Internal models - Life

An overview – what is done in reality

Tigran Kalberer

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Agenda

- **What is an internal model?**
- What architectures do we observe in reality, their challenges and solutions
- Should you use an internal model?
- Who uses internal models?
- Issues and regulators first reactions
- Our advice

Definition

Internal model

Risk management system of an insurer for the analysis of the overall risk situation of the insurance undertaking, to quantify risks and/or to determine the capital requirement on the basis of the company specific risk profile.

Related term: Standard formula

Within the Solvency II framework an internal model is intended to fully or partially replace the standard formula for the calculation of the Solvency Capital Requirement. Both quantitative and qualitative requirements will be set by the regulator and explicit approval has to be granted by the supervisor.

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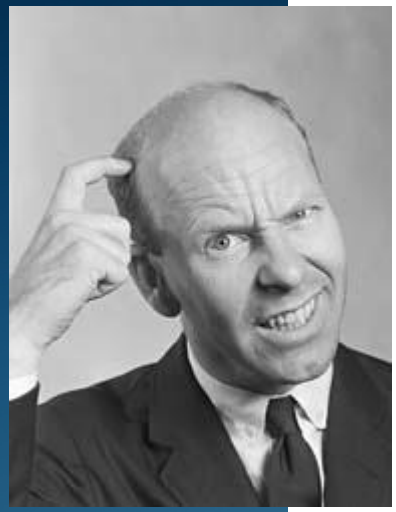
An internal model is part of risk management

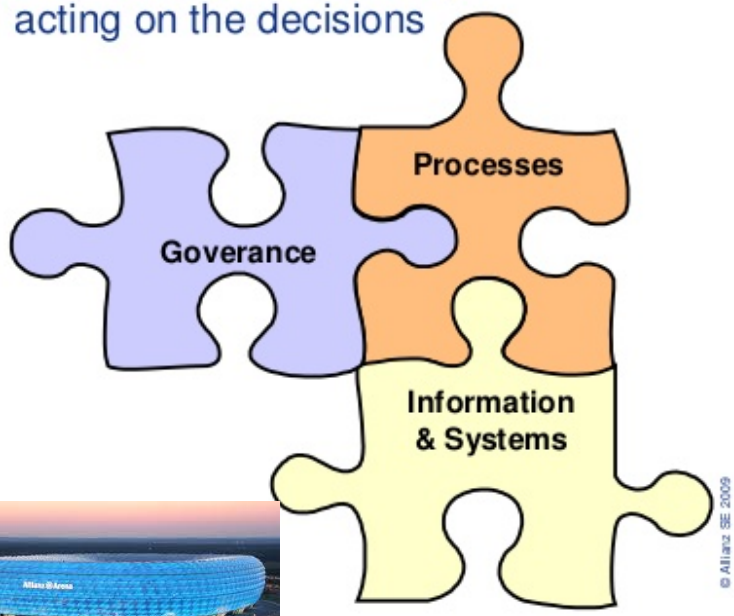


Allianz

How does Risk Management add value?

Questions…
Risk communication
Risk strategy
Risk controlling
Risk underwriting

… answering them correctly, acting on the decisions



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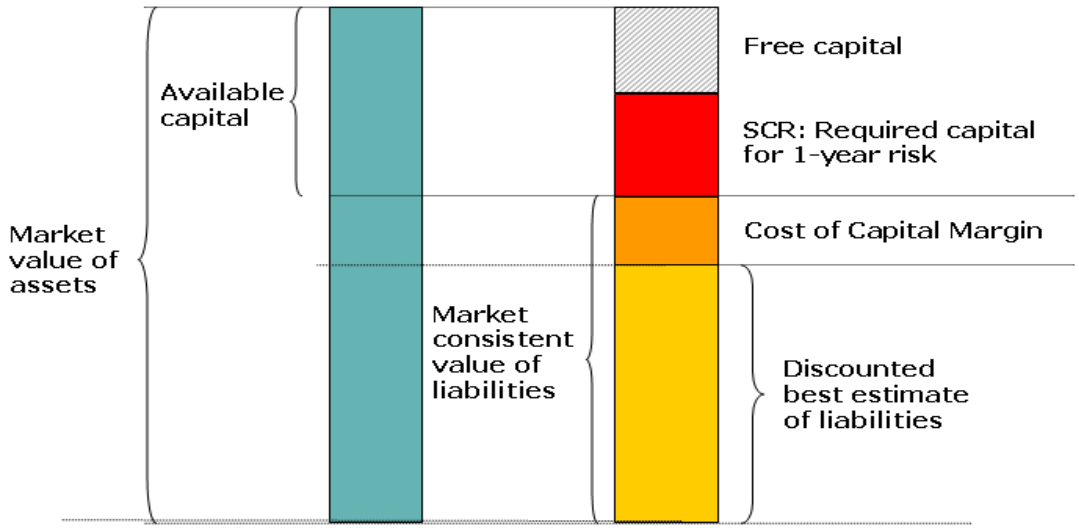
How to measure value is regarded as clear here...

