Operational Risk revisited: from Basel to the coronavirus

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Bachelier Finance Society, World Seminar

May 7, 2020

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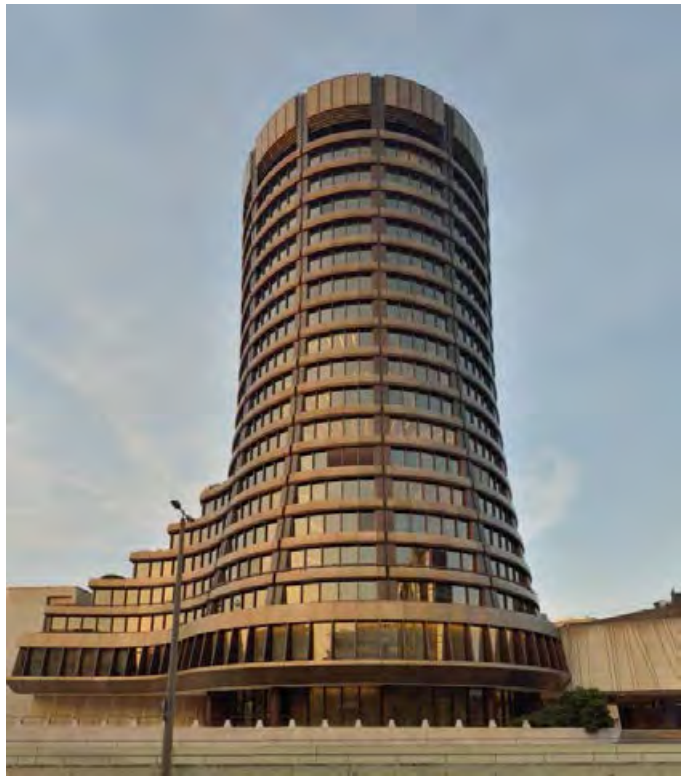
About the title

Operational Risk revisited:

