## Case

### Overview

Calculate Risk Weighted Assets for the Bank using the Internal Model approach for three counterparties (Salzburg Bank, Bank of Cluj, Bank of Mazowsze) as of 23rd February 2018. Assume notional for all the trades is 1.000.000.000 USD.

Portfolios:

**Salzburg Bank (ID = 484)(netted) :**

- 20y Receiver Swap USD6M LIBOR vs fixed 2.94% (paid annually)
- 20y Receiver Swap USD6M LIBOR vs fixed 1.94% (paid annually)
- 20y Receiver Swap USD6M LIBOR vs fixed 3.94% (paid annually)

**Bank of Cluj (ID = 47)(non netted):**

- Long 10y Payer Swaption on 10y USD6M LIBOR vs fixed 3.05% (paid annually)
- 30y Receiver Swap USD6M LIBOR vs fixed 2.93% (paid annually)

**Bank of Mazowsze (ID = 2741)(netted):**

- Long 10y (Yearly callable) Payer Bermudan Swaption on USD6M LIBOR vs fixed 3.05% (paid annually)
- Long 10y Payer Swaption on 10y USD6M LIBOR vs fixed 3.05% (paid annually)



## Case

### Data Files

- To solve the problem you need to make use of the following data:

**Market data**

- For calibration of the interest rate model for EAD calculation
- https://github.com/INTQuant-Katowice/2021/blob/master/Data/Market%20Data.xlsx

**Counterparty defaults**

- For PD model calibration
- https://github.com/INTQuant-Katowice/2021/blob/master/Data/DataPD.txt



## Overview

### Why is the industry regulated?

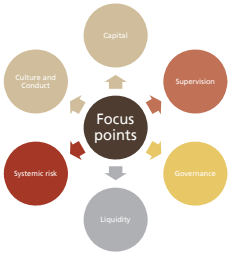
"... Regulations are like guardrails, they protect everyone from market excess ..."

- David Silberman, CFPB

"It sometimes seems like our financial system is set up to penalize those who know the least and have the least ... It appears to me that the system has gone beyond beware to buyer be damned."

- Richard Cordray, Director of CFPB

**To help manage the project:**: Introduction to Agile Project Managment (Breno Oliveira, UBS) (**16th March at 9:00**)






## Overview

### How to calculate it?

***EEE*** – Effective Expected Exposure

***EEPE*** – Effective Expected Positive Exposure

Asset Correlation – assume 0.2 in your calculation

$$RWA = 12.5 \times K \times EAD$$

Where:

$$K = [LGD * N\left[(1-R)^{-0.5} * N^{-1}(PD) + \left(\frac{R}{1-R}\right)^{0.5} * N^{-1}(0.999)\right] - LGD * PD](1 - 1.5 \times b(PD))^{-1} \times (1 + (M - 2.5) * b(PD))$$

- $N(x)$ is the cumulative distribution function of the normal distribution
- $b(x)=(0.11852-0.05478*\log(PD))^2$ - defined by the regulators
- $M$ is maturity adjustment $M = \min\left(5{,}1 + \frac{\sum_{(k:k>1,t_k\le 1)} EE_{t_k}(t_k - t_{k-1})D_{0,t_k}}{\sum_{(k:k>1,t_k\le 1)} EEE_{t_k}(t_k - t_{k-1})D_{0,t_k}}\right)$ (Discounting)

$$EAD = \alpha EEPE = \alpha \times \sum_{k=1}^{n}(\forall t_k < 1 : (t_k - t_{k-1})EEE_{t_k})$$

$$EEE_{t_0} = EPE_{t_0}: \qquad EEE_{t_i} = max(EPE_{t_i-1}, EPE_{t_i}):$$

- $\alpha$ is defined by Basel Committee , as 1.4.
- For details see:
  - 'An Explanatory Note on the Basel II IRB Risk Weight Functions'
  - **Lecture**: Regulatory Capital Requirements (Dr Tomasz Kania, UBS) (**16th March at 10:15**)



