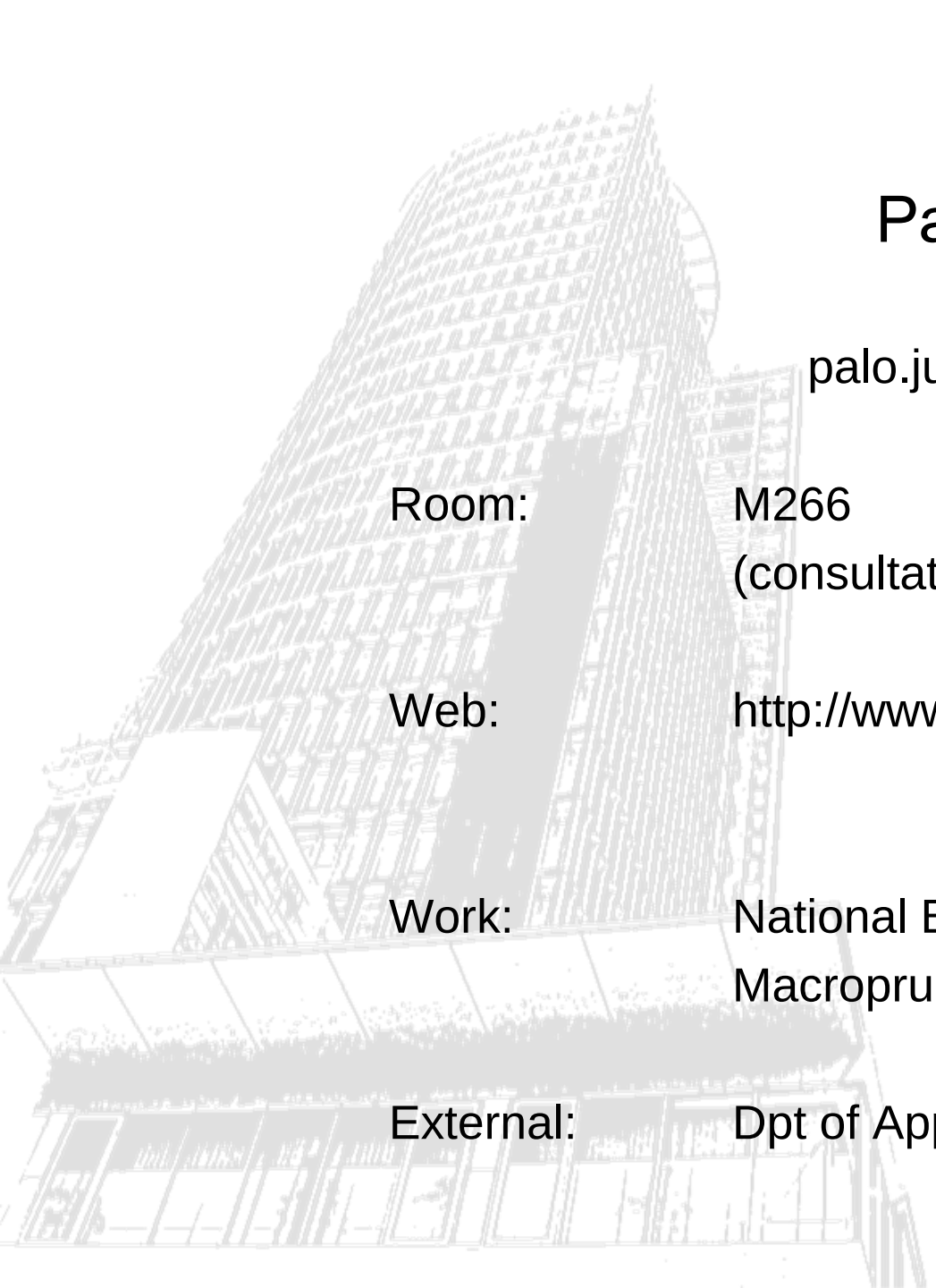
Quantitative methods in risk management

Introduction – part 1



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Macroprudential Supervision Department

External: Dpt of Applied Mathematics and Statistics

Main topics

- Motivation and objective of this course
- Light intro to risk management
  - Process of risk identification, management and measurement
  - Overview of risk types
- Issues / challenges in risk management
  - Data properties
  - Problematic / controversial assumptions
  - Impact of the ongoing crisis on risk management

Motivation

- Risk management departments – frequent career start after graduating from EFM
  - Each year: around one third out of 30-50 job offers in the field of risk management
- Link between theoretical knowledge and practice
- Focus on quantitative methods
- Opportunities for further development of methods – many things have been affected by the crisis
- Complex mathematical formulas appearing directly in the laws!

