Leaving academia

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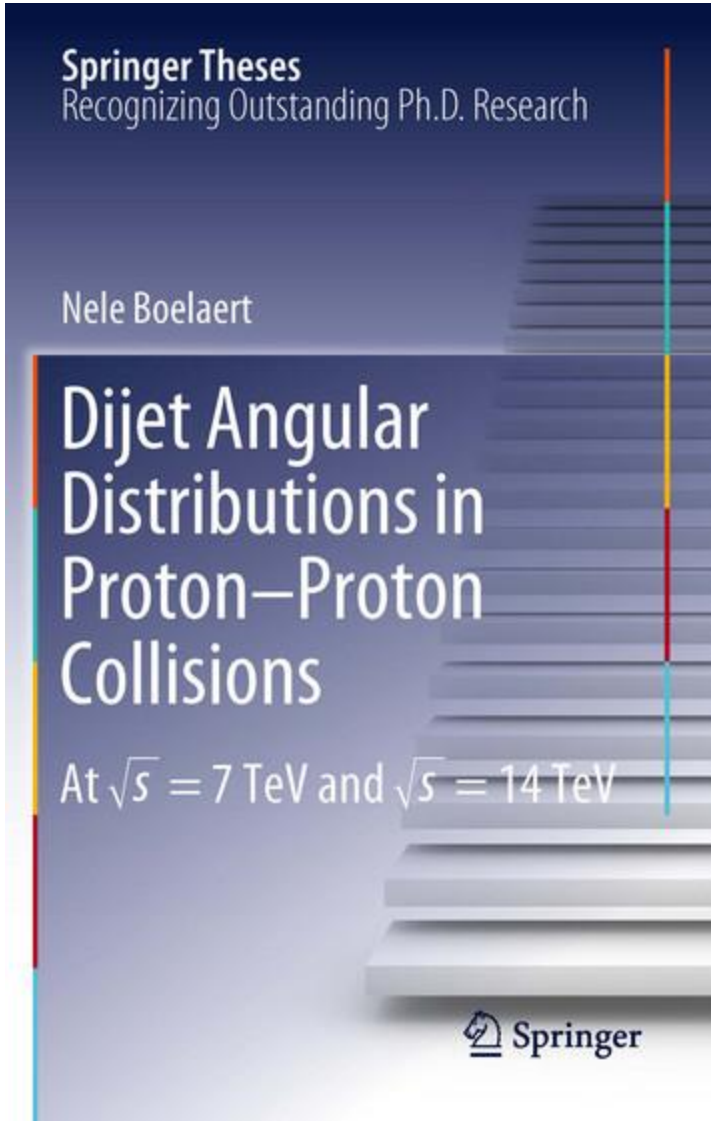
From physics to finance

- 2017 – now: senior quant at Nykredit
- 2012 – 2017: (senior) software developer at SimCorp
- 2010 – 2012: postdoc at NBI
- 2006 – 2010: PhD in experimental particle physics, Lund University
- 2001 – 2006: Master of Engineering, Ghent University Belgium

