

Quantitative Methods and Risk Management

Summer School, Munich

Gerhard Stahl, BaFin

Where did regulators come from?



Agenda

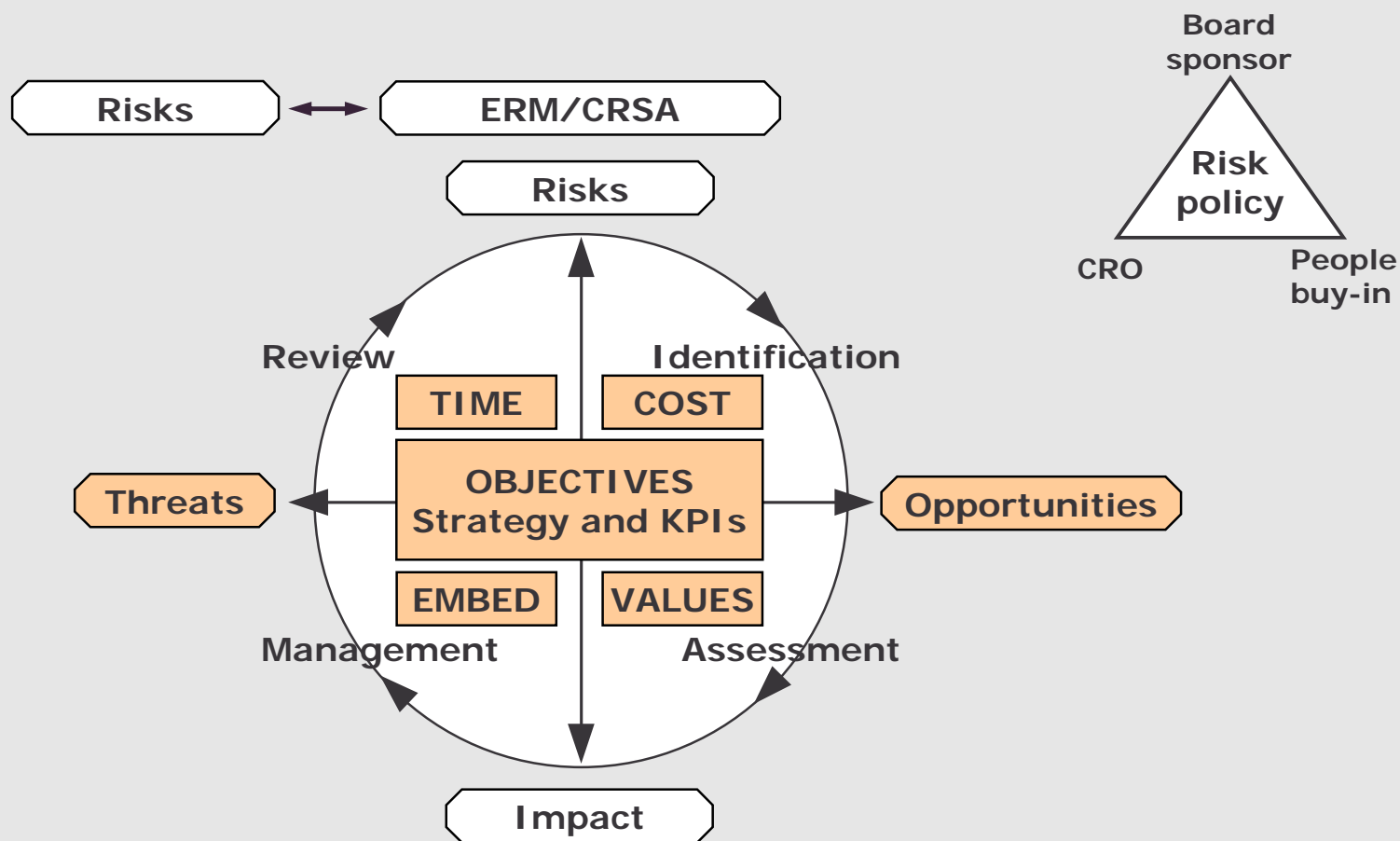
- 1. Market risk**
- 2. Credit risk**
- 3. OpRisk**
- 4. Aggregation**
- 5. Banks and Insurances**

Cross-sectional supervision activities by QRM

on-site examinations of internal models:

Banks	Funds	Insurers
<ul style="list-style-type: none"> • market risk models TB (Amendment to Basel I, since 1998) • interest rate risk banking book (since 2004) • internal ratings (Basel II IRBA, since 2005) • OpRisk (Basel II AMA, since 2006) 	<ul style="list-style-type: none"> • hedge funds (DerivateV/OGAW-RL, since 2004) 	<ul style="list-style-type: none"> • since 2005 (pre-visits) • potentially: Solvency II (starting 2008-2010)

What is Risk Management Process about?

