Financial Engineering and The Financial Crisis

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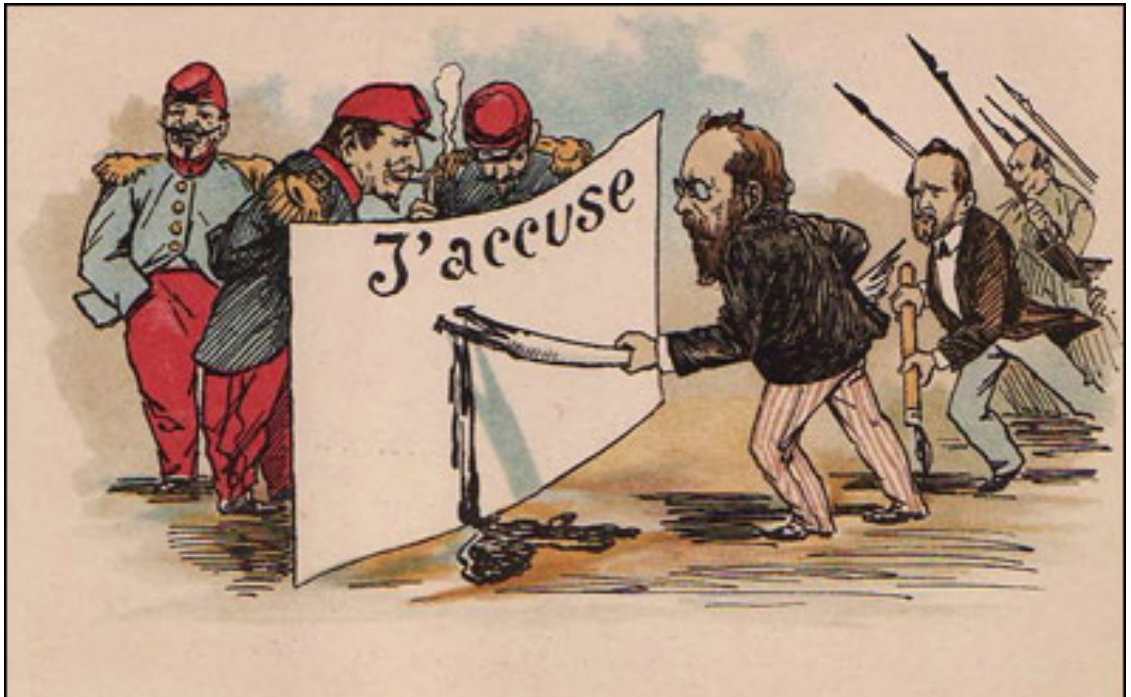
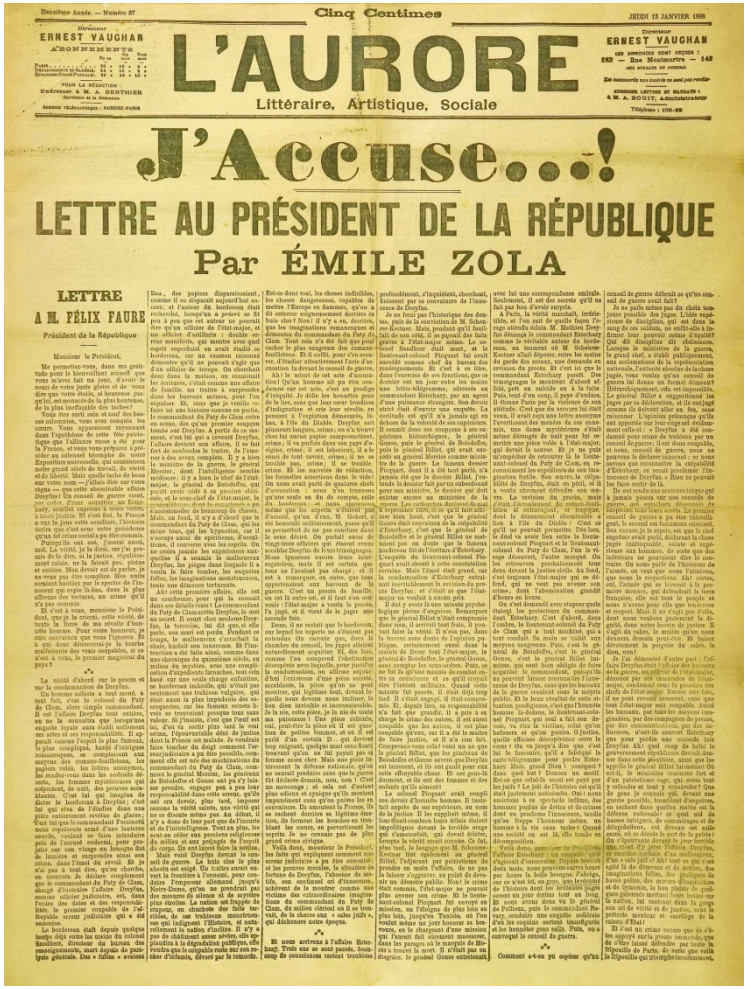
I should really start this talk with:

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JEUDI 13 JANVIER 1898

Deuxième Année. — Numéro 87

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L'AURORE

Littéraire, Artistique, Sociale

J'Accuse...!