The Economic Balance Sheet

The market consistent (economic) balance sheet



Bundesamt für Privatversicherungen BPV
Office fédéral des assurances privées OFAP
Ufficio federale delle assicurazioni private UFAP
Uffizi federal d'assicuranzas privatas UFAP

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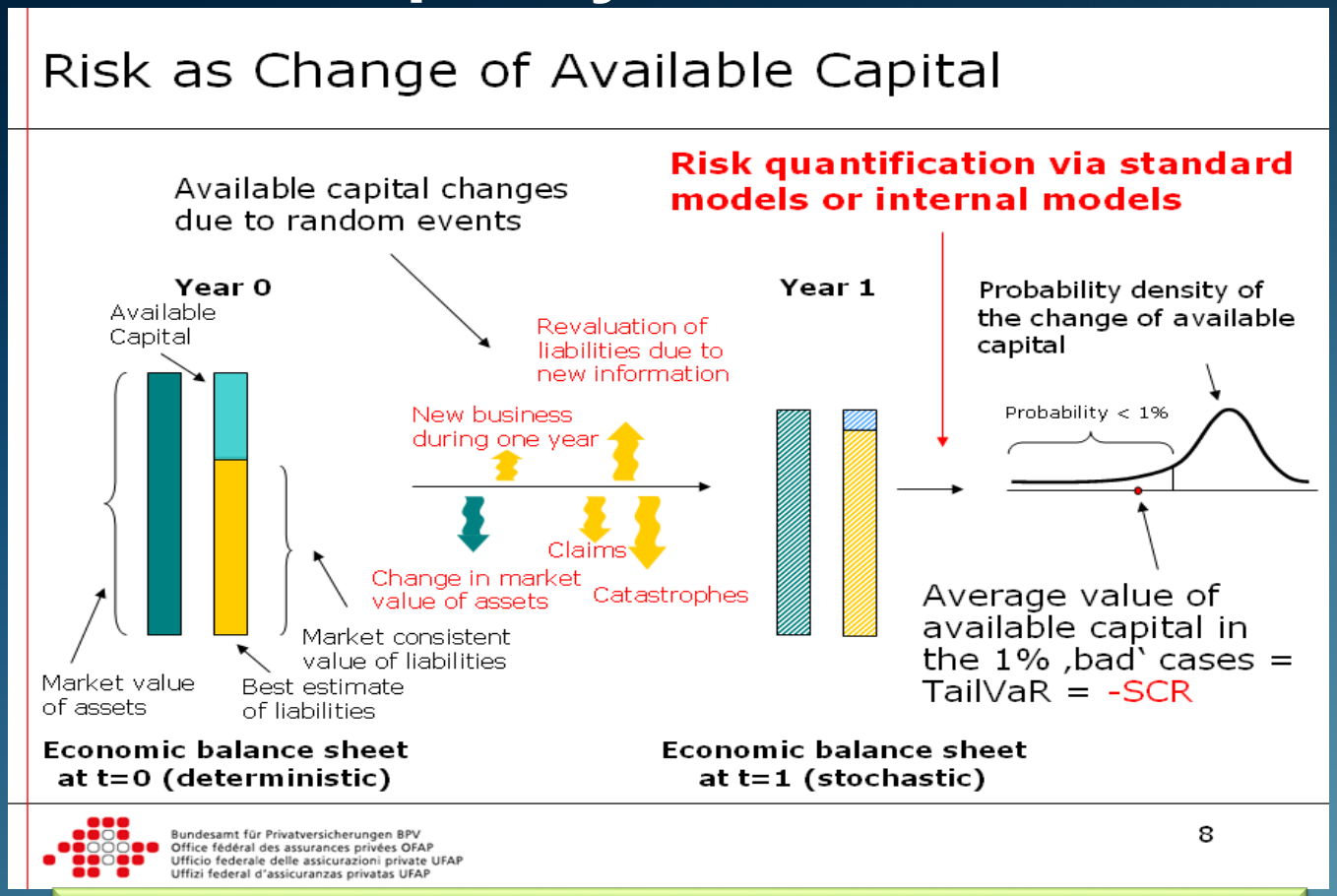
An internal model measures risk with regards to the policyholder



One year 99.5% VaR or 99% ES

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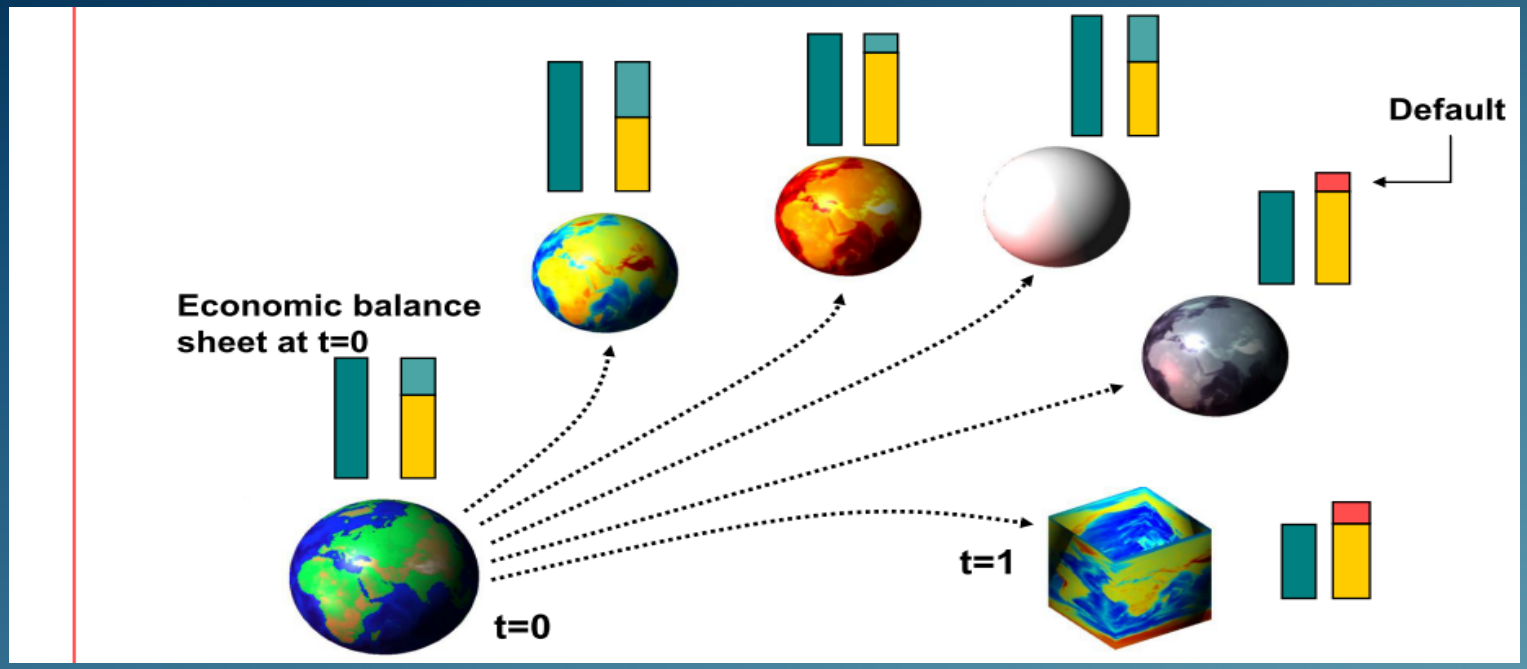
It’s quite simple, isn’t it?

