Handelsbanken Capital Markets

An introduction to the Front Office Quant
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Handelsbanken Capital Markets: Quant Team Overview

- Two main focus areas: Equities and Fixed Income & Currencies
- Experts on financial mathematics, mathematical modeling and financial markets
- Valuation & pricing across all asset classes (interest rates, currencies, equities, commodities, credits)
- 10 team members and 2 students
  - 8 quantitative analysts specialized on valuation & pricing
  - 2 quantitative developer specialized on software development
  - 3 PhDs
  - Regular internships for spring/summer

- Seated on the trading floor
- Working directly towards the trading desks
- Part of the Capital Markets business unit

Fixed Income & Currencies

Fixed Income & Currencies: Our Business

- Help corporate and institutional clients with funding and interest rate & currency risk management. Example:

Debt Capital Markets help a client issue a bond. The issue is in foreign currency for liquidity reasons (DCM)

The bank guarantees a certain level of funding and warehouses nominal outstanding after the initial offering (Credit desk)

The bank acts as Market Maker in order to guarantee the liquidity of the bond (Credit desk)

The client converts the funding to domestic currency by entering a cross-currency swap with the bank (Swap desk)

The bank manages capital costs and counterparty credit risk related to the bond and swap positions (xVA desk)

The client has secured funding by issuing a bond in foreign currency with cashflows converted into domestic currency

Inception	**Bond:** Client receives USD notional ←	**Swap:** Client pays USD notional →	**Swap:** Client receives SEK notional ←
Rate payments	**Bond:** Client pays USD Libor 3M →	**Swap:** Client receives USD Libor 3M ←	**Swap:** Client pays SEK STIBOR 3M + *x* →
Redemption	**Bond:** Client pays USD notional →	**Swap:** Client receives USD notional ←	**Swap:** Client pays SEK notional →

Fixed Income & Currencies: The Quant Role

- Trades are fewer but often larger and longer dated than in Equities → Large impact from capital costs and counterparty risk (xVA)

- Handelsbanken mainly trades linear products (bonds, FRAs, IR swaps, FX forwards/swaps and cross-currency swaps) and vanilla options (swaptions, caps/floors, FX options)

- Our business uses sophisticated tools for pricing and managing positions
  - Front Arena trading system for trade and risk management
  - C++ pricing library with Excel as user interface
  - Interest rate curves constructed in Front Arena and fed to Excel through a market data service (MDS)
  - External market data sources (e.g. Bloomberg) available through APIs in Excel

- Quants provide risk neutral pricing and price adjustments (xVA) based on models
- The challenge is to implement user friendly functionality which is computationally effective and adheres to limiting circumstances

Interest rate curves under limiting circumstances

- Forward rates, i.e. the interest rate between future times t_1 and t_2, are traded in the market. For instance the next quarter or a period between two Central Bank meetings

- Many systems construct interest rate curves in spot terms. The spot rate $r_{t,T}$ is used for discounting a claim from T to today t:

$$P(t,T) = \exp(-r_{t,T}(T - t)) = \exp(-\int_t^T f(s)ds)$$

where $P(t,T)$ denotes the discount factor and f denotes the instantaneous forward rate. This implies:

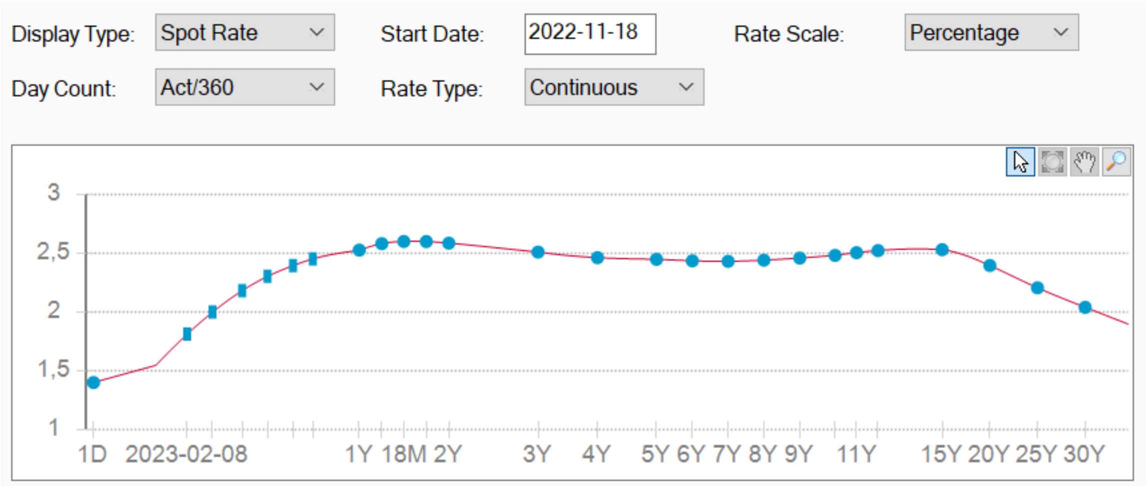
$$r_{t,T} = \frac{1}{T - t}\int_t^T f(s)ds$$