Mathematics in laws

Power is delegated to the Commission to adopt the regulatory technical standards referred to in the first subparagraph in accordance with Articles 10 to 14 of Regulation (EU) No 1093/2010.

Article 154

Risk weighted exposure amounts for retail exposures

1. The risk-weighted exposure amounts for retail exposures shall be calculated according to the following formulae:

Risk – weighted exposure amount = RW · exposure value

where the risk weight RW is defined as follows:

(i) if PD = 1, i.e., for defaulted exposures, RW shall be

$$RW = \max\{0{,}12.5 \cdot (LGD - EL_{BE})\};$$

where EL_{BE} shall be the institution's best estimate of expected loss for the defaulted exposure in accordance with Article 181(1)(h);

(ii) if 0 < PD < 1, i.e., for any possible value for PD other than under (i)

$$RW = \left(LGD \cdot N\left(\frac{1}{\sqrt{1-R}} \cdot G(PD) + \sqrt{\frac{R}{1-R}} \cdot G(0.999)\right) - LGD \cdot PD\right) \cdot 12{,}5 \cdot 1{,}06$$

where:

N(x) = the cumulative distribution function for a standard normal random variable (i.e. the probability that a normal random variable with mean zero and variance of one is less than or equal to x);

G(Z) = the inverse cumulative distribution function for a standard normal random variable (i.e. the value x such that N(x) = z);

R = the coefficient of correlation defined as

$$R = 0.03 \cdot \frac{1 - e^{-35 \cdot PD}}{1 - e^{-35}} + 0.16 \cdot \left(1 - \frac{1 - e^{-35 \cdot PD}}{1 - e^{-35}}\right)$$

Mathematics in laws

Article 262

Supervisory Formula Method

1. Under the Supervisory Formula Method, the risk weight for a securitisation position shall be calculated as follows subject to a floor of 20 % for re-securitisation positions and 7 % for all other securitisation positions:

$$12.5 \cdot \frac{S[L+T]-S[L]}{T}$$

where:

$$S[x] = \begin{cases} K_{IRBA} + K[x] - K[K_{IRBA}] + \left\{1 - \exp\left[\frac{\omega \cdot (K_{IRBA} - x)}{K_{IRBA}}\right]\right\} \cdot \frac{d \cdot K_{IRBA}}{\omega}, & \text{when } x \leq K_{IRBA} \\ x, & \text{when } x > K_{IRBA} \end{cases}$$

where:

$$h = \left(1 - \frac{K_{IRBA}}{EI,CD}\right)^N$$

$$c = \frac{K_{IRBA}}{1-h}$$

$$v = \frac{(EI,CD - K_{IRBA}) \cdot K_{IRBA} + 0{,}25 \cdot (1 - EI,CD) \cdot K_{IRBA}}{N}$$

$$f = \left(\frac{v + K_{IRBA}^2}{1-h} - c^2\right) + \frac{(1 - K_{IRBA}) \cdot K_{IRBA} - v}{(1-h) \cdot \tau}$$

$$g = \frac{(1-c) \cdot c}{f} - 1$$

$$a = g \cdot c$$

$$b = g \cdot (1-c)$$

$$d = 1 - (1-h) \cdot (1 - \text{Beta}[K_{IRBA}; a, b])$$

$$K[x] = (1-h) \cdot ((1 - \text{Beta}[x; a, b]) \cdot x + \text{Beta}[x; a+1, b] \cdot c)$$

