– Intensive Week

Case presentation

March 21, 2022

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Case – overview

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 28rd February 2022. Assume notional for all the trades is 1.000.000.000 USD.

Portfolios:

Salzburg Bank (ID = 484)(netted) :

- 1y Call Option on SPDRM striked at 95 USD
- 2y Put Option on SPDRM striked at 115 USD

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

- 6m Call Asian Option on IRNMN striked at 570 USD
- 1.5y Put Asian Option on IRNMN striked at 450 USD

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

- 1.5y Call American Option on AVNG striked at 4100 USD
- 9m Put Asian Option on AVNG striked at 4100 USD

* Any relations to the real tickers is purely coincidental

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/2022/blob/master/Data/Market%20Data.xlsx

Counterparty defaults

- For PD model calibration
- https://github.com/INTQuant-Katowice/2022/blob/master/Data/DataPD.txt

Section 2

Background

Tools

- The choice of tools is entirely yours. We would like to focus on methodology aspects rather than technicalities.
  - The examples of tools: Python, R, Mathlab, Excel, C++, abacus, tossing a coin, and many more.

…however…

- We recommend writing code in **python**
  - It's interpreted, high-level, general purpose, has large online community for support.
  - It is very popular in the industry.
  - We are offering some introductory course
    Introduction to Python (**22nd March at 13:30**)
    - in preparation: please **install Anaconda** (https://www.anaconda.com/)
    - Example of neat code editor: **Visual Studio Code** (https://code.visualstudio.com/)

Overview

Why is the industry regulated?

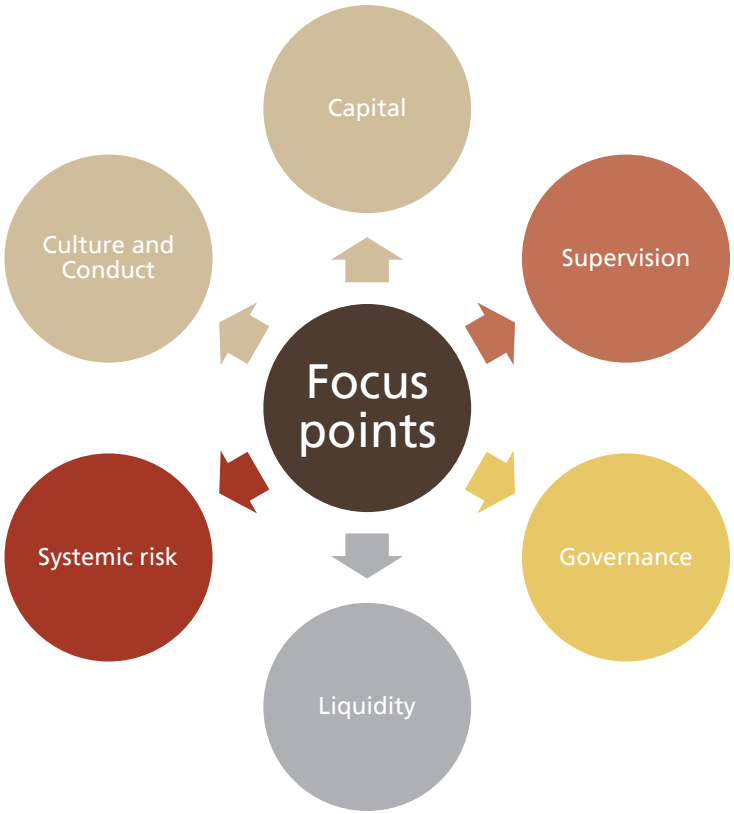
"... Regulations are like guardrails, they protect everyone from market excess ..."

- 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 (**23rd March at 10:00**)



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 $M = \min\left(5{,}1 + \frac{\sum_{(k:k>1,t_k>1)} EE_{t_k}(t_k - t_{k-1})D_{0,t_k}}{\sum_{(k:k>1,t_k\leq 1)} EEE_{t_k}(t_k - t_{k-1})D_{0,t_k}}\right)$

Discounting

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

$$EEE_{t_0} = EPE_{t_0}; \qquad EEE_{t_i} = max\left(EPE_{t_{i-1}}, EPE_{t_i}\right);$$

- α 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 (**23rd March at 11:00**)