- What might happen and what’s the probability for this («risk factor scenarios»)?
- How do these events depend on each other («dependency structures»)?
- What’s the financial impact of these scenarios («proxy models»)?



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Best practice internal model architecture is based on “global simulations”

Individual risk factors are modelled stochastically

Dependen-cies are enforced:

Global simulations

Impact of risk factors on own funds per global simulation

Determination of SCR, basically sorting

Creating dependency structures on the impact on the own funds („Aggregation“) typically does not work

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An example

Market risk
1: (Equity up 11%, interest down .8%)
...

Insurance risk
...
23456: (Lapse down 1%, Expenses 13%)
...

Enforce Dependency structure

Global simulations
...
98765: (Equity up 11%, interest down .8%, Lapse down 1%, Expenses 13%)
...

Value link

Own funds
...
98765: +1.2 bn SEK
...

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«Best-Practice»-approach

Equity	GBM	Stochastic simulation
Equity vol	n/a	Stochastic simulation
Property	GBMI	Stochastic simulation
Interest rate	PCA	Stochastic simulation
IR vol	n/a	Stochastic simulation
Currency	Lognormal	Stochastic simulation
Concentration	?	Stochastic simulation
Credit	Separate model / linked	Stochastic simulation
Life	Mortality / Normal; Pandemic / extreme scenario; Morbidity / normal; Lapse / normal; Expense / normal	Stochastic simulation
Non Life	Pricing / Frequency – average severity; Pricing large / specific; Cat / Cat models; Reserving / lognormal	Stochastic simulation
Operational	Factor	Stochastic simulation

Enforce dependency structure

Global simulations risk factors

Proxy

Linear

Global simulations value changes

All results you need

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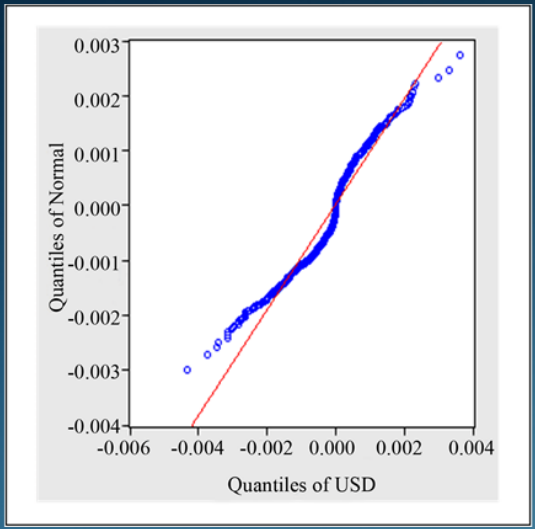
Marginal risk-factor-distributions



- Typically four risk-types:
  - Market
  - Credit
  - Insurance
  - Op
- Sometimes market and credit are combined
- Risks are modelled jointly within a risk type
- Typically existing modules from asset management are used for maket and credit risk, rarely ESGs
- Insurance risk (Life) typically normal plus extreme scenarios

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Challenges

- Granularity of market-risk model
  - We see everything from 1 million ISIN-numbers to 7 broad asset classes being modelled
  - A proper regulator puts ist finger on concentration risk here: „why are my market risks represented by 7 broad (and well diversified) asset classes?“
- Tails
  - Tail risk must not only be modelled adequately but also calibrated in a way which allows validation
  - „Your model gives a 2008 crisis once in 10‘000 years...“
- Many more
  - Distribution of biometric risks, link between spread, migration and default

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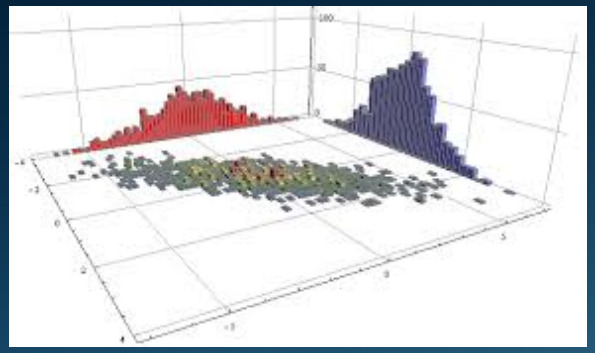
Dependency structure

Super-tough



- If risk-type simulations are provided, and a rank-correlation Gaussion copula, you can join risk-type simulations consistent with that copula („Do the Filipovic“)
- This feature is used by some global insurers
- Some link risk-type simulations by linking main indices
  - That works actually
- The most advanced insurers use causal / structural models (see Munich Re / Rainer Sachs)
  - These also give valuable insights
- Do not focus on dependency in the median region – you need tail-dependency

