buy side. Sell side firms are broker dealers; buy firms are their customers.

<table>
<thead>
<tr>
<th><strong>Buy Side Firm</strong></th>
<th><strong>Sell Side Firm</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Trading house or fund that executes trades</td>
<td>A broker/dealer – makes markets in securities</td>
</tr>
<tr>
<td>Many firms</td>
<td>Few firms</td>
</tr>
<tr>
<td>Client of broker dealer</td>
<td>Sell to “buy side” firms</td>
</tr>
<tr>
<td>Support the trading efforts of the firm – often highly specialized strategies</td>
<td>Support the sales and trading effort of the fixed income brokerage and investment banking businesses</td>
</tr>
<tr>
<td>Deep understanding of firm objectives and methods</td>
<td>Provide market “strategy” to clients and to firms’ brokerage business</td>
</tr>
<tr>
<td>Risk management and P/L attribution expertise</td>
<td></td>
</tr>
<tr>
<td><strong>Strong quantitative skills</strong></td>
<td><strong>Strong quantitative skills</strong></td>
</tr>
<tr>
<td><strong>Quick-thinking individuals</strong></td>
<td><strong>Strong communication skills</strong></td>
</tr>
<tr>
<td><strong>Strong group focus</strong></td>
<td><strong>Ability to work across groups and with salespeople and traders</strong></td>
</tr>
<tr>
<td><strong>Outside communication rarely required and often discouraged</strong></td>
<td><strong>Communication outside firm is critical</strong></td>
</tr>
</tbody>
</table>
There are two main types of role for quantitative people in a sell side firm: quant or strategist. Most people are a combination of both, but there are exceptions.

<table>
<thead>
<tr>
<th>Quant</th>
<th>Strategist</th>
</tr>
</thead>
<tbody>
<tr>
<td>Works mostly with traders, risk managers, and strategists</td>
<td>Works with sales and trading to generate customer business</td>
</tr>
<tr>
<td>Support the trading efforts of a particular business line</td>
<td>Stays abreast of asset prices in the market</td>
</tr>
<tr>
<td>Usually deal with complicated assets</td>
<td>Suggests relative value opportunities to clients</td>
</tr>
<tr>
<td>May help traders prepare/structure trades</td>
<td>Provide market “strategy” to clients and to firms’ brokerage business</td>
</tr>
<tr>
<td>Risk management and P/L attribution expertise</td>
<td>Provides ideas for “quants” to explore / often supervises them</td>
</tr>
<tr>
<td>May write research reports, but generally long shelf life</td>
<td>Strong oral and written communication skills / regular publishing requirements</td>
</tr>
<tr>
<td>Outside communication possible, but less customer focused</td>
<td>Communication within and outside the firm is critical</td>
</tr>
<tr>
<td>Tend to have stronger math and computer science skills</td>
<td></td>
</tr>
</tbody>
</table>

"Quant" vs "Strategist" Role
What is a Fixed Income Strategist?

A fixed income strategist must follow markets closely and develop quantitative tools to help investors evaluate risk and relative value as well as providing trading ideas, market color and information on new products.
Opportunities in Financial Engineering at Citi

3. Working in a Sell-Side Firm
What We Do and How We Do It

Our interaction with salespeople and traders is critical and substantial --- quant research and strategy is an integral part of our sales and trading effort. Many of our staff sit on the trading desks and accompany salespeople on visits to customers.

