Enterprise risk management at Munich re

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Agenda

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- Enterprise risk management
  - Risk strategy
  - Risk modeling
    - Credit risk
    - Insurance (aka biometric) risk
    - Pandemic risk
    - Market risk
    - Operational risk
  - 2011 ERC results

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Risk strategy

Munich Re's risk strategy

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Category	Risk criteria	Measure	Criteria's objective	ERM objective addressed
Whole portfolio criteria	**Financial strength**	· ERC · Rating · Solvency	Safeguarding sufficient excess capital and limiting frequency of negative economic results of Munich Re's **entire risk portfolio**	Maintaining Munich Re's financial strength, thereby ensuring that all liabilities to our clients can be met
	Avoiding financial distress	Negative economic earnings tolerated every 10 years		
Supple-mentary criteria	· **Peak risk management** · Individual nat cat perils · Terrorism · Pandemic · Longevity · Financial sector limit · **ALM limits** · **Liquidity**	VaR limits as % of AFR or limit for maximum exposure	Limiting losses from **individual risks** or **accumulation exposure** and **liquidity risks** that could endanger Munich Re's survival capability	Protecting and increasing the value of our shareholders' investment
Other criteria	E.g., · Counterparty-credit risk · Single risks · Alternative investments · Non-investment-grade investments	Individual risk limits in absolute value	Limiting risks that could sustainably damage the **trust of stakeholders in Munich Re**	Safeguarding Munich Re's reputation, thus perpetuating future business potential

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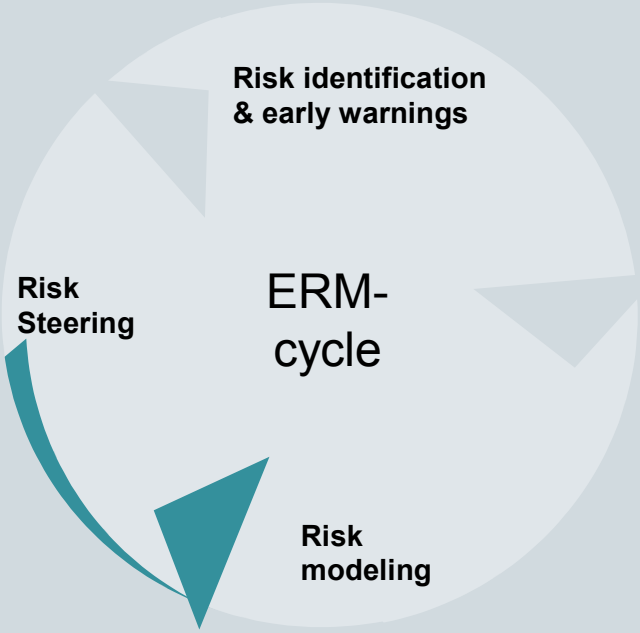
Risk modeling

Risk strategy

Set explicit limits

Clear internal and external signaling effect

Define framework for operative activities



Comprehensive risk governance and effective risk management functions

“Risk adequate” incentives and sustainable responsibility

Quantitative risk modeling: Based on economic balance sheet concept

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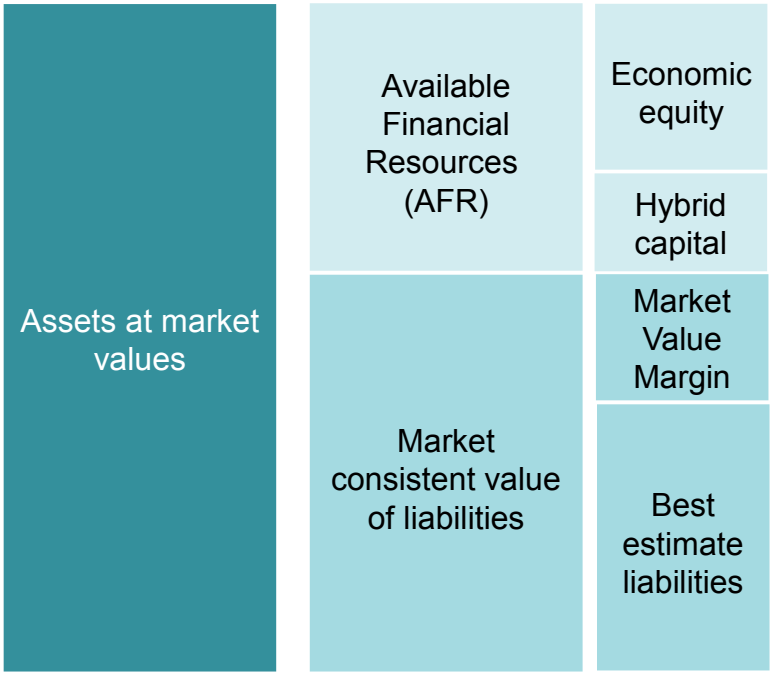
Valuation principles