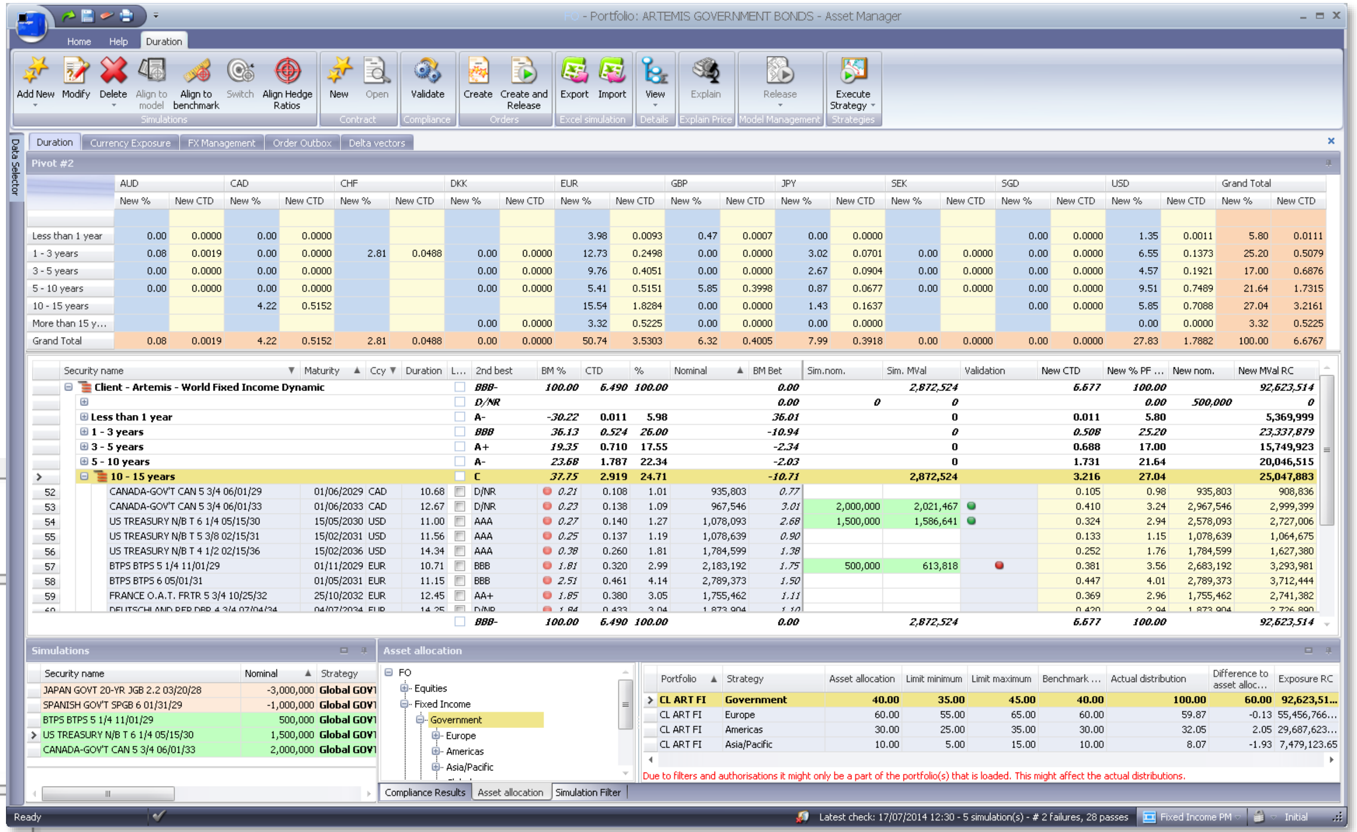


Software developer at SimCorp

- SimCorp: ~1400 employees, that make, test, sell and support one software product: **SimCorp Dimension**
- Investment management software
- Headquartered in Copenhagen

Being a developer at SimCorp

- Most developing is done in APL: **A P**rogram **L**anguage
- Also C# (front ends)
- database layer (SQL)
- Learned programming languages and finance on the job
- Additional finance courses in own time



An APL program to find all PrimeNumbers <= an integer:

```
PRIMES : (~R∊R∘.×R)/R←1↓⍳R
```

Being a developer at SimCorp

- **Agile** development – **Scrum** framework: work closely together in small teams in blocks of 2 weeks
- Product Owners decide on what needs adding, **you** can **only decide how**
- 400 developers – 1 code base: you need to understand first what is there, and then add to it/correct it.
- **Shared** code ownership
- **Code review**: get critical feedback!
- Test department (**QA**) will take your development to the limits and try to break it ☺
- **Coding standards**

Why was it fun at SimCorp

- Complicated and challenging code base; takes 1 year from being new to being productive
- Could start with no financial experience
- PhD’s in demand: >50 % in my team had a PhD in natural sciences
- Nearly 100% a developer: no admin, fighting for grants
- You work as a team, on an existing code base, you can get help if needed
- Output: what you code is being used by clients
- Flexible hours/location

And less fun

- You can not always develop the system in a way you think is best
- Flexible hours/location but still expected to be reasonable about it
- No deeper physics

Working at Nykredit

Nykredit

- Wanted more mathematics so ended up taking courses on financial modelling (in my own time)
- Senior front office quantitative analyst (so-called quant)
- Nykredit: a small big bank (Denmark 3rd largest bank)
- Biggest mortgage provider in Denmark
- Just over 4.000 employees
- Company language is Danish

Bank for boligejere

Nykredit BoligBank er for dig, der gerne vil have det meste ud af det, du har – både nu og i fremtiden. Vi er daglig bank, boligfinansiering og opsparing i et, og du får rådgivning og overblik med udgangspunkt i hele din økonomi – også din bolig.