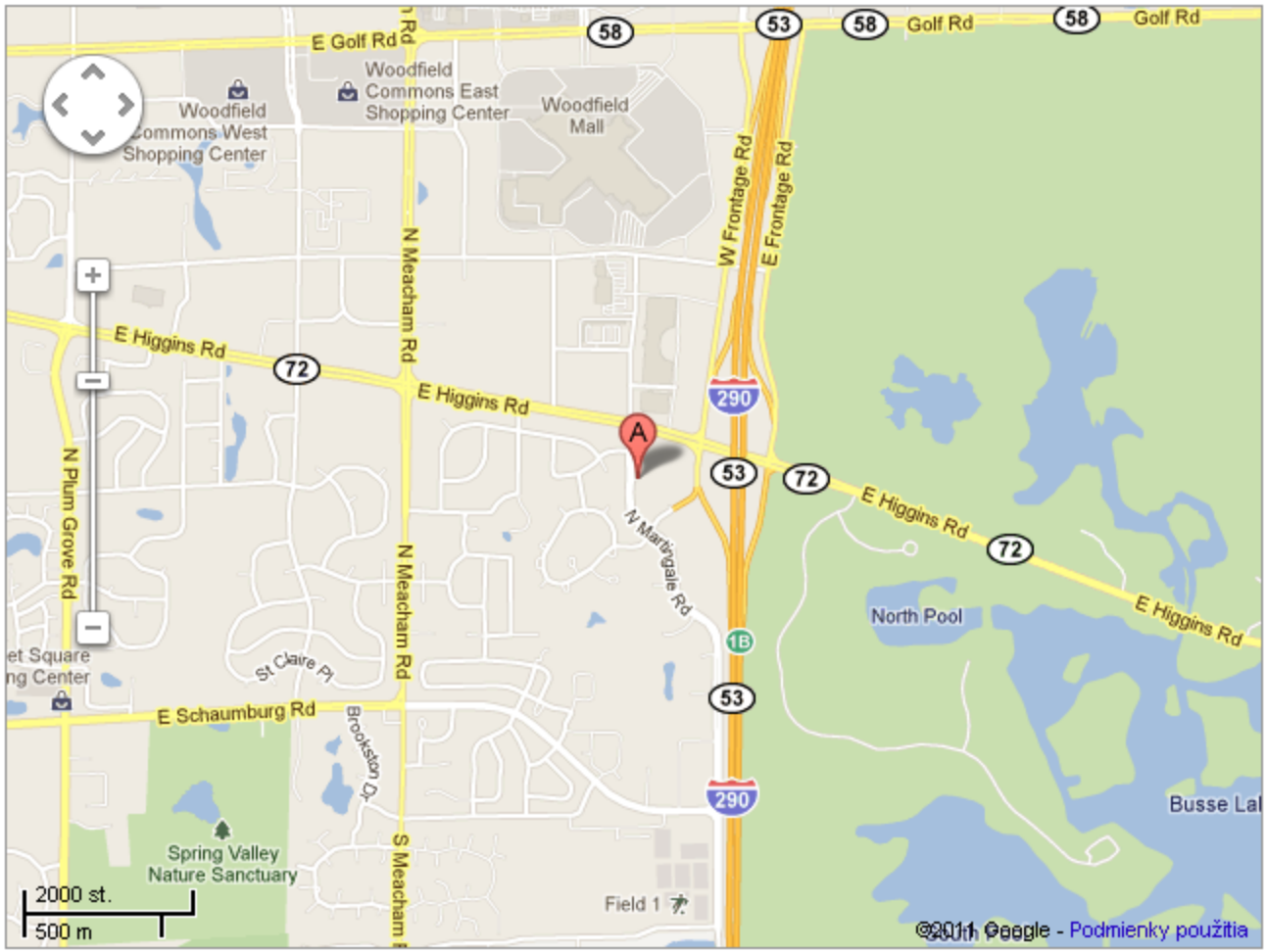
τ = 1 000;

ω = 20;

Beta [x; a, b] = the cumulative beta distribution with parameters a and b evaluated at x;

... even in street names!

A. **Society** of **Actuaries**
Ste 600, 475 North Martingale Road,
Schaumburg, IL
(847) 706-3500



Course objectives

- Overview of quantitative methods that are used or could be used in risk management
- More focus on broad overview than on technical details
- Strong emphasis on practical applicability: the application of methods (examples in Excel, Matlab, R, brief description of specific problems addressed in NBS)
- Use your existing knowledge of mathematics and statistics to understand the basic assumptions, strengths and weaknesses of each method
- Possibilities for further research (a diploma thesis, PhD?)
- However, the objective is not become a risk management specialist after completing this course (we will skip qualitative requirements, the organization's internal processes, data processing, legislation, personal skills of a risk manager ...)