From an economic view, the following valuation principles prevail:

- Assets are valued at their observable market values.
- Liabilities are valued with techniques that are consistent with financial valuation principles, e.g., options and guarantees in primary life business are valued with risk-neutral valuation techniques.

Economic balance sheet



The choice of the valuation principle is crucial for the risk measure

Economic risk capital (ERC) = 175% VaR (99.5%)

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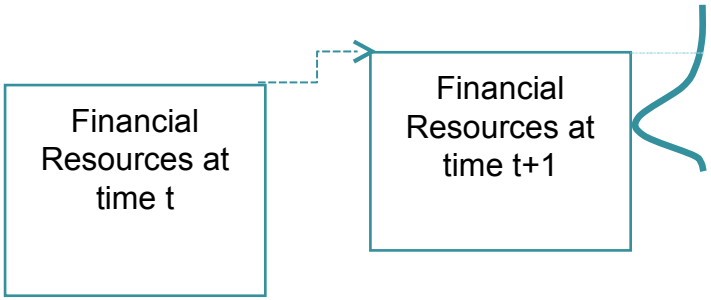
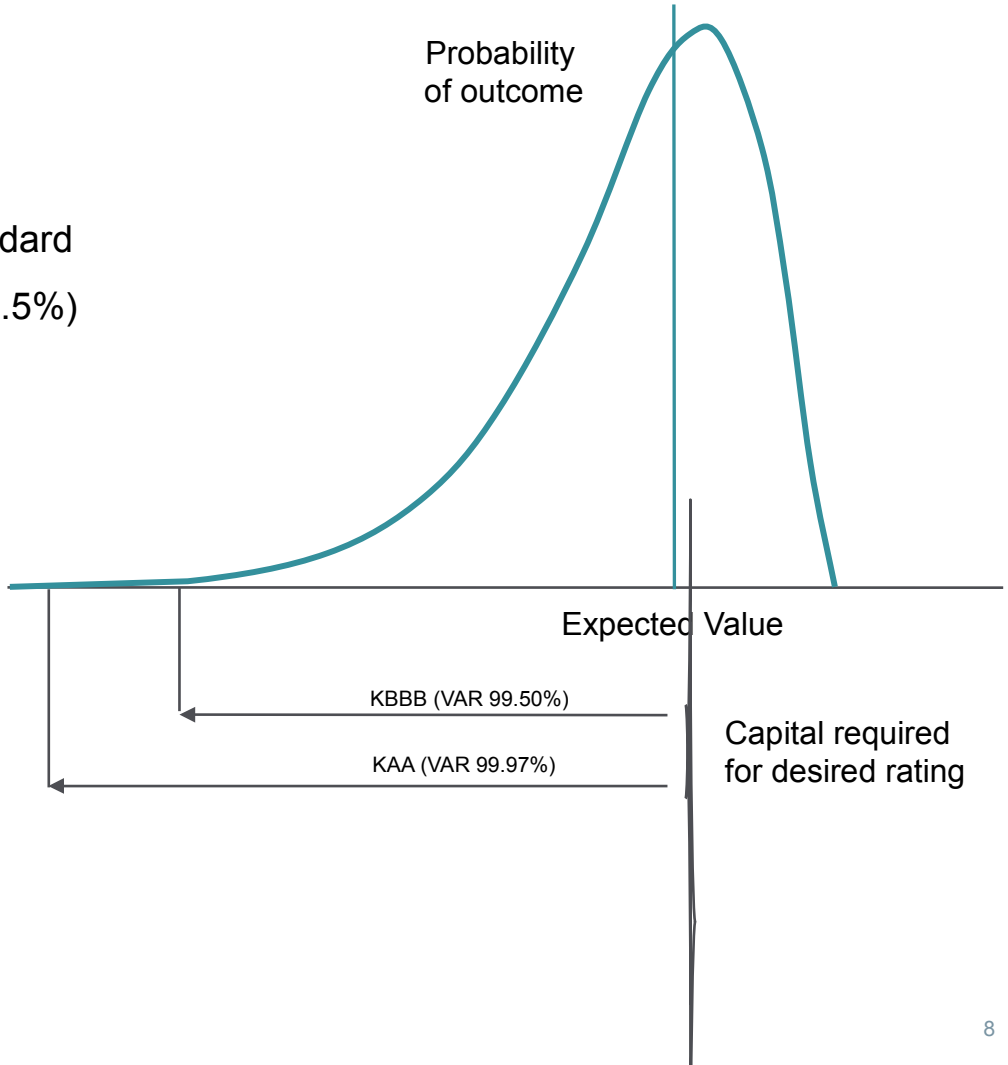
Definition