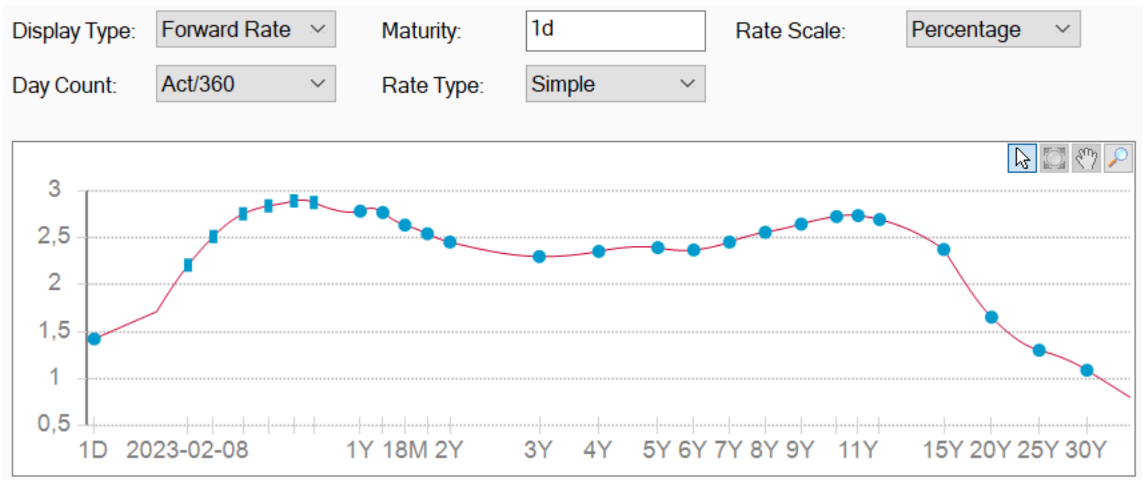
- The implementation in our system is far more established and computationally efficient for spot rates than forward rates

- How do we construct stable, forward consistent curves in spot terms? We demonstrate this for OIS curves

Interest rate curves under limiting circumstances

- We want OIS curves to reflect Central Bank policy rate changes in the short end and to be stable in the long end
- A poor choice of interpolation method in spot terms would be smooth functions like Cubic Spline or Hermite
  - Cubic Spline fits a cubic polynomial to the spot rates, which gives quadratic forward rates
  - Multi-dependencies between curve points give ripple effects when the market moves
- EUR OIS curve constructed using Cubic Spline displayed in spot terms vs forward terms



