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Applied Mathematics at Citi MQA

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Quantitative Analyst

Markets Quantitative Analysis

In today's highly regulated trading environments Quants perform an ever important role in ensuring the Financial models which we develop and used by Trading and Risk Management are fully understood and documented. In the fast paced environment of the trading desk, efficient and accurate pricing libraries are one of the key aspects that differentiate the best trading desks from the rest. Cutting edge financial modeling and tools and cutting edge software engineering is a must for the trading desk to survive in a very competitive market.

We are extensively involved in the regulatory stress tests which the Firm undertakes, ensuring that our models operate effectively in stressed market conditions.

Who are our people?

- **Quantitative Developers**
  - Excellent software development skills
  - Strong C++ / Python
  - Interest in finance.
- **Quantitative Support (Devops)**
  - Excellent technical skills
  - Python / Bash scripts
  - Interest in finance.
- **Quantitative Analysts**
  - Typically Masters / PhD level
  - Mathematics, Physics or Engineering
  - C++, Python, or Matlab skills.
  - Knowledge of finance.

Who are our clients?

MQA's key business partners are:

- Trading
- Structuring
- Sales Desks
- Risk Organization
- Valuation and Control
- Technology Risk teams.

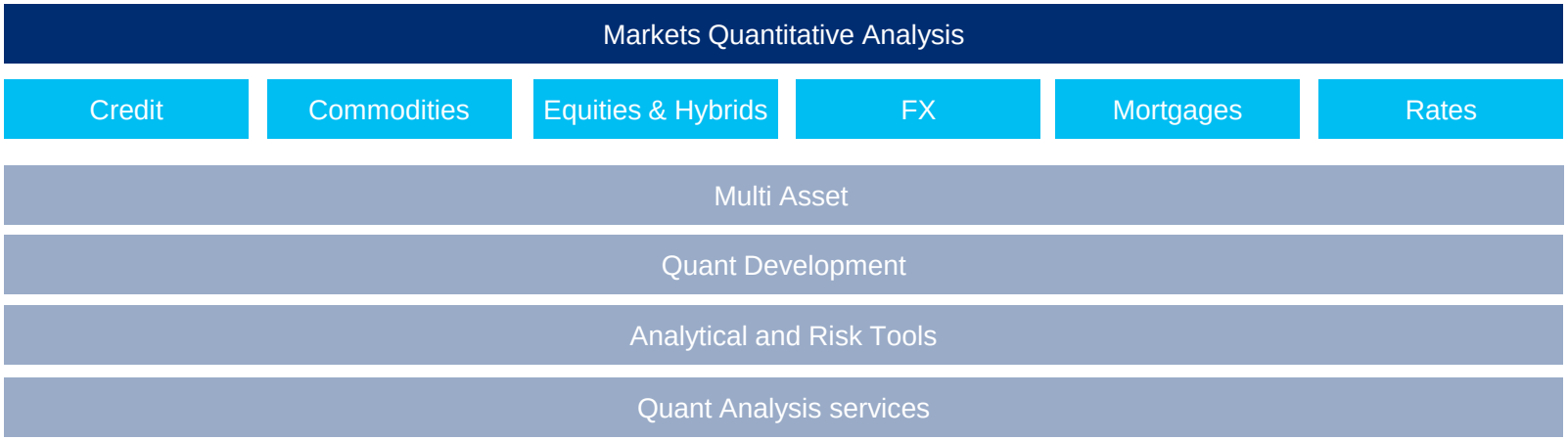
Markets Quantitative Analysis

Where are we located ?

- MQA is a global department of around 300 people, predominantly in North America and London with a small number in Asia.

- We established a presence in Budapest in September 2013.