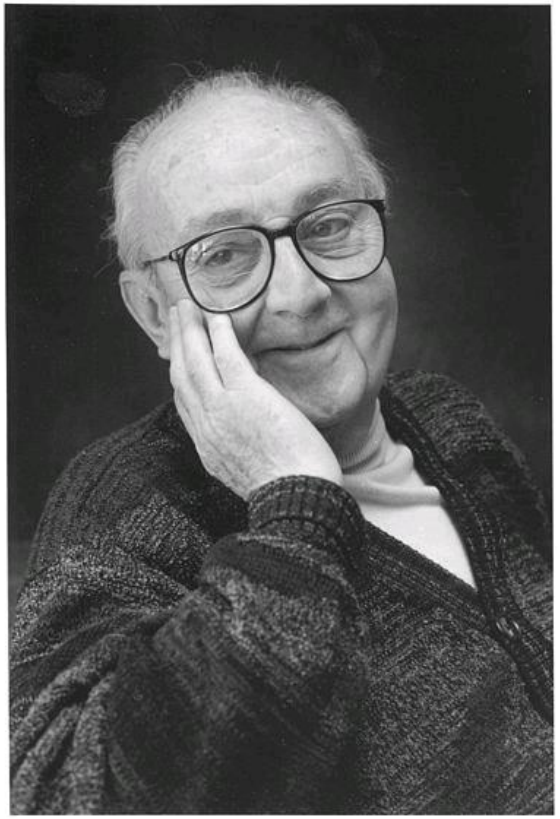
Course objectives

- Important to properly understand the fundamental objective of this course:
  - Incorrect question: Which model is right to address the given issue?
  - Correct question:
    - Which different models can be used to solve a particular problem?
    - What are their assumptions, strengths and weaknesses?
    - What is the a particular model able to capture and what is beyond its scope?
- If you are looking for "the right" models for risk management, this course is unfortunately not intended for you ☹

Motto

„Essentially, all models are wrong,
but some are useful.“

George E. P. Box
(* 1919 – † 2013)



Box, G. E. P., and Draper, N. R., (1987), Empirical Model Building and Response Surfaces, John Wiley & Sons, New York, NY (s. 424)

Grading principles / examination

- The course evaluation is based on a PROJECT (70 %) – practical part:
  - Will be specified in the next few weeks
  - Risk analysis of a simple portfolio, comparison of several methods
  - Possible work in pairs
  - Deadline: Sunday 20 May 2018 (bonus points if submitted until 13 May)

- Written TEST (30 %) – theoretical part:
  - The main focus on a comprehensive overview and understanding of the lectures
  - Date: Monday 28 May 2018

Grading policy / evaluation

- Grading scale
  - A: At least 90
  - B: At least 80, but less than 90
  - C: At least 70, but less than 80
  - D: At least 60, but less than 70
  - E: At least 50, but less than 60
  - FX: Less than 50