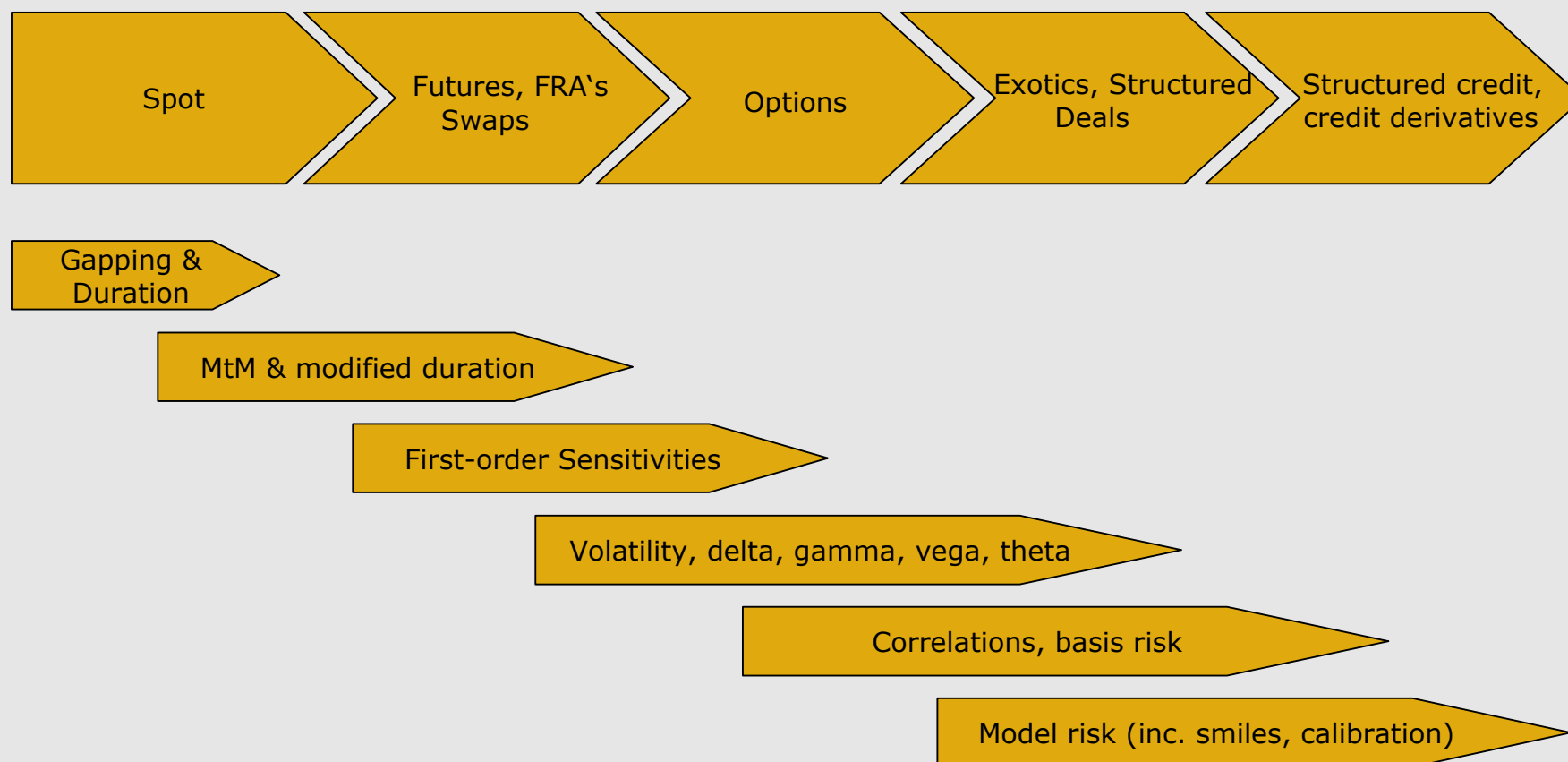


Modeling Risk - A Portfolio of Stakeholders

• Bondholders		TTC
• Shareholders	EC	PIT
• Regulators (B, I)	reg. Capital req.	99,9
• Rating agencies	EC	99,98
• Managers	EC	95

- different time horizons (!!)
- different levels of significance (!)
- conditional vs. unconditional (PIT, TTC)
- complexity of the firm, e.g. a holding (!!!) => copula, consistent modeling,.....

CFI and Internal Models



Today: VaR based regulation

Where did regulators came from?

regulatory starting point:

1. **STANDARDIZED METHODS = simple scenarios (8%)**
2. **Simpler then SPAN, the margin system of CME**
3. **HEAD** paper bridges the past to the future
=> relevancy
4. **Coherent risk measures (ES) are closely linked to portfolio approaches (monotonicity)**
$$\text{VaR}(X+Y) < \text{VaR}(X) + \text{VaR}(Y)$$
5.
$$\text{VaR}(a X) = a \text{VaR}(X)$$

Backtesting the Market Risk Amendment

- **Clean vs. dirty P&L**
- **Exclusion of exponential weightings, hybrid models**
- **Backtesting methods too simplistic**
- **EC and VaR for 10 trading days (partial view)**
- **incentive structure is ok – SM much higher RC**
- **difficult to define steering clearly – use test**
- **regulation neglects more timeline information through audits**
- **Process focused regulation – neither rules nor principles**

Annotations to HEAD – what is a good risk measure?

1. SM are weakly coherent
2. Backtestability
3. Clear substantial meaning
4. Robustness
5. good scaling behavior (time, level of significance, portfolios, ...) - risk silos, different users
6. Valuation of assets is key (marked to market, marked to model, best estimate,...)

There is no one size fits all measure of risk

What is gained if instead of a PD an ES is determined???

Which models are in place?