Basel Committee on Banking Supervision

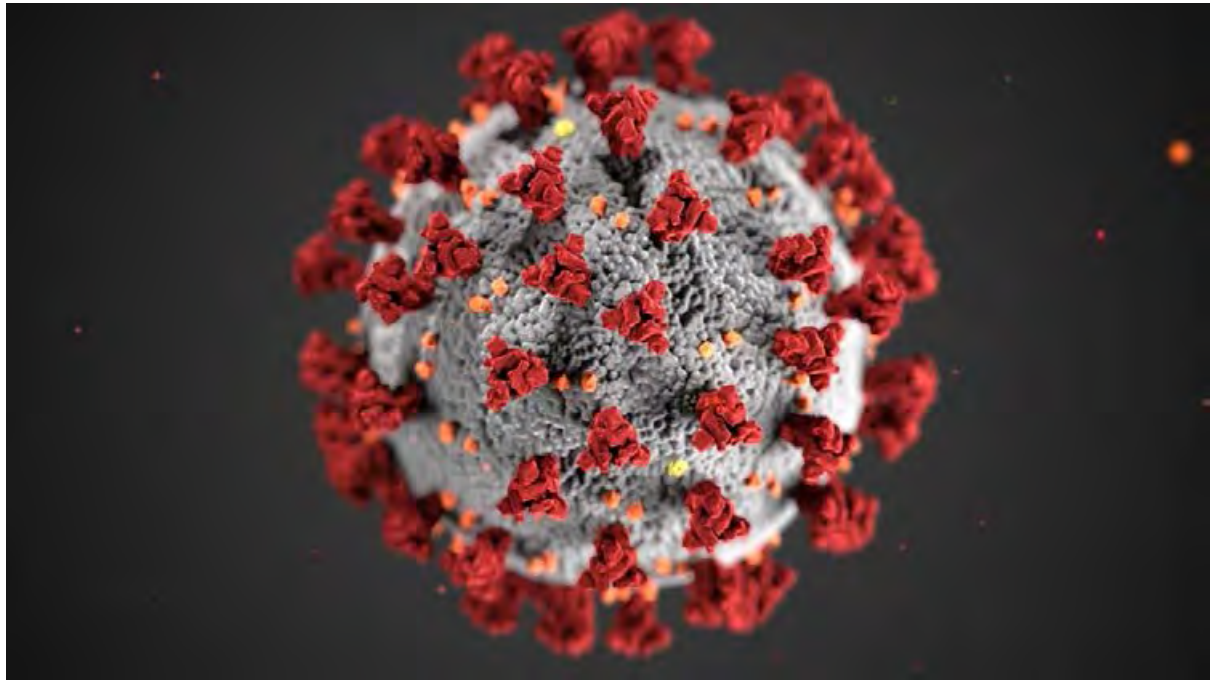
BANK FOR INTERNATIONAL SETTLEMENTS

from



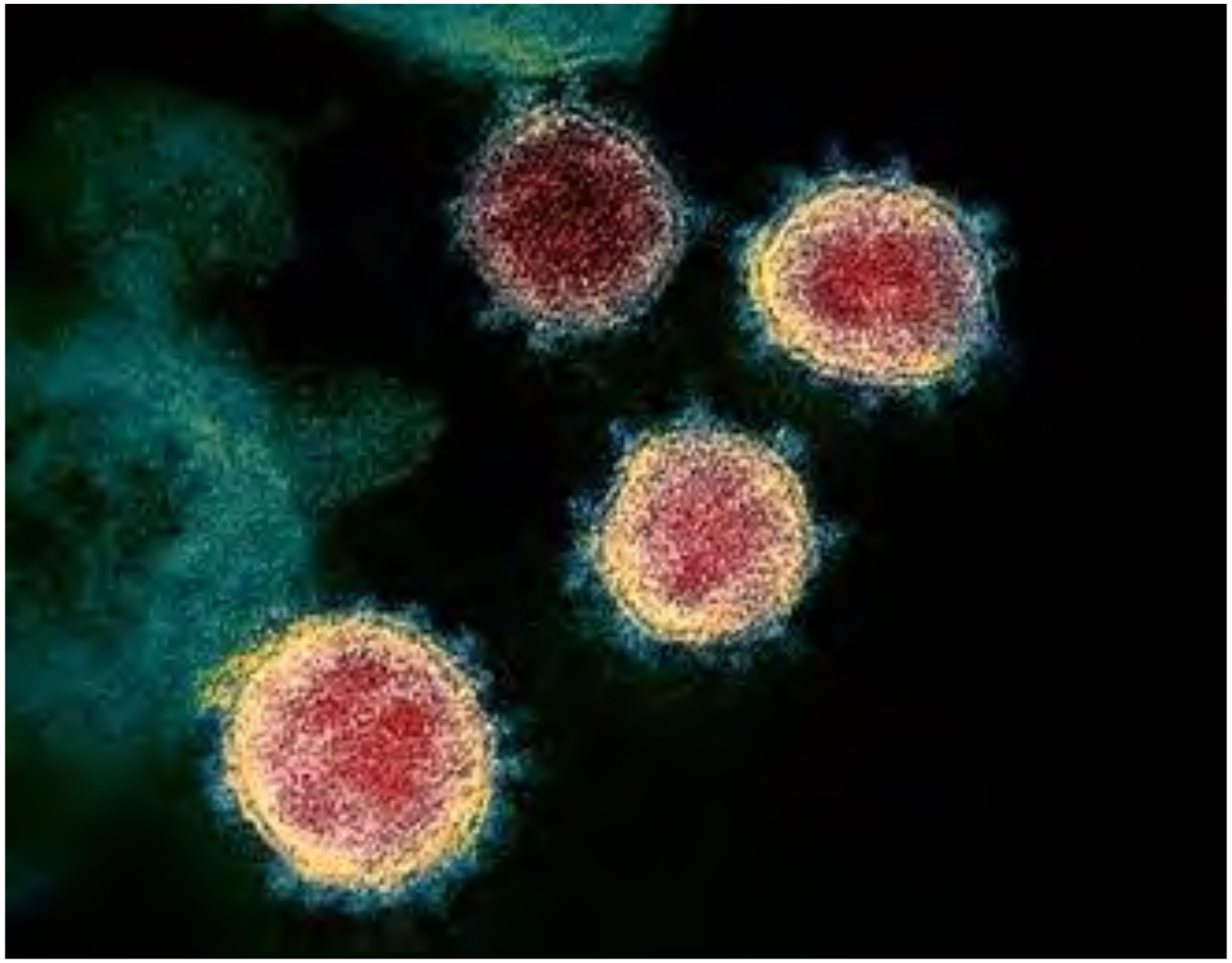
BIS building in Basel (CH)

to



SARS-CoV-2

SARS-CoV-2 and Covid19: why “corona”?



Transmission electron micrograph of SARS-CoV-19 virions with visible coronae (Wikipedia)

Risk Components (Basel II)

(now Basel IV (2017) as of 1/1/2022)