SE, HVAD VI KAN GØRE FOR DIG

Work as a quant

- C++ ”pricing” libraries that are used internally by the bank
- Python/Excel front end
- Database layer (SQL)

$$\frac{\partial V}{\partial t} + \frac{1}{2}\sigma^2 S_t^2 \frac{\partial^2 V}{\partial S_t^2} + rS_t \frac{\partial V}{\partial S_t} - rV = 0.$$

- Partial differential equations that describe prices of financial products, given how the market looks today, and assuming that prices and rates have a stochastic component
- … mixed with human emotions
- … solved using finite difference techniques, Monte Carlo or binomial/trinomial trees
- The art: write fast software for colleagues (traders, risk managers, treasury) that don’t always understand the mathematics nor have patience to do so

Being a quant at Nykredit

- Small quant team
- Our code repository = the Wild West ☺
- My time is spent on:
  - Support: help colleagues that use our software when they get stuck
  - Drift: calibration jobs, online pricing, night jobs etc: continous processing of market data so we can calculate real-time prices
  - Planning enhancements (meetings)
  - Coding and new developments
- PhD's are in demand for quant jobs: analytical skills and programming experience
- Finance experience was a must at Nykredit, but bigger banks will hire PhD's with no finance background and train them

Quant job interview

- You throw a pair of fair dice.
- You win 100 SEK if the sum of the dice is 10
- You loose 10 SEK otherwise
- Do you want to play this game?

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- Fair game: expected cost of the game = 0
- 6 x 6 = 36 outcomes. 3 combinations that make 10: (4,6), (5,5) and (6,4)
- Expected outcome = 100 SEK x 3/36 – 10 SEK x 33/36 = -1 /12
- Do not play this game!

Why it is fun at Nykredit

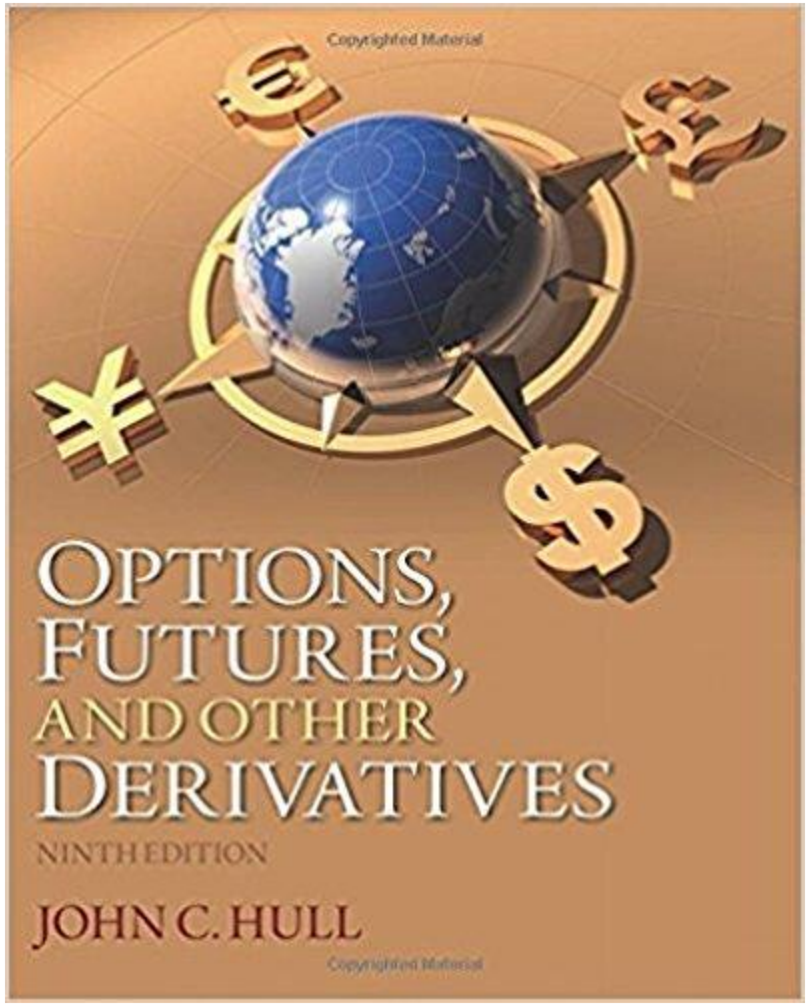
- Responsible for a very nice C++ library
- Develop software for colleagues that appreciate it
- A lot of freedom to make enhancements
- Can spend (working) time on courses and learning

