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Designing and Implementing an Internal Model

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SCOR

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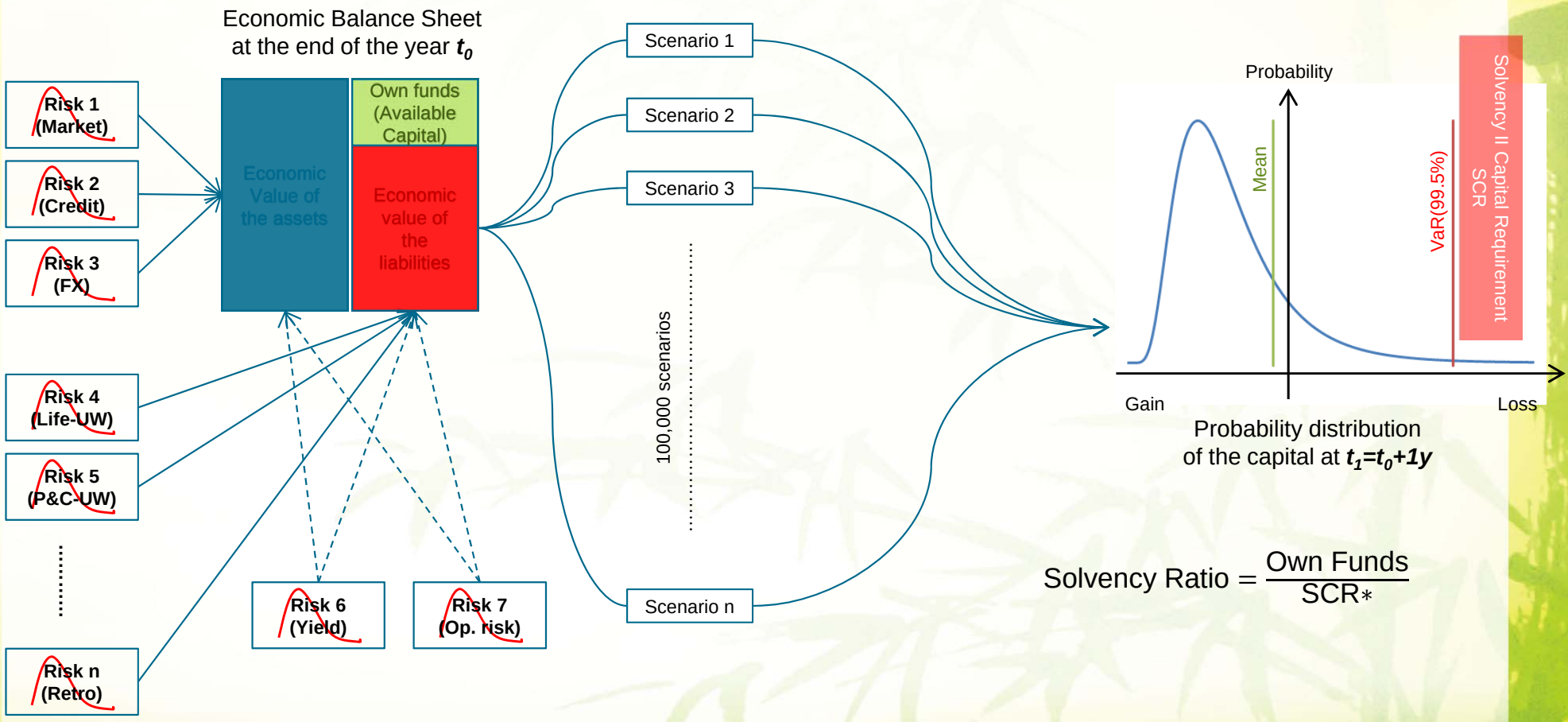
Agenda

1	What is an internal model?
2	Development of internal models
3	Model design – what do you want out of your model?
4	Model calibration and testing
5	SCOR's Group Internal Model (GIM)
6	Conclusions

What is an internal model

An internal model is here to assess *the risk* of the economic balance sheet of the company



$$\text{Solvency Ratio} = \frac{\text{Own Funds}}{\text{SCR}*}$$

*) Measured at t_1 but discounted at t_0

Aggregating risks means diversification

- The internal model allows to measure the diversification benefits
- In a simple example we show how the capital is reduced by combining risks

Measure	Hurricane	Earthquake	Portfolio	Diversification Benefits[1)]
Expected	62	16	78	0%
Std. Dev.	84	60	104	28%
VaR(99%)	418	332	544	27%
VaR(99.6%)	596	478	690	36%
TVaR(99%)	575	500	678	37%
TVaR(99.6%)	700	598	770	41%

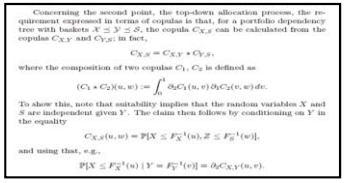
1) Diversification benefit is measured as one minus the ratio between the capital of the portfolio over the sum of the capital of each risk standalone

Internal models: development

Reality

Simplification

Model (abstraction)



Concerning the second point, the top-down allocation process, the requirement expressed in terms of copulas is that, for a portfolio dependency tree with baskets $X \preceq Y \preceq S$, the copula $C_{X,S}$ can be calculated from the copulas $C_{X,Y}$ and $C_{Y,S}$; in fact,

$$C_{X,S} = C_{X,Y} * C_{Y,S},$$

where the composition of two copulas C_1, C_2 is defined as

$$(C_1 * C_2)(u,w) := \int_0^1 \partial_2 C_1(u,v)\, \partial_1 C_2(v,w)\, dv.$$

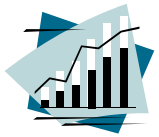
To show this, note that suitability implies that the random variables X and S are independent given Y. The claim then follows by conditioning on Y in the equality

$$C_{X,S}(u,w) = \mathbb{P}[X \le F_X^{-1}(u), Z \le F_S^{-1}(w)],$$

and using that, e.g.,

$$\mathbb{P}[X \le F_X^{-1}(u) \mid Y = F_Y^{-1}(v)] = \partial_2 C_{X,Y}(u,v).$$