Our main activities are:

• Participating in client meetings along with salespeople, both at Citi and traveling to clients in an effort to add value to their businesses
• Providing clients with information and tools such as market color, product knowledge, trade ideas, and technical support
• Developing models for asset pricing and building analytical tools, trading systems, and risk management processes
• Assisting traders in pricing potential deals, structuring products, and developing new businesses
• Risk management of fixed income inventory for the trading desks, the entire fixed income business, and our clients
• Assisting in proprietary trading activities
• Working closely with others in research to understand the various product areas and transfer information, techniques and systems across businesses

In short, we partner with the salespeople and traders in the fixed income business to generate trading activity for the business, tools for trading and risk management and market intelligence and trade ideas for our clients
It takes a coordinated effort between sales, trading, quant research, and strategy to function effectively in a broker/dealer business. Quants participate more in proprietary trading and risk management whereas strategists assist more in the sales effort.
Who Get Compensated and Why

Compensation during the first year is usually fixed in advance and standard throughout the investment banking industry. After the first year is performance-based and a good fraction of that is discretionary (i.e., bonus)

Important Determinants of Compensation

- **Linkage with the business**, and that linkage increases with
  - Overall salary level
  - Contribution to business performance
  - Directness of connection to revenue generation

- **Working across groups**
  - Leveraging activities across different areas is rewarded
  - Moving the firm into new areas of opportunity is also rewarded
  - Providing new tools and capabilities
  - Resolving conflicts and cooperation

- **Other factors**
  - Recruiting efforts
  - Departmental committees and programs
  - Diversity
Opportunities in Financial Engineering at Citi

4. Citi Quants and Strategists - Organization
To break down the “silos” between fixed income, foreign exchange, commodities, and equities, quants and strategists were split in January of 2009.

Although the groups are now separate as regards management chain, I am still recruiting for both groups and rotation assignments can vary across groups.
The split between MQA and CIRA was official January 1.
Opportunities in Financial Engineering at Citi

5. Our People
Opportunities in Financial Engineering at Citi

6. Our Programs
Entry Level Positions: Analyst and Associate

**Analyst/Hybrid Program**

- Two-year rotating position
- Junior training position
- Currently involves one-year in research and second in trading
- Undergraduate degree or one-year masters
- Less than two years of work experience after school
- Next Step: Associate program or out of firm
- 15-20 New Analysts per Year

**Associate Program***

- Senior training position
- Two-year Masters or Ph.D.
- An internship or previous industry experience is a plus
- Typically, a minimum of three years:
  - Sales and trading training program
  - Three, 3 month rotations in rates, credit, and structured products
  - Two years in line position
- Next Step: Vice-president or out
- 9 New Associates in 2009

*I am recruiting for this program only*
Associate Programs

**Full-Time**

Entry-level full-time hires can join any time during the hiring year
- Ex: 2009 class eligible to start on Jan 1, 2009

Early hires begin rotating when they arrive
- Associates rotate through credit, structured products and rates
- Role could be quant or strategy

The Citi Sales & Trading Training program begins in early August
- All new associates attend
- All associates must join by then
- Training ends in mid-October

In 2009, all of our full-time hires came from our internship program (including 3 Berkeley MFES)

**Intern Program**

10-Week Summer program
- Also have special “wintern” program

Students work with senior researchers on business problems
- Strategists/quants propose projects
- Interns are “matched” to projects
- Projects evaluated on merit
- NO MAKE WORK!

Interns attend twice-weekly luncheon seminars taught by senior strategists

Interns can work in more than one group, but relatively rare

The internship has been a successful route into the firm for many interns

7 Summer Interns in 2009
3-4 Berkeley “winterns”
What We Look for in Successful Candidates

We look for candidates that are highly motivated and have strong educational backgrounds, including extremely good quantitative, technical, and communication skills. Experience in finance is also a plus.

We seek to hire people who:

1. Have superior analytical and technical skills
2. Are highly motivated and passionate about financial markets
3. Possess strong interpersonal skills, because our staff interact directly with clients, salespeople, and traders
4. Have the ability to synthesize information and organize it in creative way
5. Demonstrate ability to generate and carry out creative research
6. Typically hold advanced degrees in quantitative fields – finance, economics, mathematics, engineering, computer science, operations research, physics, statistics

We believe that people with exceptionally strong quantitative skills can come to a deep understanding of the financial markets through the work experience alone.