LETTRE AU PRÉSIDENT DE LA RÉPUBLIQUE

Par ÉMILE ZOLA

LETTRE

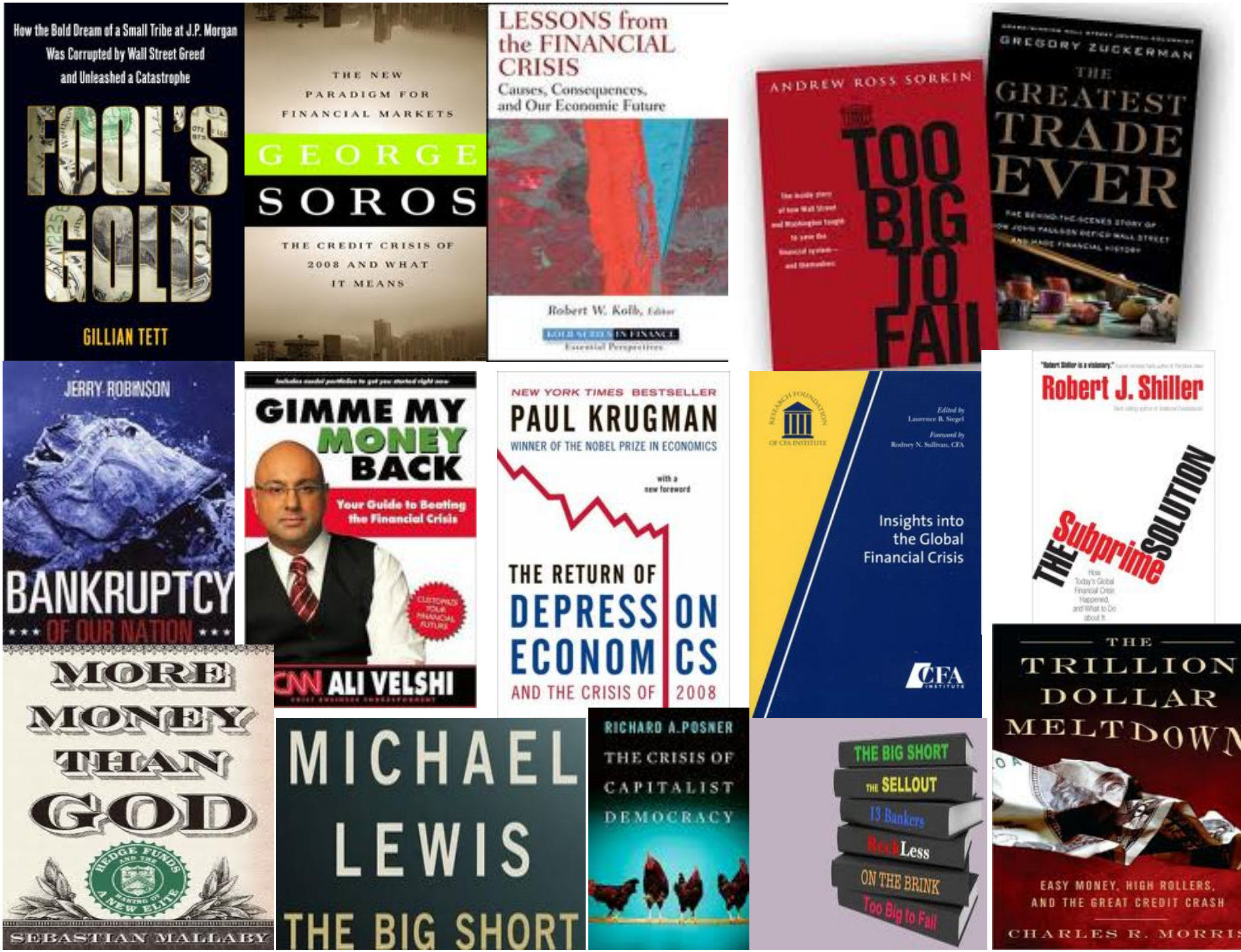
A M. FÉLIX FAURE

Président de la République

Monsieur le Président,

J'accuse XYZ

Others have …


How the Bold Dream of a Small Tribe at J.P. Morgan Was Corrupted by Wall Street Greed and Unleashed a Catastrophe
FOOL'S GOLD
GILLIAN TETT
THE NEW PARADIGM FOR FINANCIAL MARKETS
GEORGE SOROS
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13 Bankers
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ON THE BRINK
Too Big to Fail
THE TRILLION DOLLAR MELTDOWN
EASY MONEY, HIGH ROLLERS, AND THE GREAT CREDIT CRASH
CHARLES R. MORRIS

Some issues coming out of the crisis:

- Local politics versus global banks
- Too big to fail versus too big to save
- Complexity (in various dimensions) and a reigning opaqueness on a massive scale
- The "Heads, the bank wins, tails, you loose"-syndrome, privatizing gains versus socializing losses
- "RM is there to transfer risk from those who do not want to have it to those who understand it" turned out to be a myth

My real worry however!