Methodology

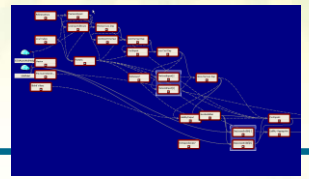


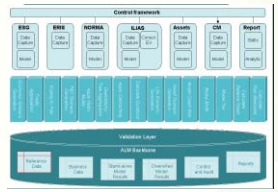
Data

Assumptions

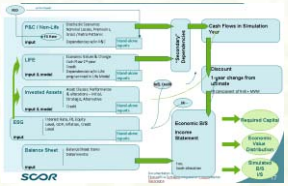
Industrialization

Model realization

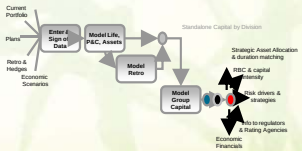




Conceptual Framework



Implementation Framework

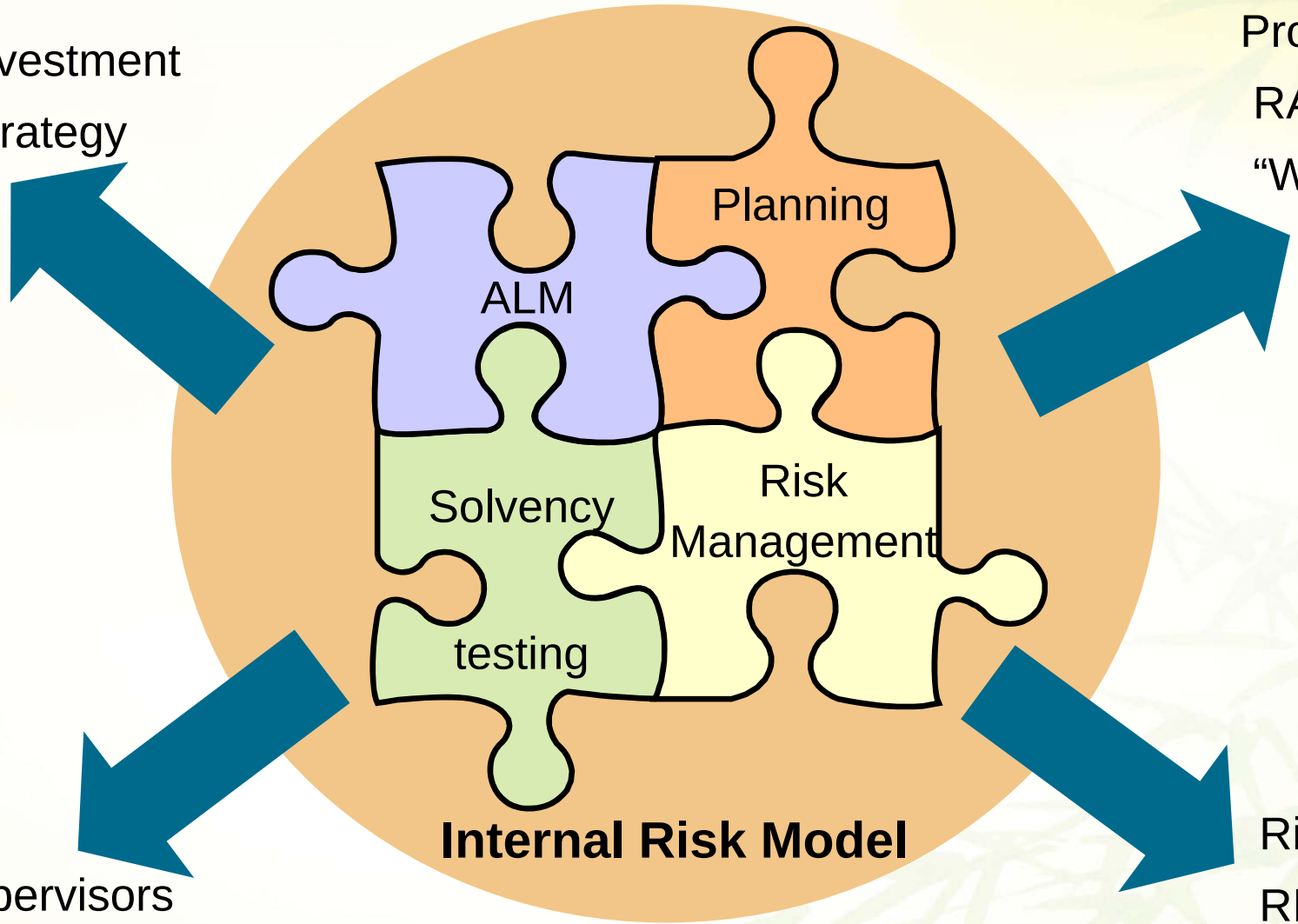


Processes

Objectives of internal models

- Internal models should provide a way to assess the **need for capital** to cover the risk assumed
- They should provide a **unified way of communicating about risks** within the company and with outside stakeholders (Solvency requirements, rating agencies, investors)
- They should set the framework for taking **strategic decisions**, balancing risk and return: “Flight Simulator”
- They should allow the **optimisation** of both the asset and liability portfolios by modelling the diversification benefits
- They should make it possible to **measure the economic performance** of the various lines of business

Internal risk models: Applications and benefits



Investment
Strategy

Profitability Analysis
RAC Allocation
"What-if" Analysis

Supervisors
Rating Agencies

Risk Mitigation,
RI Optimization

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Why an internal model?

At the heart of capital management the internal model gives answers to **how much capital is needed**. It is thus becoming an unavoidable instrument for the industry because:

- Peak risks are growing
- Regulators require them to assess the solvency of companies (Solvency 2, SST)
- Shareholders are becoming more demanding & more attentive (Return on Equity ROE, new accounting rules)
- The integration of world financial markets requires a more efficient use of capital (competition between various financial institutions) and increases the dependence between various risks
- Insurers already have technically mature methods for risk analysis and capital allocation

Peak risks are growing

Peak risks are growing due to:

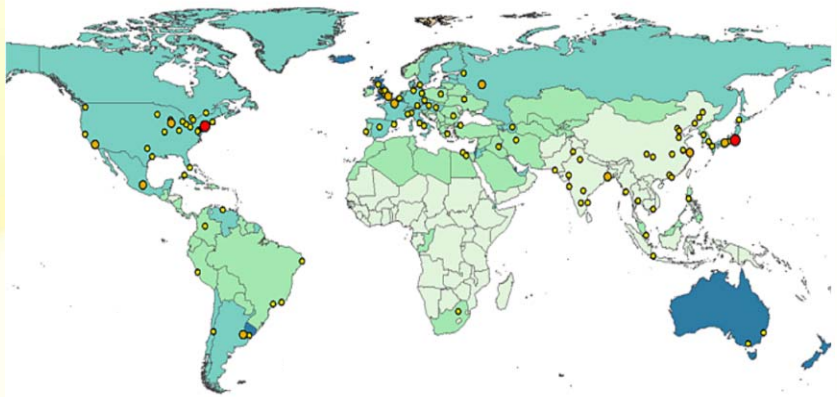
- **Demographic changes**: concentration of populations in hazardous areas, movement of populations favours the spread of disease (AIDS, SARS, A H1N1, etc…)
- **Social & political changes**: better living standards, more demanding people (e.g. liability), evolution of legal systems, terrorism, political instabilities in oil rich regions, etc.
- **New technologies** could bring new risks: nanotechnology, cell phones, new drugs (VIOXX) etc.
- **New financial products** (especially in life insurance and credit). The financial crisis has shown the risk these instruments can bring to unprepared investors