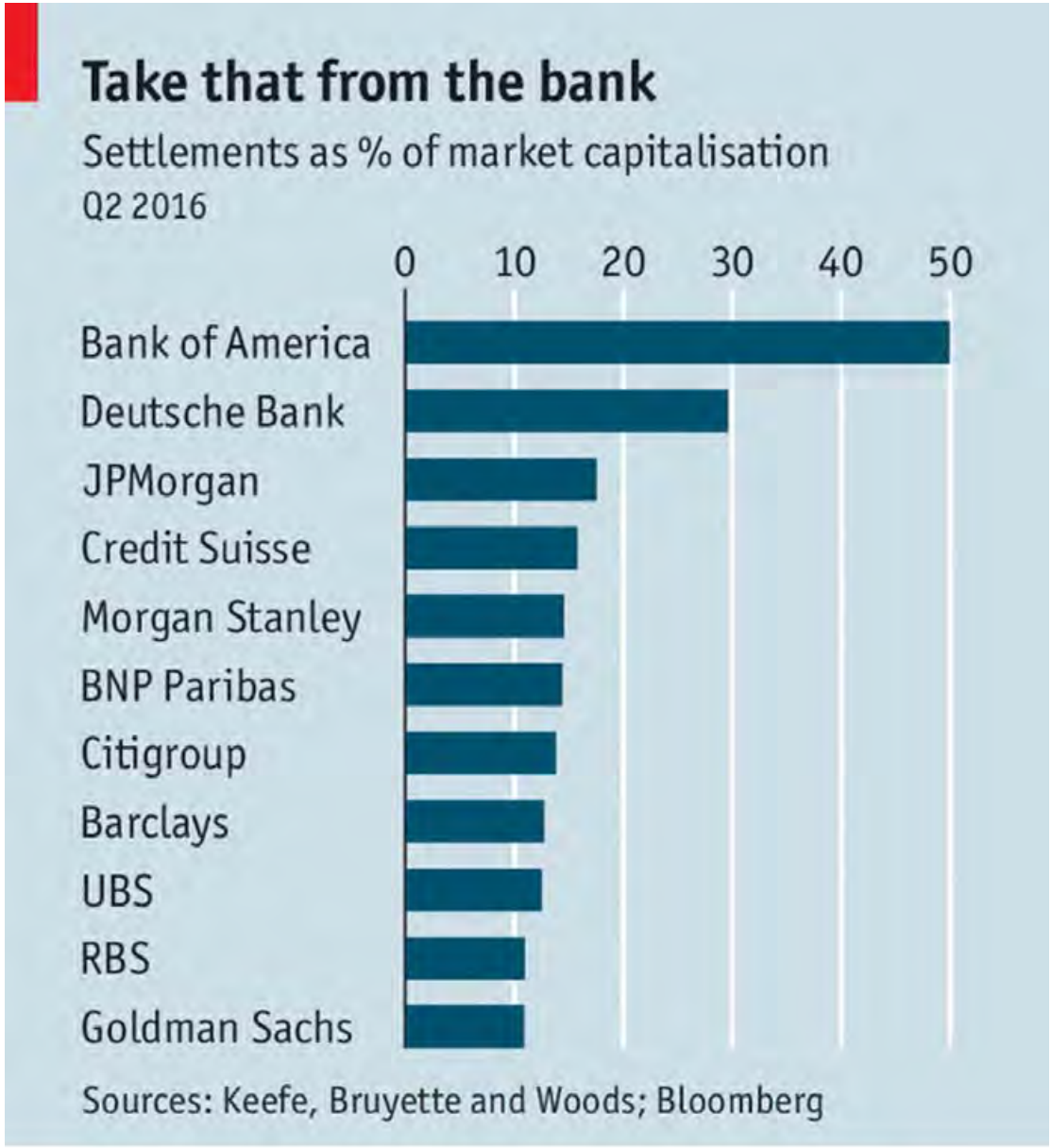
(also Solvency II (2019), SST (2011), FSA, BoE, ...)

- Credit Risk
- Market Risk
- Operational Risk
- Business Risk ...

Operational Risk: The risk of loss resulting from inadequate or failed internal processes, people and systems or from external events. Including legal risk, but excluding strategic and reputational risk.