Going forward, Financial Engineers will increasingly have a crucial role to play in helping to solve society's three main problems:

Social Insurance

Social Insurance

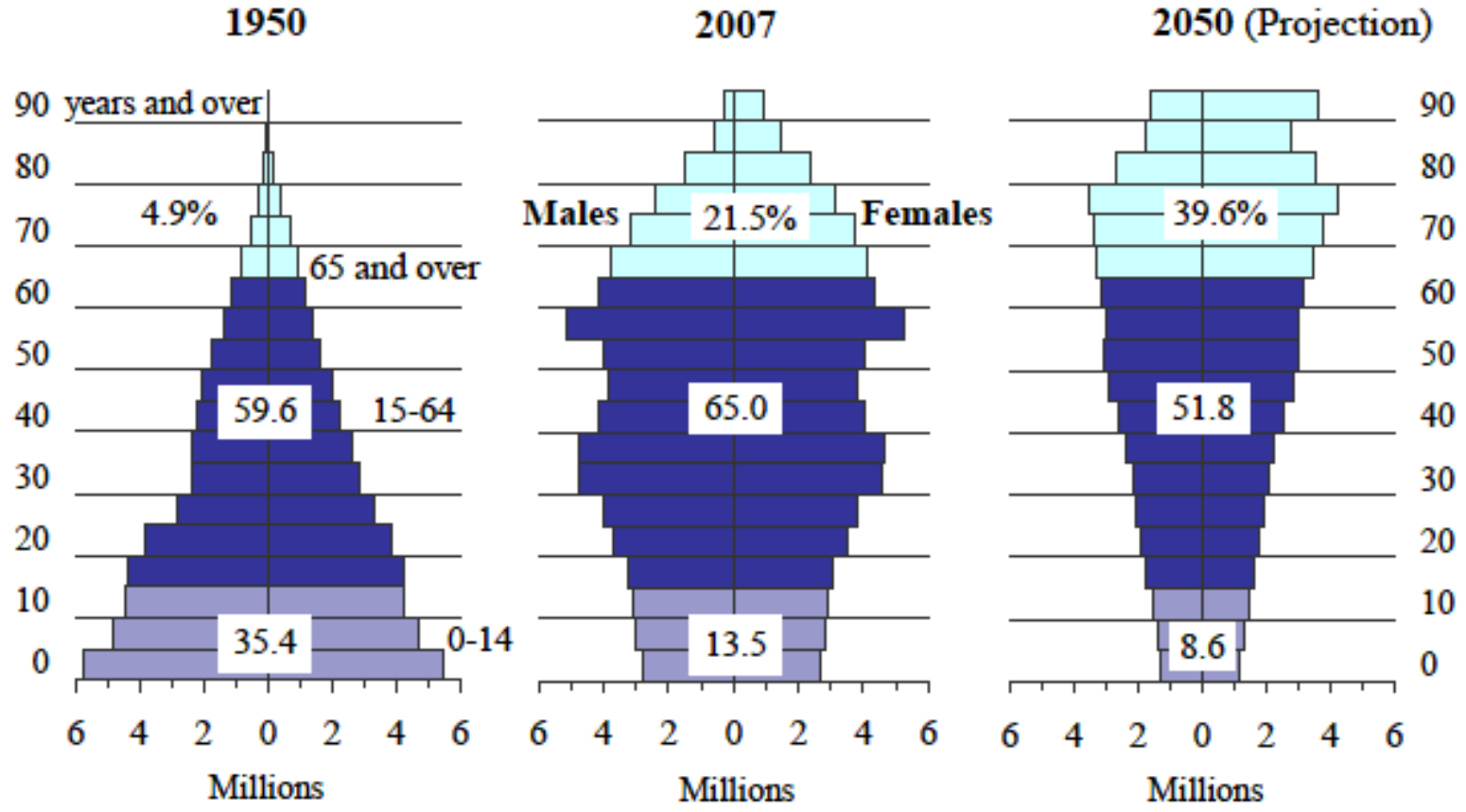
Social Insurance

Social = Life, Pensions, Health, …

A picture tells a 1000 words:

Figure 2.3

Changes in the Population Pyramid



Source: Statistics Bureau, MIC; Ministry of Health, Labour and Welfare.

Japan

not just

Some issues relevant for actuaries:

- Demographics, biometrics, longevity
- Low interest rates versus guarantees
- Embedded options, stress testing
- Investment (non-)opportunities, ALM
- Regulation (Solvency 2, SST, Basel III, …)
- Accounting, CG-structuring
- National deficits/debts (macroecon, politics)
- Bond markets (government, corporate, …)
- QE … → resulting Risk Management issues

This begs the question: what is the Financial Engineer's position in a changing world*?

I do hope we will seriously start taking up this gauntlet as this is THE REAL PROBLEM!

*The meaning of this, geopolitical, environmental and socio-economic, is no doubt fully clear to all present here today.

But let us return to the current crisis:

Three early FE-warnings which till today are not well enough understood:

- 1992: Joseph Stiglitz on misunderstanding the power and perceived innovation of loan securitization
- 1998: Embrechts-McNeil-Straumann RiskLab report on properties and pitfalls of linear correlation → our 2005 QRM book
- 2001: RiskLab-LSE report "An academic response to Basel II"
- C.Donnelly, P.Embrechts (2010) The devil is in the tails. ASTIN Bulletin 40(1), 1-33

Some ingredients of a toxic mix:

- Large Complex Financial Institutions
- Misuse of securitization
- Manufacturing (& holding) of systemic "AAA" tailrisk
- Inadequately capitalized … free lunch!
- Regulatory arbitrage (banking → trading book)
- Some of the LCFIs' warehousing of such risks went from 5 Bio $ in 2/06 to 50+ Bio $ by 9/07
- Leverage: 30+:1
- Accounting misuses: REPO 105, …
- … leading to Wall Street alchemy