The growth of peak risks is closely related to the growth of population in urbanized areas[1)]

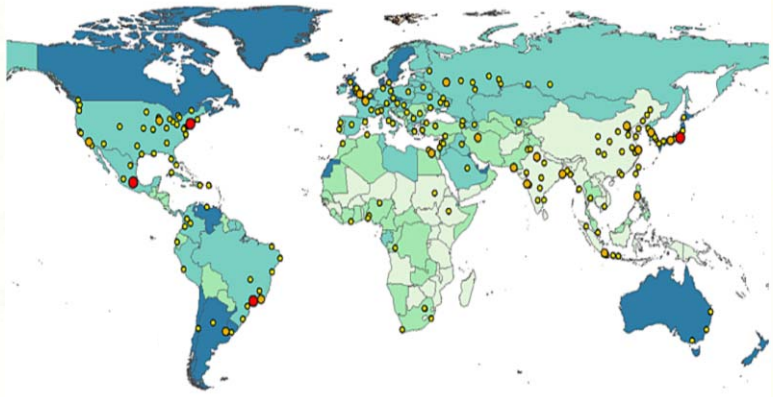
Percentage Urban: 0-25% | 25-50% | 50-75% | 75-100%

City Population: 1 - 5 million | 5 – 10 million | > 10 million

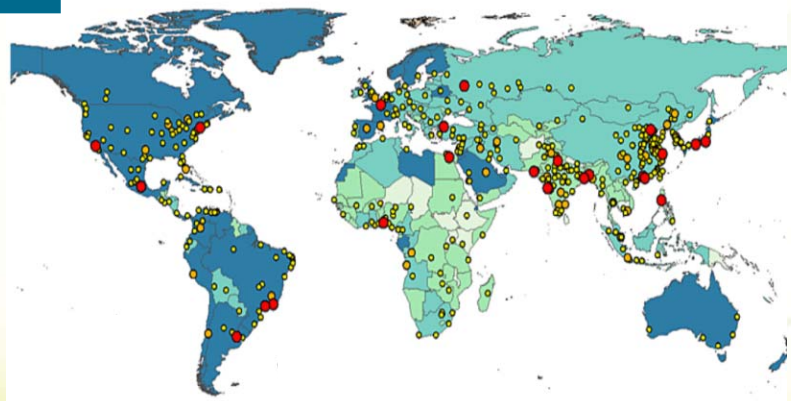
1960



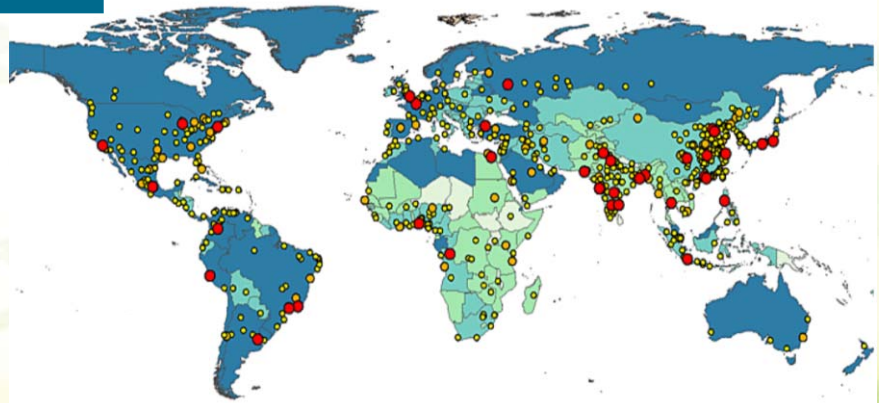
1980



2011

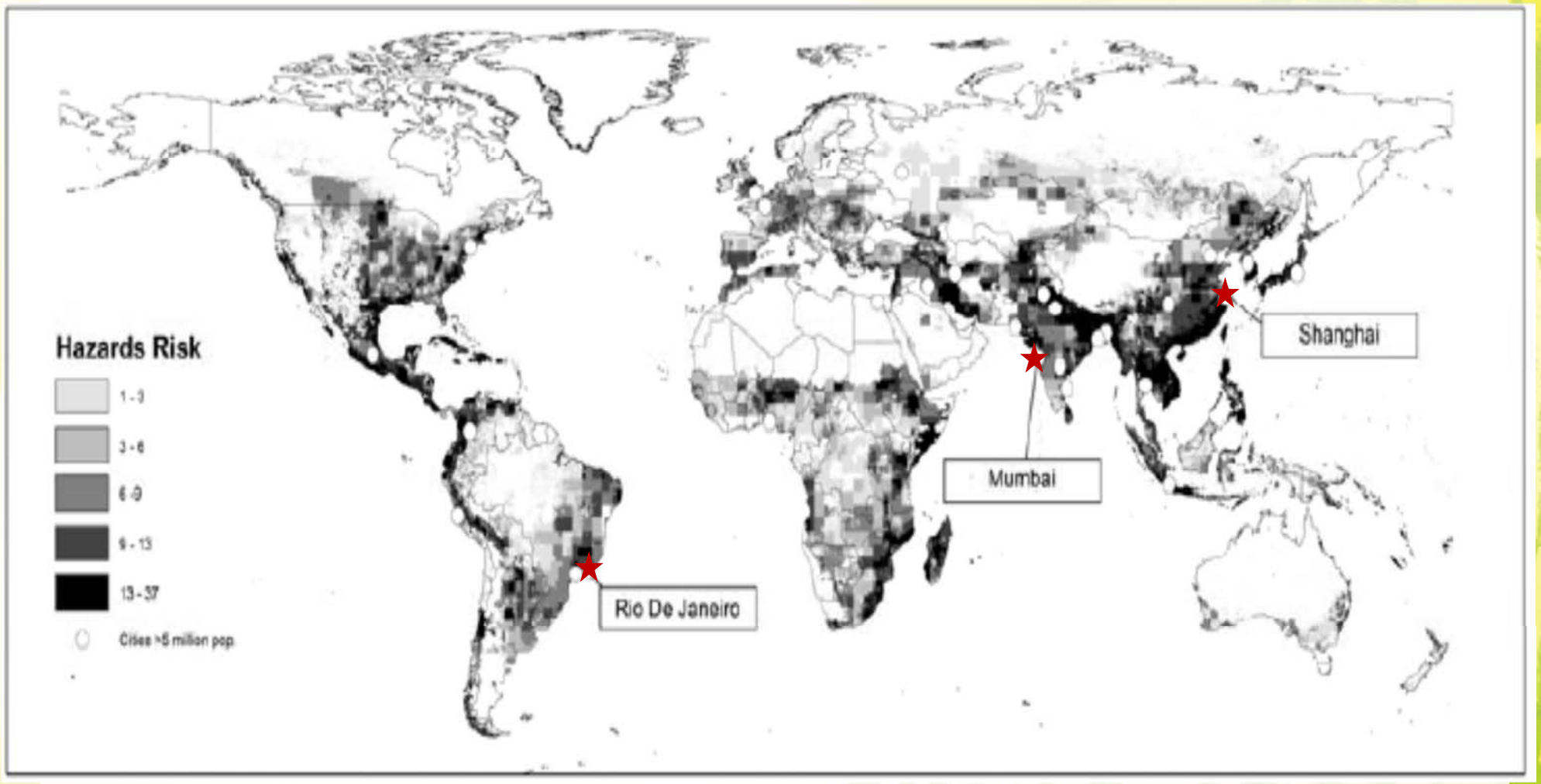


2025



1) *"World population prospects", United Nations, 2011*

Urban populations concentrated in riskiest areas[1)]