## Credit Regulatory Capital (RWA)

### How to calculate it?

**Expected Exposure (EE)**

- The amount of money that the counterparty owes UBS at the time of default event
- In case of traded derivatives it requires the usage of underlying market risk factor models.
  - The most popular approach is simulation of market risk factor using Monte Carlo technique
  - For simple products under simple models there exist closed form solutions (e.g. Black Scholes model)

**Creditworthiness**

- **Probability of Default (PD)**
  - The probability of the counterparty default in a given time period
  - Estimated using statistical modelling based on historical defaults
- **Loss Given Default (LGD)**
  - Fraction of the total EAD that is lost

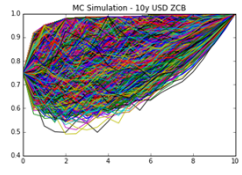


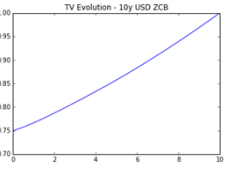
## Risk Factor Simulation

### Short rate modelling

- We can employ MC simulation to model the short rate diffusion thru time:
  - SDE:
    dr = θ (r, t) dt + σ (t) dZ
- The Zero Coupon Bond price P(t, T) will be given by something like:
  $P(t,T) = A(t,T)\, e^{-B(t,T)r(t)}$
- All bond prices depend on the same rate r;
- In r's SDE, there is only one source of uncertainty. This is called a one factor model;

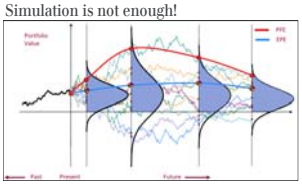
- (For simple products [e.g. swaps, options] a closed form approach could be used)
- **More info**: Introduction to MC Simulation in Finance (Olga Bączkowska, UBS) (**15th March at 10:15**)
- **More info:** Ho-Lee model calibration (Jacek Trepkowski, UBS)(**17th March at 10:00**)



## Calculating Risk Profiles

Simulation is not enough!



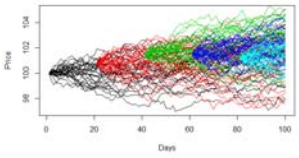
Simulation would give you only a Day 0 TV

- Calculating RWA requires knowledge of TV distribution at each point in time
- MC simulation can provide very general solution to problem of pricing a derivatives regardless of it's complexity
- For consistency we need to treat portfolio as a whole, which force us to price trades on scenario by scenario
- Issue: **scenario consistency**

- That would require **nesting MC** for each time and scenario we want to price
- Nesting the MC gives rise to high usage of computational usage.

$$10{,}000 \rightarrow 10 \times 10{,}000 \times 10{,}000 = 10^9$$

- One of the solutions to this is a **American Monte Carlo** algorithm.
  - **More info:** Introduction to MC Simulation in Finance (Olga Bączkowska, UBS) (**15th March at 10:15**)
  - 'Valuing American Options by Simulation', Longstaff, Schwartz.

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## Calculating Risk Profiles

Risk measures definitions

| Profile | Description | How to compute |
|---|---|---|
| EPEt | Expected Postivive Exposure:<br>Expectation of the portolio value floored at zero. | $EPE_t = P(0,t) \times E[(V_t - C_t)^+ B_t^{-1}]$ |
| PFEt | Potential Future Exposure:<br>97.5% quantile of the portfolio value at time t | $PFE_t = \inf\{x: P[(V_t - C_t) \le x] \ge \alpha\}, \alpha = 97.5$ |
| Reverse EPEt | Equivalent to $EPE_t$ but from the counterparty's point of view | |

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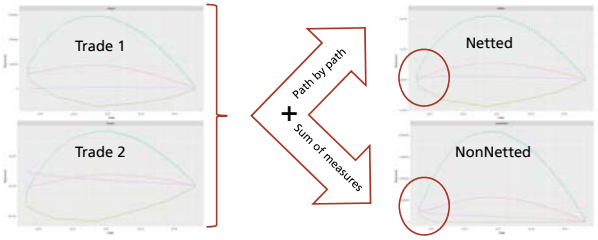
## Netted vs Nonnetted

Brief overview

- Banks often have more then one active trade with a counterparty.
- Two options to aggregate risk profiles:
  - **Netting** – calculated values of all trades for each scenarios (simulation paths) are added separately. Path by path aggregation
  - **No netting** – aggregated risk measures are sum of risk measures for specific trades

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## Expectation

What we would like to see?