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

Section 3

Exposure at Default

Risk Factor Simulation

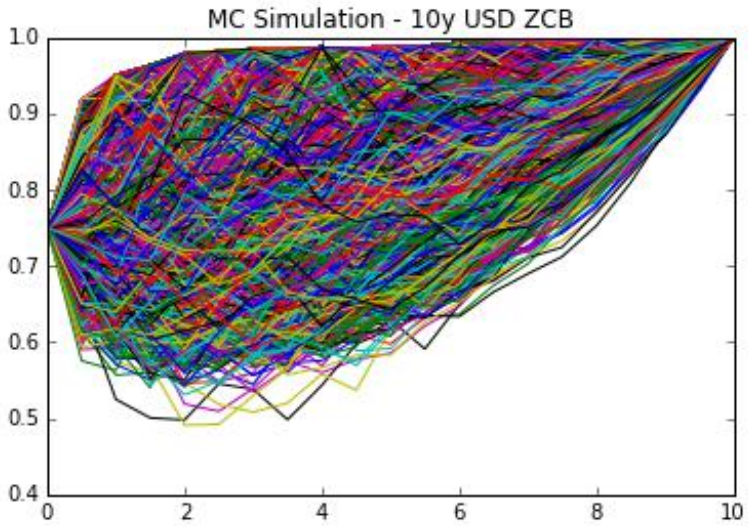
Short rate modelling

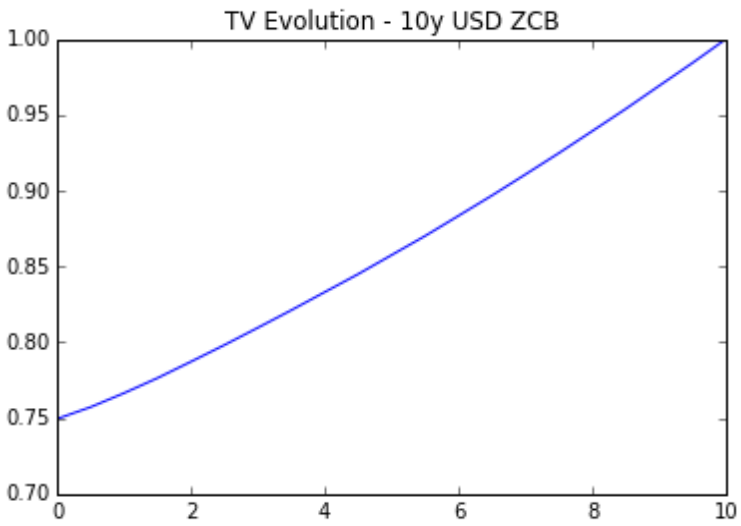
- We can employ MC simulation to model the evolution of stock price thru time:
  - SDE:

$$dS = \mu S dt + \sigma(t)\, S\, dZ$$

- In S's SDE, there is only one source of uncertainty. This is called a one factor model;

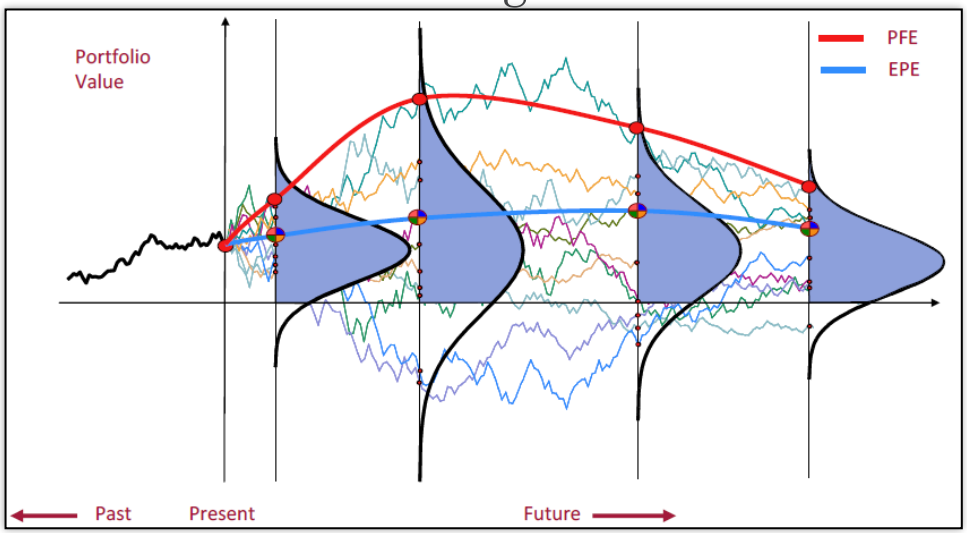
- (For simple products [e.g. options] a closed form approach could be used)
- **More info**: Introduction to MC Simulation in Finance (**21st March at 14:45**)
- **More info:** Modeling Equity Prices (**22nd March at 9:00**)





Calculating Risk Profiles

Simulation is not enough!