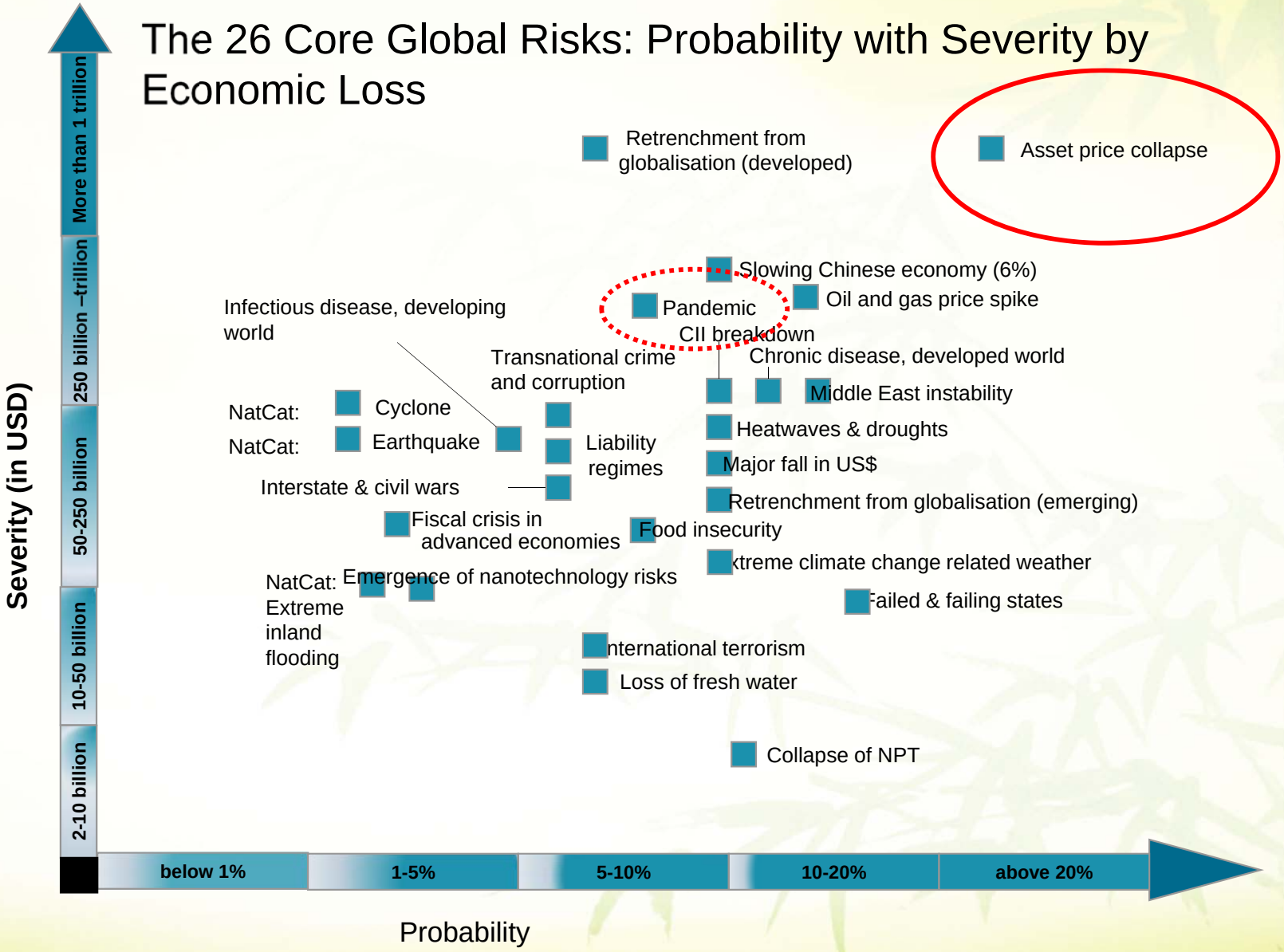


The potential economic and human consequences of an event such as a pandemic or a natural catastrophe are increasing.

1) Sherbinin, Shiller & Pulsipher (2007)

New risks are multiplying with varying levels of severity and probability

The 26 Core Global Risks: Probability with Severity by Economic Loss



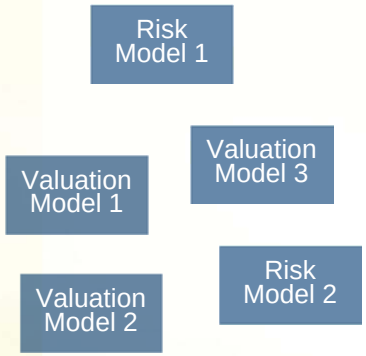
Internal models: Historical evolution

De Finetti 1940 — Value Protection

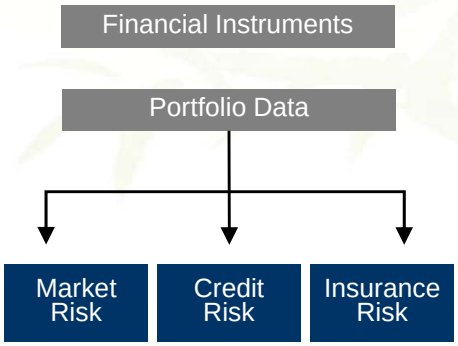
Risk Based Solvency 1995-2000 — Value Sustainment