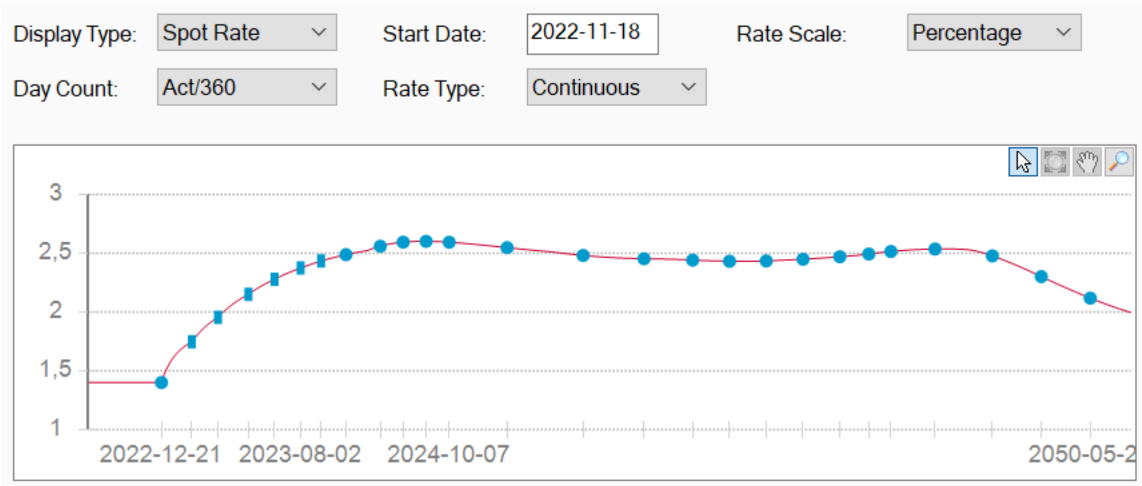


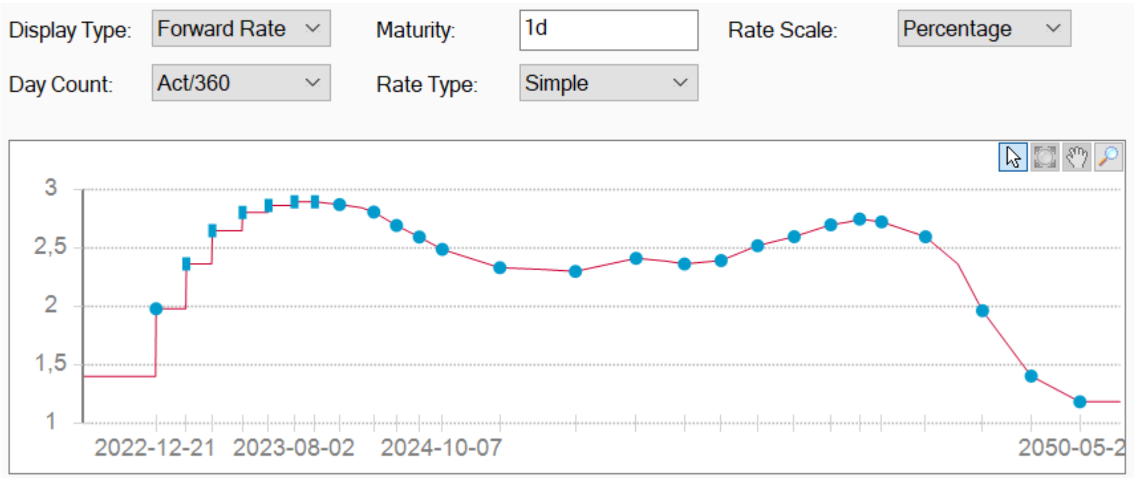
Interest rate curves under limiting circumstances

- A more sophisticated construction in spot terms would be:
  - Linear RT for piecewise constant forward rates in the short end
  - Quadratic Spline RT for linear forward rates in the long end
  - Condition on equality of first order derivative between interpolation segments to ensure continuous forward rates
  - These interpolation methods are local in forward terms

$$r_{t,T}(T - t) = \int_t^T f(s)ds \quad \rightarrow \quad \begin{matrix} r_{t,T}(T - t) \in O(x^n) \\ f \in O(x^{n-1}) \end{matrix}$$

- EUR OIS curve constructed using sophisticated interpolation displayed in spot terms vs forward terms





Interest rate curves under limiting circumstances

- More sophisticated reasoning is needed for longer tenors (i.e. IBOR rates) and collateral curves
- Some details have been left out for simplicity and for the sake of not disclosing business secrets

- This example is meant to demonstrate Fixed Income Quant work at a trading floor
- The result of this work is stable and computationally efficient since it relies on established implementations for calculating risks
- The computational efficiency allows us to leverage more sophisticated risk meassures such as benchmark deltas
- The implementation can be carried out without overriding core-functionality, which implies low maintenance

Recent initiatives

- Transition from LIBOR to RFR rates
- Developing optimal curve shape and hierarchy
- Incorporating spikes on curves
- Increasing focus on XVA: CVA, DVA, FVA, KVA, CollVA, etc

  After 2008: counterparty credit risk must be considered in derivatives valuation

$$\mathrm{CVA} = (1 - R) * \sum_t \mathrm{P}_{\mathrm{default}}(t) * \mathbb{E}[\mathrm{exposure}(t)^{+}]$$

- Upgrading to new versions of the used pricing and risk software
- Maintaining in-house C++, C# pricing libraries and VBA tools