And less fun

- When our ”drift” jobs go down, people get angry
- Flexible hours/location only in emergencies
- Formal dress code

Literature & courses

- *Finance - Markets, Instruments & Investments*
  Hans Byström: 1-day easy introduction
- *Options, Futures, and Other Derivatives*
  John Hull: standard work
- *Financial Engineering And Risk Management*,
  Part I and II: Coursera course by Columbia University
- To do:
  https://www.coursera.org/specializations/deep-learning

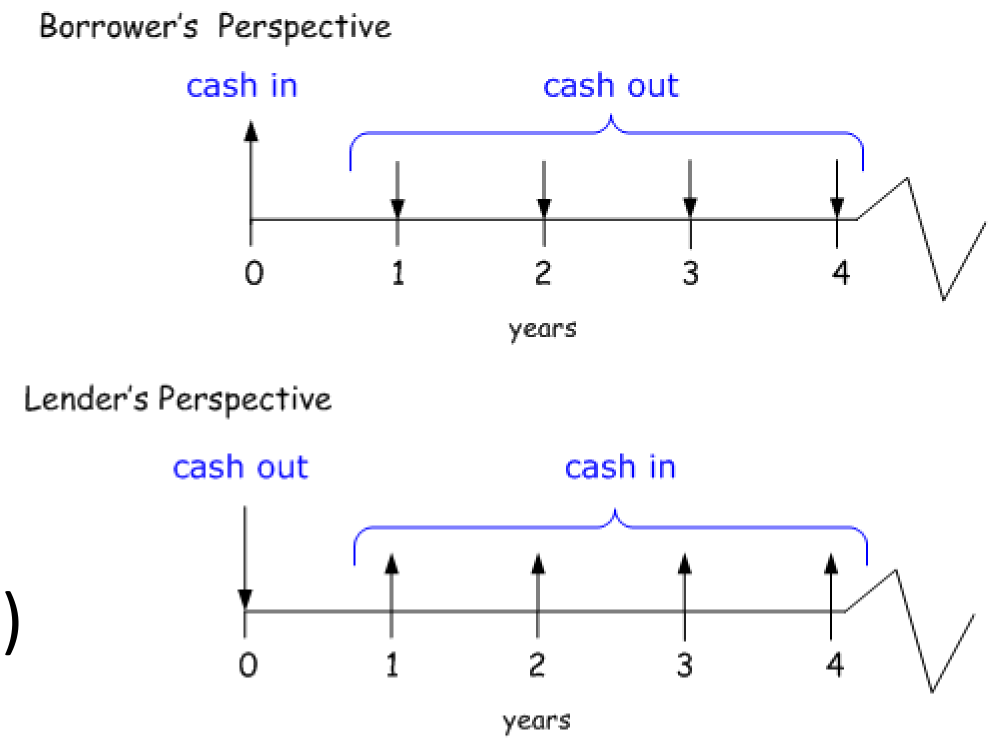


Finance teaser

- Cash flows
- Time value of money
- Aribtrage
- Fair prices

Cash flows

- E.g. loan
  - Borrow 1M today
  - Interest rate: 2.5%
  - Over 30 years
  - Every 3 monhts: pay interest + redemption (i.e. paying off the loan)
- Cash flow borrower (house owner) is inverse cash flow lender (bank or investor)
- Cash flows can be uncertain:
  - Borrower can go bankrupt
  - Loans can be with non-fixed interest rate that depends on the market in X years



Time value of money

- I have 1000 SEK today. I invest it at an annual rate of 5%. How much do I have in 10 years?