Capital Management ~2005 — Value Creation

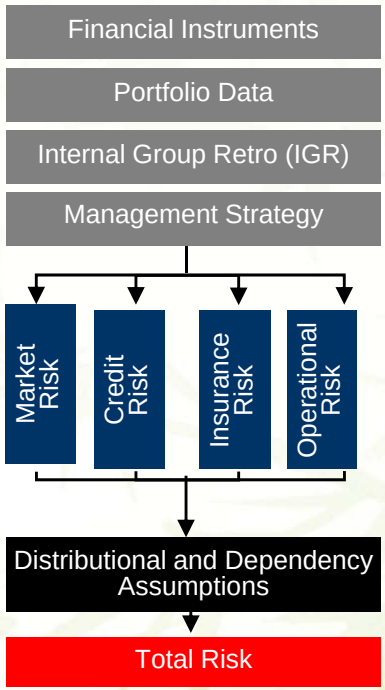
Collection of sub models quantifying parts of the risks



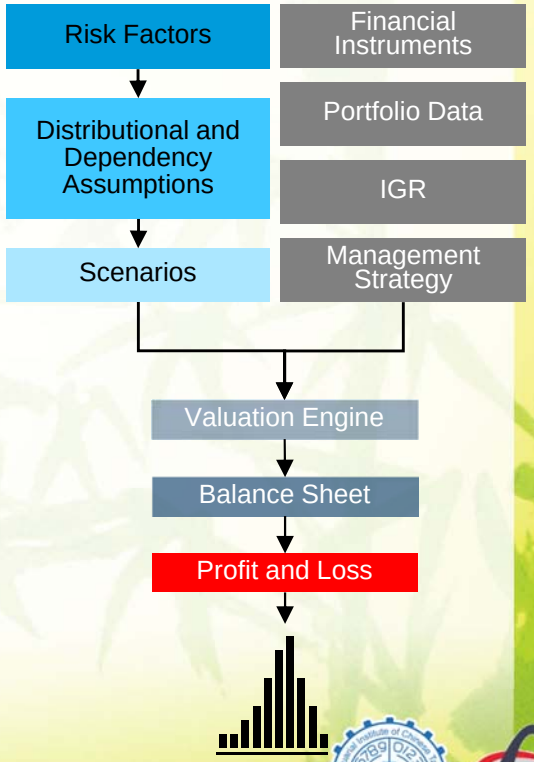
Quantification of different risk types with portfolio effects



Risk types are combined to arrive at the company's total risk



Modelling of underlying risk drivers and emphasize on the whole distribution



Slide inspired by Philipp Keller

Evolution of SCOR's internal Model & Reports

2003
- Introduction of Calendar Year RAC
- Available capital as Risk-supporting capital (shareholders equity + long-term debt)
- Operational Risk: 10% of risk-supporting capital
- Peer Review of Investment Policies

2004
- Reporting of Underwriting risk market outlook based on ESG
- Analyzes of invested assets including sensitivity tests
- Risk drivers, based on expected shortfall 5%
- Model integration including P&C Retro model in the Group Internal Model (GIM)

2005
- Comparison with Rating Agencies Capital requirements
- Operational Risk: 5% of shareholders equity

2006
- Switch from Remetrica to Igloo
- Performance Review of Hedge Funds Investments

2007
- Credit risk reported out separately for the calendar year capital

2008
- First full run: Life model, Divisional split, Diversified interest-rate volatility of Liabilities / interest rate effects on net result, Measuring diversified FX-risk on net result
- First SST Report: One-Year Change, Risk Margin, CoCPIT project
- NORMA (gross and retro P&C-Scenarios as input for the GIM)
- Life model by Lines of Business

2009
- NORMA: stress scenarios
- Analysis of performance / sensitivity of P&C-Retrocession
- More granular Life model (geographical split)
- Use of CADET for Strong Momentum strategic plan

2010
- Adaptations to Solvency 2 (available capital) and use of 99.5% VaR
- Integration of TaRe portfolio in ILIAS (Life model)
- New method for calibrating dependencies for P&C risks: PrObEx

2011

2012
- Solvency 2 pre-application: full model delivered to the ACP (June)
- RMS used for pandemic risk
- Internal Model Statistical Analysis (IMSA) developed

- The model continuously evolves with improvements, adaptations, faster processes, better data control, better reporting...
- We are finalising the internal model policies that allow flexibility in its implementation while satisfying the regulators' need for stability

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Types of Models

- Models can be loosely grouped into:
  - **Deterministic models**: A number of factors are estimated and applied to volume measures (e.g. premium income etc.)
  - **Distribution-based models**: Probability distributions for different risks are determined and aggregated
  - **Scenario-based models**: A (frequently large) number of scenarios is generated to value the company in various countries around the world
- Most models are a mix of all three approaches
- Deterministic models present the danger that the underlying factors have to be regularly updated to take into account changing risk exposures
- Distribution and scenario-based models can be equivalent. Distribution-based models can be computationally efficient, whereas scenario-based models can be more intuitive and flexible

Should the internal model meet the requirements of all stakeholders?