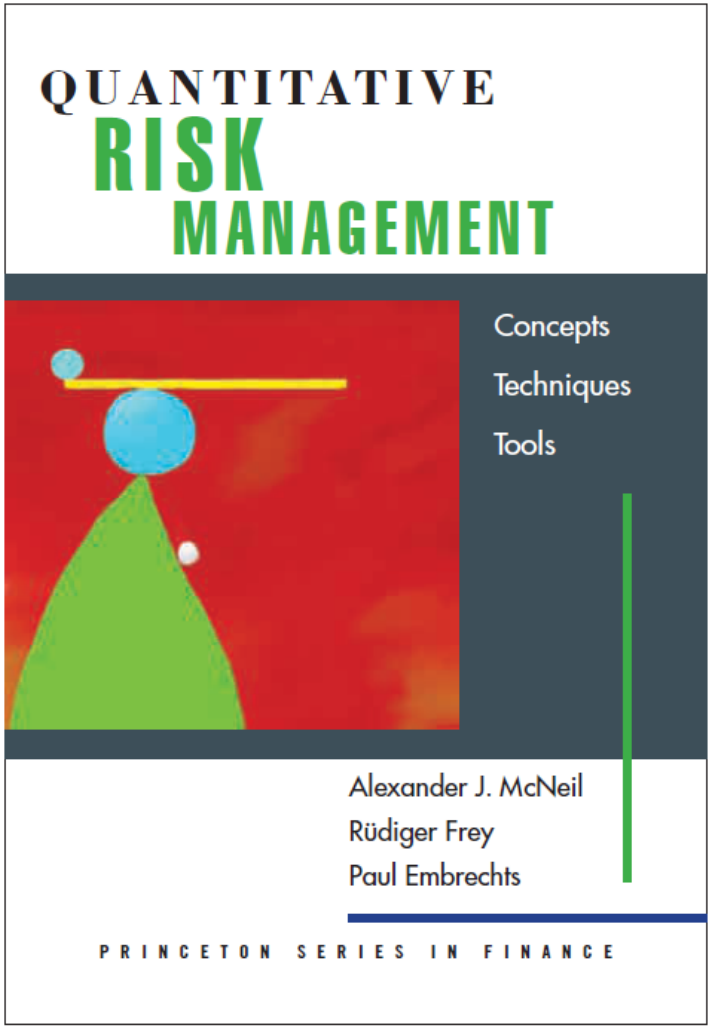
Course syllabus

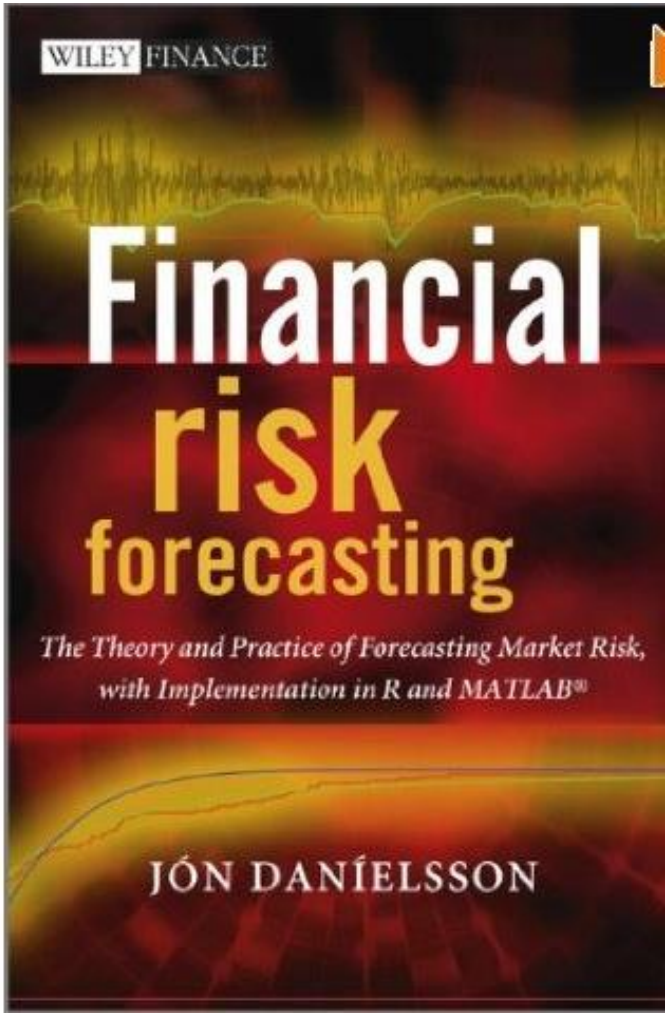
- The course will cover both practical (economical) as well as theoretical (mathematical / statistical) part
- Economic part
  - Focus on models for credit and market risks
- Mathematical / statistical part
  - Distributions with fat tails
  - Volatility clustering
  - Complex dependce structures
  - Methods of dimension reduction (dealing with large portfolios)

Course syllabus

- The "classic" risk measure - Value at Risk
- Methods for generating stress scenarios in case of multidimensional data
  - principal components analysis
  - models based on a mixture of several normal distributions
- Methods for modeling of a dependence structure - copulas
- Credit risk measurement (different approaches)
- Credit derivatives and their valuation
- Dealing with extreme events - extreme value theory
- Appendix: The models used in the management of operational risk and in (non-life) insurance

Main literature





Your feedback

- Your (early) feedback is crucial in order to organize the course in such a way that you can benefit from it as much as possible

- Hence, any feedback would be very appreciated at any time!