However, prior financial education and/or industry experience is helpful from a competitive perspective and is becoming increasingly so.
Past Projects for Associate-Level Interns

• Convexity of mortgage to-be-announced bonds on price skew (Mortgage Research)
• A Model for Credit Default Swaps (Quant Credit Trading Strategy)
• Modeling default rate-dependent recovery value of corporate bonds default with Copula model to pricing CDOs (Structured Products Research)
• Design an affine term-structure model with doubly stochastic Poisson processes, stochastic volatility model (Interest Rate Derivatives)
• Evaluate stochastic volatility models (Interest Rate Derivatives)
• Quasi Monte Carlo Methods and their Applications (Derivatives)
• Using Mortgage Bankers Association Index to Predict Aggregate Prepayment Speeds (Mortgage Strategy)
• Develop structural model for corporate default and spreads for assessing relative value among investment-grade corporate and high yield bonds (Quantitative Credit Modeling)
• Build prepayment option-adjusted lattice-based pricer for loans
• Calculate historical corporate credit risk premium using structural models
• Relative value equity volatility model for proprietary trading (Equity Quant)
Major Product Lines

- **Interest Rate Products**
  - US Treasury and Agency Securities
  - Interest Rate Derivatives (Swaps, Futures, etc)
  - Agency-Backed Mortgage Securities

- **Credit Products**
  - Investment Grade and High Yield Corporate Bonds and Loans, CDS, and LCDS
  - Credit Derivatives – Correlation
  - Emerging Markets

- **Foreign Exchange**
  - Quantitative Investor Solutions
  - FX Structuring
  - Proprietary Trading

- **Equities**
  - Equity Derivatives Research
  - Equity Proprietary Investments
Major Product Lines

- **Structured Products**
  - Non-Agency Backed Mortgages
  - Other Asset-Backed Securities (Autos, Credit Cards, HELs)
  - CDOs (ABS, Loans, Bonds, CMBS, CDO^2)
  - Commercial Mortgage-Backed Securities (CMBS)

- **Portfolio Products / Risk Management**
  - Bond Portfolio Analysis
  - Analytical Tools
  - Risk Management
  - Cross-Product Margining
  - Counterparty Credit Risk
Major Quant Groups

The major quant groups had traditionally been organized along trading desk lines, but increasingly, they are becoming organized along product and analytical tools lines, working across several desks.

- **Mortgage Research**
  - Build stochastic models for mortgage prepayment and default risk, home price appreciation and the ABX index
  - Heavily simulation based on interest rates, prepayments and housing prices; parallel computing
  - Structured mortgage products include sub-prime and non-agency mortgages

- **Prime Brokerage / Multi-Asset Quant Group**
  - Serves our prime brokerage business
  - Handles all fixed income, equity, currency and commodities products
  - Modeling contingent exposure to several asset classes at once, often in different currencies, sometimes having debt and equity-like exposure

- **Cross Product Margining**
  - Combines client exposures across desks and products including commodities
  - Requires expertise over the range of cash and derivative products and their risk factors
  - Used to set margin and manage Citi’s exposure to various clients
  - Allows firm to make margin calls

- **Rates Quantitative Analysis**
  - US Treasury term structure models – serves many groups
  - Heavy strategy effort – Citi is primary dealer
  - Treasury futures, derivates, swaps, and swaptions
  - Work with volatility traders, building models, generating risk reports (in-depth risk, profit attribution analysis, model statistics, etc.) and extend the applications of these models
  - Mortgage options
Major Quant Groups (cont.)