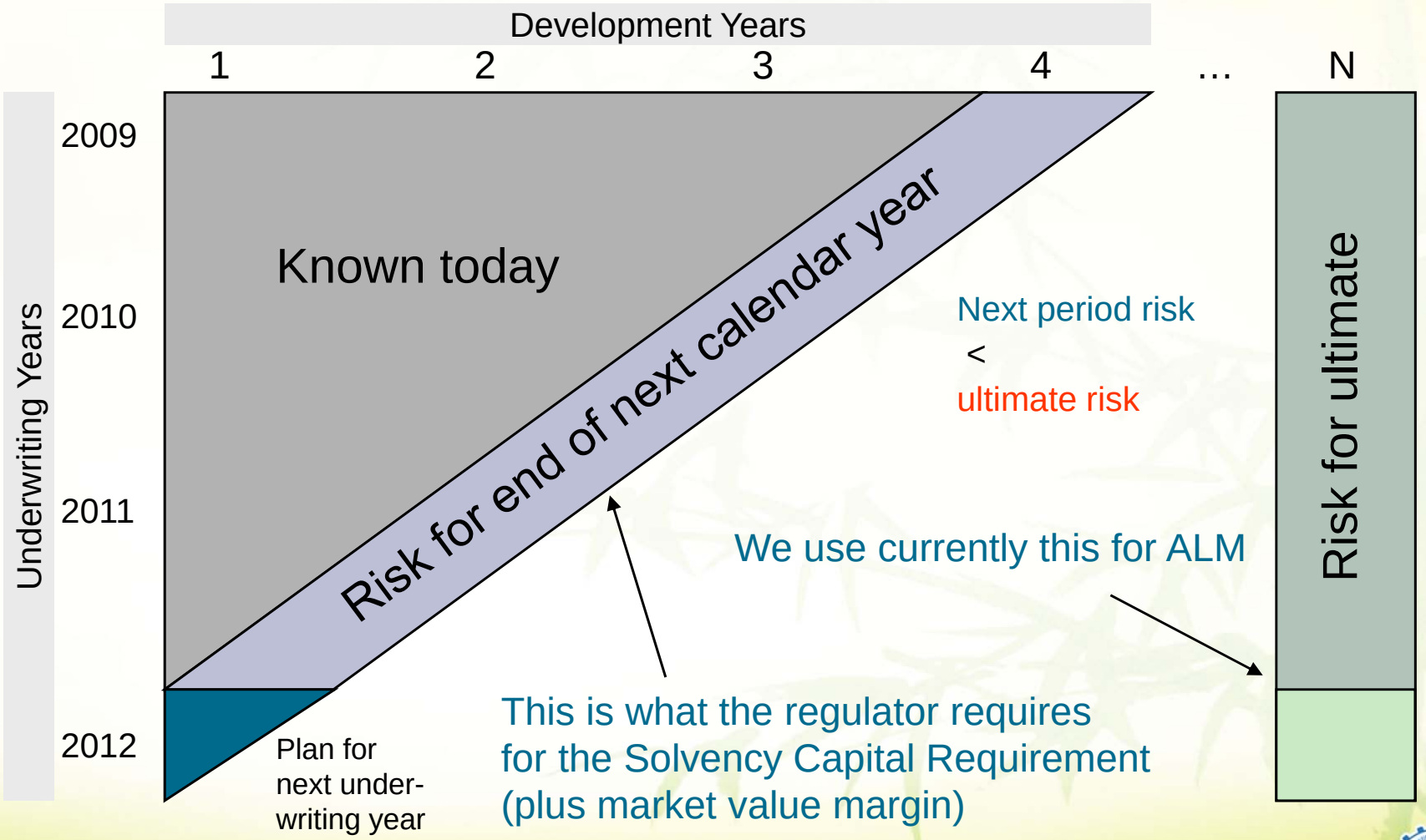
- There are various points of view on the company and various models to assess the risks
- Rating agencies, for instance, have their own capital model that does not coincide with the internal model
- Regulators are fixing a certain number of principles concerning risk assessment that are not necessarily the same as those required to manage the company (yearly versus ultimate)
- The internal model should make it possible to satisfy all the requirements but should not depend on them
- Companies need to design their internal model in order to **steer their portfolio** rather than to satisfy regulators or rating agencies

SCOR internal model: Adapting GIM to Solvency 2 and Swiss Solvency Test

- For Solvency 2 and the SST, the relevant risk is the risk of the regulated legal entity and not the LoBs
- Thus, the model needs to split risks between legal entities as well as Lines of Business (multiplying the number of variables and parameters)
- The calendar year capital for Solvency 2 and the SST is based on the ***yearly fluctuations of the reserves and other risks*** and not on the ultimate losses
- Regulators are concerned about the company surviving one year and being able to run-off or sell its liabilities
- SCOR's GIM needed to adapt to these constraints, without losing its generality and its application to capital management and ALM

Gap between regulatory requirements and company view on the risks: Example of P&C reserving

- In a P&C reserving triangle the difference between our internal model and the regulatory requirements is clear:



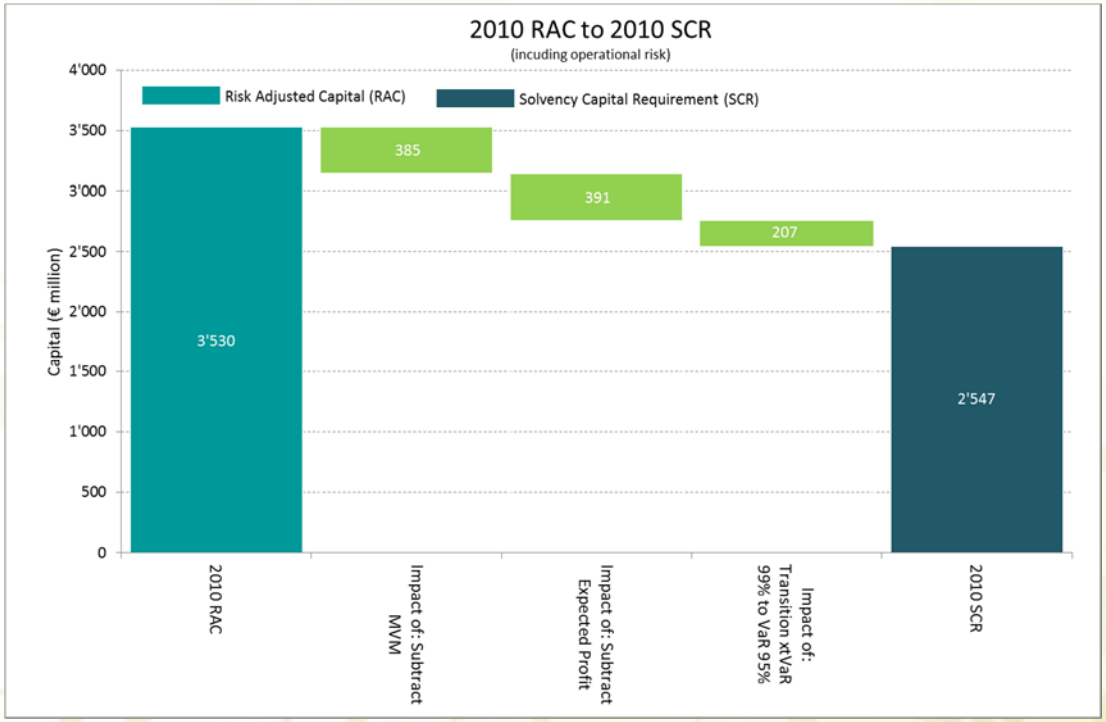
Impact of Transition to Solvency 2 Capital Requirement

- Transition from the 2010 Reported Capital Requirement ("**Risk Adjusted Capital**" with risk measure **xtVaR 99%)** …
- … to "**Solvency Capital Requirement**" with the risk measure **VaR 99.5%**

Steps:

- Subtract Risk Margin (RM) (€385m for Life)
- Subtract Profit (€391m)
- Change risk measure (€207m)

- Note the **RM** and **Profit** are subtracted from the **Available Capital**
- Result:
  - RAC = €3,530 million
  - SCR = €2,547 million



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How to Calibrate Dependences?

Dependences can hardly be described by one number such as a linear correlation coefficient

We just saw that it is possible to use the ***copulas*** to model dependences

In insurance, there is often not enough liability data to estimate the copulas

Nevertheless, copulas can be used to translate an opinion about dependences in the portfolio into a model:

- Select a copula with an appropriate shape
  - *increased dependences in the tail*
    - this feature is observable in historic insurance loss data
- Try to estimate conditional probabilities by asking questions such as "What if a particular risk turned very bad?"
  - Think about *adverse scenarios* in the portfolio
  - Look at *causal relations* between risks

Is it possible to statistically test internal models?

