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Model Validation

Workshop

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Model Risk Management & Control

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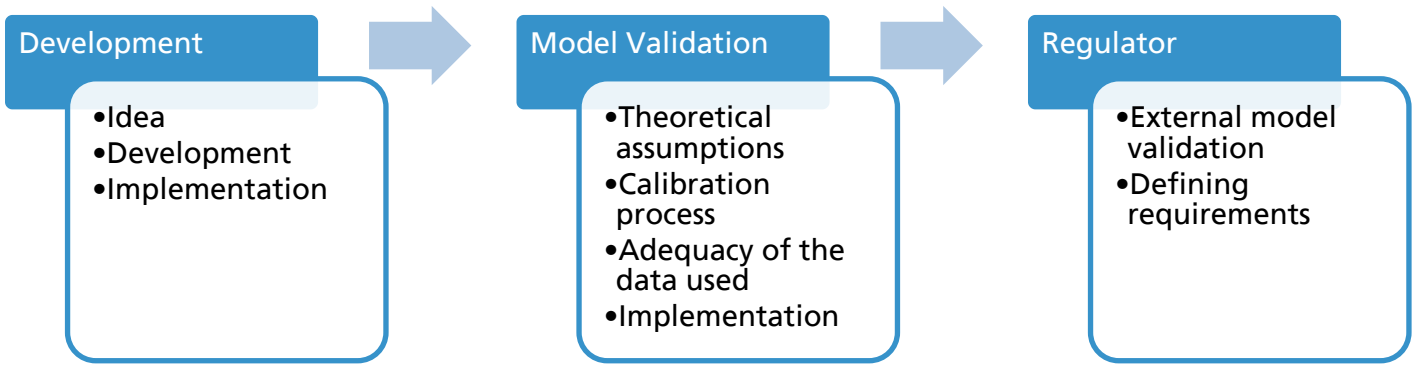
Model Validation

What is this all about?

- Enforced on financial institutions by regulators
- With aim to ensure that whenever bank use model it is done in appropriate manner
- Especially relevant for:
  - capital requirement related models
  - used in trading models (front desk)



Credit Risk

What is the credit risk?

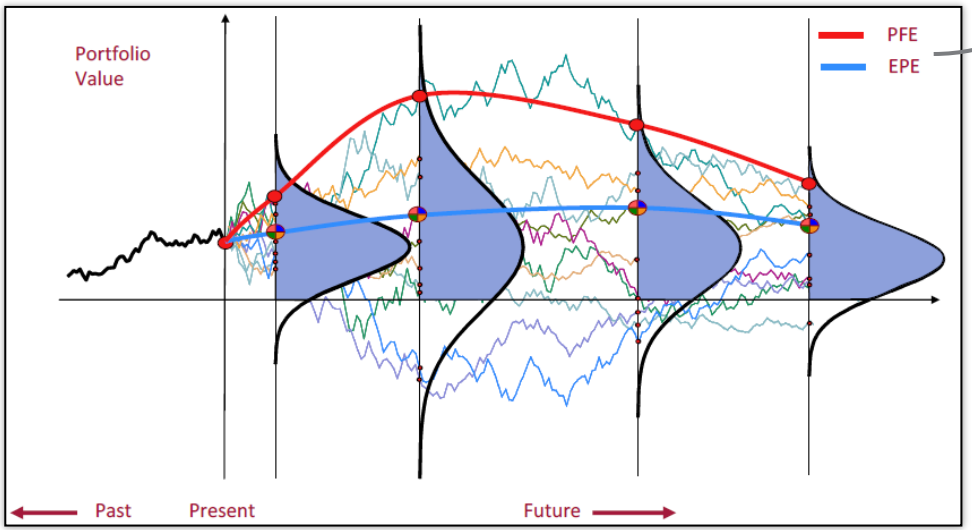
I. Risk of the counterparty defaulting:
   - Client unable to pay the mortgage
   - Friend unwilling to pay us back
   - Lehman Brothers couldn't keep their end of the bargains

II. Depends on various factors
   - Quality of the counterparty – Friend with stable income is less risky one
   - Economy - crisis could decrease company ability to sell its product
   - Management – company even in very bad financial situation could improve instead of going into the default

III. How to quantify credit risk?
   - PD – Probability of Default
   - LGD – Loss Given Default
   - EAD – Exposure at Default
   - Expected Loss = PD * LGD * EAD

Credit Risk

Credit Risk Pricing



courtesy of Giovanni Cesari, UBS

- $\mathrm{CVA} = \mathrm{LGD} \times \int_0^T EAD \times PD \; du$

Exposure At Default

Loss Given Default

Probability of Default

- Pricing the credit risk requires three ingredients:
  - LGD, PD – counterparty dependent
  - EAD – derivative dependent

- Exposure profilling:
  - Calculating CVA requires knowledge of Trade Value distribution at each point in time
  - MC simulation can provide very general solution to problem of pricing a derivatives regardless of it's complexity
- LGD, PD modelling:
  - For CVA PD/LGD comes from market implied spread
  - For other purposes statistical models based on internal or external historical data

R fundamentals

During the workshop we will extensively use R

We will mainly use base functions and *dplyr* approach for data processing, but obviously you are free to use whatever fit you best during the exercises.