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Challenges

- A regulator who accepts linear correlation is not a proper regulator
- Copulas are a hype
  - Nice try but how to calibrate?
  - There is not enough data in the quantiles – you do not need to try
  - „We already moved beyond copulas“
  - I have never seen a copula being properly validated
- Validation is hardly achievable and often neglected
  - And this is often spotted by a regulator
- All solutions known to me are based on sound actuarial judgement

The best-practice tail dependency approach

- Create a sound process to identify, discuss, document and sign-off **extreme scenarios**
- These are scenarios which combine extreme risk events
  - E.g. gov‘t interest rates go down and bonds default
- You will never have observed these scenarios, but you need to attach an occurence probability to them
- You need to discuss this with your mangement, even the board
- Document this discussion and update it regularly
- You then can use these scenarios to calibrate whatever model you use: copulas, causal models, factor models etc.
- You also can just simulate these scenarios additionally: SST-approach. The difference is cosmetic.
- See: SST, Scor green book, Munich Re publications

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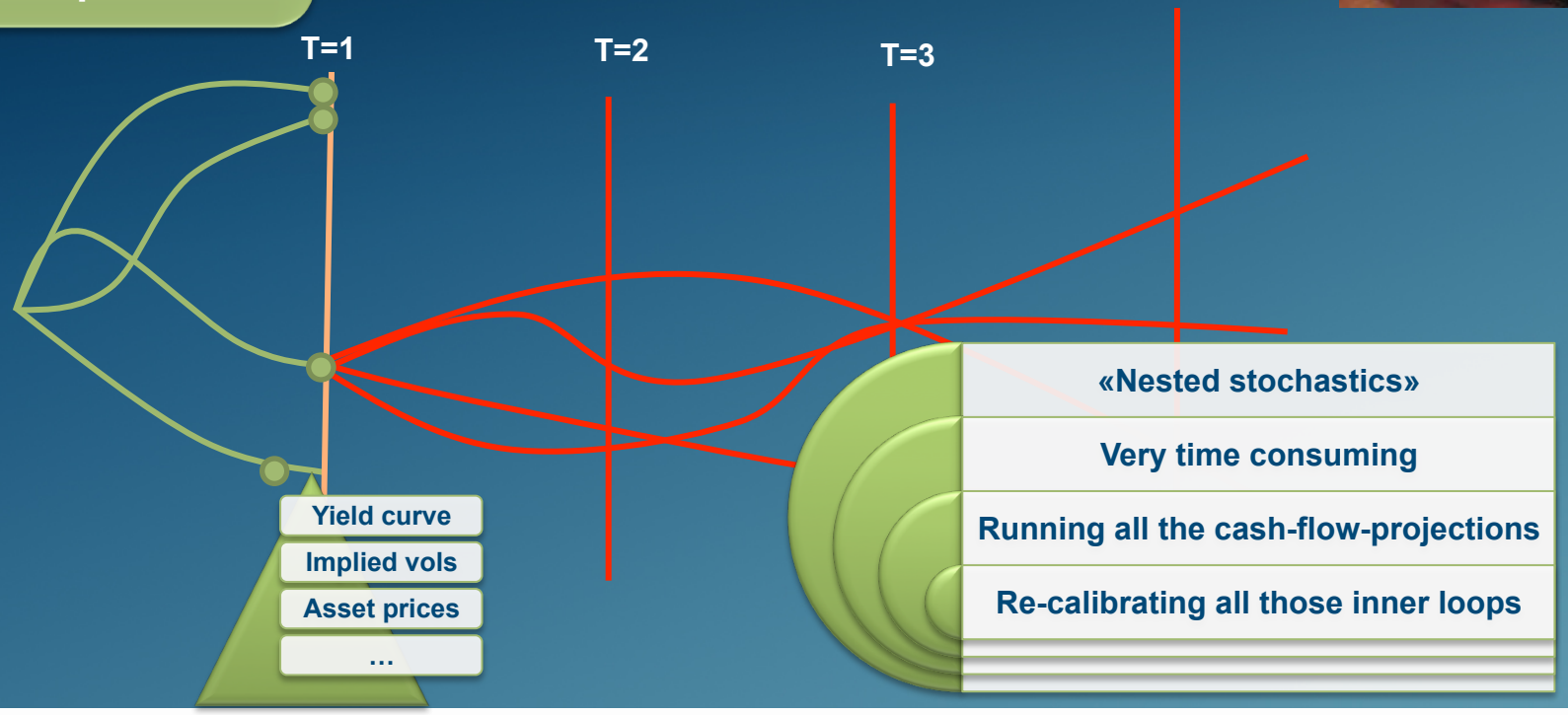
In theory we now need nested stochastics

Scenarios for determination of VaR of basic own funds:

«Outer loops»

Scenarios for determining best-estimate after one year:«Inner loops»



We replace the inner loop-valuation by an approximation function (proxy)

Outer loops

Faster runtimes
Quick (re-)evaluation
Fast and reliable decision-making basis

Value of Liabilities ≈ f(Yield curve at t=1, Vols at t=1, Asset prices at t=1 etc.)

- Yield curve
- Implied vols
- Asset prices
- …

There are different approaches to create proxies – but their application is similar

Optimise fit of linear combinations of „candidate assets“ / „basis functions“

Approach	Description
Replication Portfolio Technique (RPT)	Basis functions are typically assets (ie contingent future cash-flows)
Least Squares Monte Carlo (LSMC)	Basis functions which are polynomials in the first year risk factors.

Determine function by enforcing fit to selected points

Curve fitting	Also uses basis functions which are polynomials in the risk factors.

Numerical effort varies wildly

Approach	Description
Replication Portfolio Technique (RPT)	One calibration run
Least Squares Monte Carlo (LSMC)	One calibration run
Curve fitting	n calibration runs (n: no. of coefficients)
Nested stochastics	Loads of runs (compares to 5‘000 calibration runs)
Nested stochastics light	10 inner loops (compares to 10 calibration runs)

We see all kinds of issues with the RPT

- What we see in practice – at most of your competitors

Subsequent calibrations of our RP look completely different even though we didn't have significant changes

RP shows massive offsetting positions.