• **Foreign Exchange**
  - Develops foreign exchange strategies for real money managers, leverage funds, and investment portfolios
  - Structure FX derivatives that manage risk or maximize the returns of trade ideas
  - Proprietary trading strategies (ranging from hours to months) encompass G10 FX, emerging markets and fixed income

• **Equity Derivatives**
  - Support sales and trading effort, mainly to hedge fund clients
  - Assist in proprietary trading and pricing complex equity options
  - Collaborate with strategy groups on convertible bonds, program trading, and risk arbitrage

• **Credit Derivatives / Correlation**
  - Correlation and Tranchéd Products (Copulas and Base Correlation)
  - Gap and jump-to-default risk

• **Structured Products (CDOs, CMBS, ABS) CMBS Modeling**
  - Enhance the existing interest-rate driven approach to real estate forecasts for CMBS models
  - Hedging CLO portfolios for default risk
  - Develop consumer bankruptcy prediction and a credit card stress models

• **Quantitative Credit Trading Strategy**
  - Analyze credit risk and relative value across credit trading disks (Investment-grade, high yield, loans, CDS and LCDS)
  - Loan pricing, including loan prepayments, revolving loan usage and loan credit default swaps
  - Portfolio techniques, including optimal allocation of assets, maximizing risk-adjusted returns using “forward looking techniques and non-Gaussian returns
  - Develop long/short CDS trading strategies based on Citigroup model and fundamental analyses
  - Risk manage Citi’s internal credit portfolios
Major Quant Groups (cont.)

- **Risk Management**
  - Analyze credit risk and relative value across credit trading disks (Investment-grade, high yield, loans, CDS and LCDS)
  - Loan pricing, including loan prepayments, revolving loan usage and loan credit default swaps
  - Portfolio techniques, including optimal allocation of assets, maximizing risk-adjusted returns using “forward looking techniques and non-Gaussian returns
  - Develop long/short CDS trading strategies based on Citigroup model and fundamental analyses
  - Risk manage Citi’s internal credit portfolios

- **Analytical Tools**
  - Deliver data and analytical tools to trading groups globally across the firm
  - Maintain databases of prices, interest rates, and other market data and build models for display and analyses of those data
  - Manage cross-groups environment for standard analytics including yield calculations, interest rate and credit curve construction methods, risk measures, and other standard financial analytical tools
  - Monitor and plan for global storage of information, server requirements, databases and other processing equipment

- **Emerging Markets**
  - Generate trade ideas and market commentary for clients and Citi trading desks for sovereign bonds, credit derivatives, FX options and country-specific interest rate swaps
  - Build quantitative models and gather information for publications and presentations and attend to sales and client requests for data and analysis
  - Maintaining computational and data delivery systems for emerging markets trading and strategy.
Functional Groupings

• Econometric/Statistical Modeling
  – Mortgage prepayment models
  – Default/delinquency models
  – Regression-type models for predicting yield spreads, volatilities, issuance, etc.
  – Principal Components
  – Machine Learning / Automated Trading

• Term Structure, Option Pricing Models, and Simulation Techniques
  – Interest rate options
  – Arbitrage-free yield curves
  – Monte Carlo simulation methods
  – Options pricing
  – Credit Derivatives / Structured Credit Products

• Credit Modeling
  – Default and Credit State Transition Models
  – Structured Credit Analytics (i.e., Tranched Products)
  – Correlation Modeling
  – Statistical Models and Hybrids
  – Fundamental Analysis
Opportunities in Financial Engineering at Citi

7. Other Groups within Citi that Hire Quants
**Risk Oversight**

This group is responsible for managing the risk of the firm at the highest levels of the firm. They construct models of risk on all asset classes around the globe. This group is highly quantitative and has high visibility within the firm.

**Model Validation**

This group also is responsible for managing the risk of the firm. They examine the models that the trading desks use for pricing and hedging and ensure that they are sound and implemented properly. The equation for the probability of default is given by:

$$ PD(t) = 1 - \exp\left[-\int_{t_0}^{t} \lambda \, dt\right] $$

The equation for the probability of default is also given by:

$$ \delta_t^f = \log\left(\frac{V_A}{K}\right) + \left(r_t - \frac{1}{2} \sigma_A^2\right)T $$

$$ \sigma_A \sqrt{T} $$

*Source: Citigroup*
Financial Strategies

This group is responsible for developing customized solutions for clients.