Let's open script "*0_R_introduction.R*" and get familiar with some functions that we will use

Problem 1

Normally distributed variable?

- Most popular assumption done during the modelling
- Multiple well know tests could be applied, but should one blindly take test result without looking into the data?
- Open script "*1_Tests.R*" and let's take a closer look

Problem 2

Linear regression used for modelling default probability

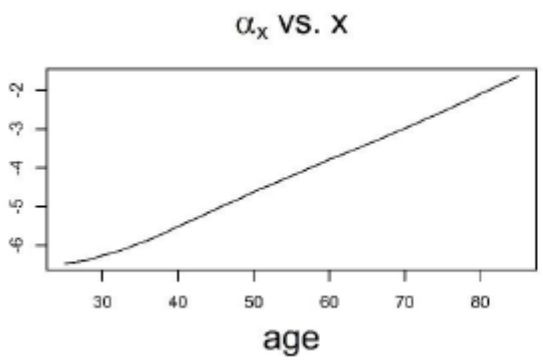
- Some bank offers short term loans with relatively high risk of clients not fulfilling their obligations
- Data set* with three variables:
  - *income* – monthly income of a client
  - *loan_size* – amount of money that client own to the bank
  - default – binary variable saying if client did default or not
- Model defined as: $default \sim intercept + \beta_1 income + \beta_2 loan\ size + error\ term$
- Let's open script "*2_Linear_regression.R*" and check if this approach is appropriate

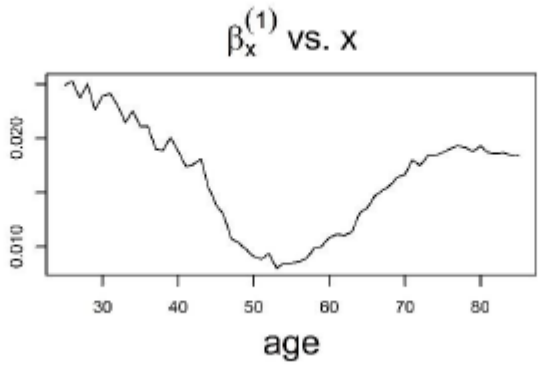
* all the datasets used during this workshop are simulated or publicly available

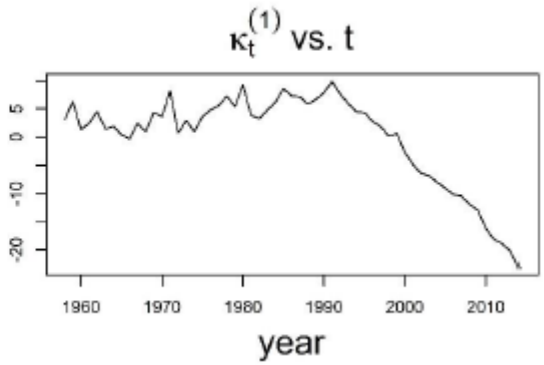
Problem 3

Population death probability modelled by Lee-Carter model *("3_stochastic_mortality.R")*

- With aim to model death probability of male population of Poland (based on mortality tables)
- Generalized Linear Model (GLM)
- Number of deaths as modelled variable (assumed binomial distribution)
- Logit link function (same as in logistic regression)
- Lee-Carter specifically is defined as: $\eta_{xt} = \alpha_x + B_x^{(1)} \kappa_t^{(1)}$



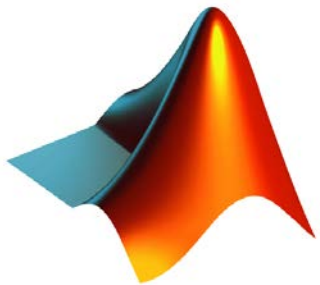




Tools

What are the main tools used in the industry? What should I learn?