Process of risk management

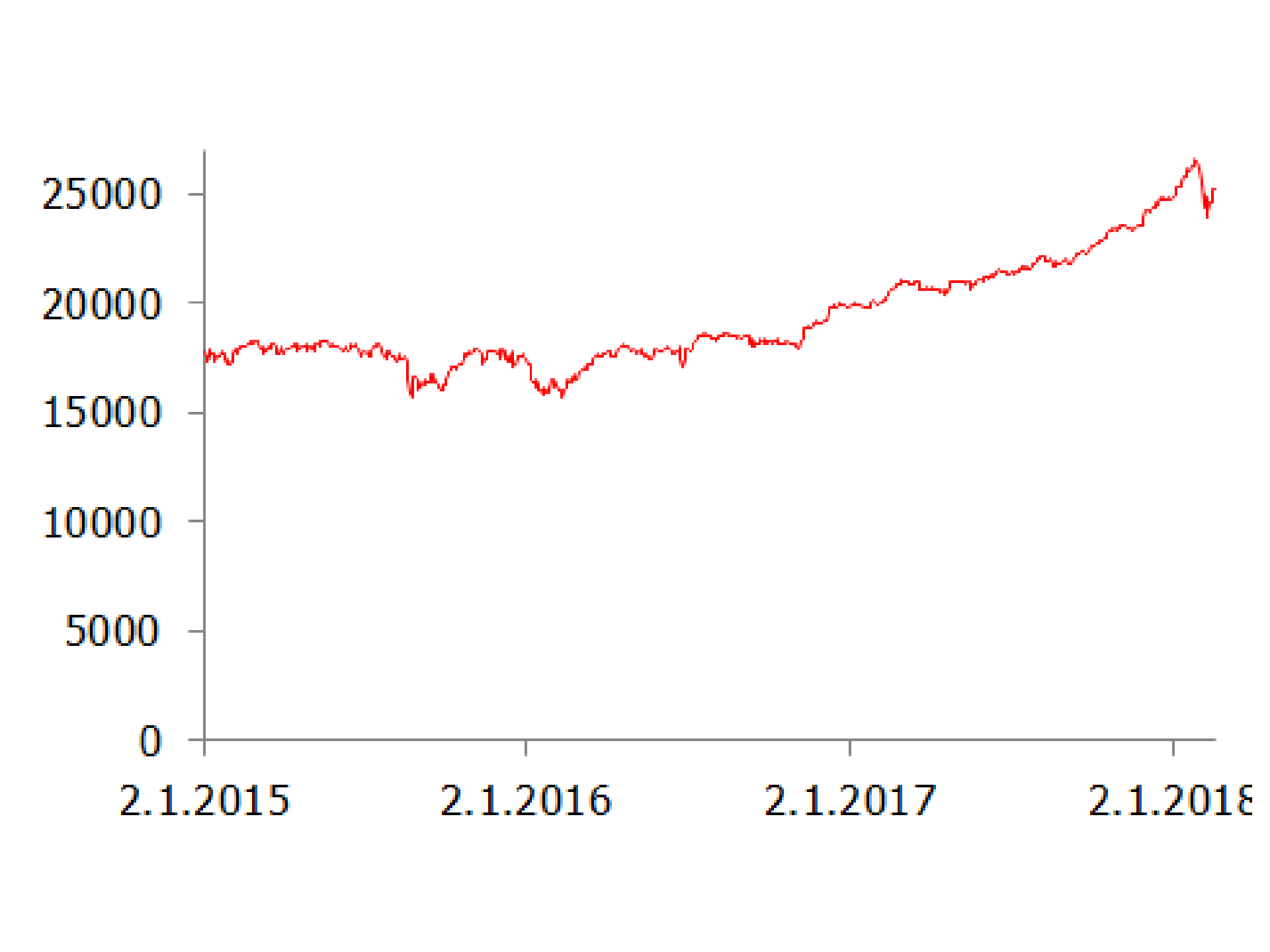
- Identification of risks
  - Where and what type of risk?
  - What are the risk factors?
  - Each individual transaction includes several types of risks!