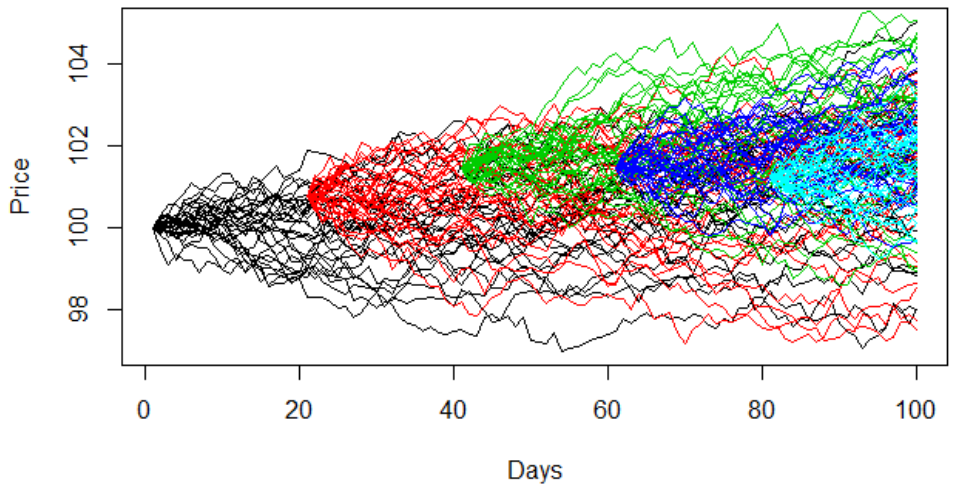
Simulation would give you only a Day 0 TV

- 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 (**21st March at 14:45**)
  - 'Valuing American Options by Simulation', Longstaff, Schwartz.