In summary (Acharya et al., NYU Stern School, 2010):

"The new banking model of
"originate-distribute-and-hold"
incurred massive systemic tail-risks that finally brought the financial sector down!"
In other words: these LCFIs were (and hence(*) the global financial system was)

"long a massive economic catastrophe bond which was totally mispriced, if priced at all"

* Reasons for "hence": network complexity, interconnectedness, global business …

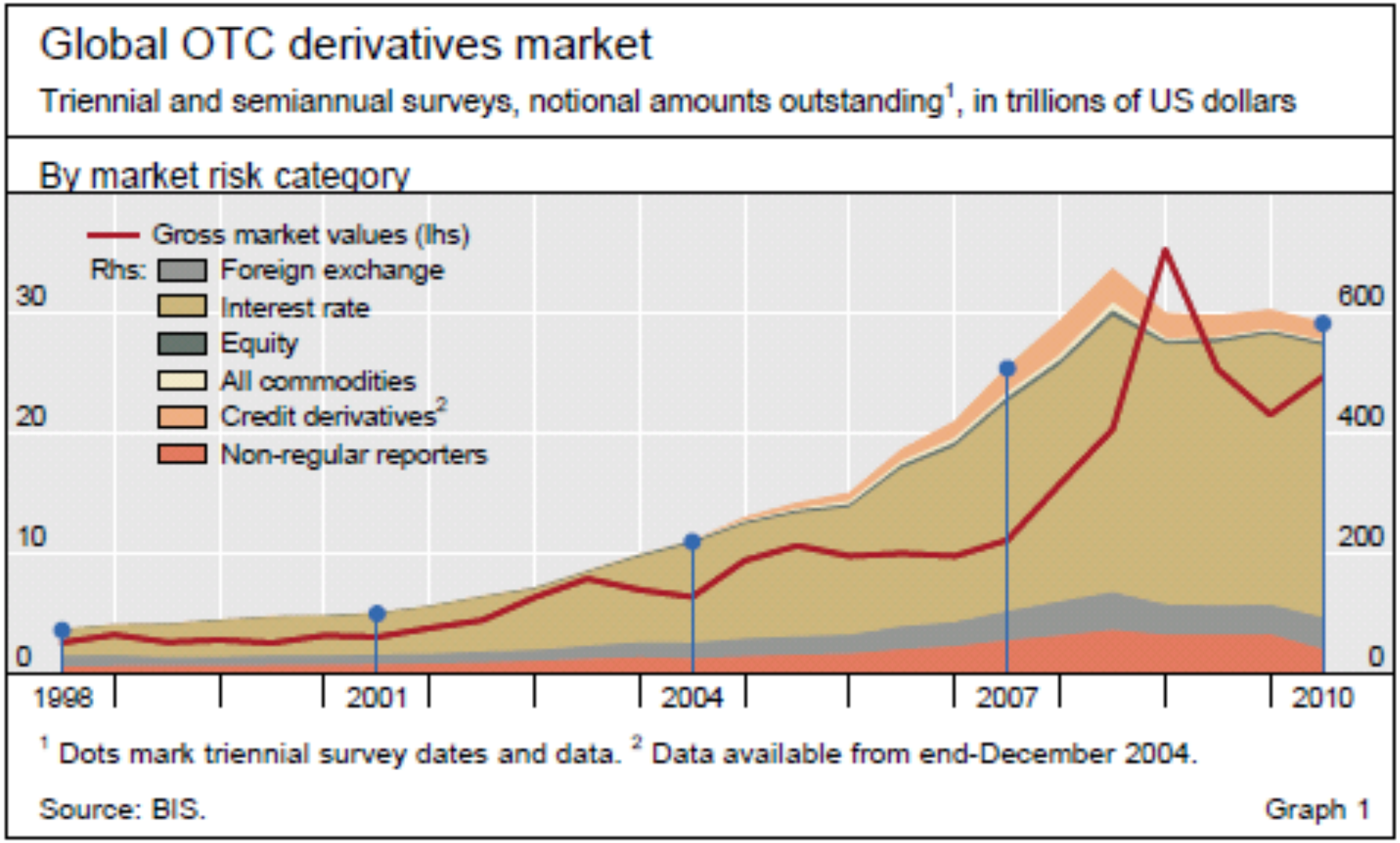
Minimizing the probability of a future crisis with similar devastating consequences:

- Prevention: “RM is most effective at prevention. Failing at prevention results in damage control, which is often expensive and ineffective.”
- Education: at all LEVELS, in all FIELDS!!!!
- Communication: we as FE professionals, industry selling products society needs, the media “giving us news we need not just news we want”

Some things we need(ed) to know!