Coronavirus

Financial crisis

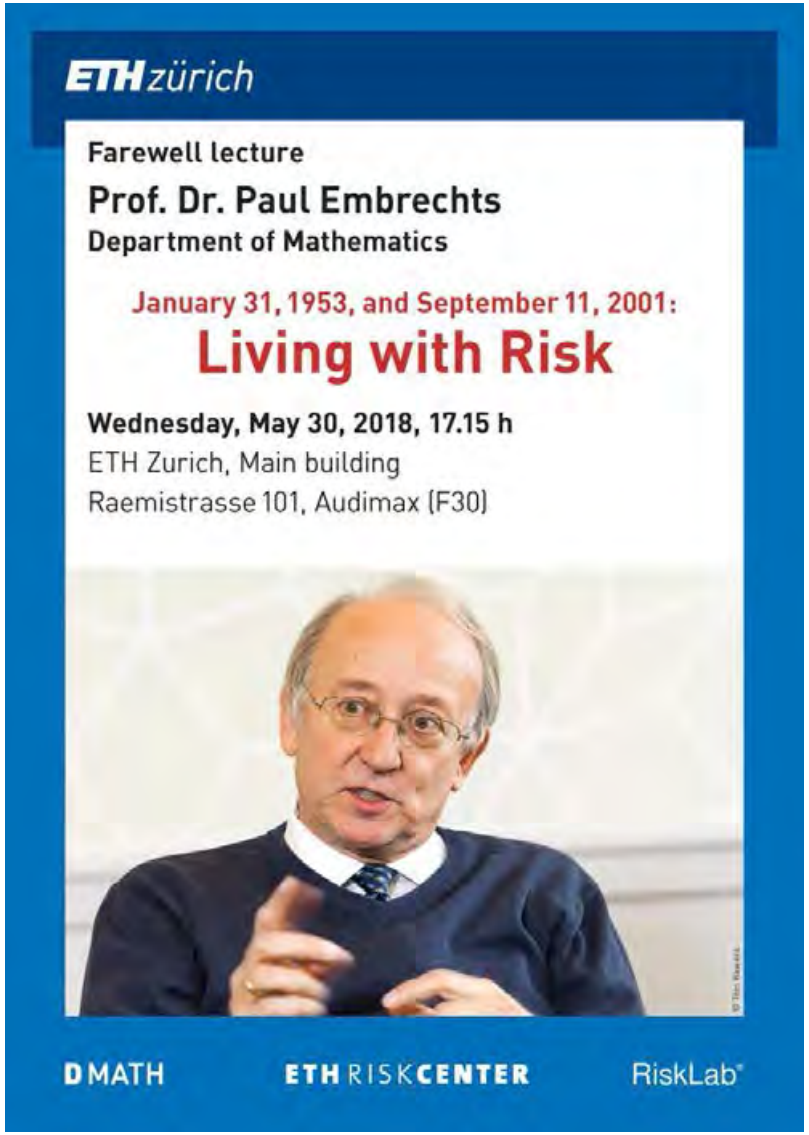


Coming out of the

Financial Crisis

From **The Economist**, 13/8/2016: OpRisk losses as % of market capitalisation for Q2 2016

My Farewell Lecture at ETH on May 30, 2018:



After 42’30”:

https://video.ethz.ch/speakers/lecture/32c992d0-4586-45de-98ea-dea16af0c154.html

What next … academically**?**

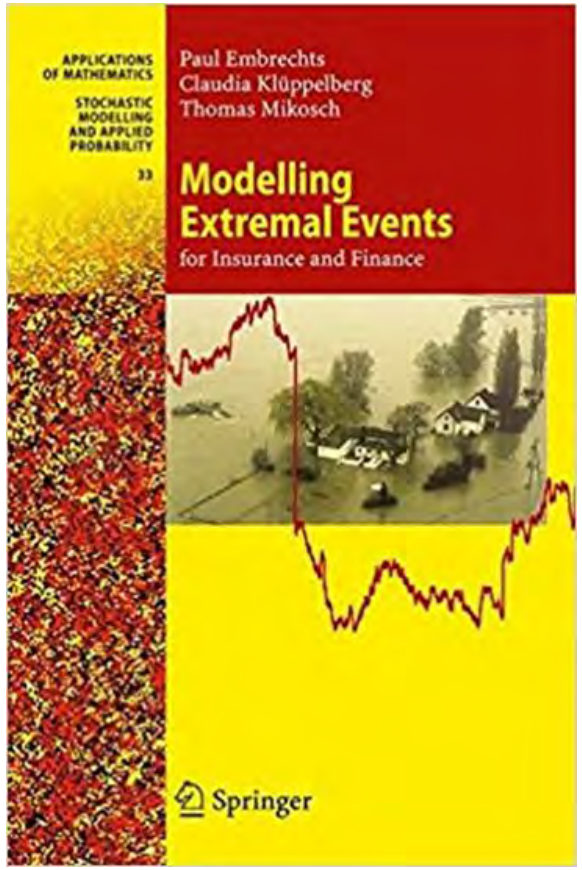
From a **pre-emeritus** research portfolio on
"The mathematical understanding of risk"
to a **post-emeritus** mandate/**book project** on

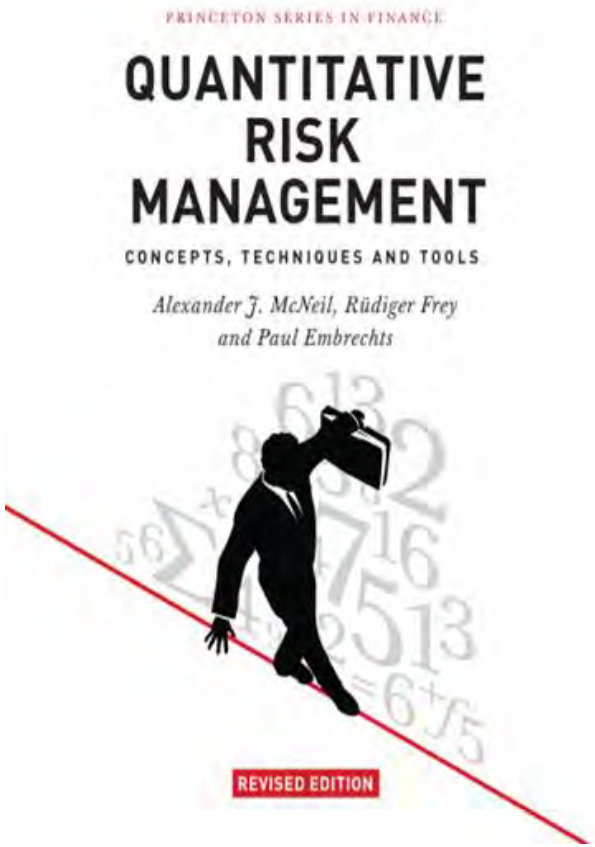
"The public understanding and communication of risk" (*)