Markets Quantitative Analysis

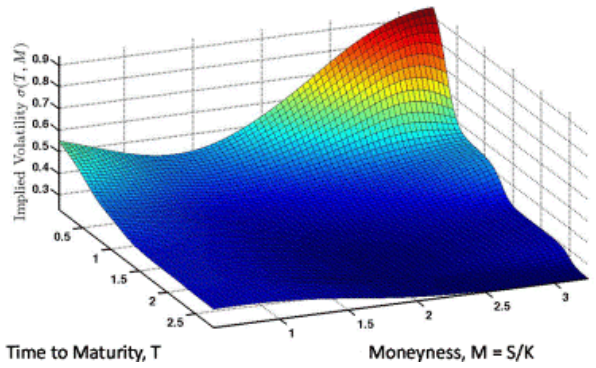


- MQA have teams of quantitative analysts vertically aligned to the Trading desks according to asset class. E.g. G10 Rates and Local Markets, Credit including Credit Algorithmic Trading, FX, Commodities, Mortgages and Equities & Hybrids.
- MQA also have teams which are horizontally aligned and whose work span multiple asset classes to address cross asset requirements in areas such as Risk Management, Investment Strategy Modelling, Trade analysis and Trade Identification tools, CVA and regulatory requirements (Dodd-Frank, Basel II / III).
- An important part of MQA is the Quant Development team whose role it is to provide a common interface and functionality across all the asset-class aligned model libraries, plus provide a robust and state-of the art development platform and toolset for the department.
- We are building out the Quant Analysis services team in Budapest to provide cross asset class services such as model development, documentation, performance analysis and support to all MQA teams.

Markets Quantitative Analysis

How do we work?

1. Observe Market Behaviour



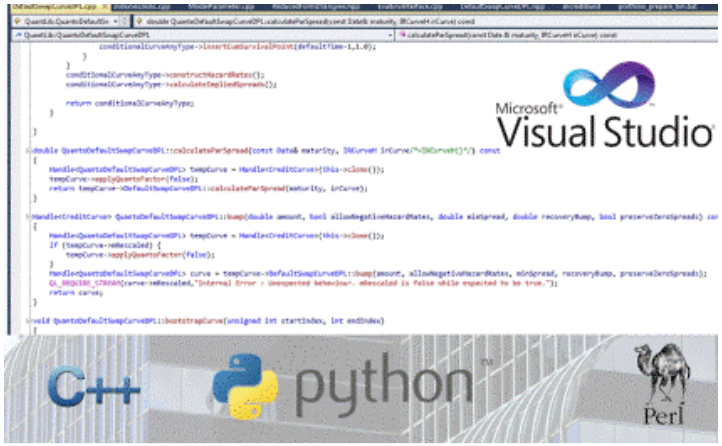
2. Build Mathematical Model

$$PV = \sum_{fl} \boldsymbol{F_i}\tau_i \boldsymbol{DF_i} - S\sum_{fx} \tau_i \boldsymbol{DF_i}$$

$$PV = \boldsymbol{DF}[FN(d_1) - XN(d_2)]$$

$$PV = (1-R) * \int_0^T \boldsymbol{DF}(\boldsymbol{t}) dP(t) - S\sum_{i=0}^{N} \tau_i \boldsymbol{DF_i} * (1 - P(t_i))$$

3. Implementation



4. Deliver

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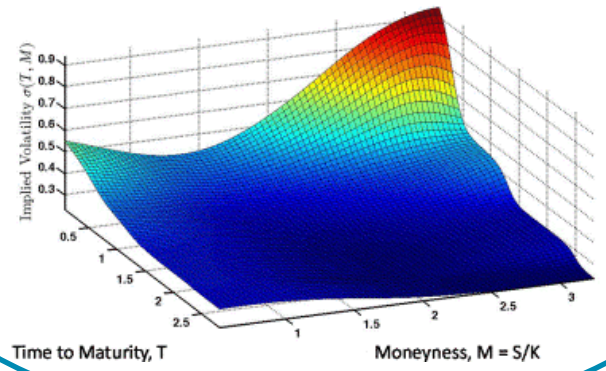

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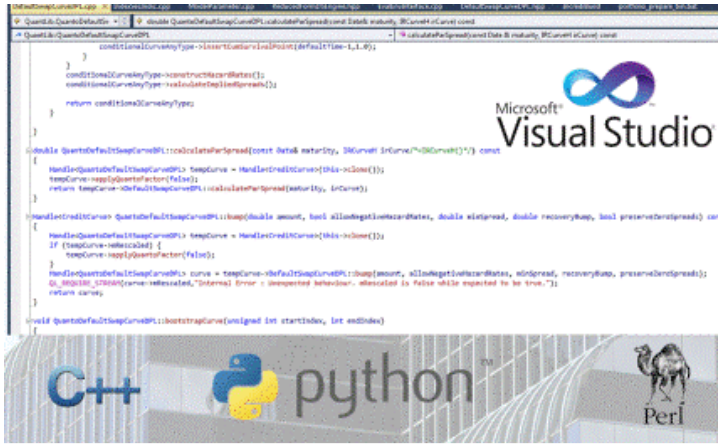

4. Deliver

Knowledge of financial products

- Types of derivatives
- Understand risk, XVA, etc.
- Problem definition

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Example #1:

European call option:

- Maturity: T
- Current price of the underlying stock: S_0
- Volatility of the underlying stock: σ
- Strike price of the option: K
- Payoff = $(S(T) - K)^+$
- $DF = e^{-rT}$

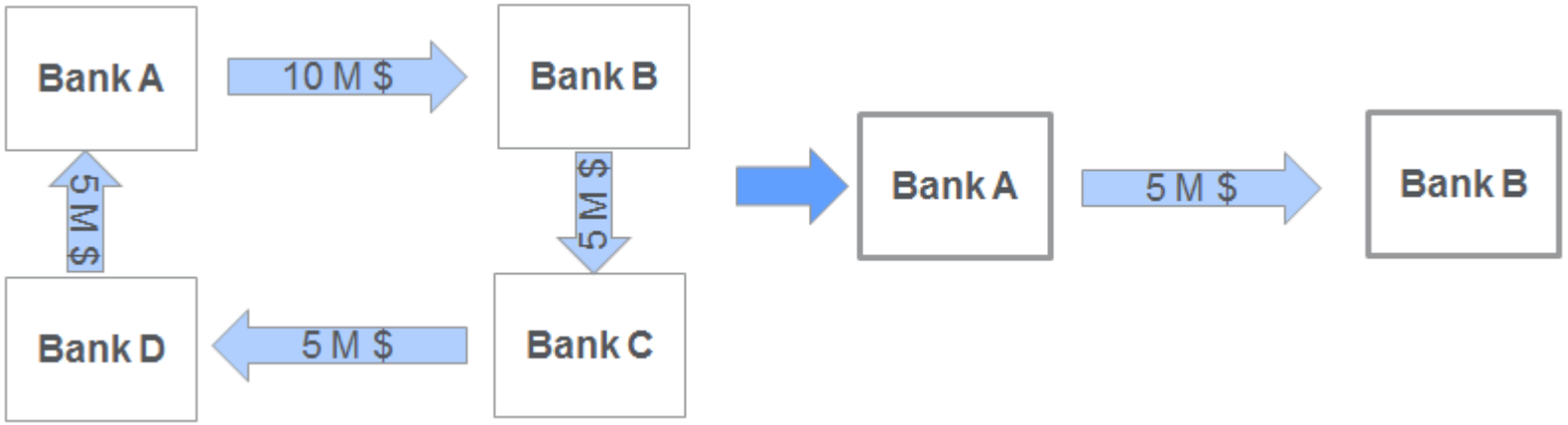
How much is its fair price?

Knowledge of financial products

- Types of derivatives
- Understand risk, XVA, etc.
- Problem definition

Example #2:

Trade compression (uni- or multilateral)



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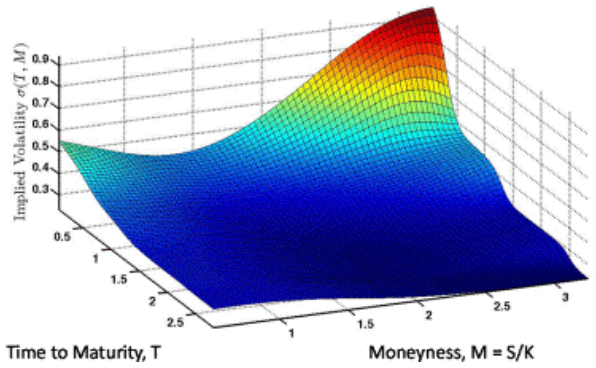

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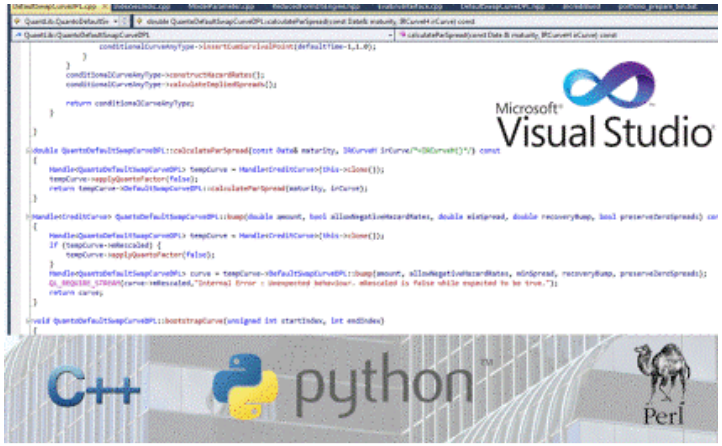