1. The Winner: Historical Simulation
2. Monte-Carlo-Simulation
3. Delta-Gamma Approaches (**REAL TIME** VaR)

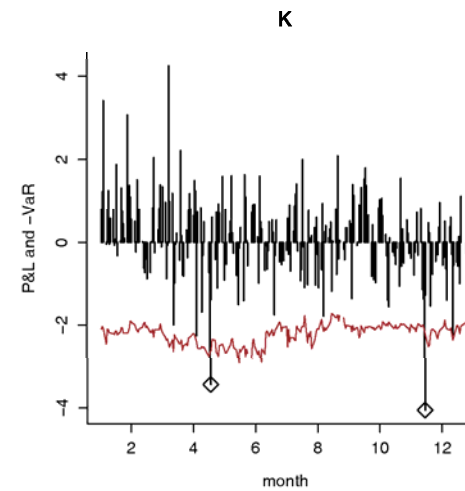
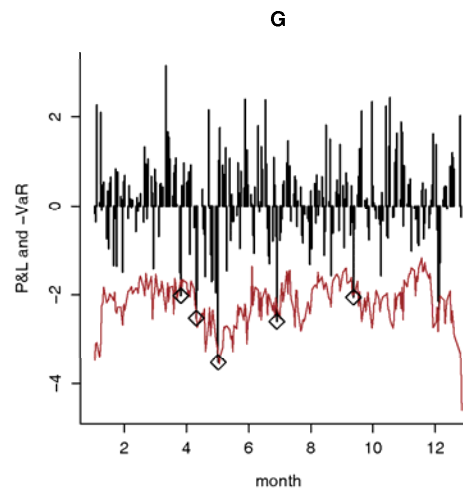
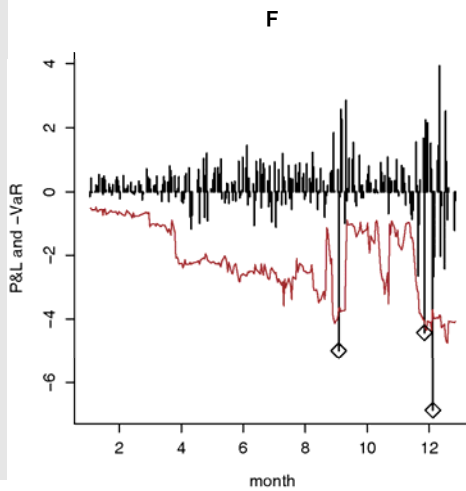
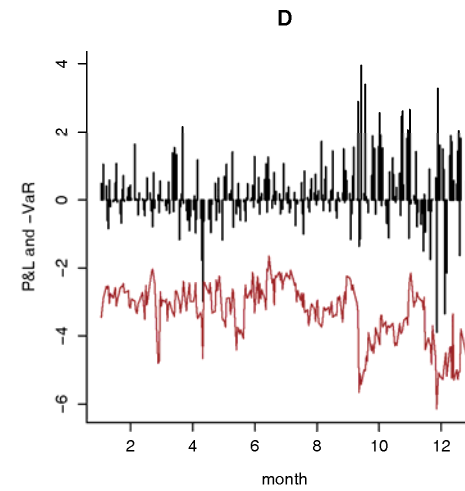
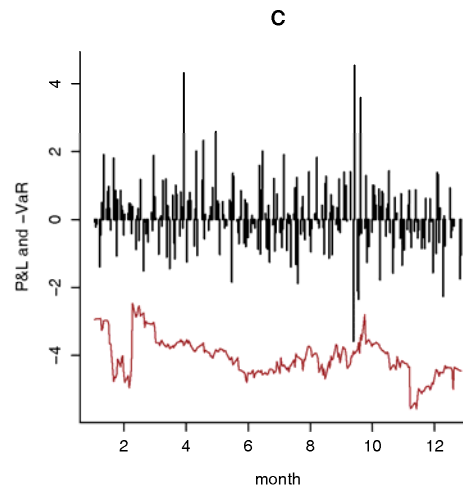
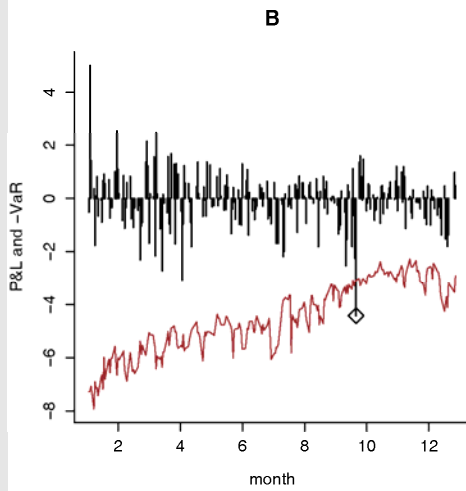
Cont.

- 1. One period bottom-up models**
- 2. Assumptions:**
 1. Square-root of time scaling
 2. Aggregating silos by the assumption of uncorrelatedness
- 3. Mapping error, approximation error, estimation error, numerical errors**
- 4. Market data of high quality**
- 5. Marked-to-market (model) valuation**
- 6. Often crude methods for pricing model errors**
- 7. Stress tests depend on models**