- RAC is computed for a probability of 1% or 0.5%, which represents a 1/100 or 1/200 years event
- In most of the insured risks, such an event *has never been observed* or has been observed only once
- This means that the tails of the distributions *have to be inferred* from data from the last 10 to 30 years in the best cases
- The 1/100 years RAC is thus based on a *theoretical estimate* of the shock size
- It is considered more as the *rule of the game* than as a realistic risk cover
- It is a *compromise* between pure betting and not doing anything because we cannot statistically estimate it

Stress testing the models is crucial

- Bakounine used to say: “Reality is always wider than any doctrine”, in other words, a model is only a simplification of reality
- Testing the output of internal models is thus a must to gain confidence in its results and to understand its limitations
- We just saw that it is difficult, or even impossible, to *statistically test* the model. We can only *stress test* it
- There are at least four ways of stress testing the models
  1. Test the sensitivity to parameters (sensitivity analysis)
  2. Test the predictions against real outcomes (historical test)
  3. Test the model against scenarios
  4. Study the reasonableness of the extreme scenarios of the Monte-Carlo simulations (reverse stress-test)

Testing stochastic models with scenarios

- Scenarios can be seen as thought experiments about possible future world situations
- Scenarios are different from sensitivity analysis where the impact of a (small) change to a single variable is evaluated
- Scenario results can be compared to simulation results in order to assess the probability of the scenarios in question
- By comparing the probability of the scenario given by the internal model to the expected frequency of such a scenario, we can assess whether the internal model is realistic and has really taken into account enough dependencies between risks
- By studying the extreme outcomes of the Monte-Carlo simulations, it is possible to determine their plausibility

Scenario-based simulation vs. distribution-based simulation

Scenario-based

Pro

Risk is modelled at its source. When more random variables are modelled on the same scenarios, their dependence is recorded automatically:

- E.g. economic scenarios with impact on random variables "asset value *A*" and "value of liabilities *L*"

Con

For many risks, the random variable cannot be modelled or it is extremely difficult to calibrate the models.

Distribution-based

Con

The source of the risk is forgotten. Appropriate dependencies more difficult/ impossible to incorporate:

- the different scenarios cannot be distinguished anymore. The dependence of another risk (with different outcomes) cannot be recorded properly in this way.

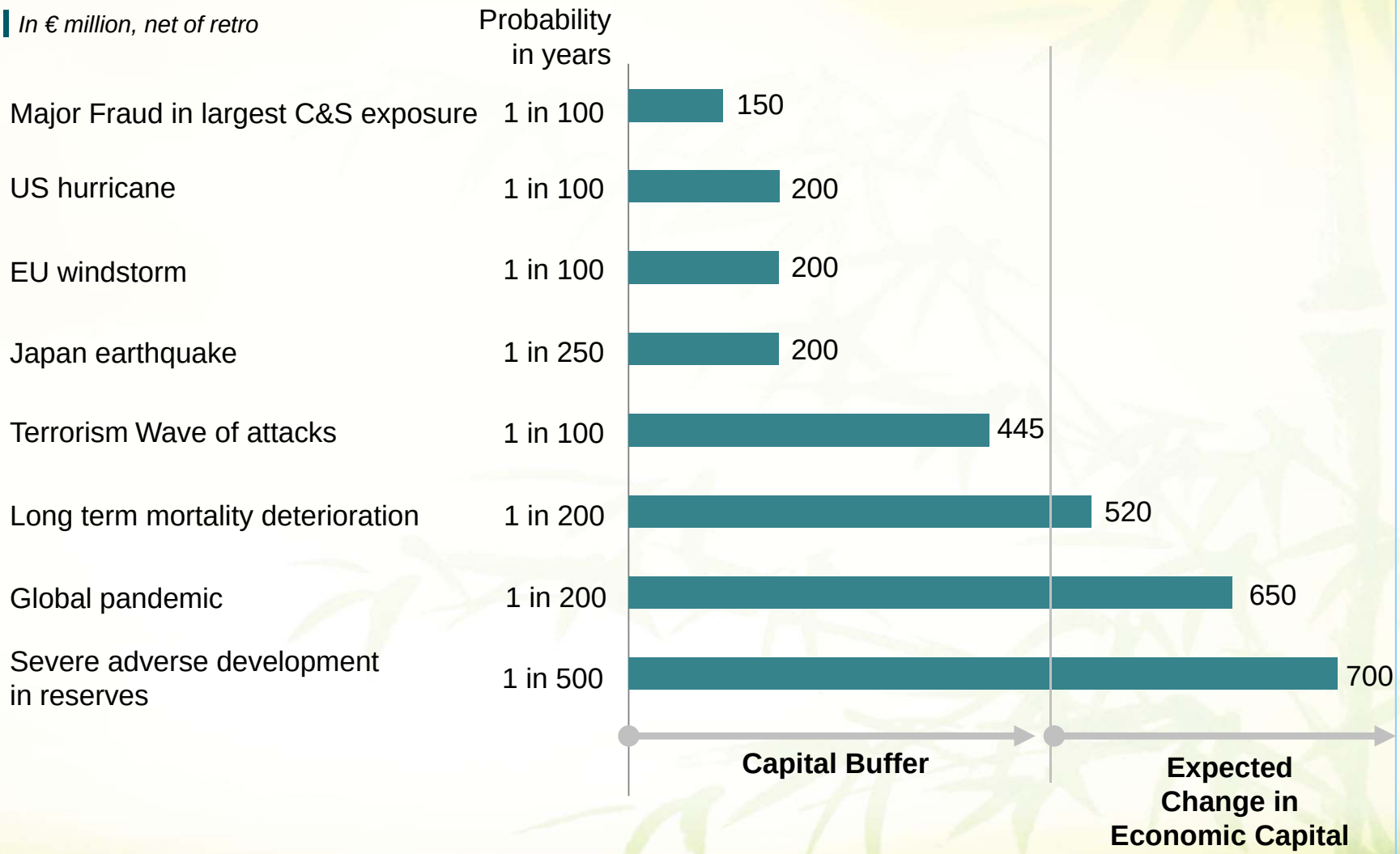
Pro

For many risks the random variable may be difficult or impossible to model, but the distribution can be estimated using statistics.