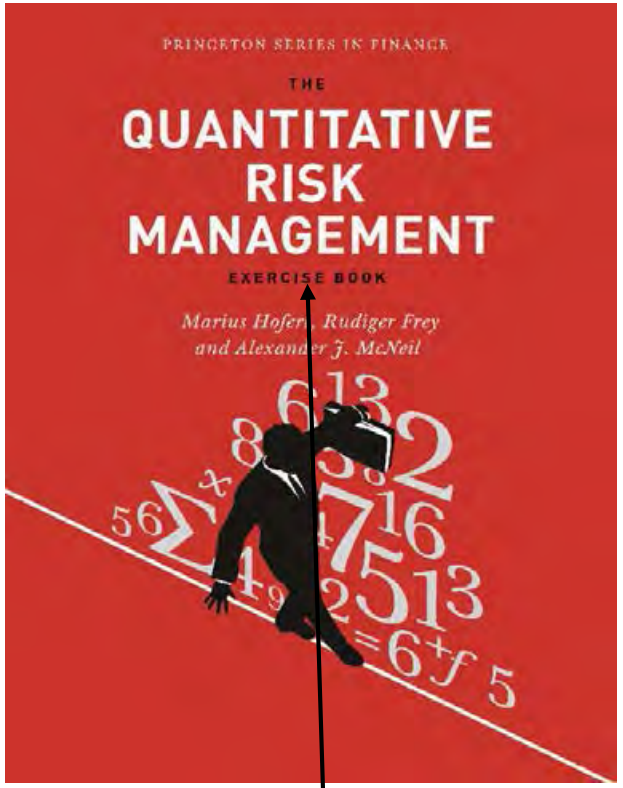
(with **Valérie Chavez-Demoulin** (UNIL Lausanne) & **Marius Hofert** (Waterloo))

(*) Working title 2020/21

The new (coffee-table)book should be a bridge from the more technical

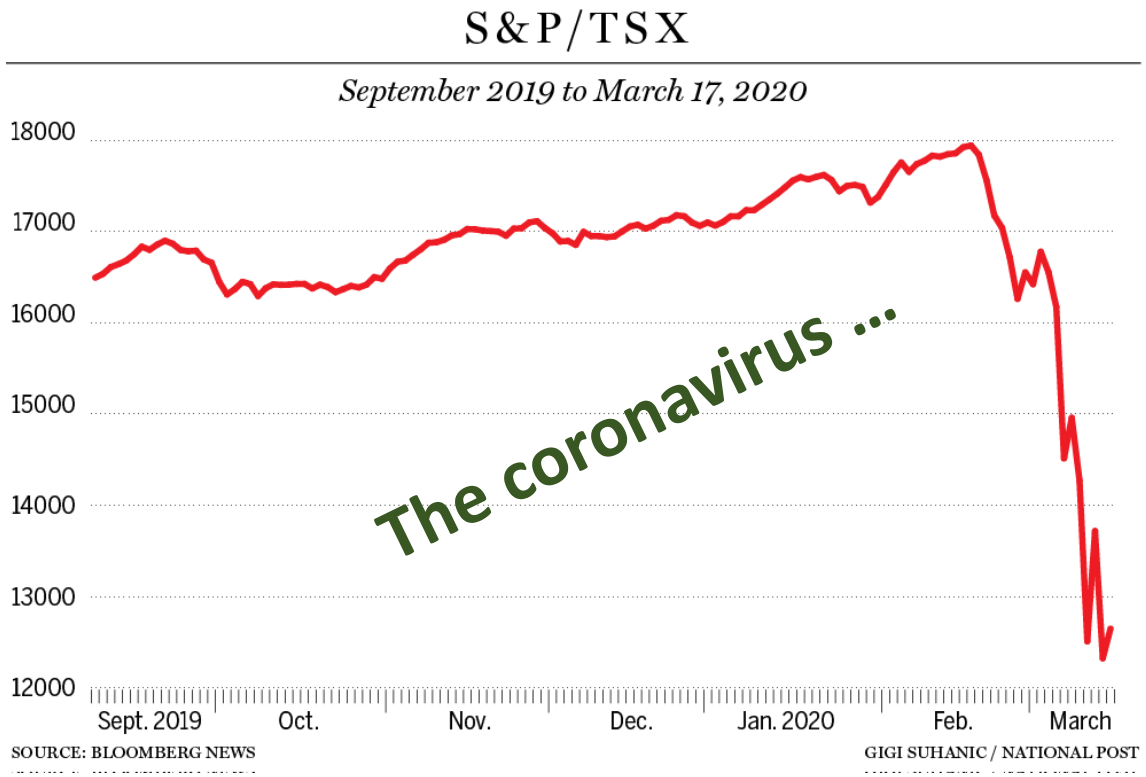






New: **Exercise book**
www.qrmtutorial.org

to the general public!



- March 16 drop by 12%
- Largest one-day **drop** since 19/10/87
- Several circuit breakers were activated

...

- A global worldwide **economic tsunami**

The great wave off Kanagawa
Katsushika Hokusai
(31/10/1760 - 10/5/1849)

Government financial **rescue** programs:

- USA: 2.3tr USD (TARP 475bn USD)
- EU: €540bn (~ 590bn USD)
- CH: 60bn CHF (~ 62bn USD)
- ...