Data quality matters

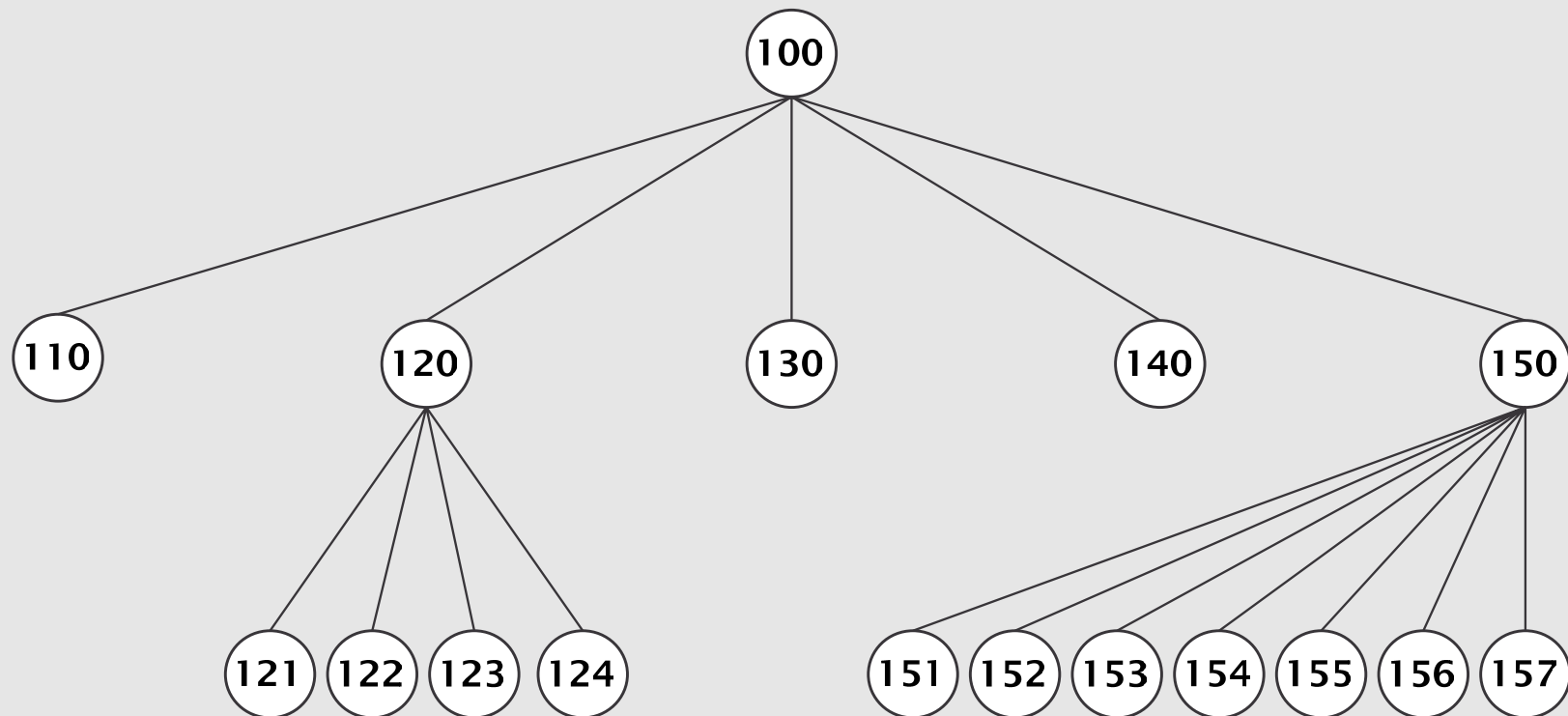
- **quality and availability of data**
- **Outliers (e.g. unexpected interest rate decisions)**
- **Missing values (banking holidays)**
- **Mis-keyed values**
- **Time heterogeneous data (trading resp. time zones, different points of market liquidity)**
- **Uncertainty from imputation techniques (EM algo.) neglected.**

Time series for P&L and - VaR



Portfolio Tree

Trading Book



Credit Risk

- Credit risk is key for the business model of a universal bank
- Hence, for core credit segments (retail, corporates, banks,...) rating models were established long before Basel II
- Rating systems actually in place were not implemented from scratch
- Typically, they are a hybrid models blending the existing ones with newer approaches (external data, KMV, RiskCalc, statistical models)

B_1 : Equity Capital Ratio

Assuming that B_1 is the equity capital ratio C in percentage defined by

$$C := \frac{\text{EK}}{\text{BS} + \text{ML} + 0,5(\text{GB} + \text{WO} + \text{VU})} * 100$$