Calculating Risk Profiles

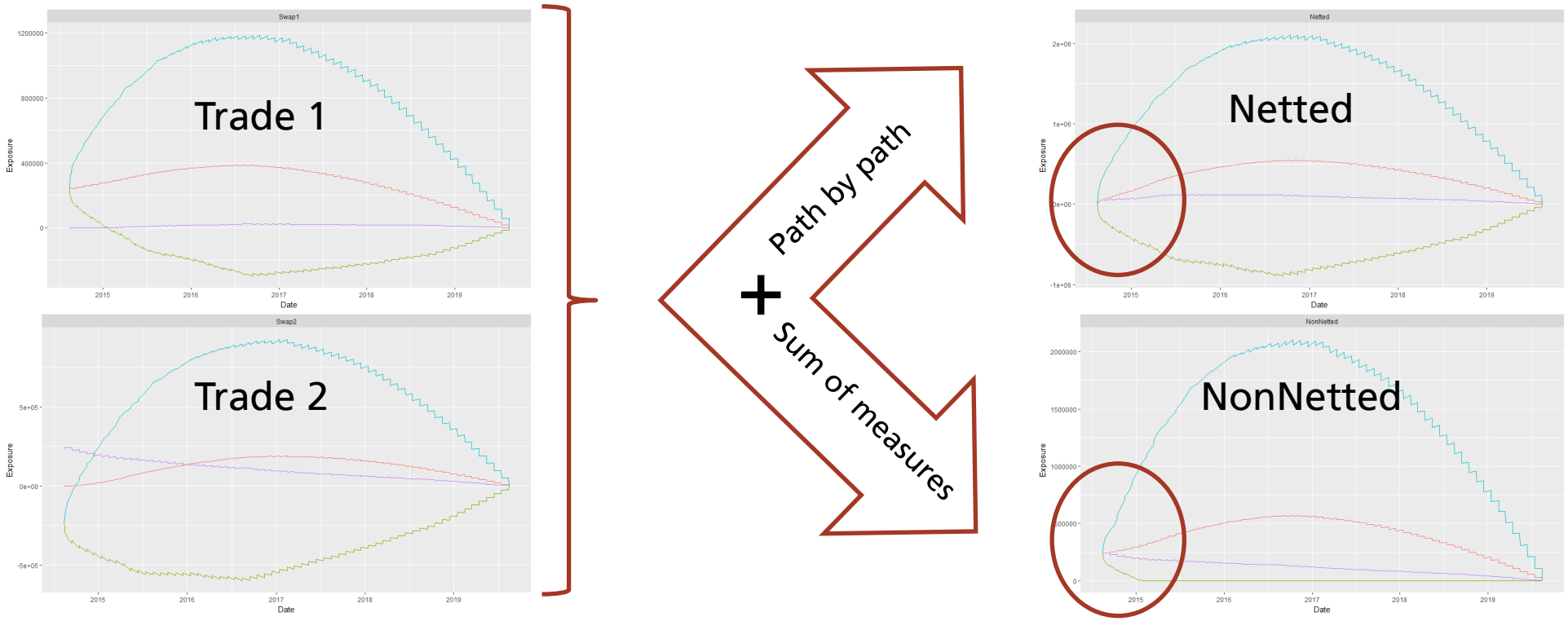
Risk measures definitions

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

Netted vs Nonnetted

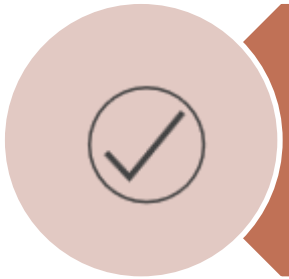
Brief overview

- 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



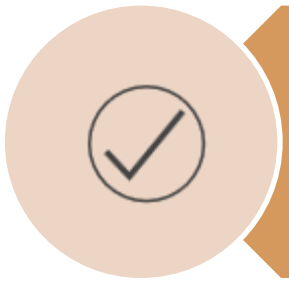
Expectation

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

Section 4

PD & LGD

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)

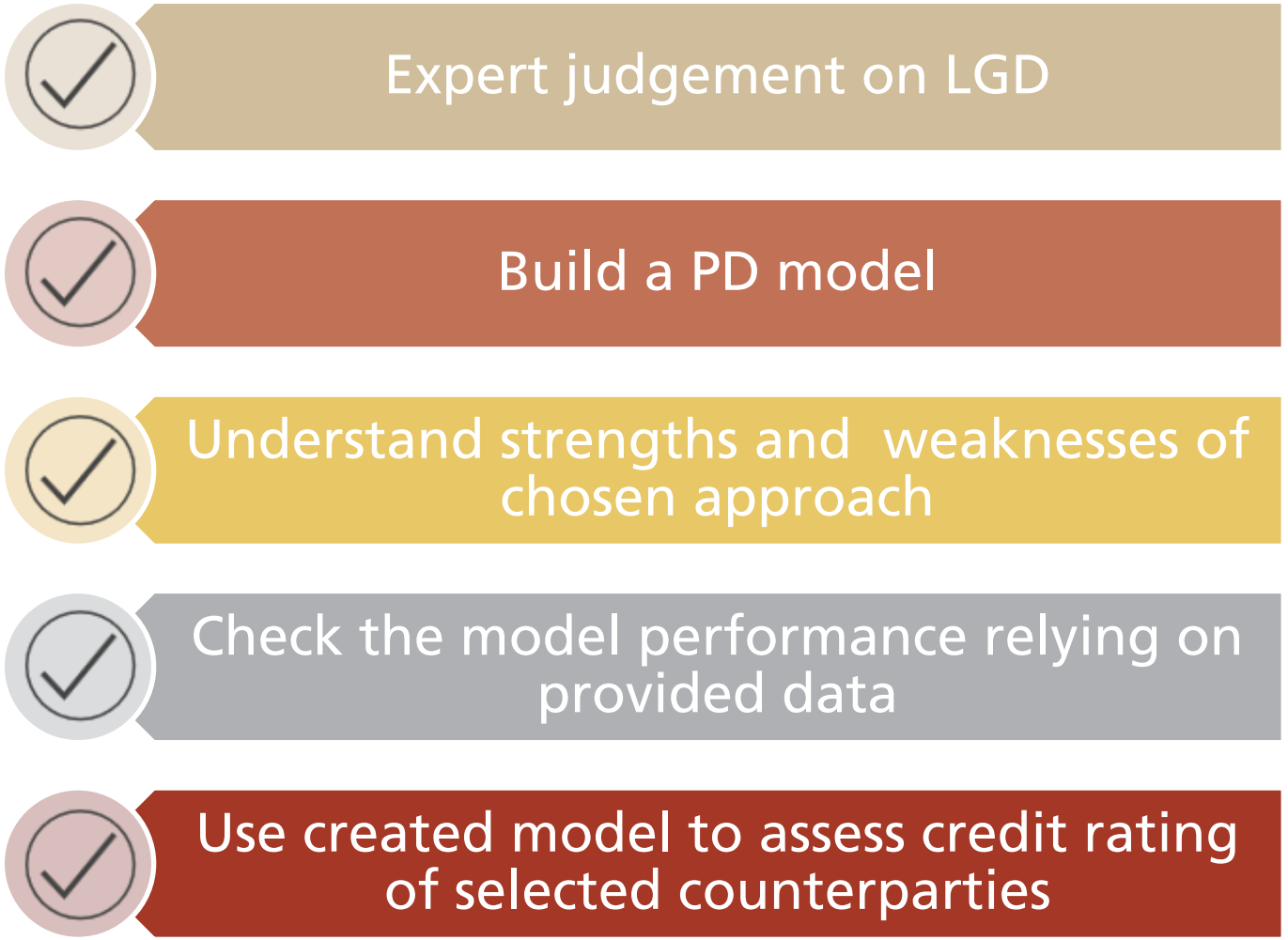
From statistical point of view PD is an estimator of default rate (share of defaulted counterparties over all observations), usually modelled via GLM models (logit, probit regressions)