Capital Buffer to absorb single worst case scenarios

Buffer capital checked against single worst-case scenarios (examples)

In € million, net of retro



Protecting the company against model shortcomings

- To protect the company against the inevitable shortcomings of the model is to set *exposure limits for each extreme scenario*
- For instance one can decide not to allow any scenario to consume more than 15% of the company's available capital
- One can add a certain *buffer to the capital* that is strictly required from the model
- Another good measure is to *limit capital exposure to particular risks*. For instance, the company would not allow more than 5% of its available capital to be exposed to terrorism
- Develop accumulation control system and give limits purely to the sum of exposures

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SCOR's main model principles

Risk is modelled at the origin

- Data is entered and signed-off by the people who are in charge of the corresponding business (P&C for Norma and Life for ILIAS)
- Models are developed in their related divisions (NORMA and ILIAS) in close cooperation with the FinMod team who is the ultimate responsible for the GIM and the integration of all risk models
- The responsibility of the parameterization and the life cycles of the partial models lies in the divisions

Strong focus on dependency modelling

- Non-linear treatment by mirrored-clayton copulas to ensure strong dependence in the tails
- The Economic Scenario Generator (ESG) uses bootstrapping to conserve historical dependencies between economic variables and to produce consistent scenarios
- Dependencies are calibrated using also expert judgments within the PrObEx framework, which is scientifically sound

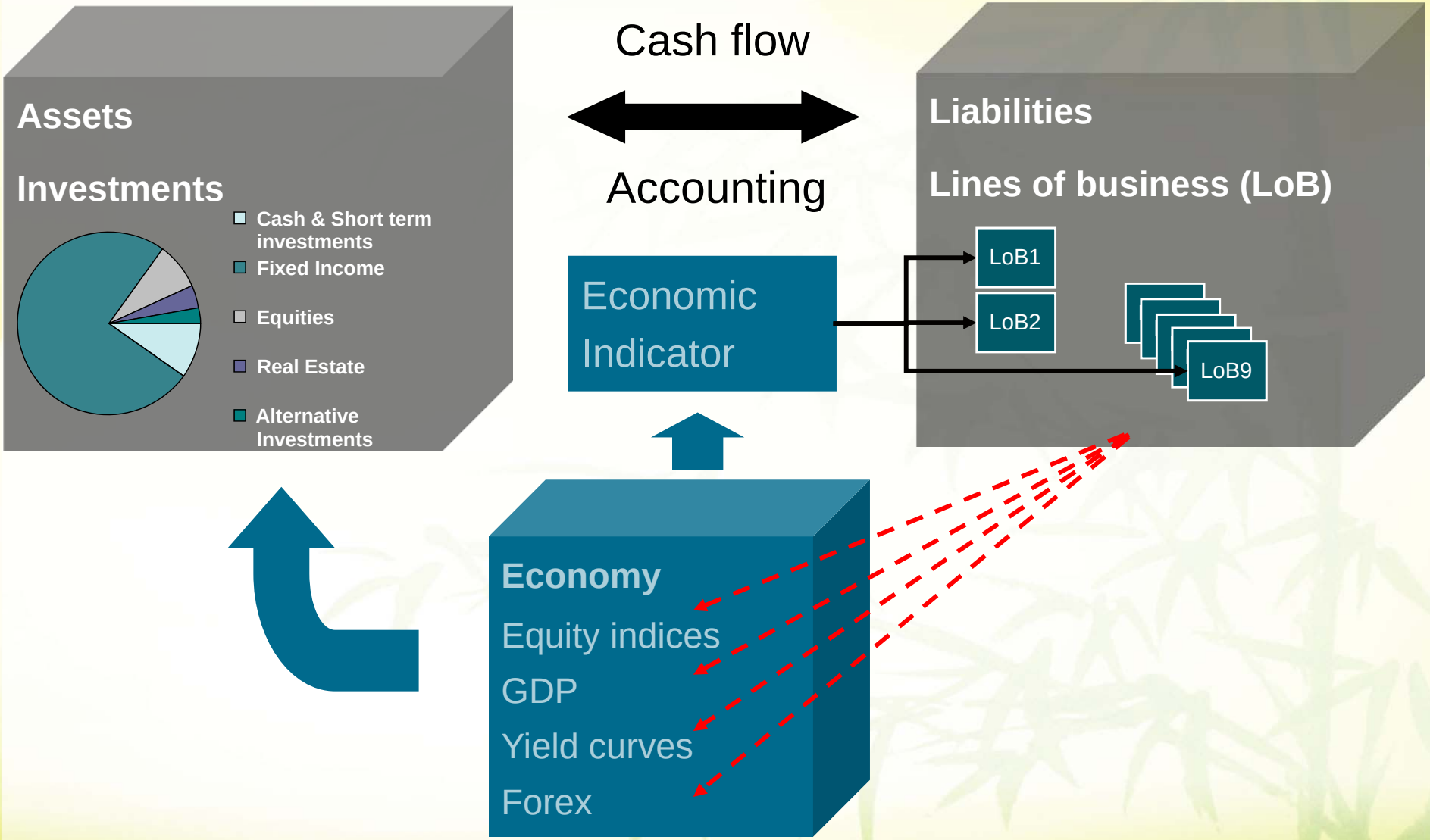
Full balance sheet approach

- From the current balance sheet a stochastic one-year projection of future balance sheets is calculated
- All risks are considered, such as underwriting, market, yield, credit, foreign and exchange risks
- All valuation is done on a market consistent basis

Capital allocation via Euler principle

- Fully change in economic value distribution is produced
- Expected profit and capital requirements at the different thresholds and for different risk measures are computed
- Capital allocation is calculated by the marginal contribution to the TVaR (Euler principle) and preserve RoRaC compatibility

Integrating all models in the approach



Conclusion on SCOR's Group Internal Model

GIM at level of best peers

- SCOR is through the publication of the "Blue Book"[1)] and various (research) papers at the forefront of the (re)insurance discussion on quantitative risk management
- With development of the ESG, Norma and Ilias SCOR fulfils industry leading standards in stochastic modelling

GIM is fully embedded in SCOR's strategy

- The group internal model is fully aligned with our strategy to be a capital driven company
- Together with CaDeT it was used to calculate key figures for our "Strong Momentum"- Plan
- It is used for M&A activities (Transamerica RE)

GIM is **embedded** in the company

- Numerous departments and around 100 individual people contribute data, assumptions or analysis to the operational run
- The produced results are used in a lot of activities of SCOR, ranging from sharing our experience on risk modelling with clients to the presentation to our investors

The GIM is fully operational

- With around 30-40 model runs in the last months the group internal model is fully operational and can deliver additional value to the business
- The internal model is well established in SCOR and contributes with diverse analyses to the understanding of our business (M&A activities, retro optimization, investment strategy, planning)

1) From Principle-Based Risk Management to Solvency Requirements

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- The development of internal models helps to improve risk awareness and anchors risk management and governance deeper in industry practices
- Internal models provide valuable assessments, especially in relative terms, as well as guidance in business decisions
- They facilitate reasonable discussions about strategic choices and their possible consequences
- They will be playing an increasingly important role and already have a material impact on transforming the business models of insurers and reinsurers
- The challenge for the future is to create a fully dynamic model with adaptive strategies