- Present following risk profiles:
  - Quantile 97.5%
  - Quantile 2.5%
  - Expected Exposure
  - Reverse Expected Exposure
- At different levels of aggregation:
  - Trade level
  - Portfolio level
  - Firmwide
- Tests
  - Option pricing
  - Swaps

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## LGD&PD

A brief overview

**Loss Given Default:**

The amount of historical data on LGD is usually substantially less than for PD

This enables the company's to sometimes fall-back to expert judgment approach

- Assume some number based on the situation in the given industry/country
- Either use the most conservative value possible (100%) – all is lost.

**In this exercise we assume LGD is 60% for all the counterparties**

**Probability of Default:**

Considered time horizon is one year

Usually bucketed into ratings (AAA, BB+, etc.)

Depends both on obligor - specific factors (e.g. equity to assets, revenue growth) and macroeconomic conditions (e.g. unemployment rate, GDP growth)

From statistical point of view PD is an estimator of default rate (share of defaulted counterparties over all observations), usually modelled via GLM models (logit, probit regressions)

Statistical models serves a support for Credit Officers responsible for credit condition assessment

**More info:** Credit Risk Fundamentals (Sara Nowogórska, UBS)(**18th March at 8:00**)

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## Expectation

What we would like to see?

- Expert judgement on LGD
- Build a PD model
- Understand strengths and weaknesses of chosen approach
- Check the model performance relying on provided data
- Use created model to assess credit rating of selected counterparties

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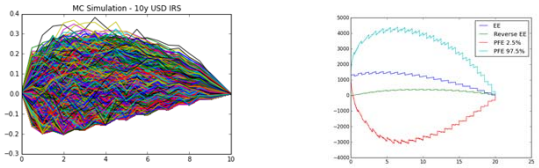
## Swap

What is it?

- if swap struck ATM (typical at trade inception), then its MtM = 0 at t=0;
- Expected value of the swap is not zero throughout its life because there are cashflows between inception and maturity;
- But at maturity, after all cashflows have been settled, the trade value is obviously equal to zero







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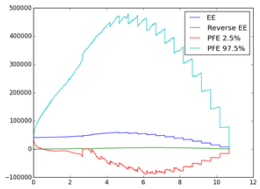
## Swaption

What it is?

- An European option to enter into a swap that starts immediately after expiry date
- How to price a swaption?
  - Knowing the swap price distribution for t=expiry, it's easy to compute the price of a swaption
  - Jamshidian decomposition technique => saves computation time
  - Enough to calibrate the model
  - **More info:** Ho-Lee model calibration (Jacek Trepkowski, UBS)(**17th March at 10:00**)
- Easy to compute the price today, what about price distribution over time?

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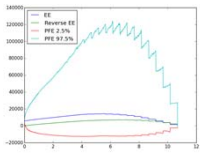
## Bermudan Swaption

What it is?

- an option that gives its holder to enter into a swap, that has a certain maturity date, at a few specified exercise dates;
- upon exercise, the swap cashflows start being exchanged as if it were an usual swap;
- think of this product as a natural hedge for a portfolio of mortgages whereby the borrowers have the option to refinance at a lower rate;
- usually, the exercise dates are yearly after a "non-call" period;
  - Eg.: 10yNC3 bermudan USD receiver struck at 3%
  - Holder has the option to enter into a 7y swap after 3y, rec'ing rates at 3%
  - if after 3y the option has not been exercised, holder still has the option to enter into a 6y swap after 4y
  - finally, holder has the option to enter into a 1y swap receiving fixed at 3% after 9y. If not exercised after 9y this option expires worthless