On 7/5, 2pm, worldwide: 3 843 484 confirmed, 265 659 deceased

Some comments on **OpRisk** & **Coronavirus**:

- A coronavirus-type pandemic was predicted in numerous **scientific papers**, e.g. 2005 … including possible transmission bats -> people
- In highly visible talks, like Bill Gates' TED talk in 2015 <- Ebola
- Or books: Nassim Taleb's **Black Swan**, p. 317 <- physical networks
- And hence it is **not** a Black Swan in Taleb's language! ... and& today
- Pandemic stress testing is part of insurance regulation, e.g. within **Solvency 2** and the **Swiss Solvency Test**: Spanish Flu type 0.15% mortality increase as stress event, BCP/M, ORSA, ...
- There exists a huge literature on the history of pandemics and estimates of their **return periods**. The next pandemic was "around the corner", see -->

Further examples:

- --> **UK Financial Sector Market Wide Pandemic Exercise 2006** - Progress Report (May 2008) FSA, HM Treasury and Bank of England: "Previous flu pandemics have occurred at **10 - 40 year** intervals. **It is now 39 years since the last pandemic** (*). The international consensus is that a flu pandemic could occur at any time … "
- **BIS (2011), Principles for the Sound Management of Operational Risk**, Basel Committee on Banking Supervision: "… a pandemic event that affects human resources can result in significant financial losses to the bank, as well as broader disruptions to the financial system. To provide resiliency against this risk, a bank should establish business continuity plans … " … what about societal continuity plans (PE)?
- **We should have been better prepared … we were not!**

(*) 1968-69 Hong Kong flu (H3N2) pandemic with about 1 to 2 million deaths worldwide!

From **Albert Camus**' 1947 "**La Peste**" (The Plague)

"Il y a eu dans le monde autant de pestes comme des guerres. Et pourtant pestes et guerres trouvent les gens toujours aussi dépourvus." (*)

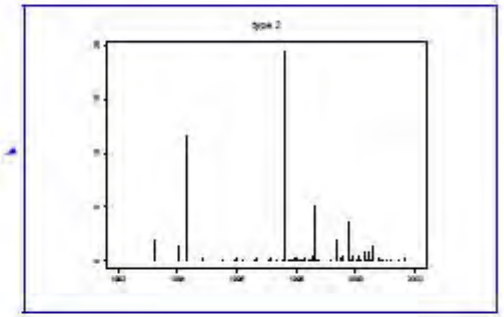
(*) "There have been as many plagues as wars in history: yet always plagues and wars take people equally by surprise."

The structure of OpRisk data

A **possible** mathematical modelling approach for general OpRisk-type of data; however …

Loss Distribution Approach (LDA) within AMA-Framework, Basel II

	RT_1	$\cdots$	RT_k	$\cdots$	RT_7	
BL_1						
$\vdots$						
BL_i			$L_{i,k}^{T+1}$			
$\vdots$						
BL_8						
						L^{T+1}



Very heavy-tailed

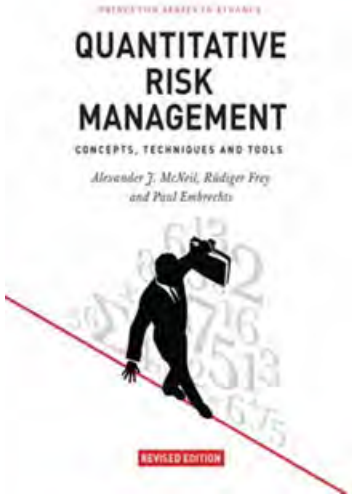
Internal, external,
expert opinion data

Matrix structured loss data

Calculate a risk measure of

A complicated stochastic structure

"Insurance Analytics"



Chapter 13

$$L^{T+1} = \sum_{i=1}^{8} \sum_{k=1}^{7} L_{i,k}^{T+1}$$

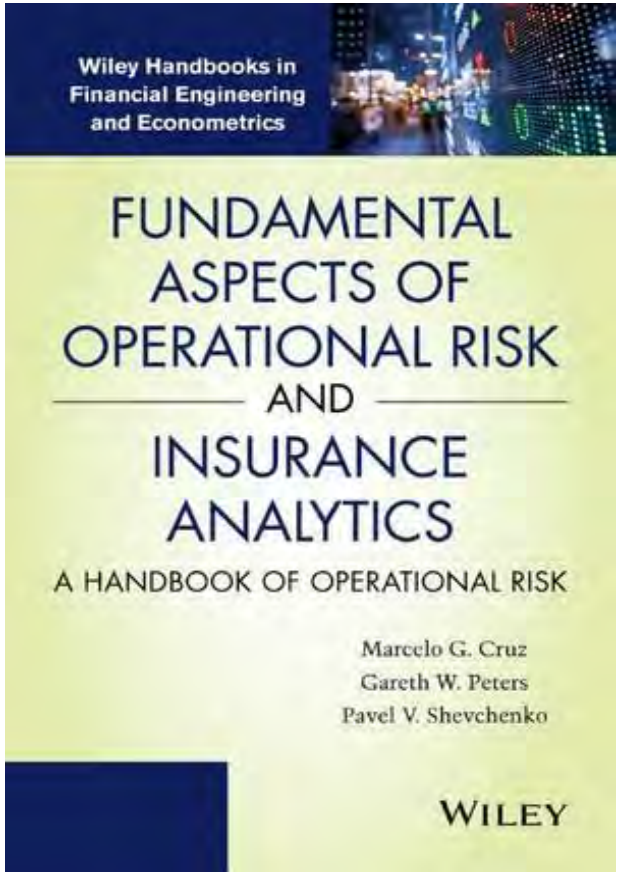
$$L_{i,k}^{T+1} = \sum_{\ell=1}^{N_{i,k}^{T+1}} X_{i,k}^{\ell}$$

$X_{i,k}^{\ell}$: loss severities

$N_{i,k}^{T+1}$: loss frequencies

together with left-censoring, inter-dependencies, reporting delays (IBNR-like), non-stationarity, insurance cover, extreme heavy-tailedness …

As a consequence, a lot has been written on the topic (e.g.):



2015, 900 pages!