Different RP calibrations - all with a good fit – result in completely different SCR.

No validation in terms of SCR.

Finding the right RP is an art involving expert judgement rather than maths.

Backtesting fails.

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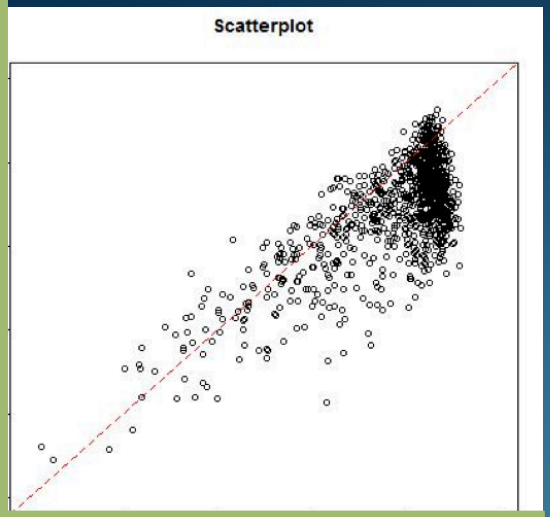
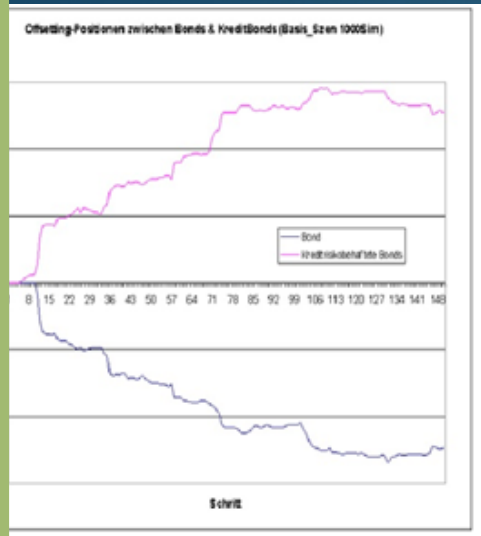
Another failing RPT approach

Slow convergence

Out-of-sample-test fails



Large Off-setting positions



Lacking robustness all over the place

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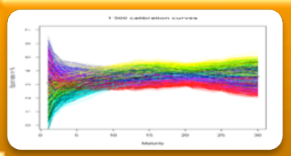
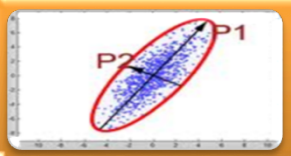
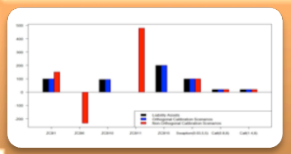
Solution – Target process



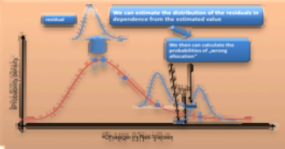
Use many different outer scenarios with wildly varying initial conditions



Use PCAs of candidate assets instead of single candidate assets



Benchmark current RP against subset of candidate assets serving as liabilities



Validate current RP with error estimation

A lot of perfectly orthogonal information

Challenge: Automated generation of calibration scenarios

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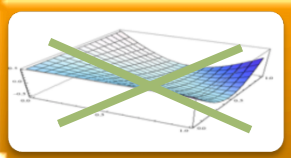
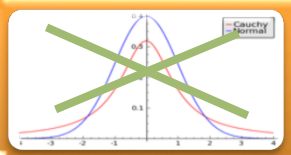
The standard approach is a very simplistic approximation

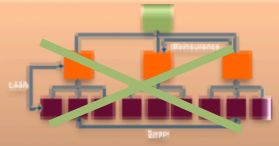


Cannot be used if impacts are non-linear in the risk factors



Does not reflect heavy tails

Does not reflect tail-dependency



Does not allow to model group structures adequately

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Should you use an internal model?

Do you want to manage your business properly?

Your business is not properly reflected by the standard formula

You understand that an internal model comes with considerable development and maintenance costs

You are willing to invest heavily in documentation, validation and governance processes

Use standard model for regulator and IM for yourself

Get internal model approval and use internal model

An IM should not have the purpose of just reducing regulatory capital

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So which companies use internal models and why

- Swiss companies (80 or so)
  - Simply because FINMA is a proper regulator and punishes the use of the standard model – but now back-pedals considering the effort and the lack of comparability
- Large multinational companies
  - For managing the business
  - To reflect group effects
  - Prestige
- Nordics (say 6 or so)
  - Internal model for internal purposes
  - Standard model for the regulator – as it is ultra-weak in the EU
- The EU-standard model would not pass EIOPA's suggested requirements for internal models...