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

More info: Credit Risk Fundamentals (**22nd March at 11:15**)

Expectation

What we would like to see?



Section 5

Financial derivatives

Financial Derivatives

What is it?

European Option

- The European Call Option gives the holder the right to buy the asset at a predetermined price K and at a predetermined time T.
- The European Put Option gives the holder the right to sell the asset at a predetermined price K and at a predetermined time T.

Asian Option

- Payoff is determined by the average underlying price over some period of time

American option

- Can be exercised at any time before maturity T

Section 6

Input data

Market Data

Option Prices	• Tenors between 3m and 2y • Given across 4 strikes • Needed for Black Sholes model calibration • Modeling Equity Prices (22nd March at 9:00)

Strike (K)	T = 3/12	T = 6/12	T = 1	T = 2
3800	390.11	533.89	772.02	1137.69
4000	263.32	418.41	629.96	949.82
4200	168.86	307.22	510.59	823.7
4500	77.04	182.42	365.85	687.14

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/2022/blob/master/Data/Description.txt

Section 7

Timeline proposal

Timeline proposal

Only a suggestion

PD

- Wednesday 23rd
  - Initial model fitted to the data
- Thursday 24th
  - Choose a specific model as a basis for Friday's Q&A session
- Friday 25th
  - Having dealt with outliers and NAs in the data
- Monday 28th
  - Final model chosen, assessed and PD assigned

EAD

- Wednesday 23rd
  - Equity model chosen
- Friday 25th
  - Pricing vanilla/asian options
- Monday 28th
  - Pricing american options
  - Initial trades profiles produced
- Wednesday 30th
  - Aggregation of single profiles

Section 8

Grading

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 american options
- 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

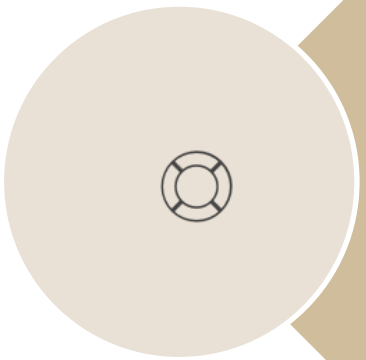
Reports

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 31st March 2022 5PM**
- **Sent to: piotr-a.morawski@ubs.com**

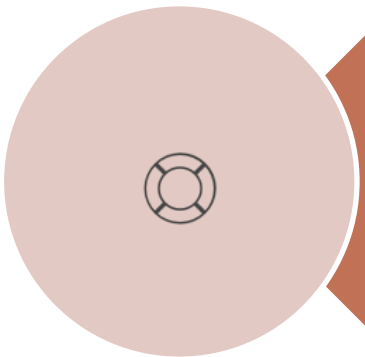
Contact information

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, olga.glowka@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 25th at 9:30 + Monday March 28th at 9:30 + Wednesday March 30th 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

Thank You

Good luck!

- Questions?

Appendix: Bonus Portfolio

Was exercise too easy?

What to do if you get the exercise done before the deadline?

- Play table tennis,
- Play Board games,
- Beer,
- Visit all the pubs in Katowice,
- Get more points by calculating RWA for additional portfolio.

Portfolio of Bank of Siena (ID: 61) (netted):

- 2y Call American Option on AVNG striked at 4150 USD
- 1y Put Asian Option on IRNMN striked at 460 USD

Few tricks:

- Simulating two tickers at once would require to make use of set of correlated brownians. Assume correlation of 80%