Equities

Introduction

- Large number of asset classes
  - Commodities, Credits, Equities, FX
- Fast paced environment with many exchange-traded products
  - Nasdaq, Euroclear
- Maturities up to five years and the bank is generally on “sell-side”
- Focus on intra-day valuation and correct EOD-pricing/fixing in a risk-adverse environment
- Portfolio a combination of linear and more complicated derivatives
- Main stakeholders:
  - Equity market-making
  - Execution

Non-linear products

- Generally:

$$derivative_t = F(S_t^i, r_t, d_t, \sigma_t, \Sigma)$$

- Calibration of input params:

  - Rates (swaps, fras, …)
  - Future/implied dividend (options, dividend swaps, declared dividends)
  - Volatility (options)
  - Correlations (…)

- Pricing (Model-choice, calibration and simulation):

  - Analytic solution
  - Finite difference
  - Monte Carlo

Input parameters

- Market-quoted prices / yields input
- Volatility (ex):

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< > OMX STOCKHOLM 30 INDEX Index ▾ | OMON ▾ | Related Functions Menu ▾ Message

OMX ↑2076.029 -11.339
At 11:33 O 2082.204 H 2086.109 L 2074.676 Prev 2087.368 XC

OMX Index | 95) Actions ▾ | 96) Export ▾ | 97) Settings ▾ | Option Monitor

OMX STOCKHOLM 30 INDEX ↑2076.029 -11.339 -.5432% / Hi 2086.109 Lo 2074.676 Volm 0 HV 17.60

Center 2076.458 Strikes 5 Exp 16-Dec-22 Exch NASDAQ OMX Stockh 92) Events Calendar | EVTS »

Calc Mode As of 21-Nov-2022

81) Center Strike | 82) Calls/Puts | 83) Calls | 84) Puts | 85) Term Structure | 87) Moneyness