with

EK equity capital

BS balance total

ML obligations out of rental and leasing business

GB obligations out of warrantees and guarantees

WO acceptance liability

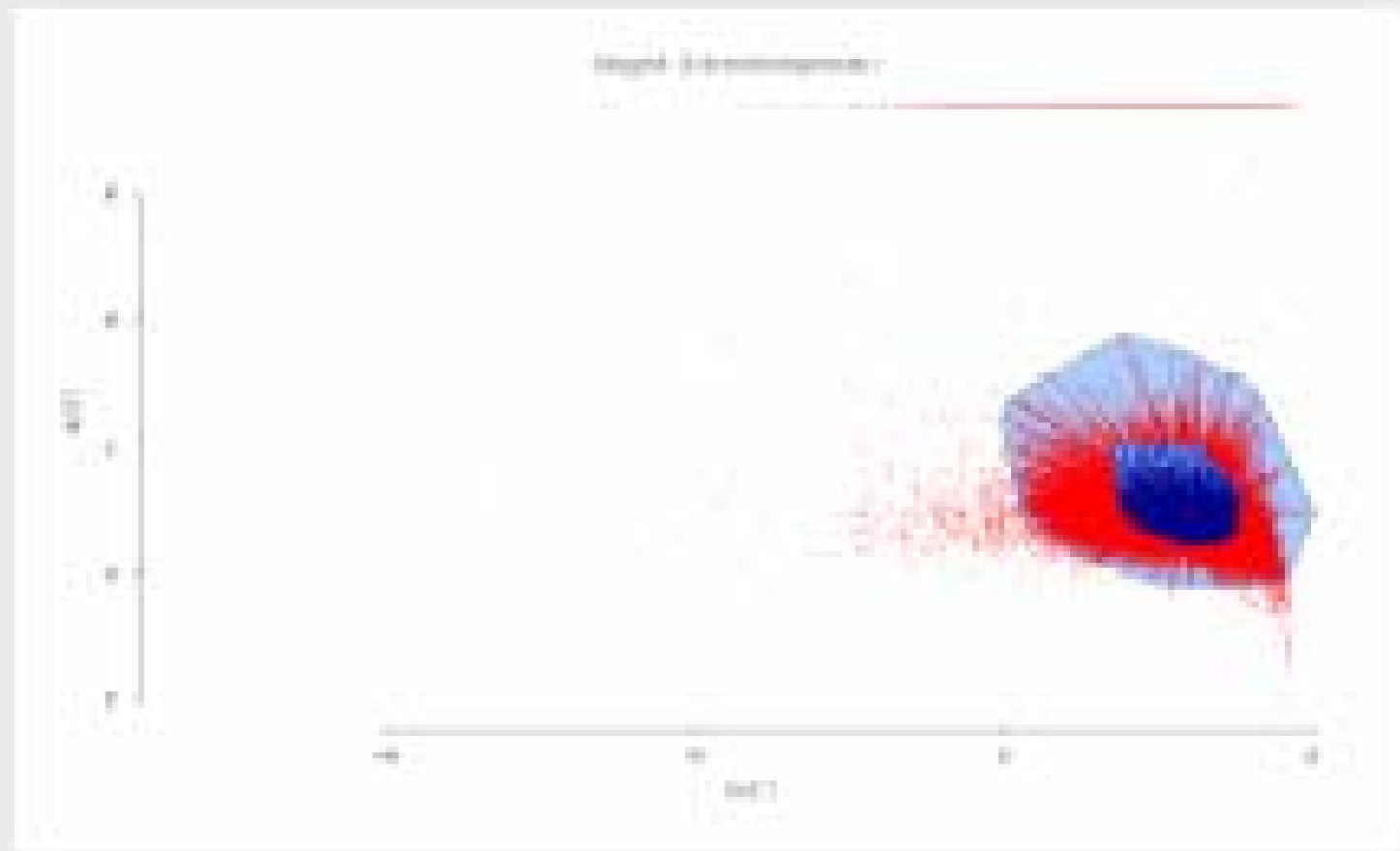
VU obligations to associated companies

Data Quality

poor data quality of ratios

- ratios out of annual balance sheet are characterized by numerous and extreme outliers
- in approx. 30% of all observations at least one ratio is outside of the 1% or 99% quantile
- ratios of the qualitative section are in some cases significantly beyond the respective range
- Only 20-30% were complete an error free

Bagplot of Balance sheet data



Influence of outliers on PD

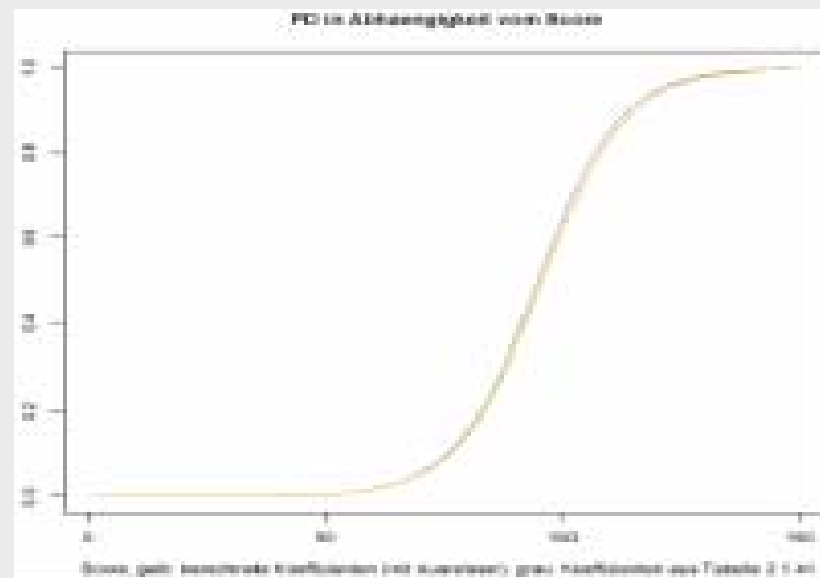
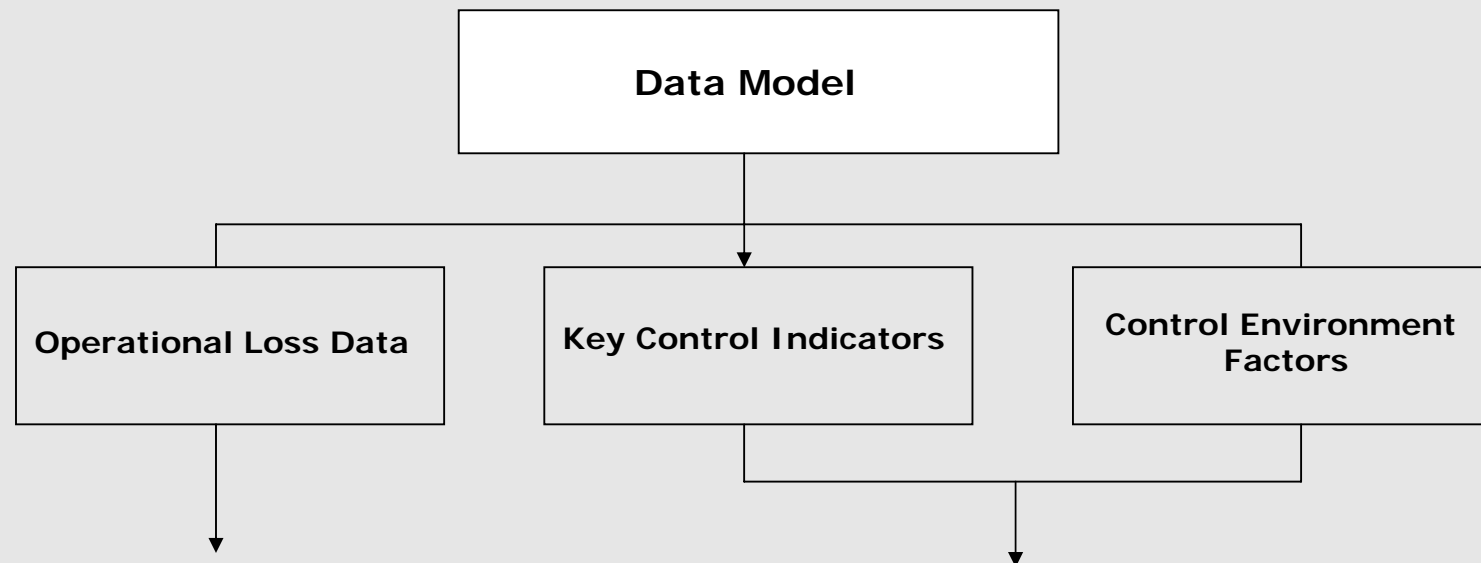