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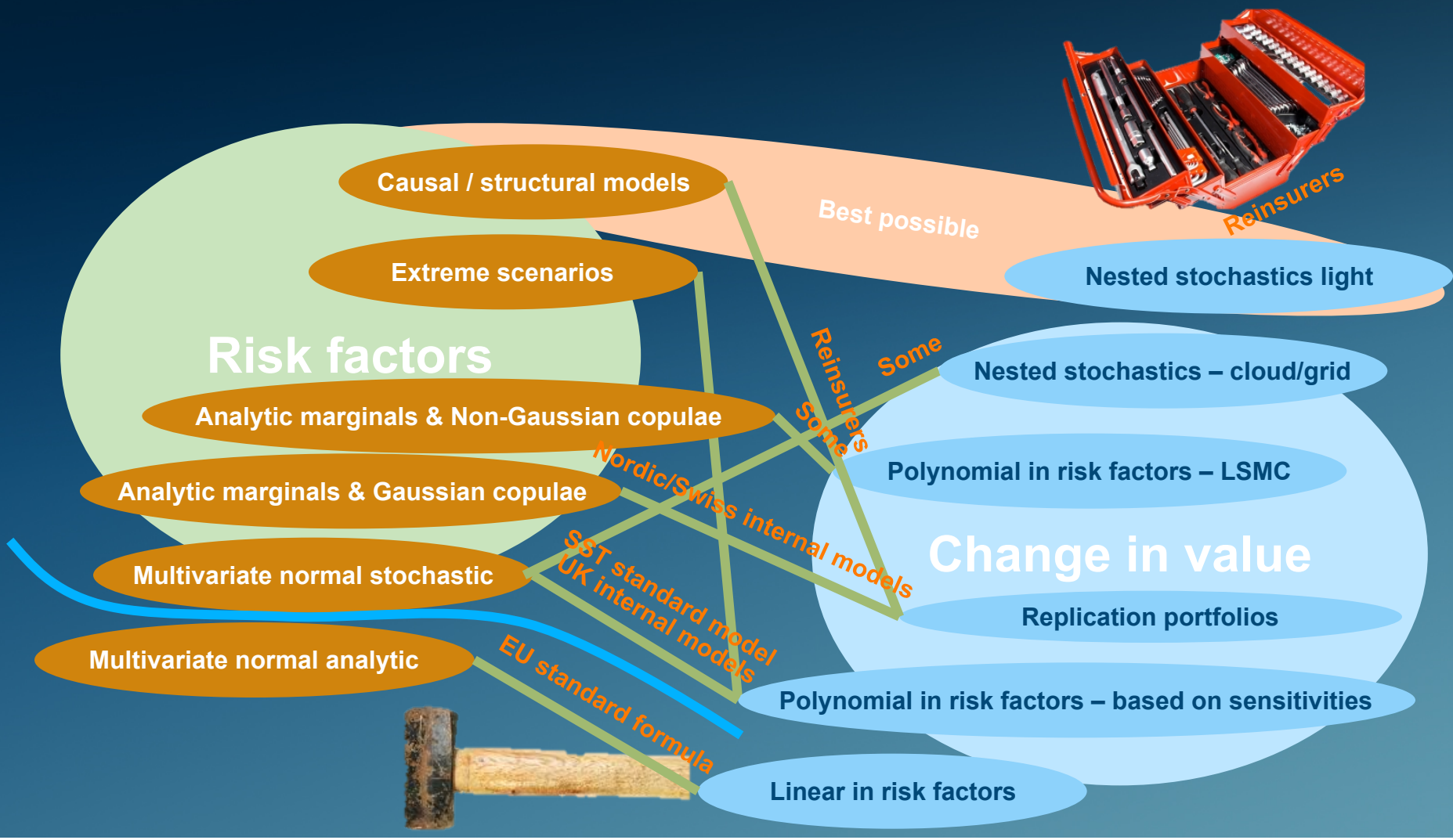
What is the industry doing?



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What are the issues?

Cash-flow-models are part of an internal model...

- Cash-flow-models
  - ESGs are not fit for purpose
  - Credit risk not reflected
    - Too low TVOG
    - No credit risk absorption by liabilities
  - Management rules do not cover financial distress area adequately
  - Management rules not driven by Solvency-ratio
  - Inconsistencies introduced by regulatory fudge-factors

Calibrate at the right points

Just do it

Discipline

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Can all be solved – and is actually not onerous

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What are the issues?

Proxies were not thought through...

- Proxy models are not robust
  - All those RPT-issues...
  - Non-justifiable choice of sensitivities for fitting proxies
  - No out-of-sample validation
  - Inconsistencies between cash-flow-models and risk-models (asset model / credit model)
  - How do I create proper calibration simulations for proxy-models?
- Dependency structures
  - 4‘000 * 4‘000 correlation matrices can not be calibrated robustly
  - Where is the data to calibrate copulae please?

Use 2012 insights

Use ESG-Recalibration technology

Use causal / structural models calibrated with extreme scenarios

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What are the issues?

- Projection of capital
  - Already needed in the cash-flow-projection models to drive management decisions
  - Market Value Margin
  - ORSA
- How to incorporate non-market risks?
  - We do not have additivity (double-countinmg of buffers...)
- How to reflect multi-asset dependency?
  - With-profits liabilities are put-options on baskets...

LSMC

Use the right drivers

LSMC

LSMC

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What are the issues?

Do not underestimate documentation and validation

- Regulators require error-estimation in terms of SCR
- Documentation should actually be readable
  - 2‘000 Excel sheets are not a documentation
- Each judgement call must be validated
  - And rightly so – we have seen it all

2012 insights on error-estimation

These are all people issues and need money

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Overview – current issues with internal models

- Life companies re-consider the standard model for regulatory reporting as it is beneficial in terms of required capital
- The global simulation approach replaces stress test approaches
- Modelling credit risk in cash-flow models is key (risk-absorption)
- Companies struggle with proxy models
  - Robustness, lacking automation
- Companies struggle with large-scale correlation matrices
  - Causal and factor models advance
- Companies struggle with calibration of copulae
- First regulator feedback is by no means encouraging (validation, processes, documentation)
- Industrialisation is key (daily push to Ipad of CRO)

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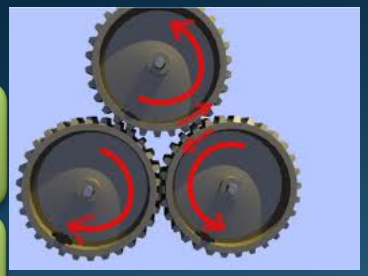
Our advice