- Risk Measurement
  - The system allows the measurement (data collection, internal processes ...)
  - Appropriate quantitative techniques - intensity proportional materiality

- Risk Management
  - Determination of the strategy, what I want to embrace risk (risk appetite)
  - Limits chosen level of risk for the operation
  - Stress testing
  - Back-testing
  - Mitigation (risk mitigation, hedging)

What is a (financial) risk?

- Financial risk = a potential future financial loss related to a given financial instrument or to a given portfolio of financial instruments
- The definition is not harmonized!
- Two basic (and relatively independent) parts of risk:
  - Probability of an event
  - Size of the potential impact
- General principle:
  - A risk is related to uncertainty
  - Combination of techniques from financial mathematics, probability theory, statistics, time series analysis, actuarial mathematics and stochastic processes theory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Types of risks

- Main risks:
  - Credit risk
  - Market risks
  - Counterparty risk
  - Operational risk
  - Liquidity risk

- Additional risks
  - Strategic risk
  - Legal risk
  - Reputational risk
  - Model risk

  - Systemic risk

Typy rizík

- Hlavné riziká:
  - Kreditné riziko (*credit risk*)
  - Trhové riziká (*market risks*)
  - Riziko protistrany (*counterparty risk*)
  - Operačné riziko (*operational risk*)
  - Riziko likvidity (*liquidity risk*)

- Ostatné riziká
  - Strategické riziko (*strategic risk*)
  - Právne riziko (*legal risk*)
  - Reputačné riziko (*reputational risk*)
  - Riziko modelu (*model risk*)

  - Systémové riziko (*systemic risk*)

Credit risk

- Credit risk = a risk that a borrower fails to deliver payments which he or she is obliged to pay in case of different type of claims (bonds, loans, settlement of financial derivatives ...) because he or she is unable or unwilling to do so

- In addition to this "traditional" concept, credit risk also includes, e.g.:
  - Settlement risk (riziko vysporiadania)
  - Risk from guarantees granted (riziko z poskytnutých záruk)
  - The risk related to unused overdraft facility (eg credit cards) - nevyčerpané prečerpania
  - The risk of a bond impairment due to a reduction in the credit rating of the issuer

Market risks

- Market risk = a risk of an adverse impact of movements in market factors (equity prices, interest rates, FX rates, commodity prices) on the value of financial instruments

- Market risk types
  - *Interest rate risk (úrokové riziko)*
  - *Equity risk (akciové riziko)*
  - *FX risk, currency risk* (crisis => re-denomination risk) – devízové riziko
  - *Commodity risk (komoditné riziko)*
  - *Credit spread risk (riziko kreditných prirážok)*

- Different types of impacts:
  - General risk (overall market) vs. specific risk (only the relevant counterparty)
  - Changing values, prices, volatilities, ...
  - Further impacts: Change in the shape of yield curve, change in dividend policy

Operational risk

- Operational risk (operačné riziko) includes:
  - Improper or faulty internal processes in the bank
  - Human error
  - Failure of the banks' internal system
  - External or internal fraud
  - External events (eg natural disasters)

- Closely associated with the functioning of internal processes (focus on qualitative side)

- Difficult to measure
  - it is present everywhere, but the identification of proper loss amounts is tricky
  - extreme events, potentially very high impact

- Example: Calculate the extent to which the bank is exposed to losses caused by earthquake damage or internal fraud
  - e.g. loss of 4.9 billion. € at Société Générale (Jérôme Kerviel, 2008)

Liquidity risk

- Liquidity risk = potential loss due to the fact that the bank is unable to meet its obligations on the contractual basis due to a lack of liquid assets

- Key aspects:
  - Short-term liquidity risk
  - Market liquidity risk
  - Funding liquidity risk

Exercises – risk identification

- 1. SLSP purchased ŽSR bond with a fixed coupon of 4% and maturity 5 years. This investment has been financed by retail term deposits with remaining average maturity 9 months. Identify the risk factors in this transaction!

- VÚB enters into a forward contract with Commerzbank related toa purchase of Facebook shares with a maturity of one year [Valuation function: $F_t = S_t \, e^{r(T-t)}$]