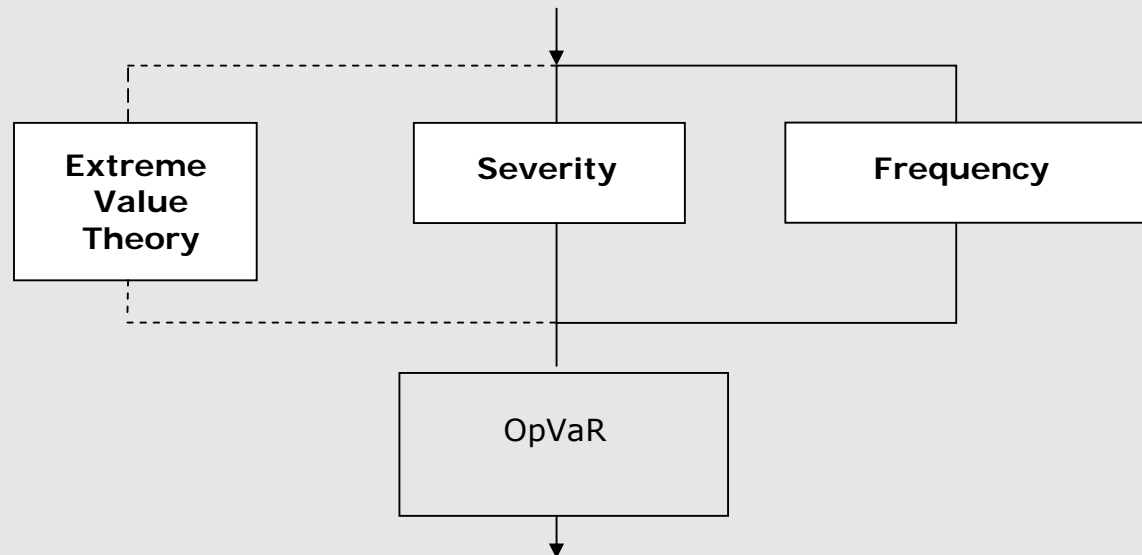
Abbildung 12: Nicht-Abschneiden des Ausreißers führt zu Unterschätzung der PD, mittlere PD sinkt von 0,96% auf 0,95%; ca. 8% der Kreditnehmer werden in eine benachbarte Ratingklasse eingeordnet
 ➔ Anforderung an Qualitätssicherung

OpRisk - Database Modelling



- data sources:
 - internal data
 - **external** consortium
 - external collection of publicly known cases

LDA : Stochastic Modelling



- issues:
 - extrapolation beyond experience (to the 1000-year event)
 - how to "back-test"
 - "merging" of internal and external data, bias removal
 - infinite mean models?

Current state of OpRisk modelling at banks ...

... lags business practice in P/C insurance:

- little to none explicit modelling of accumulation alias dependencies
- little to none modelling of “exposure” (tiny step would be to replace gross loss modelling by loss ratios)
- little to none modelling of “explaining variables” (e.g. US versus non-US business)
- risk models are qualitatively ill-prepared to allow optimization of insurance coverage
- no modelling of “reserve risk”

Similarities and differences

- ❖ goals for internal models in Solvency II are similar to the goals and principles of the regulatory approval of internal models for the market risk in the trading books of banks
- ❖ but: there are significant differences in the risk management practices:
 - ◇ Very similar models used in banking
 - ◇ In contrast a variety of risk measures is used by insurance undertakings:
 - TailVaR (beyond the 100-year-event)
 - VaR (1400-year-event)
 - 2 x VaR (100-year-event)