4. Deliver

Maths experience

- Stochastic calculus
- PDEs
- Monte Carlo methods

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Example #1:

Stock price $S(t)$ is modelled as a generalized Wiener process:

$$dS = \mu S dt + \sigma S dz$$

One can derive the following Itô process:

$$S(t + \Delta t) - S(t) = \mu S(t)\Delta t + \sigma S(t)\epsilon\sqrt{\Delta t}$$

Maths experience

Example #2:

- Trading set with one counterparty:

Input: $\begin{bmatrix} c_1 & A_{1,1} & \dots & A_{1,M} \\ \vdots & \vdots & \ddots & \vdots \\ c_N & A_{N,1} & \dots & A_{N,M} \end{bmatrix}$ e.g. 2000 trades

notional — MtM and risk factors, e.g. DV01_3m, DV01_1y, …

Output: $\begin{bmatrix} w_1 \\ \vdots \\ w_N \end{bmatrix}$ weights of original notional

Sum of each factor: $\begin{bmatrix} \Sigma_1 & \dots & \Sigma_M \end{bmatrix}$

risk profile

- Objective:

$$\mathbf{w}: \underset{\mathbf{w}}{\operatorname{argmin}}\ \mathbf{c}^T\mathbf{w}$$

such that $\mathbf{0} \le w_i \le w_{max}$, $\boldsymbol{\Sigma} + \mathbf{L} \le \mathbf{A}^T\mathbf{w} \le \boldsymbol{\Sigma} + \mathbf{U}$ → (canonical form) $\begin{bmatrix} \mathbf{A}^T \\ -\mathbf{A}^T \end{bmatrix} \le \begin{bmatrix} \boldsymbol{\Sigma} + \mathbf{U} \\ -(\boldsymbol{\Sigma} + \mathbf{L}) \end{bmatrix}$

→ LP optimization problem

Maths experience

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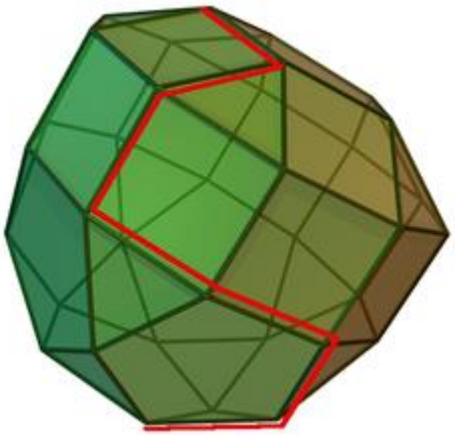
→ LP optimization problem: simplex



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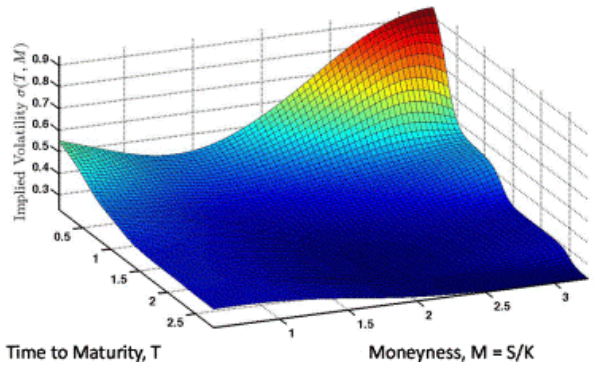

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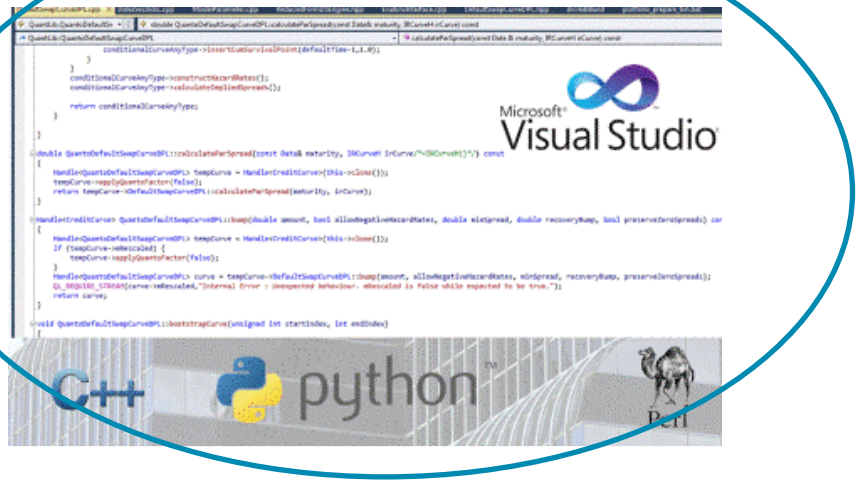

