# Financial Crisis

**Origins and Consequences on Financial Institutions Focusing on Insurance Companies (Session 2)**

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ActuaRisk

# Agenda

1. Required Capital
2. Internal Models for Risk Management Purposes
3. Are Mathematical Models Efficient Tools to Model Financial Markets?
4. Conclusion

# 1. Required Capital

Required Capital

# Introduction

Karel Van Miert (ex-EU Commissioner for Competition):

*"Dat de markt zichzelf corrigeert, is een grote leugen. De markt kan zich corrigeren, als de markt werkt.Maar uit mijn ervaring als commissaris voor de Concurrentie weet ik dat heel wat markten niet werken. Je hebt kartels, allerhande toestanden. Er is kuddegeest. Zeker in de banksector.* ***Ik heb altijd gezegd dat bankiers kuddedieren zijn. Als de ene bank iets doet, doet de andere het ook. 'Als die dat risico aankunnen, dan wij ook.' Dat naïeve geloof dat de sky the limit is.*** *Dat is jezelf dingen wijsmaken. Je mag ambitieus zijn, maar je moet altijd beseffen dat zaken ook een negatieve wending kunnen nemen."*

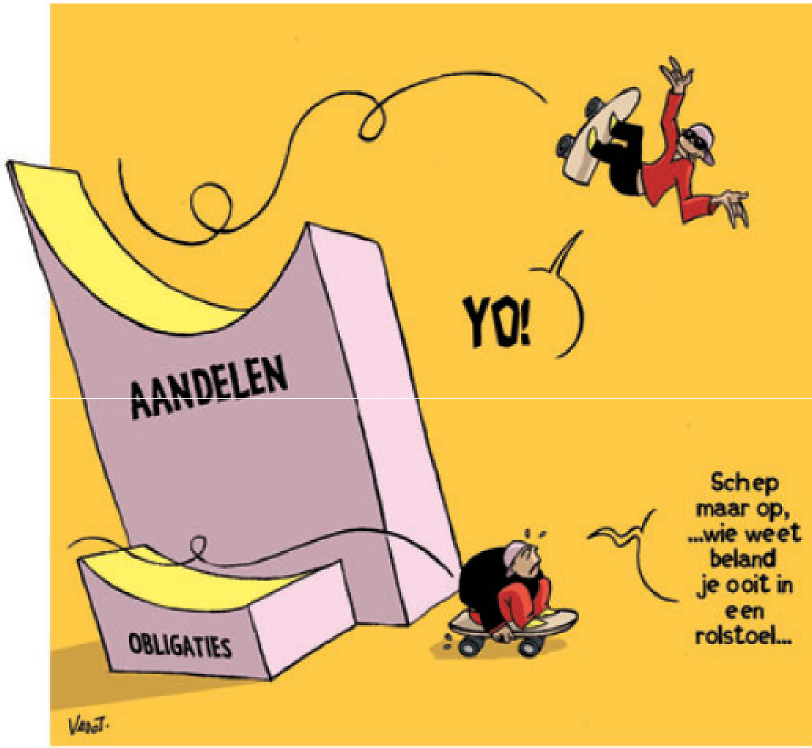
Source: De Tijd, Feb 28th 2009,

Required Capital

# ABC to Invest in Financial Products

Generally speaking investors should considerer the following elements:

1. Analyse your needs
2. Chose your investment horizon
3. Assess your risk appetite
4. Diversify
5. Keep you informed




Source: De Tijd, Aug 9th 2008,

These rules are often used by individuals.
Should financial institutions use more sophisticated rules?

Required Capital

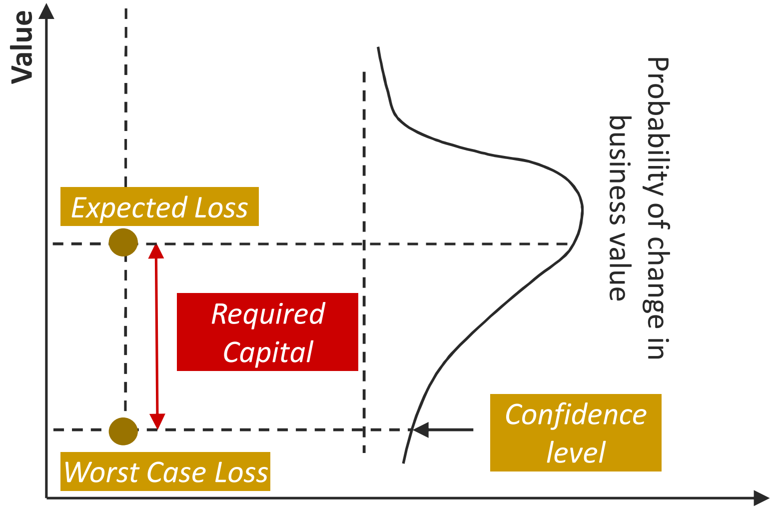
# Rules to Protect the Economy

- An important objective of governments is to provide a stable economic environment for private individuals and businesses.
- One way they do this is by providing a reliable financial system where bank and insurer failures are rare and where depositors and policyholders are protected.
- To increase confidence in the financial system and protect people and businesses, there has been a trend worldwide toward the development of progressively more complicated rules on the capital that financial institutions are required to keep.
- The ability of a financial institution to absorb unexpected losses is critically dependent on the amount of equity and other forms of capital held.