  Future Value: $FV = \ 1000 \times (1 + 0.05)^{10} = 1629$

- How much is 1000 SEK in 10 years worth today?

  Present Value: $\mathrm{P}V = \ 1000 \times \frac{1}{(1+0.05)^{10}} = 614$

- The Future Value, **discounted** with the interest rate, gives the Present Value:

$$\mathrm{P}V = \frac{1}{(1+r)^m} FV$$

- **discount factor**: $d_m = \frac{1}{(1+r)^m}$

Arbitrage

- Arbitrage: *the simultaneous buying and selling of assets in different markets in order to take advantage of differing prices for the same asset.*
- Finance theory is based on **aribitrage-free** pricing: the **law of one price**
- There is no free lunch: I cannot invest 0 SEK today, and be 100% certain that I have earned 100 SEK in 1 year
- If a stock goes to 0, it can never be above 0 again. Otherwise, I could buy it at no cost today and sell it for a risk-free profit as soon as its value > 0.
- Reality: rare arbitrage possibilities do exist

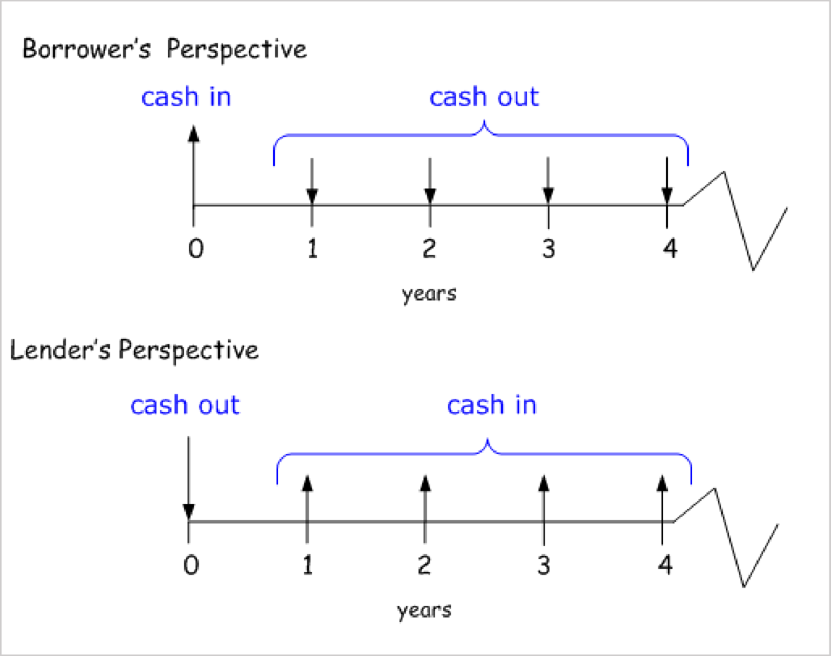
No-arbitrage and loan rates

- How to determine a fair rate on a 30Y loan?
- **NPV** = Net Present Value (at T = 0): sum of all (future) cash flows, discounted to T = 0:

$$NPV = -C_0 + \frac{C_1}{1+r} + \frac{C_2}{(1+r)^2} + \ldots + \frac{C_T}{(1+r)^T}$$

$$\begin{aligned}
-\,C_0 &= Initial\ Investment \\
C &= Cash\ Flow \\
r &= Discount\ Rate \\
T &= Time
\end{aligned}$$

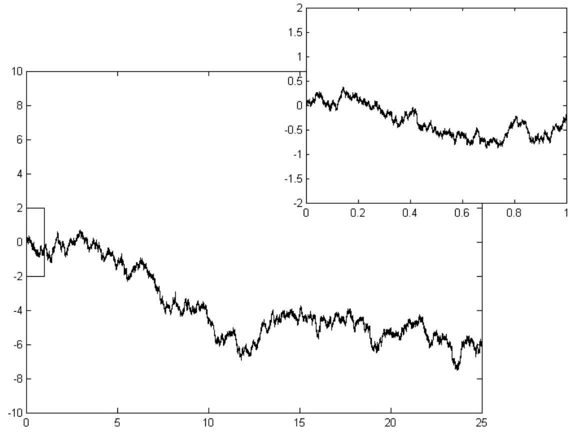
- The cash flows: C1, …. , CT: borrower pays **interest** and **redemption** (paying off the loan)
- No-aribtrage means: NPV = 0.
- **Fair rate** = choose interest rate so that the NPV of the loan equals 0
- Banks: will add a small **spread** to the fair rate to account for running costs