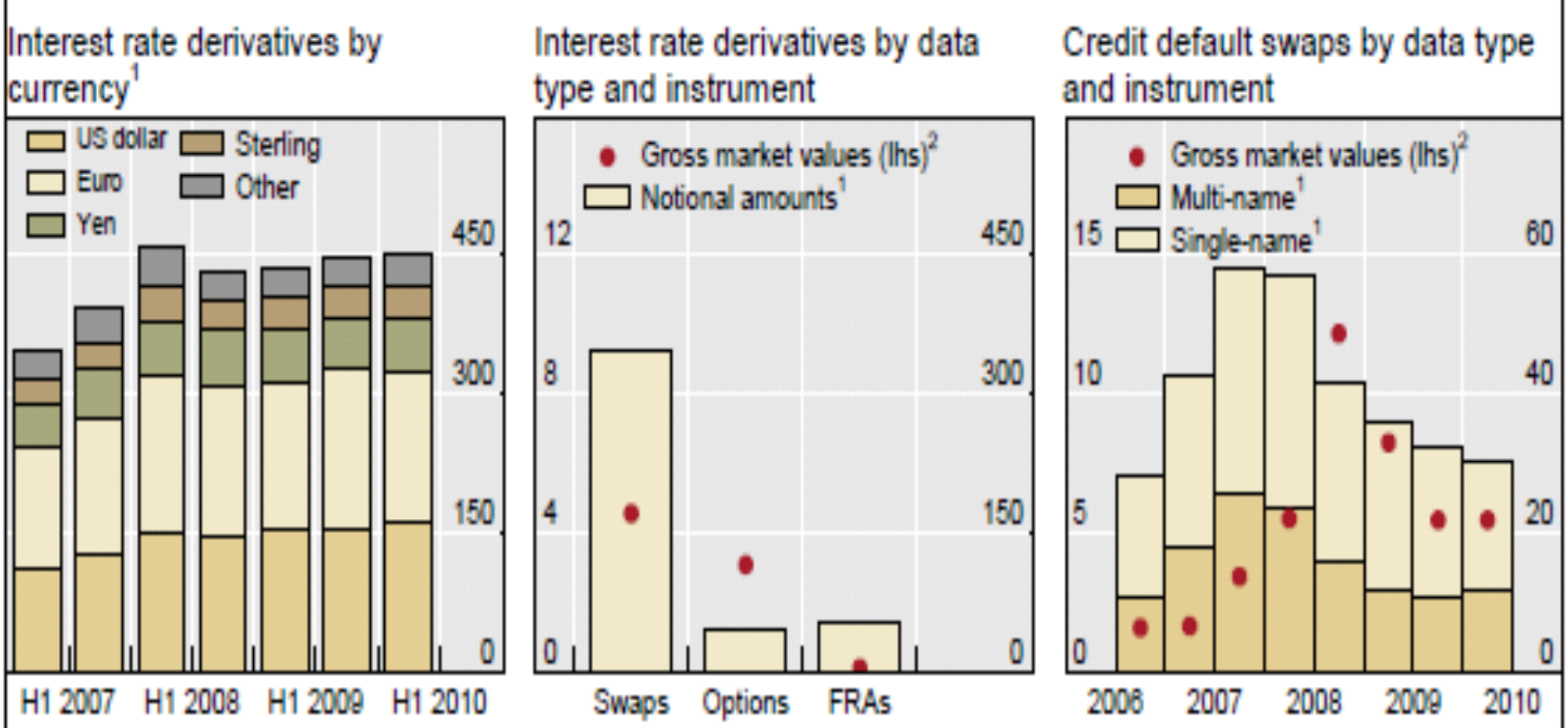
- 1 tri $ = 1 000 000 000 000 $ … a story
- World GDP = 58 tri $, US GDP = 14.5 tri $ (US deficit = 1.35 tri $, debt = 13.6 tri $)
- Nominal amount CDS (6/10) = 30 tri $
- Nominal amount of OTC (6/10) = 583 tri $
- CDO volume 2006: 2.7 tri $
- 1/2007: in the US, about 12 AAA-rated companies, and about 65 000 AAA-rated securitization instruments, etc … etc …

From the BIS' Triennial and Semiannual Surveys on Positions in OTC derivatives Markets at end-June, 2010



Global OTC derivatives

In trillions of US dollars and in per cent



[1] Notional amounts outstanding (rhs). [2] As a percentage of the notional amount outstanding.

Source: BIS.

Graph 4

Interludium:

- From 1 trillion $ to 1 trillionth of a second! (The latter is called a picosecond (1 ps))
- 1 ps is about the switching time of the (currently) world's fastest transistors
- Light travels 0.3 mm in (+/-) 1 ps
- Quiz: why do I mention this?
- High-frequency trading … do we need it?
- "Speed-of-light trading" … really?
- Co-location etc … what next?

An early warning of things to come?
The Flash-Crash of May 6, 2010!

- 998.50/9.2%
- 600 in 5’

Hence new Risk Management challenges!

From the SEC/CFTC Report on May 6, 2010:

- The algorithm was programmed to execute the trade "without regard to price or time," which meant that it continued to sell even as prices dropped sharply.
- Startlingly, as the computers of the high-frequency traders traded contracts back and forth, a "hot potato" effect was created, as contracts changed hands 27,000 times in 14 seconds, but with eventually only 200 actually being bought or sold.
- … end of story, … so far!