Calls Ticker	Bid	Ask	Last	IVM	Volm	Strike	Puts Ticker	Bid	Ask	Last	IVM	Volm
16-Dec-22 (25d); CSize 100; IDiv .44; R 2.31; IFwd 2079.74						5	16-Dec-22 (25d); CSize 100; IDiv .44; R 2.31; IFwd 2079.74					
1) OMX 12 C2065	49.50	52.75	45.50y	20.36		2065	39) OMX 12 P2065	33.25	35.50	36.00y	18.91	519
2) OMX 12 C2070	46.50	49.50	48.00	20.07	1	2070	40) OMX 12 P2070	35.00	37.50	36.00	18.80	1
3) OMX 12 C2075	43.50	46.50		19.93		2075	41) OMX 12 P2075	37.00	39.50	43.50y	18.50	
4) OMX 12 C2080	40.75	43.50	46.75y	19.74		2080	42) OMX 12 P2080	39.25	41.75	36.75y	18.37	
5) OMX 12 C2085	38.00	40.75		19.57		2085	43) OMX 12 P2085	41.25	44.00		18.14	
20-Jan-23 (60d); CSize 100; IDiv .55; R 2.31; IFwd 2083.22						5	20-Jan-23 (60d); CSize 100; IDiv .55; R 2.31; IFwd 2083.22					
6) OMX 1/23 C2060	78.25	81.75	42.00y	20.50		2060	44) OMX 1/23 P2060	53.50	56.25	67.25y	19.61	
7) OMX 1/23 C2070	72.25	75.75		20.26		2070	45) OMX 1/23 P2070	57.25	60.00	57.50y	19.35	
8) OMX 1/23 C2080	66.50	69.75		19.97		2080	46) OMX 1/23 P2080	61.50	64.25		19.15	
9) OMX 1/23 C2090	61.00	64.25	83.00y	19.78		2090	47) OMX 1/23 P2090	65.75	68.75	66.50y	18.90	
10) OMX 1/23 C2100	55.75	58.75	59.50y	19.45		2100	48) OMX 1/23 P2100	70.25	73.75	71.25y	18.70	
17-Feb-23 (88d); CSize 100; IDiv .39; R 2.31; IFwd 2086.91						5	17-Feb-23 (88d); CSize 100; IDiv .39; R 2.31; IFwd 2086.91					
11) OMX 2/23 C2060	95.75	99.50		20.78		2060	49) OMX 2/23 P2060	67.25	70.25		20.06	
12) OMX 2/23 C2070	89.75	93.50		20.64		2070	50) OMX 2/23 P2070	71.00	74.25	86.50y	19.84	
13) OMX 2/23 C2080	84.00	87.50	89.50y	20.42		2080	51) OMX 2/23 P2080	75.00	78.25	73.00y	19.60	
14) OMX 2/23 C2090	78.50	81.75	71.50y	20.15		2090	52) OMX 2/23 P2090	79.25	82.75		19.47	
15) OMX 2/23 C2100	72.75	76.25	70.25y	19.95		2100	53) OMX 2/23 P2100	83.75	87.25		19.20	
17-Mar-23 (116d); CSize 100; IDiv .51; R 2.54; IFwd 2090.14						5	17-Mar-23 (116d); CSize 100; IDiv .51; R 2.54; IFwd 2090.14					
16) OMX 3/23 C2040	122.50	127.00	113.75y	21.40		2040	54) OMX 3/23 P2040	71.50	74.75	73.25y	20.75	
17) OMX 3/23 C2060	109.75	114.25	116.80y	20.94		2060	55) OMX 3/23 P2060	78.50	82.00	113.00y	20.32	
18) OMX 3/23 C2080	98.00	102.00	120.00y	20.53		2080	56) OMX 3/23 P2080	86.25	89.75	126.00y	19.89	
19) OMX 3/23 C2100	86.75	90.50	85.00y	20.11		2100	57) OMX 3/23 P2100	94.50	98.50	89.50y	19.48	
20) OMX 3/23 C2120	76.25	80.00	73.00y	19.74		2120	58) OMX 3/23 P2120	103.75	107.75	94.50y	19.09	
16-Jun-23 (207d); CSize 100; IDiv 3.91; R 3.11; IFwd 2063.85						5	16-Jun-23 (207d); CSize 100; IDiv 3.91; R 3.11; IFwd 2063.85					
21) OMX 6/23 C2040	136.25	141.00	71.50y	20.96		2040	59) OMX 6/23 P2040	111.00	115.25	236.75y	20.46	
22) OMX 6/23 C2060	124.75	129.50	84.75y	20.65		2060	60) OMX 6/23 P2060	119.50	123.50		20.22	
23) OMX 6/23 C2080	113.75	118.75	140.50y	20.34		2080	61) OMX 6/23 P2080	128.00	132.25	179.50y	19.85	
24) OMX 6/23 C2100	103.25	108.00	101.00y	20.01		2100	62) OMX 6/23 P2100	137.25	141.50	206.00y	19.54	
25) OMX 6/23 C2120	93.50	98.00	102.25y	19.72		2120	63) OMX 6/23 P2120	147.50	151.50		19.30	
15-Sep-23 (298d); CSize 100; IDiv 2.89; R 3.22; IFwd 2078.11						5	15-Sep-23 (298d); CSize 100; IDiv 2.89; R 3.22; IFwd 2078.11					

Building the surface

- Undiscounted European call:

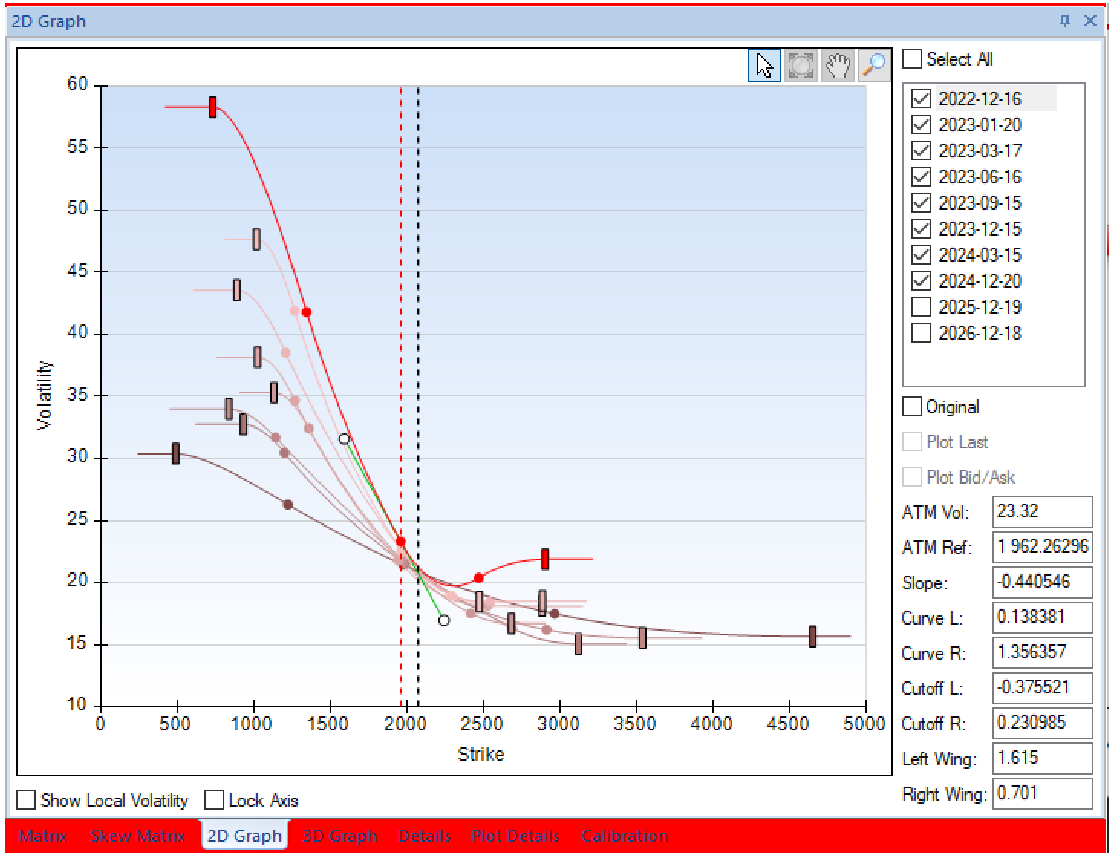
$$C(U_0, K, T) = \int_K^\infty dU_T \phi(U_T, T; U_0)\,(U_T - K) \qquad \phi(U_T, T; U_0) \geq 0$$

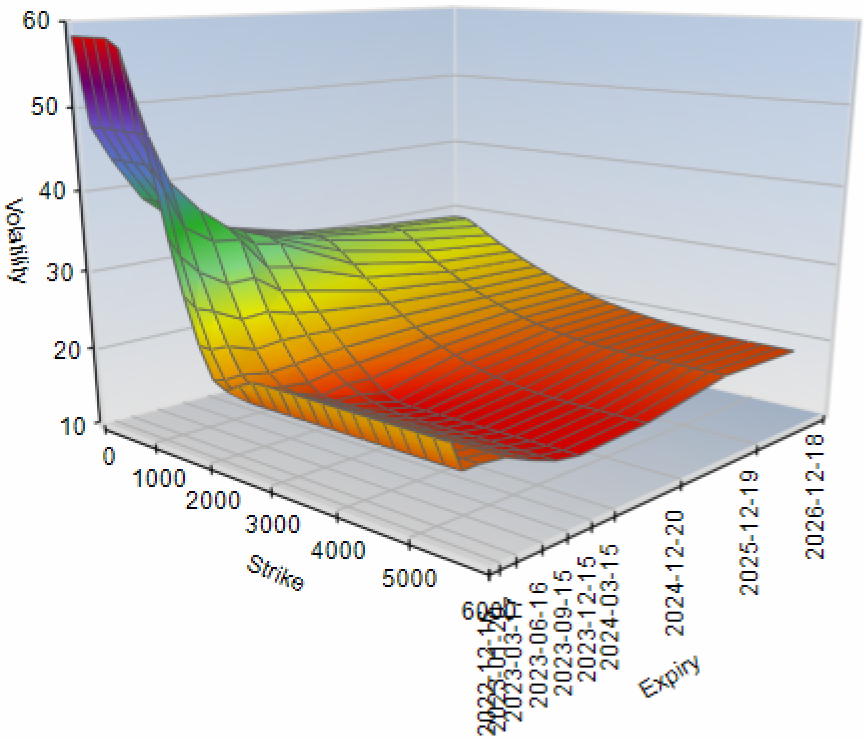
- Finite set $\{C_i(T_j)\}$ so some inter/extra-polation scheme needed

- However … By direct differentiation (+ calendar arb)

$$\frac{\partial C}{\partial K} \leq 0, \qquad \frac{\partial^2 C}{\partial K^2} \geq 0 \qquad \frac{\partial C}{\partial T} \geq 0$$