Required Capital

# Required Capital

- It is widely accepted that the capital a financial institution requires should cover the difference between expected losses over some time horizon and "worst-case losses" over the same time horizon.




- The worst-case loss is the loss that is not expected to be exceeded with some high degree of confidence.
  - Expected losses are usually covered by the way a financial institution prices its products. For example, the interest rate charge by a bank is designed to recover expected loan losses. Capital is a cushion to protect the bank from an extremely unfavourable outcome.

Basel II
Solvency II

**This crisis suggests that some refinements are needed...**

# 2. Internal Models for Risk Management Purposes

# Solvency II Evolution for Insurers

**Solvency I** specified capital requirements in terms of a simple set of factors to be applied to technical provisions or premiums. These defined additional 'solvency margins' to be maintained over and above the technical provisions.

A set of simple factors, as used for **Solvency I**, cannot cope well with the diversity of risks in typical insurance portfolios.

**Solvency II**

**Solvency I**

More advanced companies have developed sophisticated internal models to measure the effects of adverse events on their portfolios. Provided they can be validated to an adequate standard, these models will form the basis of the capital assessment under **Solvency II**. Companies that do not have an internal model of the required standard will still be able to use a factor-based system (the 'Standard Approach'), although it is likely to be more complex than the **Solvency I** system.

# Why Internal Models?

- The level of risk in an insurance portfolio depends on many different factors:
  - The level of premium rates will have an effect as a company writing more profitable products will require less capital than a company writing less profitable business.
  - The existence of options and guarantees in the product range has an effect, as does investment policy.
  - The degree to which assets and liabilities are matched will have an impact on the capital requirements, but also an aggressive investment strategy, investing in high-risk assets, will obviously require more capital.
  - Risk management techniques, such as the use of reinsurance and hedging, can reduce risk levels.
- Most large institutions preferred to use the internal model-based approach because it better reflects the benefits of diversification and led to lower capital requirements.

→ **A simple example to analyse the relevance of internal models...**
**Using three different models to determine required capital...**

# Traditional VaR Model

A risk measure summarizes the information contained in the distribution function of a r.v. (or risk) in one single real number. We conventionally assume that a negative value for the realisation of a risk means a loss whereas a positive value actually points to a gain.

For a r.v. $X$, the $p$-quantile risk measure is defined as

$$Q_p(X) = \inf\{x \mid P[X \le x] \ge p\}, \qquad 0 < p < 1.$$

Furthermore, the value at risk at a $p$-confidence level, denoted by $VaR_p(X)$, is now defined as

$$VaR_p(X) = Q_{1-p}(X).$$

Let $P_0 = P > 0$ be the current price at time 0 of a particular investment portfolio, whereas $P_t$ is its price at the end of the $t^{th}$ period $(t = 1, 2, \ldots, n)$. We define the log-return of the investment portfolio in the $t^{th}$ period as

$$R_t = \ln\left(\frac{P_t}{P_{t-1}}\right).$$

If the subsequent log-returns $R_t$ of the investment portfolio are independent and have identical normal distributions with mean $\mu$ and standard deviation $\sigma$ then it follows that the value at risk of the investment portfolio is given by

$$VaR_p = P\left(e^{\mu + \phi^{-1}(1-p)\sigma} - 1\right).$$

Required capital, $CAP$, of a portfolio is given by

$$CAP = -VaR_{99\%}$$

Source: http://www.actuarisk.be/files/PaperBaselSite.pdf

# VaR: Cornish-Fisher Expansion

If the $R_t$'s are not normally distributed, but the deviations from normality are *"small"* enough, then we can approximate the non-normal distribution using the Cornish-Fisher expansion. In this case, the VaR becomes

$$VaR_p = P\left(e^{\mu+\eta(1-p)\sigma}-1\right),$$

with $\eta(p)$ given by

$$\begin{aligned}\eta(p) = {} & \phi^{-1}(p)+\frac{1}{6}\left(\left(\phi^{-1}(p)\right)^3-1\right)\gamma \\ & +\frac{1}{24}\left(\left(\phi^{-1}(p)\right)^3-3\phi^{-1}(p)\right)\kappa \quad , \\ & -\frac{1}{36}\left(2\left(\phi^{-1}(p)\right)^3-5\phi^{-1}(p)\right)\gamma^2\end{aligned}$$

where $\gamma$ and $\kappa$ are the skewness and kurtosis of $R$ respectively.