- Do it right from the beginning – architecture is important
- Use a global simulation approach
- Use a well-structured approach to define extreme scenarios
- Avoid all those Replication Portfolio issues
- Define governance and ownership first
- Documentation and validation is key
- Industrialise your Solvency II processes

What is viewed as cutting edge today will become standard practice tomorrow

Questions

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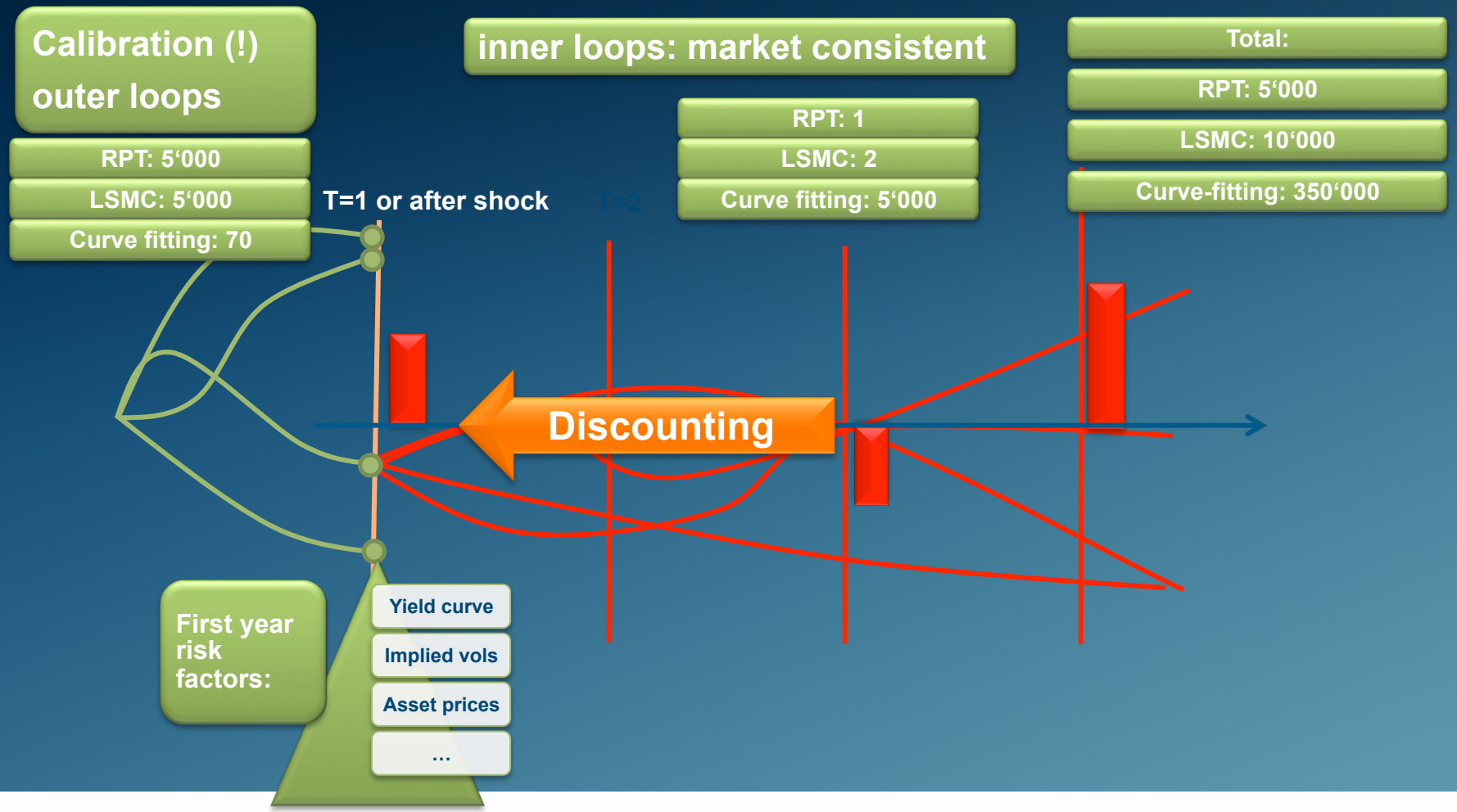
First step – calibration input and cash-flow-projection of liabilities and candidate assets



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Result

Scenarios	Liabilities	Basis-function 1	Basis-function 2	…	Basis-function m
1	1	1	1	…	1
2	2	1	2	…	4
…	…	…	…	…	…
n	42	1	N	…	42^2

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Second step: optimize – then hope

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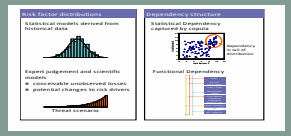
Swiss Re's approach of risk modelling relies on separating risk factors and exposures and uses simulation techniques

Risk factors and dependencies

Distribution for each relevant risk factor

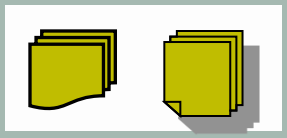
Dependency structure among risk factors



External world in which Swiss Re operates

Exposures

Exposures describing how economic values of assets and liabilities respond to realisations of risk factors



Swiss Re's link to the external world

Change in value of assets and liabilities

Exposures are combined with risk factor realisations to obtain the change in value of assets and liabilities per realisation

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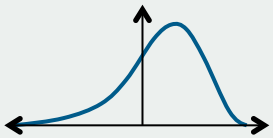
Impact of external world on Swiss Re's portfolios

Evaluation

Economic profit or loss for each set of risk factor simulations collected as a distribution

Economic profit & loss distribution



This calculation is performed for 1'000'000 joint realisations of all risk factors

Zurich's group model

Reflection of intercompany defaults (dynamic model)