4. Deliver

Software development skills

- Coding financial math models
- Python, C++, (Perl, Matlab)
- Data cleaning
- Testing frameworks: unit tests, regular re-evaluation of model performances
- Model documentation
- Design patterns
- Git version control
- Linux and Windows shell
- Data science and machine learning techniques
- …

Example #1:
Choosing the number of trials
Model limitations (e.g. products)

Example #2:
Coding with numerical libraries
Interface design

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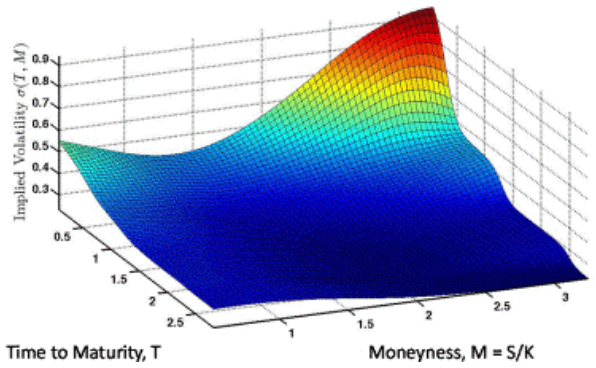

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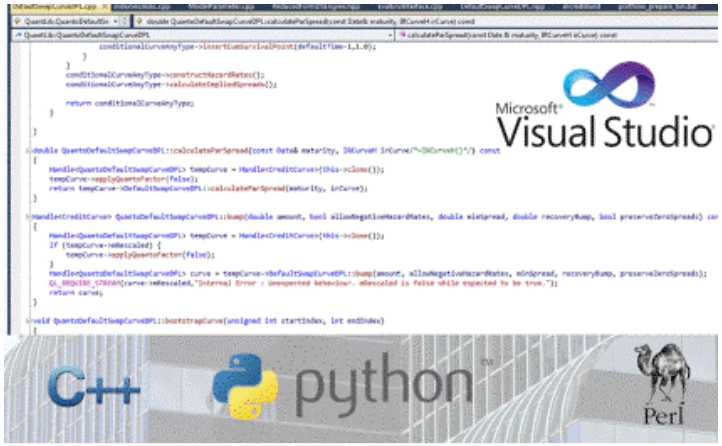

4. Deliver

Soft skills

- Have good written and spoken English
- Would like to work as part of a global team with the opportunity to travel to London and New York
- Would like to receive expert training
- Team work in a heterogeneous environment

Recommended readings

- John C. Hull: Options, Futures, and Other Derivatives
- Steven E. Shreve: Stochastic Calculus for Finance I-II
- Learn Python the Hard Way (online book), https://learnpythonthehardway.org

MQA Summer Internship program

Summer Intern program for 4+1 pre-final year students. During the internship, our interns will work side by side with our top experts in order to build, optimize, test and implement tools and features for our financial models and systems that will be used to analyze the market situation and assess investment risk

- **Quant Developer (BSc, MSc or PhD)**
  - Technical development and optimization of the analytics libraries and server components requiring software development skills in C++ or Python along with good numerical skills.
- **Quant Support (BSc, MSc or PhD)**
  - Supporting the development infrastructure, databases and productivity tools along with the build, testing and release management of the analytics libraries requiring Computer Science skills. Working in Python or Linux bash languages.
- **Quant (MSc or PhD)**
  - Research, development, optimization, documentation and performance analysis of the Financial Models used in the analytics libraries requiring a strong academic background in Mathematics and experience of programming in C++ or using MATLAB.
- **Trading Associate (BSc, MSc or PhD) - NEW**
  - Supporting senior traders, developing and back-testing trading strategies, requiring good numerical skills and experience of analysis in Excel and Python.

Eligibility: Currently completing a BSc/MSc/PhD at a Hungarian institution in Computer Science, Engineering, Mathematics, Physics, Finance, Economics, or similar

Thanks for your attention!

Q & A

Visit **jobs.citi.com** + keywords**: Internship + Budapest**

Questions ?