Concerning prevention, we tried and failed with:

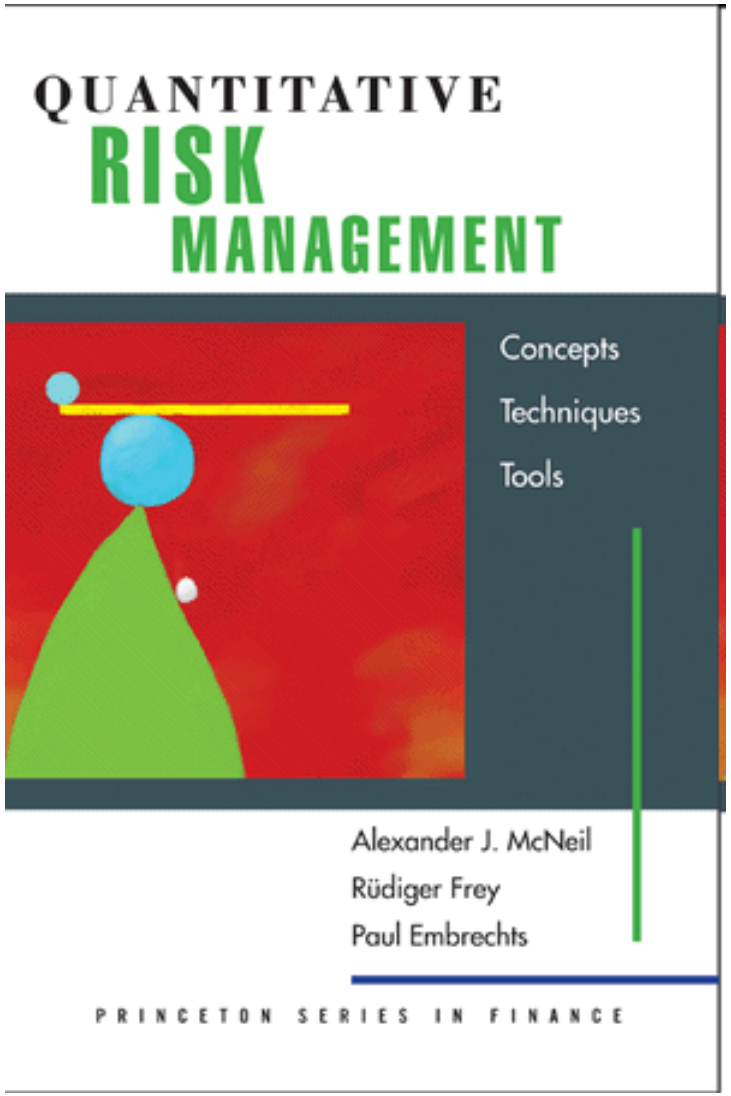
Embrechts, P. et al. (2001):
An academic response to Basel II.
Financial Markets Group, London School of Economics. (Mailed as an official response to the Basel Committee)

→ PE website since 2001!

et al. = Jón Daníelsson
Charles Goodhart
Con Keating
Felix Muennich
Olivier Renault
Hyun Song Shin

In this official response on Basel II we warned very explicitly for:

- Poor quality risk measures (Value-at-Risk)
- Endogeneity of risk, inherent procyclicality
- Lack of measurement of systemic risk
- Impossibility of accurate quantitative measurement of regulatory capital for certain risk classes (OR, 99.9%, 1yr VaR)
- Insufficient quality of rating agencies' assessment of default risk for securitized products
- Industry-wide underestimation of downside/ extreme risk, and - dependence ("correlation")



… because of the latter (see also Stiglitz (1992) and Embrechts-McNeil-Straumann (1998)) we included:

Chapter on Extreme Value Theory
"life beyond Normality"

Chapter on Dependence Modelling
"life beyond Linear Correlation"

2005

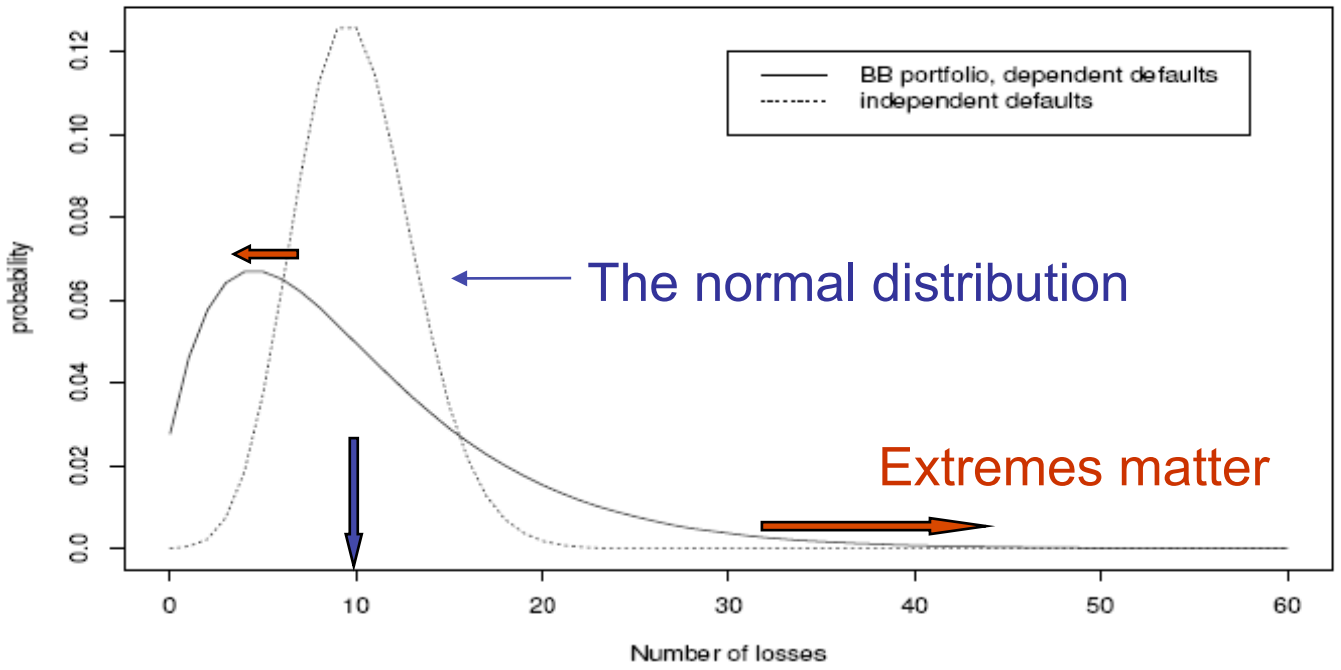
and much more FE relevant material …

As an illustration, from Chapter 9, we take the following example, for which the key message is:

beware of Model Uncertainty (1)

micro-

Impact of dependence on loss distribution



Distribution of number of defaults for homogeneous portfolio of 1000 BB loans with default probability $\approx 1\%$; Bernoulli mixture model with default correlation $\approx 0.22\%$ is compared with independent default model.

Correlation matters

As a consequence:

- The pricing (and hedging) of super-senior AAA CDO tranches has substantial model uncertainty (= MU)
- Pricing of CDO**2, CDO**3 products, besides being more than questionable from an economic point of view, is quantitatively near impossible (← MU)
- Hence beware of warehousing such risks!
- Similar examples with other products …

And as a further illustration,
from Chapter 5:
beware of Model Uncertainty (2)

Simulation of a two-dimensional portfolio with marginal distributions given as

F(1)=LN(0,1) and F(2)=LN(0,9)

and dependence:

Corr = 50% → no solution

Corr = 30% → no solution

Corr = 10% → infinitely many solutions

So understand the model conditions!

From the QRM book:

Theorem 5.25 (attainable correlations). *Let (X_1, X_2) be a random vector with finite-variance marginal dfs F_1 and F_2 and an unspecified joint df; assume also that* $\mathrm{var}(X_1) > 0$ *and* $\mathrm{var}(X_2) > 0$. *The following statements hold.*

(1) *The attainable correlations form a closed interval* $[\rho_{\min}, \rho_{\max}]$ *with* $\rho_{\min} < 0 < \rho_{\max}$.

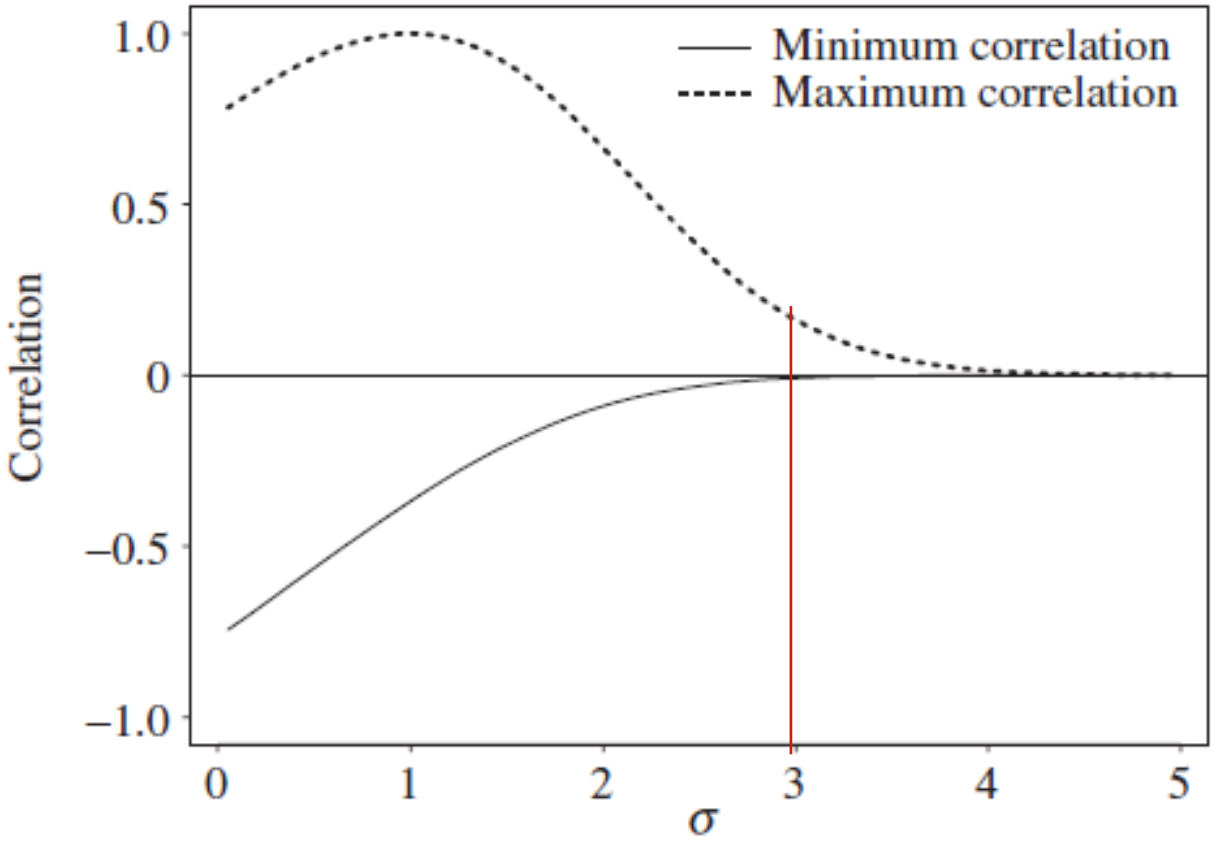
(2) *The minimum correlation* $\rho = \rho_{\min}$ *is attained if and only if* X_1 *and* X_2 *are countermonotonic. The maximum correlation* $\rho = \rho_{\max}$ *is attained if and only if* X_1 *and* X_2 *are comonotonic.*