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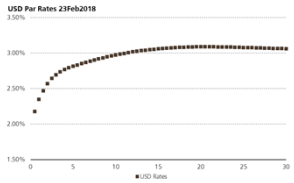
## Market Data

| | |
|---|---|
| **Par Rates** | • Swap rates for tenors between 6m and 30y<br>• Convert to zero rates in order to price zero coupon bonds |
| **Swaptions** | • Normal volatilities* for ATM swaptions of various expiries and tenors<br>* To convert to option prices, one needs to multiply by the swap annuity<br>$A(t, T_1, T_2) = \sum_{i=1}^{n}(T_i - T_{i-1})\,P(T_i)$<br>ATM Swaption price = Normal Vol x A |

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## Counterparty default data (PD)

Composition of default data

- Simulated data, tab delimited
- Data table contains 26 annual financial statements for Developed Market Banks together with default indicator
- Data covers period 2000 – 2014
- Usually for confidentiality reasons additional information like counterparty name, statement date or domicile are not present in the dataset
- Data contains outliers and missing values what is an additional model development challenge
- The detail description of the variables in the file: https://github.com/INTQuant-Katowice/2021/blob/master/Data/Description.txt

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## Timeline proposal

Only a suggestion

**PD**

- Wednesday 17th: • Initial model fitted to the data
- Thursday 18th: • Choose a specific model as a basis for Friday's Q&A session
- Friday 19th: • Having dealt with outliers and NAs in the data
- Monday 22nd: • Final model chosen, assessed and PD assigned

**EAD**

- Wednesday 17th: • Interest Rate Model Chosen
- Friday 19th: • Pricing options • Pricing swaps
- Monday 22nd: • Initial trades profiles produced
- Wednesday 24th: • Aggregation of single profiles

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## Grading

Most important things to have in mind

- The most important thing is that the exercise is completed.
  - The simplest and working > Fancy and failing
  - Fancy and working > simple and working
- Milestones

**EAD**
- Able to properly price options
- Able to properly price swaps
- Able to extract sensible risk profile for single trade
- Able to aggregate on various level

**PD**
- Assess the PD model (visualizations and fit quality measures)
- Motivate decision to go for a given specification
- Assign a PD to each counterparty
- Extract PDs of the three counterparties that are in the scope of EAD part

**RWA**
- Apply regulatory formula to calculate RWA

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## Reports

Most important things to have in mind

- **Written reports:**
  - 10-15 pages (including pictures, graphs cover page, etc.)
  - Focus: methodology and testing mostly. Implementation details are of low importance.
- **Presentation:**
  - 30 min per team (20-25 min presentations + 5-10 mins questions)
  - Given the length no more than 25 slides needed.
- **Deadline**: **Thursday 25th March 2021 5PM**
- **Sent to: piotr-a.morawski@ubs.com**

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## Contact information

What to do in case of problems?

Each team is allowed to ask one Question a day by an email.
- Sent the questions to: piotr-a.morawski@ubs.com
- Be sure to start the subject with phrase: **INTQuant Question – Day X**
- Be mindful to formulate your question properly to pinpoint the core of the problem
  - Questions like: **'Why it is not working?'** will be answered with **'Because you are doing something wrong.'**
- Make the questions methodology oriented not implementation oriented.

Skype conferences calls
- **Friday March 19th at 9:30 + Monday March 22nd at 9:30 + Wednesday March 24th at 9:30**
- The session will be open for all teams
- We will try to split time equally among all the teams
- Try to explore and narrow down the problems before asking about them as we might not have enough time to engage into detailed discussions

www.ubs.com

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## Appendix: Bonus Portfolio

Was exercise too easy?

What to do if you get the exercise done before the deadline?
- Play table tennis (Obsolete),
- Play Board games online (www.boardgamearena.com)
- Beer,
- Visit all the pubs in Katowice (Obsolete),
- Get more points by calculating RWA for additional portfolio.

Portfolio of Bank of Siena (ID: 61) (netted):
- 10y Receiver Swap USD6M LIBOR vs fixed 2.84% (paid annually)
- 10y Payer Swap EUR6M LIBOR vs fixed 1.85% (paid annually)

Few tricks:
- Simulating additional currency would require to make use of brownians correlated to USD. Assume correlation of 80%
- Assume fixed spot rate of 1.23 EURUSD as conversion rate to aggregate.

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