Very much capital markets oriented, but with a financial economic focus

Extremely topical focus and wide range of problems

Economic & Market Analysis

This group is focused on the macro economic environment as it affects fixed income markets

They provide our clients with perspectives on the economy, including impending Fed actions and predictions of major economic releases.
Salomon Direct, Salomon Smith Barney’s sales, trading and research site allows you to click on a security or icon to send the security’s identification and pricing level to the Yield Book Calculator.
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8. Wrapping Up
Other Departmental Activities

We are concerned with the continuing development and advancement of our staff and have created several programs to facilitate ongoing learning and career development.

- **Mentoring Programs**
  - Analysts are assigned both a junior and senior mentor – a Vice-President and a Director
  - Associates are assigned a single mentor - a Director or a Managing Director
  - Generally mentors and mentees meet at least once a quarter and discuss issues regarding the department, personality difficulties, answer questions, etc.

- **Fixed Income Research Seminar**
  - Tuesdays at 5:15 pm between September and June we hold a seminar on finance and/or the markets
  - Speakers range from Citigroup staff to renowned academics
  - Well attended by the firm

- **Other Departmental Activities**
  - Quarterly Town Hall Meeting
  - Committees (Synergy, Diversity)
A Few Words on Diversity

Citi is committed to building a racially and culturally diverse work force at all levels of the firm

• **Diversity is a natural outgrowth of Citi culture**
  – Citibank has had a global presence for over a century and tended to hire and promote talented people in countries around the world
  – The emphasis is shifting toward within-country diversity

• **We at Citi support diversity because:**
  – It is in the spirit of the law
  – It is good for business
  – It is consistent with our values as a firm – it is the right thing to do.
What I Think I Have Learned

I reflect on my experience in the business, not because I think that I have gained extreme wisdom, but because students often ask my opinion on these issues. Thus, take this advice for what you think it is worth.

• Find Out What You Like To Do and Do It!
  – Look around – see what jobs are out there
  – That is where internships help a lot – get one
  – Talk is cheap, especially in finance – don’t always listen to people; develop your own internal compass

• Success Can Mean Different Things to Different People
  – Develop your own view of success
  – Pursue it within the context of the goals and objectives of your job and firm

• Find Your Career Path
  – Patterns of hiring, promotion, personnel deployment, marketing, and strategy all change rapidly
  – There are many paths to success and most are not repeatable

• Embrace Change!
  – Market conditions and opportunities change rapidly
  – Change is the rule, be prepared as it will happen; and fast
  – Good people are never unemployed for long
What I Think I Have Learned (cont.)

• Look for Opportunities Where Others are Not Looking
  – The “hottest” areas are not always where opportunity is greatest
  – Try not to compare your success with others

• Keep Improving Yourself
  – Beware when you find yourself in a job that is not challenging to you
  – Treat others with respect; be a team player
  – You should always be growing as there is a lifetime of learning in this business

• Communicate Your Career Goals, but Act with Patience
  – If you want to move, continue to focus on your current job, but let your management know about your aspirations
  – A good manager will want to keep a good employee in the firm
  – If you are dissatisfied, if possible, wait for the job you want. Changing jobs is risky; particularly when going to a lesser firm or more money or title

• Find a Mentor
  – If your firm doesn’t have a mentoring program, find someone outside your area that you can talk to about how to maneuver in that firm’s corporate culture
  – Seek advice before acting

• Network
  – Get around, but DON’T GOSSIP!
  – Be a good colleague; make your skills known by helping others
What I Don’t Know

- I Don’t Know the Extent of My Ignorance
  - “You don’t know what you don’t know”
  - Perhaps this is the most important lesson
Opportunities in Financial Engineering at Citi

9. Q & A
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