Volatility surface





Model-choice and calibration

- Once curves / surfaces are calibrated, pick your favorite model

<u>Heston:</u>

$$dS = \mu S dt + \sqrt{v} S dZ_1$$

$$dv = \kappa(\theta - v)\, dt + \sigma\sqrt{v} dZ_2 \qquad \langle dZ_1, dZ_2 \rangle = \rho dt$$

$$Cost = \sum_{i,j} |(F(S_t, K_i, T_j) - C(K_i, T_j))|$$

Pricing / hedging

- Exotics:

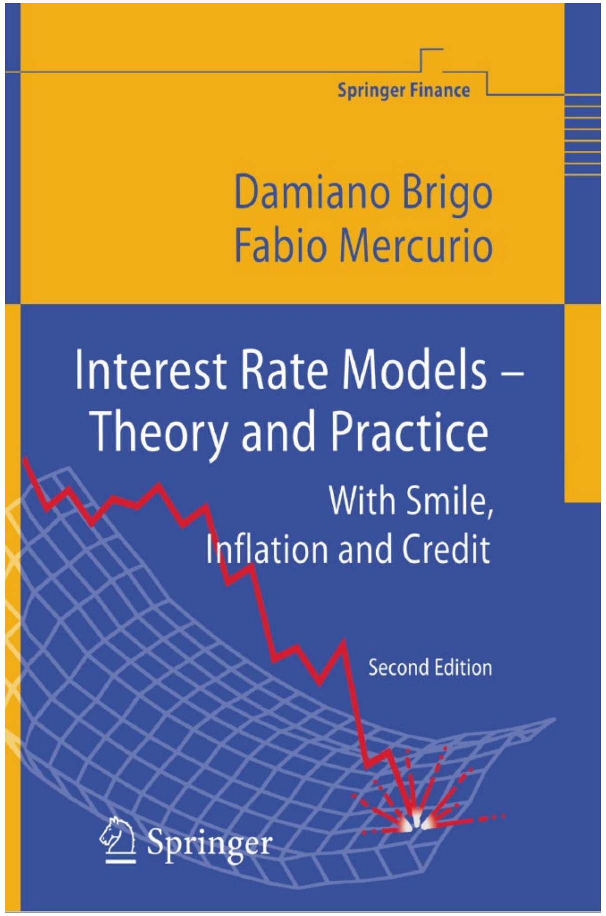
  - Asians
  - Barriers
  - Autocalls etc etc

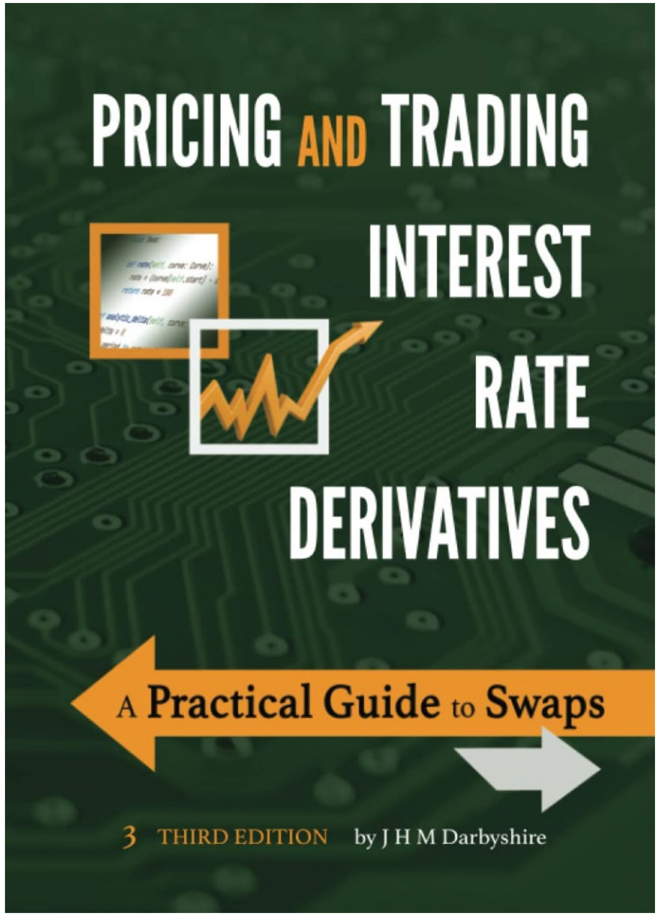
- Computation:
  - Generally very few analytic solutions and FD / MC-schemes necessary.
  - Performance ... (C++)