(3) $\rho_{\min} = -1$ *if and only if* X_1 *and* $-X_2$ *are of the same type (see Section A.1.1), and* $\rho_{\max} = 1$ *if and only if* X_1 *and* X_2 *are of the same type.*

(A result due to M. Fréchet and V. Hoeffding (1940s))

As an example: LN(0,1), LN(0,σ^2)

$$\rho_{\min} = \frac{e^{-\sigma} - 1}{\sqrt{(e-1)(e^{\sigma^2} - 1)}}, \qquad \rho_{\max} = \frac{e^{\sigma} - 1}{\sqrt{(e-1)(e^{\sigma^2} - 1)}}$$



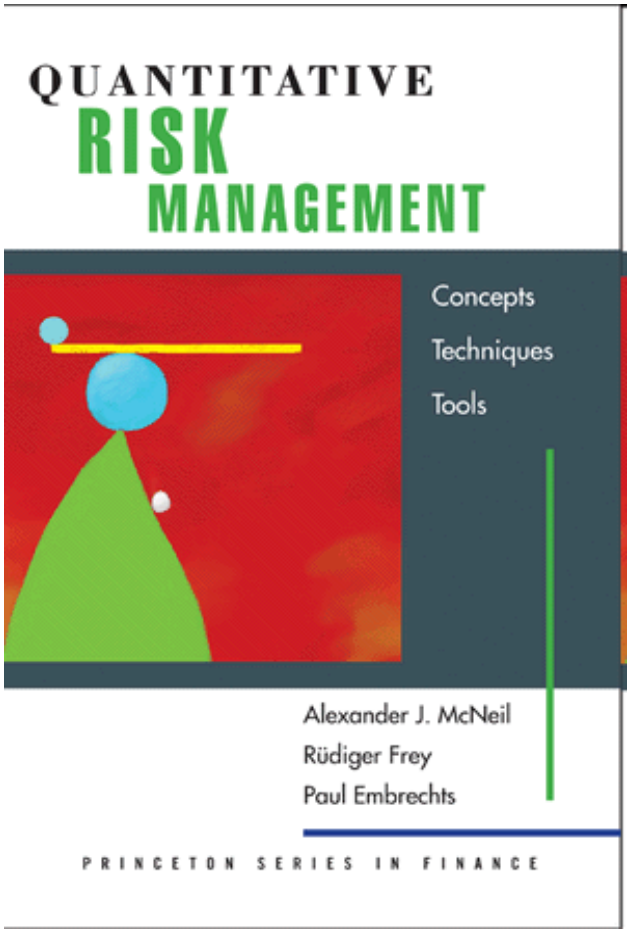
Some key MU-issues:

- How to combine marginal risk information into a multivariate model environment
- Copula methodology is one possibility in the static case, however
- Three reasons for using copulas: pedagogic, pedagogic, stress testing
- MU often exists at the structural parametric level (as above) and this on top of statistical (estimation) uncertainty
- OR-Robust Optimisation, ...

Mathematics is of key importance for

- understanding and clarifying models and prices used in finance, insurance and economics
- making heuristic methods mathematically precise, and asking for clear, unambiguous definitions!
- highlighting model conditions and restrictions on applicability
- working out numerous explicit examples
- leading the way for stress testing and robustness properties
- and it would be bad if the current crisis would induce a shying away from mathematics!

A nice example of the importance of Financial Engineering (QRM) and the research done at RiskLab (relevance!) of ETH Zurich!



Basel Committee
on Banking Supervision

Joint Forum

Developments in Modelling Risk Aggregation

October 2010

BANK FOR INTERNATIONAL SETTLEMENTS

But mathematics is just one small piece of the complex RM puzzle:

Some very basic RM rules:

- If you don't understand it, don't sell/buy it
- Speak to "the guys in the boiler room"
- Beware of "new" paradigms, like the New Economy, the New Risk Management: "new" usually means that tried and trusted measures of the past are being ignored
- Always understand your gains and beware of volume (even/especially AAA)
- Concerning Basel II+ or III: do not try to reinvent the wheel, check countries and institutions that came through the crisis less harmed, understand why!!! (Q&A?)

(Some) Lessons Hopefully Learned:

1) Beware of "new paradigms"
2) There is no such thing as a free lunch
3) Question (excessive) gains … "Ask why?"
4) Ask: "What would it take to break the product?"
5) Watch out for (and understand) volume
6) Balance between qualitative and quantitative, between rational and irrational (or behavioral)
7) Multidisciplinarity →
8) Complexity … no easy fixes (mathematics)
9) Better education (→ QRM and …) !!!!
10) Learn from neighboring fields: →

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* RiskLab, ETH Zurich (Eidgenössische Technische Hochschule Zürich)

Teachers: Valérie Chavez-Demoulin, Anthony Davison and Paul Embrechts
Information: www.math.ethz.ch/~valerie or PE website!

Thank You!