OpRisk under Basel IV

In December 2017, the Basel Committee on Banking Supervision introduced the **new standardised** approach for calculating operational risk capital charge, which **replaces all operational risk approaches under Basel II**

Under Basel IV

- A single **non-model based** method using as components BIC, LC and ILM (= Internal Loss Multiplier) = f(BIC,LC) (see (*))
- **OpRisk Capital = ILM x BIC**
- 10 years of loss data as basis for LC and hence ILM
- Hence drop Basel II BIA, SA and AMA/LDA Pillar 1 Ansatz
- Move more towards Pillar 2 (≈ SST, Solvency 2, ORSA for insurance)
- Business Indicator Component (BIC) via bucket weights
- **Start: January 1, 2022**
- **BCBS**' aim: improve comparability and reduce complexity in AMA/LDA (<- "Darwinism" did not work!)

(*) Recall: OpRisk Capital = f(BIC,LC) x BIC

$f(x, y)$ = log (exp(1) -1 + $(\frac{15y}{x})^{0.8}$)

x = BIC

y = LC = "average annual OpRisk loss over last 10 years" (…) (corresponds to risk sensitivity)

0.541 (y= 0) $\leq f(x, y) \leq$ 1 ($15y = x$)

Reference: BIS (15/12/2019) - OPE Calculation of RWA for operational risk - OPE25 - Standardised approach – Version effective as of 01 Jan 2022 - New standardised approach as set out in the December 2017 Basel III publication.

Resulting mathematical problems

Based on joint work with G. Puccetti, R. Wang, L. Rüschendorf, …

Loss Distribution Approach (LDA) within AMA-Framework, Basel II

(2) VaR(1)

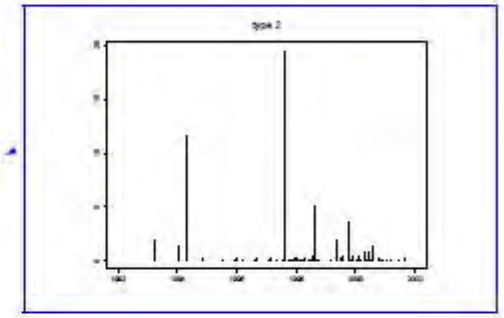
VaR(i)

VaR(8)

(3) $\sum VaR(i)$

$= VaR^{+}$

	RT_1	$\cdots$	RT_k	$\cdots$	RT_7	
BL_1						
$\vdots$						
BL_i			$L_{i,k}^{T+1}$			
$\vdots$						
BL_8						
						L^{T+1}



Very heavy-tailed

Internal, external,
expert opinion data

Matrix structured loss data

<- (1) superimpose

Calculate a risk measure of

A general fundamental problem in Quantitative Risk Management (relevant for OpRisk modelling)

- Risk factors: $\mathbf{X} = (X_1, \ldots, X_d)$
- Model assumption: $X_i \sim F_i$, F_i known, $i = 1, \ldots, d$
- A financial position $\Psi(\mathbf{X})$
- A risk measure/pricing function: $\rho(\Psi(\mathbf{X}))$

Calculate $\rho(\Psi(\mathbf{X}))$

As examples we look at $\Psi(\mathbf{X})) = \sum_{i=1}^{d} X_i$ with ρ = VaR and ρ = ES

and calculate (inf,sup) – bounds under **full inter-dependence uncertainty**

What do we know about this problem?

1) d = 2: solved analytically (Makarov)
2) d ≥ 3:
   2.1) homogeneous case (F_1 = … = F_d):
   partial (sharp) analytic results exist for VaR and ES
   2.2) inhomogeneous case:
   no analytic results, but Rearrangement Algorithm see website (*) maintained by Giovanni Puccetti
3) From "full inter-dependence uncertainty" to "partial dependence assumptions": an extensive literature exists

(*) The RA: https://sites.google.com/site/rearrangementalgorithm/home

Bounds in the inhomogeneous case: the Rearrangement Algorithm (RA)

(Embrechts, P., Puccetti, G., Rüschendorf, L. (2013): Model uncertainty and VaR aggregation. *Journal of Banking and Finance* 37(8), 2750-2764)

- A fast numerical procedure
- Based on the CM-idea
- Discretization of relevant quantile regions
- d possibly large (~1000s)
- Applicable to $\overline{\mathrm{VaR}}_p$, $\underline{\mathrm{VaR}}_p$ and $\underline{\mathrm{ES}}_p$

CM = Complete Mixability (B.Wang, R. Wang (2011), ...)