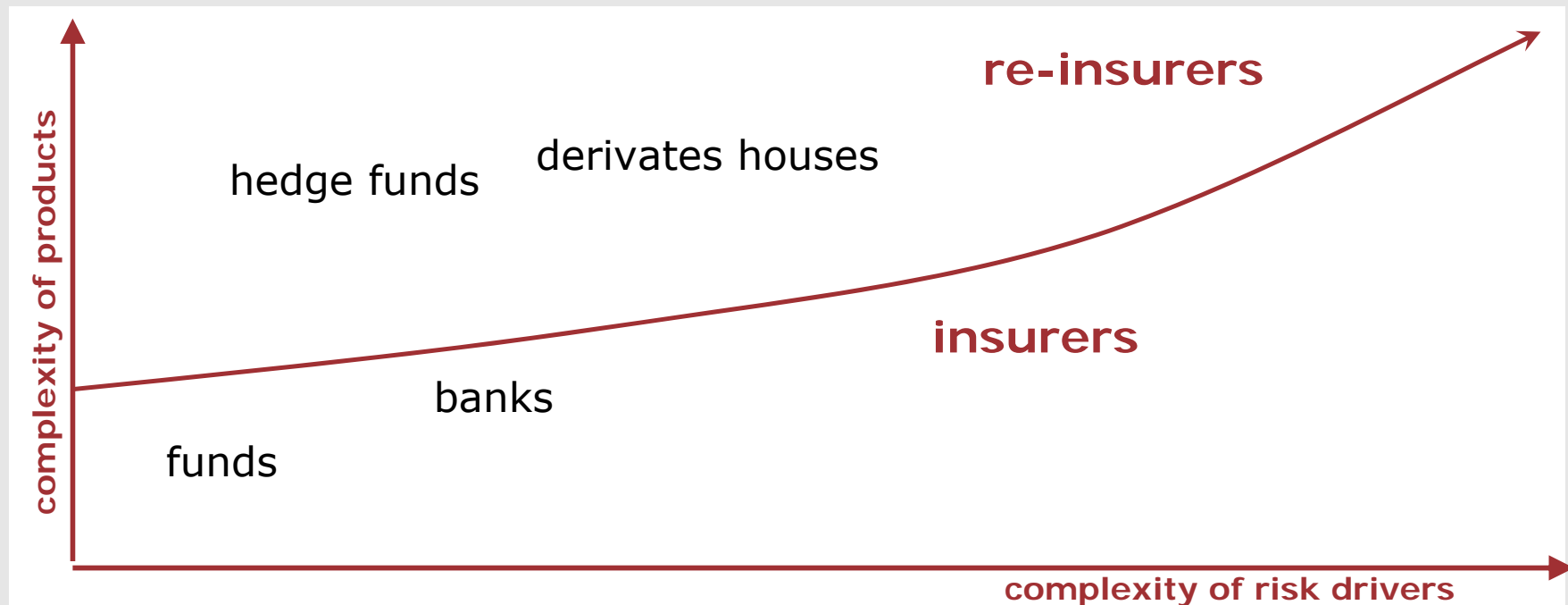
The “back-testing” challenge

Banking	Insurance
<ul style="list-style-type: none">• Profits and losses are computed daily for the trading book• VaR models for market risk can easily be 'back-tested'• Using modern statistical techniques, the quality of 99%-VaR models, which predict the 100-day-event, can be assessed using about 100 daily data points.• A completely different solution to back-testing needs to be found for Solvency II.	<ul style="list-style-type: none">• Quarterly or, more commonly yearly profit and loss data• 200 years are needed to assess the quality of a model that predicts the 200-year-event.

Similarities and Differences

Similarities / Synergies	
<p>similar products:</p> <ul style="list-style-type: none"> • structured products • interest rate and credit derivatives 	<p>similar tools and models:</p> <ul style="list-style-type: none"> • market risk (Black-Karasinski) • credit risk (CreditMetrics)
Banks / Basel II	insurers / Solvency II
<ul style="list-style-type: none"> • input-oriented • partial models (market and ratings) • shorter horizons • aggregation of risk numbers • in market risk: thousands of risk drivers or simple „earnings at risk“ • absolute risk measure 	<ul style="list-style-type: none"> • output-oriented • holistic modeling • longer horizons • aggregation of distributions • King's road: small number of accumulation events, which explain losses at the group level • risk relative to a benchmark (RNP)