- Prototyping the models is most often done in R, SAS, Matlab
- Production version of models are often written in C++ and C#
- Some models (often those that are used for staff like capital requirements calculation, stress testing) have production implementation in R, SAS, Matlab
- Other environments/languages that are also popular are Python and VBA
- Where is the future:
  - R
  - Python




Problem 4

Testing model's prediction power on historical data

- We need to model the trade value throughout the whole trade period to know how much we are exposed in case of the counterparty gone bankrupt.
- To do that we need to simulate the Risk Factors driving the trade value.
- In simple case of stock option the only Risk factor relevant is the price of the underlying stock.
- Model: linear model calibrated over the last month of data, used to predict the next day stock price.
  - Underlying assumption: the stock prices is a Black-Sholes process.
- **Principle of backtesting**: using available market data to compare model prediction against the historical realisation.
- Use the script: "*4_Backtesting.R*"

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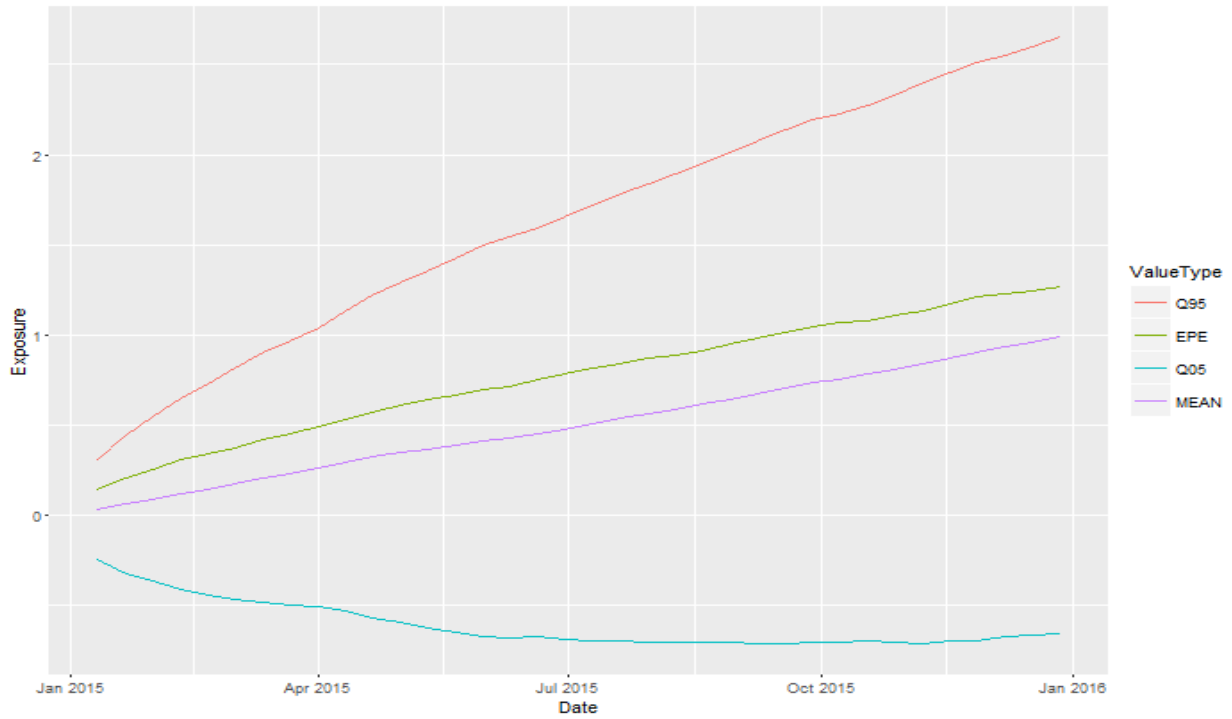
Problem 5

CVA calculation

- Profile the exposure of a simple stock call option
  - Simulate underlying stock movement using MC technique
  - Measure the Expected Positive Exposure at each point in time
- Combine the Exposure profile with Default Probability and Loss Given Default of the counterparty.
  - Open script: 5_CVA.R



People

Who works in risk modelling/quantitative finance?

- Most common background:
  - Mathematics
  - Econometrics / Quantitative finance
  - Physics
- PhD's

Problem 6

Loss Given Default (LGD) model – building benchmark model

- It is relevant not only if counterparty would default, but also the percentage of our loan that we could lost in case od default
- Dataset: US clients with collateralized loans that did default at some point in time (also macroeconomic variables at the year of default are also included in the dataset)
- Based on historical default data probit model was fitted:
  $loss\ given\ default \sim intercept + \beta_1 loan\ to\ value + \beta_2 GPD\ growth + \beta_3 unemplyment\ rate + \beta_4 inflation +\ error\ term$
- Let's open script "*6_LGD.R*"

Problem 7

Stress model – are all variables stressed in appropriate manner?

- We would like to know how much we could lost if another crisis would hit us (alternatively any other scenario)
- One approach to model the loss is to use build PD and LGD models and then stress their inputs:
  - increased unemployment rate
  - decreased growth of gross domestic product
  - drop of the house prices
- Let's open script "*7_Stress_model.R*"

Sum up

What are the most important takeaways?

- Appling model without checking it could result in an underestimation of risk or required capital buffer.
- Which could create incentive to get into more risky transitions. On single bank perspective it could lead to huge losses and potential bankruptcy. While on a whole financial system level it could result in crisis.
- There is a huge universe of models and if you enjoy getting to understand every one of them then model validation is an areas that is worth considering.

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