ZFS | ~~ZIC~~ | ZLIC | ZIP | ZDHL | ZAIC | ZAL | FNWL | FGI | … | … | …

Results for all major entities in the Group

ZFS | ZIC | ZLIC | ZIP | ZDHL | ZAIC | ZAL | FNWL | FGI | … | … | …

Global Aggregation of Risk Types, Aggregation with Scenarios

Scenarios (where relevant)

Same Risk Modules as in internal RBC model

P&R* | Cat | Life Liab. | Business Risk | Market/ALM | Investment Credit | Reinsurance Credit | opRisk

Key differences

- Legal view vs. management view
- Reflection of intercompany transactions (CRTIs)
- Full stochastic approaches in SST/Solvency II for all risk types
- Operational risk not (yet) reflected

Market Value Margin

MVM

FINMA Methodology

MCBS

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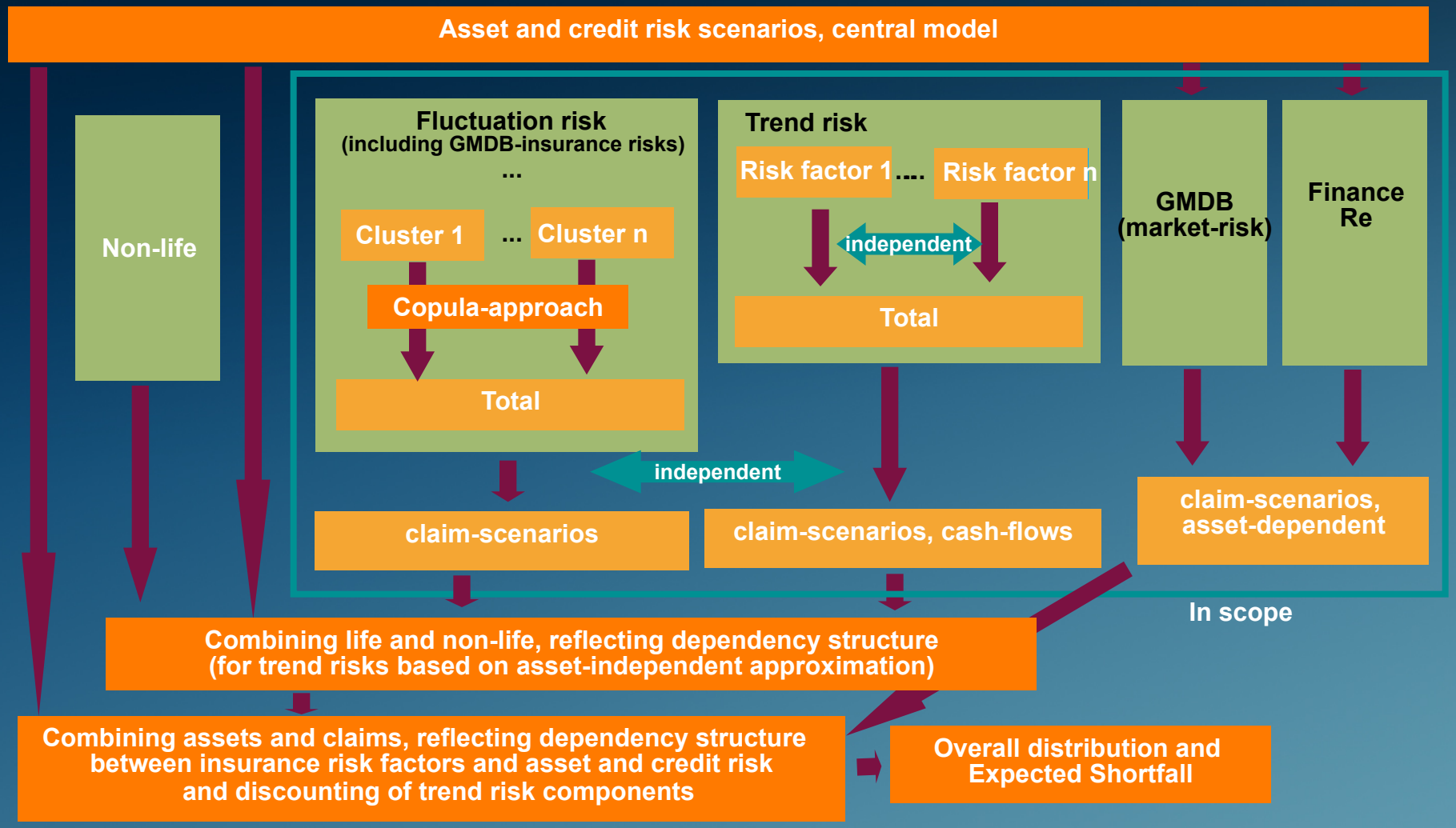
Scor's model as in the "green book"



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Industry Trends in EC Modeling Technology

- Use of parallel computing resources to avoid unnecessary approximations and eliminate the need for validation
- If proxy, then productionalized and accurate
- Seriatim asset modeling is becoming a standard in EC systems
- Manage and store data at a very granular level for rapid feedback
- Daily monitoring requires sophisticated automation capabilities
- Web-based interfaces for collection of requests and accessing reports
- Security considerations around providing access to reports from disparate locations

The Framework Directive in theory requires nested stochastics

- Article 75 1) b) FD: liabilities shall be valued at the amount for which they could be transferred, or settled, between knowledgeable willing parties in an arm's length transaction.
- Article 77 2)FD: The best estimate shall correspond to the **probability-weighted average of future cash-flows**, taking account of the time value of money (expected present value of future cash-flows),…
- Article 88 FD: Basic own funds shall consist of the following items:
  - (1) the excess of assets over liabilities, …
  - (2) subordinated liabilities.
- Article 101 3) FD: The Solvency Capital Requirement … shall correspond to **the Value-at-Risk of the basic own** funds of an insurance … undertaking subject to a confidence level of 99,5 % over a one-year period.