Required capital $CAP$ of a portfolio is given by

$$CAP = -VaR_{99\%}$$

Source: http://www.actuarisk.be/files/PaperBaselSite.pdf

# Extreme Value Theory

There are many problems in risk management that deal with extreme events – events that are unlikely to occur, but can be very costly when they do. These include large market falls, the outbreak of financial crises, etc. Consequently, risk management practitioners need to measure the risk associated with these extreme events.

However, estimation of VaR at extreme confidence levels is faced with a difficult problem: *as we have relatively few extreme observations on which to base our estimates, the standard error on the estimates of these VaR's can be significant and this uncertainty increases as our confidence level gets higher*.

To bypass these problems, practitioners resort to theory, or to be more precise, to statistical models which deal with extreme events – extreme value theory.

As extreme value theory deals with the maximum losses, we do not work with the total log-return series. From the original daily series, we select the minimum quarterly log-return observed each quarter. This technique is commonly known as the block maxima method.

Assuming that each month contains 30 days, we define the minimum quarterly log-returns for a portfolio as:

$$R_t^{\min} = \min\left\{R_k, k \in \left[90\cdot(t-1)+1, 90\cdot(t-1)+90\right]\right\},$$
$$\text{and } t = 1,2,3,\ldots$$

The required capital of a portfolio is now given by:

$$CAP = -P\left(e^{Q_{1-p}\left(R^{\min}\right)} - 1\right),$$

where

$$\begin{cases} Q_{1-p}\left(R^{\min}\right) = -\hat{\mu} - \dfrac{\hat{\sigma}}{\hat{\xi}}\left(\left(\ln\left(\dfrac{1}{p}\right)\right)^{-\hat{\xi}} - 1\right) & \text{if } \hat{\xi} \neq 0 \\ Q_{1-p}\left(R^{\min}\right) = -\hat{\mu} + \hat{\sigma}\ln\left(\ln\left(\dfrac{1}{p}\right)\right) & \text{if } \hat{\xi} = 0 \end{cases}.$$

Source: http://www.actuarisk.be/files/PaperBaselSite.pdf

# Capital Requirements

- For a porfolio worthed €1 Bio invested in the Dow Jones:

## Traditional VaR

| | Dow Jones Portfolio |
|---|---|
| Log-Return Average | 2.16% |
| Log-Return Volatility | 8.80% |
| $Q_{1\%}(R)$ | -18.30% |
| CAP | €167,2 Mio |

## Cornish-Fisher Expansion

| | Dow Jones Portfolio |
|---|---|
| Log-Return Skewness | -0.51023 |
| Log-Return Kurtosis | 1.33729 |
| $\eta(0.01)$ | -2.91619 |
| $Q_{1\%}(R)$ | -23.49% |
| *CAP* | €209,3 Mio |

## Extreme Value Theory

| | Dow Jones Portfolio |
|---|---|
| $\hat{\mu}$ | 0.05006 |
| $\hat{\sigma}$ | 0.04530 |
| $\hat{\xi}$ | 0.27962 |
| $Q_{1\%}(R^{\min})$ | -47.44% |
| *CAP* | €377,7 Mio |

At 99% confidence level, the three models provide different levels of required capital.
**Which capital is the correct one?**

Source: http://www.actuarisk.be/files/PaperBaselSite.pdf

# 3. Are Mathematical Models Efficient Tools to Model Financial Markets?

# Quantitative Investment

- In 1993, Myron Scholes and Robert C. Merton joined forces with John Meriweather, the legendary bond trader of Salomon Brothers. With 13 other partners, they launched a new hedge fund, Long Term Capital Management (LTCM), which promised to use mathematical models to make investors tremendous amounts of money.
- Documentary: *BBC Horizon (1999)*

# Comments on the Documentary

- We have seen the extraordinary story of a beautiful mathematical formula that changed the world, the financial markets, and indeed capitalism itself. It could do the unthinkable – it took the risk out of playing the money-markets. To its inventors it brought the Nobel Prize for economics. To those who used it, it brought great wealth. But this glittering tale ended in tragedy.
- Relying on mathematics, LTCM traded and borrowed on a scale never seen before. But the mathematical model was based on normal market behaviour and unforeseen events were about to send the markets wild. The calculations in LTCM's models became hopelessly out of kilter, and when the company collapsed in 1998, it nearly brought down the entire global economy.

# 4. Conclusion

# Conclusion

- In finance, mathematical models should not be considered as the Holy Grail. They have to be used cautiously as their have clear limits in trying to model the financial world.
- The current crisis tends to demonstrate that we have not learnt so much from previous crisis (cf LTCM collapse)!
- Let's hope that the current crisis will allow decision makers to refine current and future practices of financial institutions/practitioners…