Investment funds, banks, insurers

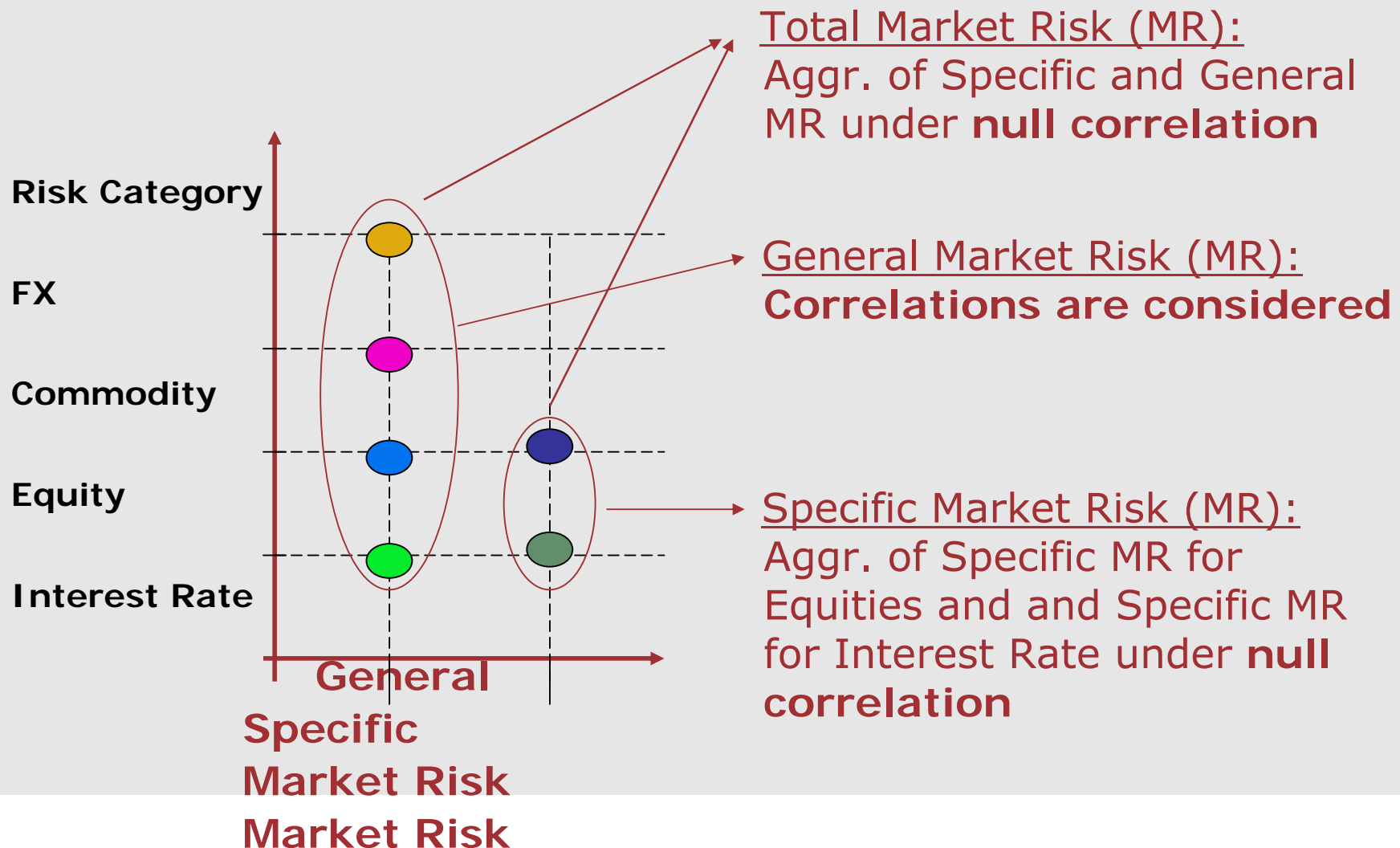


market risk	+ credit risk + exotic deriv. (e.g. whether)	+ insurance risks + longer time horizons → more uncertainty
-------------	---	---

Aggregation: The Technical side of the problem

$$\begin{aligned}\rho_{k\alpha}((X_t + Y_t)) &= \Psi(k) \Theta(t) \rho_{\alpha}(X_1 + Y_1) \\ &\leq \Psi(k) \Theta(t) (\rho_{\alpha}(X_1) + \rho_{\alpha}(Y_1))\end{aligned}$$

Market Risk - Aggregation



AMA risk matrix – 56 segments

	Internal Fraud	External Fraud	Employment practices & workplace security	Clients Products/ business services	Damage to physical assets	Business disruption & system failures	Execution Delivery & Process Management
Corporate Finance							
Trading and Sales							
Retail Banking							
Commercial Banking							
Payment and Settlement							
Agency Services							
Asset Management							
Retail Brokerage							

Aggregation over time

10-day VaR: $VaR(X_{10}) = \sqrt{10} \quad VaR(X_1)$

The Generator Matrix: $P(t) = \exp(\Lambda t)$

Problems: $t \rightarrow 0$ or $t \rightarrow \infty$

CLT for heavy tailed distributions \sqrt{t} rule
conservative

Aggregation at fixed time

- VaR Aggregation of sectors (risk categories, segments [BL, regions, ...])
- Aggregation Users = Scaling t, α

$$VaR_{k\alpha}(t X) = \Psi(k) \Theta(t) VaR_{\alpha}(X)$$

- Correlation and copula (note simple sum = Frechet copula, Gaussian, t-copula are dominant, dependency of tail events)
- Simple sum vs. granularity of risk process
- The importance of **model risk**

Relevancy of Aggregation

- Aggregation under stress impossible
- Aggregation can not be observed via prices, hence gut feeling is difficult to develop
- Aggregation reduces EC or RC to 50%
- Without aggregation EC and RC would be too high
- Often only expert opinions available
- Only a few people know how the aggregation model is calibrated
- Copulas difficult to communicate

Rules vs. principles based regulation

Vicky Fitt's critique (1995!!)

- One mistake we have made, which acts as a big disincentive to self-control, is to have detailed, prescriptive rules
- **The focus should be on the risks and not on the rules**
- Rules cannot cover all circumstances, yet detail suggest that they do
- They are never arbitrage free, so they influence in an artificial and unnecessary way how business is conducted
- they cover quantifiable risks, yet most accidents are caused as a direct consequence of unquantifiable risks
- they are resource intensive – a whole industry has grown up around regulator-set capital requirements

Lessons from IM Audits

- Stochastic modelling and regulation
- Non-linear instruments, complex hedging strategies
- Large-scale forecasting models with thousands of variables
- Portfolio view of risk

Are multivariate non-linear stochastic models complex?

No!!

the interdisciplinary use of VaR-Models induces
the complexity

However modeling is an
important part of the story

All models are wrong but some are useful

Im Leben ist es ja nie der mathematische Satz, den wir brauchen, sondern wir benützen den mathematischen Satz nur, um aus Sätzen, die nicht der Mathematik angehören, auf andere zu schließen, welche gleichfalls nicht der Mathematik angehören.

Ludwig Wittgenstein, 1921

Tractatus, Satz 6.211