- Risk:

  Shifting and repricing

Literature


Springer Finance
Damiano Brigo
Fabio Mercurio
Interest Rate Models –
Theory and Practice
With Smile,
Inflation and Credit
Second Edition
Springer


PRICING AND TRADING
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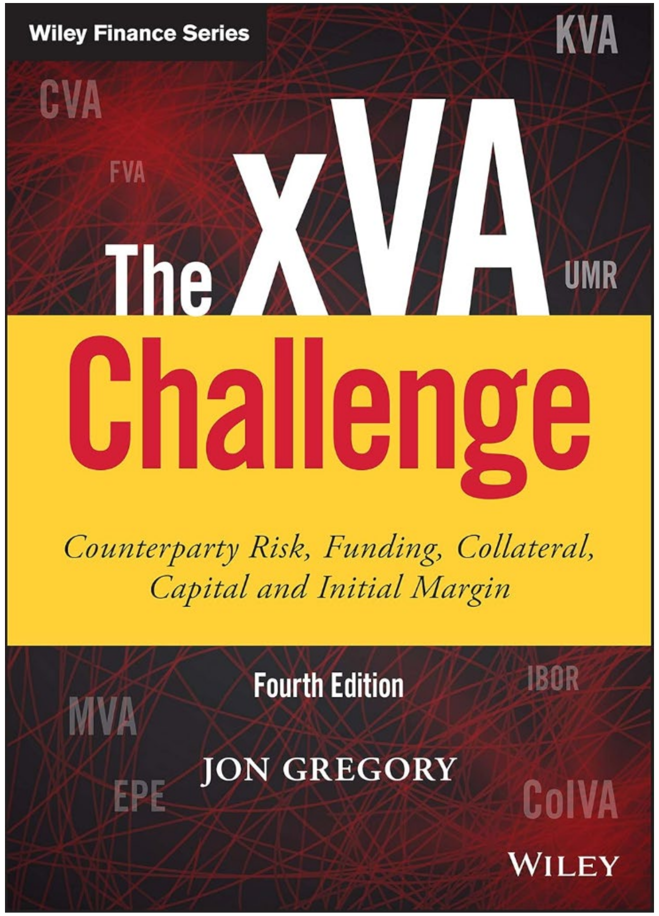
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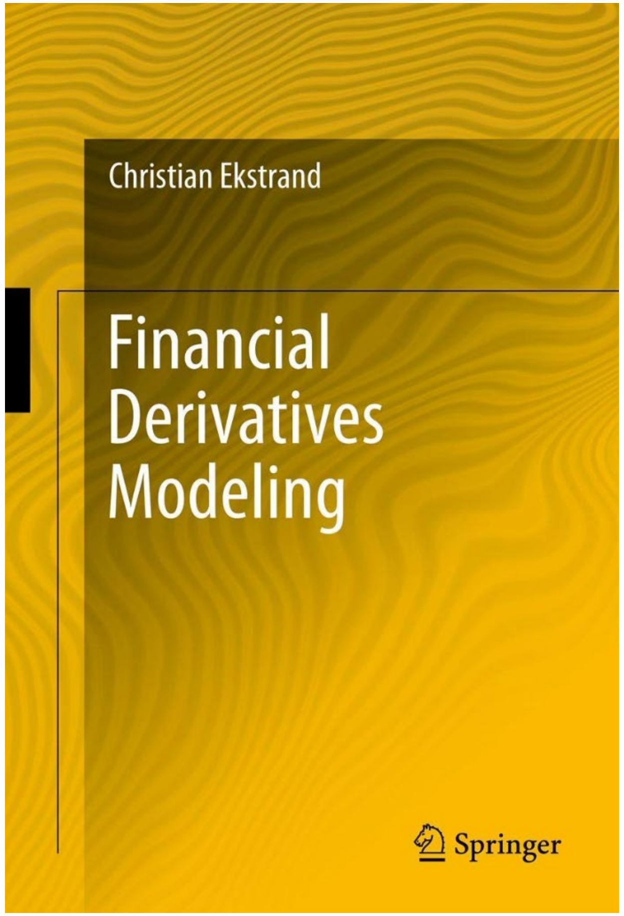
Christian Ekstrand
Financial
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Modeling
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POV ChatGPT and I after having finished writing the code