Example 1: $P(X_i > x) = (1+x)^{-2}$, $x \geq 0$, i = 1, … ,d

Bounds on VaR and ES for the sum of d Pareto(2) distributed rvs for $p = 0.999$; VaR_p^+ corresponds to the comonotonic case.

DU-gaps

434

320

	$d = 8$	$d = 56$
$\underline{\mathrm{VaR}}_p$	31	53
$\underline{\mathrm{ES}}_p$	178	472
VaR_p^+	245	1715
$\overline{\mathrm{VaR}}_p$	465	3454
$\overline{\mathrm{ES}}_p$	498	3486
$\overline{\mathrm{VaR}}_p/\mathrm{VaR}_p^+$	1.898	2.014
$\overline{\mathrm{ES}}_p/\overline{\mathrm{VaR}}_p$	1.071	1.009

can be explained

Comonotonic case: sum of marginal VaRs = d x marginal VaR

Comonotonic case: sum of marginal ESs = d x marginal ES

+/- factor 2 can be explained: Karamata's Theorem

+/- factor 1 can be explained (theorem)

Example 2: $P(\Psi(\mathbf{X}) > x)$ estimation as a function of co-variables, for x typically large -> high-quantile estimation using EVT

[1] Chavez-Demoulin, V., Embrechts, P., Hofert, M. (2016): An extreme value approach for modeling Operational Risk losses depending on covariates. Journal of Risk and Insurance 83(3), 735-776

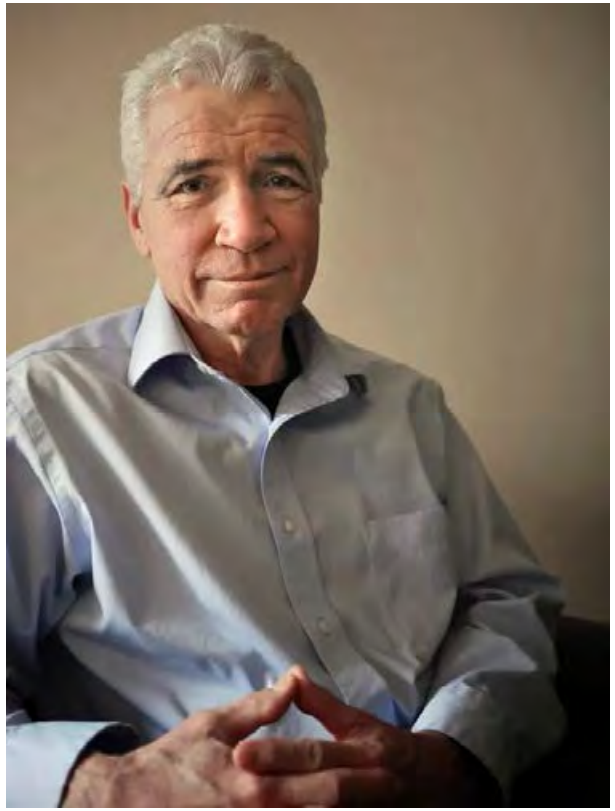
[2] Embrechts, P., Mizgier, K.J., Chen, X. (2018): Modeling Operational Risk Depending on Covariates. An Empirical Investigation. Journal of Operational Risk 13(3), 17-46 **(Best Paper Award J. OpRisk (2018))**

Weitzman’s Dismal "Theorem"

From OpRisk to Climate Change

- **Neslehova, J., Embrechts, P., Chavez-Demoulin, V.** (2006): Infinite mean models and the LDA for operational risk, *Journal of Operational Risk* **1(1)**, 3-25. The first paper!
- **Moscadelli, M.** (2004). The modelling of operational risk: experience with the analysis of the data collected by the Basel committee. Technical Report 517, Banca d'Italia. Several "infinite mean EVT based models" for the official BCBS-OpRisk impact study data!
- The consequences of "infinite mean models" ...

Weitzman’s Dismal "Theorem"



Martin L. Weitzman
(1/4/1942 – 27/8/2019)

- Environmental Economist
- Climate Change and the Economics of Catastrophes
- The Dismal Theorem (2009), On Modeling and Interpreting the Economics of Catastrophic Climate Change, *The Review of Economics and Statistics,* XCI(1)

The general idea is that under limited conditions concerning the structure of uncertainty and preferences, the expected loss from certain risks such as climate change is infinite, and standard economic analysis cannot be applied. (*)

(*) Quoted from: W. Nordhaus (2009), An analysis of the Dismal Theorem, Cowles Foundation, Yale.

Conclusion

- Operational Risk is a highly relevant risk class and needs to be well-understood by all relevant players, including academia
- Goes well beyond banking and insurance
- Important intersection with areas like Climate Change and Cyber Risk
- The Dismal Theorem is relevant through The Economics of Catastrophes
- Leads to interesting mathematical and statistical questions and demands from researchers a high degree of cross-disciplinary thinking and collaboration
- **Unfortunately,** the 2007-2008 Financial Crisis did, and the current COVID-19 Pandemic does offer important examples of OpRisk's relevance!

Thank you and keep well in these difficult times!