No-arbitrage example – forward rates

- Assume that today we know:
  - Return on 20Y investment = 2%
  - Return on 25Y investment = 2.5%
- Two investment schemes:
  1. Invest 100 SEK in a 25Y scheme. After 25Y:
     $$100(1+0.025)^{25}$$
  2. Invest 100 SEK in a 20Y scheme, followed by a 20Y to 25Y investment at the $r(20Y, 25Y)$ **forward rate**:
     $$100(1+0.020)^{20}(1+r(20Y,25Y))^{5}$$
- Both schemes should give the same outcome, otherwise there could be arbitrage (e.g. if scheme 1 had a lower outcome, then you could borrow S money via scheme 1 and invest it via scheme 2)
- Arbitrage lets us calculate the forward rate $r(20Y, 25Y)$ from rates we observe today

Stochastic interest rates

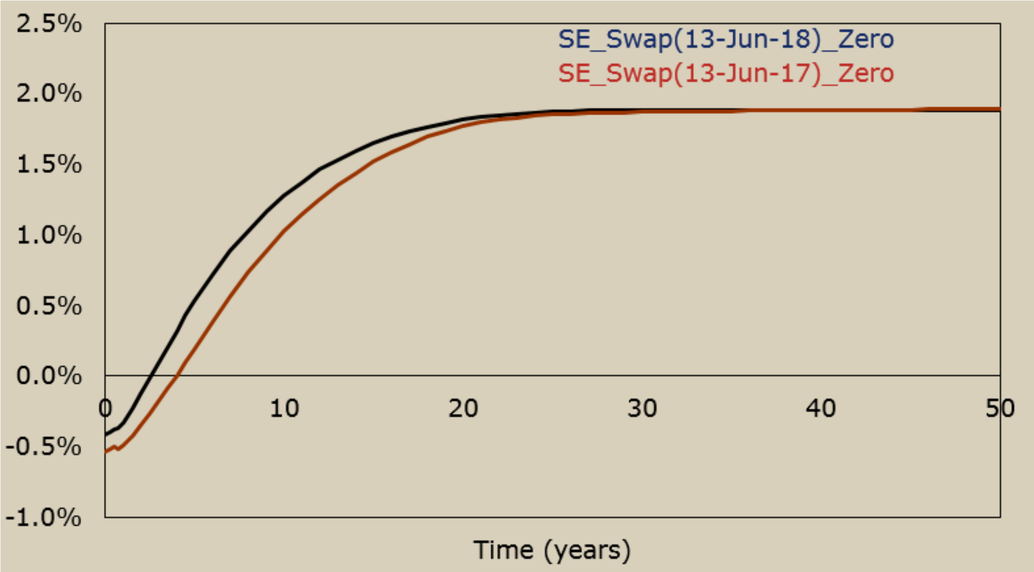


- Stochastic interest rates and stock prices
- Need to model it with Wiener process:

$$dr(t) = (\theta(t) - \kappa r(t))dt + \sigma(t)dW(t), \; r(t) = r_0$$

- No-arbitrage principle says that any financial instrument dependent on interest rate follows the following PDE for its value:

$$f'_t + \frac{1}{2}\sigma^2(t) f''_{xx} + \kappa(t)(\theta - x) f'_x - xf \quad = \quad 0 \qquad\qquad r(t) = x(t) + m(t)$$



Fair price

- **Fair price** of an investment: calculate all expected future cash flows (payments/costs) for an investment, and calculate how much these flows are worth today (i.e. discount future cash flows).
- Future cash flows can be uncertain (stochastic interest rates, bankruptcy, …)
- Determining today’s value of future cash flows is not trivial either (interest rate dependent)
- Quants calculate fair prices, traders/sales people will add a margin to make a living

Questions?