Events that lead to a deviation of MCEV

- From the expected value
- Over a one year horizon
- 99.5th percentile = Solvency II standard
- Munich Re targets 175% of VaR(99.5%)
- Sufficient to maintain AA rating or VaR(99.97%)



Distribution of Financial Position



All risks are separately analyzed and aggregated using the underlying risk drivers

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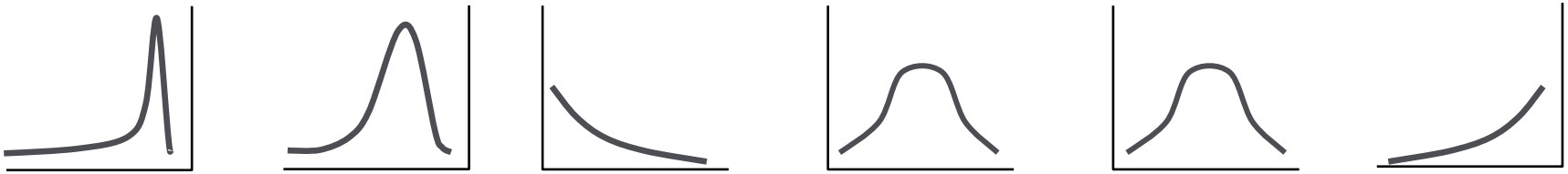
RISK

Credit	P&C Basic Risk	P&C Large Losses	Life & Health	Market	Operational
· Corporate bonds · Retro receivables · Deposit receivables	· Premium risk · Reserve risk	· Nat Cat · Terror · Further large losses	· Mortality · Lapse · Incidence · Recovery · Dis. mortality · Calamity	· Equities · Real estate · Interest rates · Exchange rates · Implied volatilities	· Fraud · Business interruption · Reporting · IT risks · Legal risks



Individual modeling of all risk drivers

Credit risk: Portfolio models

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Credit risk models quantify credit risks under consideration of portfolio effects:

- Default models: losses due to defaults are analysed.
- Mark-to-market models: in addition losses due to changes in market values of instruments are taken into account.

Munich Re uses economic **CreditMetrics** approach (mark-to-market model) implemented in the CreditManager software. Three main components:

- Change of credit quality of a counterparty over the horizon of the analysis (MRCM: 1 year) ➔ **Ratings** with respective transition probabilities
- Change of market value of an instrument taking into account possible changes in the credit quality of the issuer ➔ **Credit spreads**, **recovery rates**
- Dependency of changes in credit quality of several issuers ➔ **Correlations**

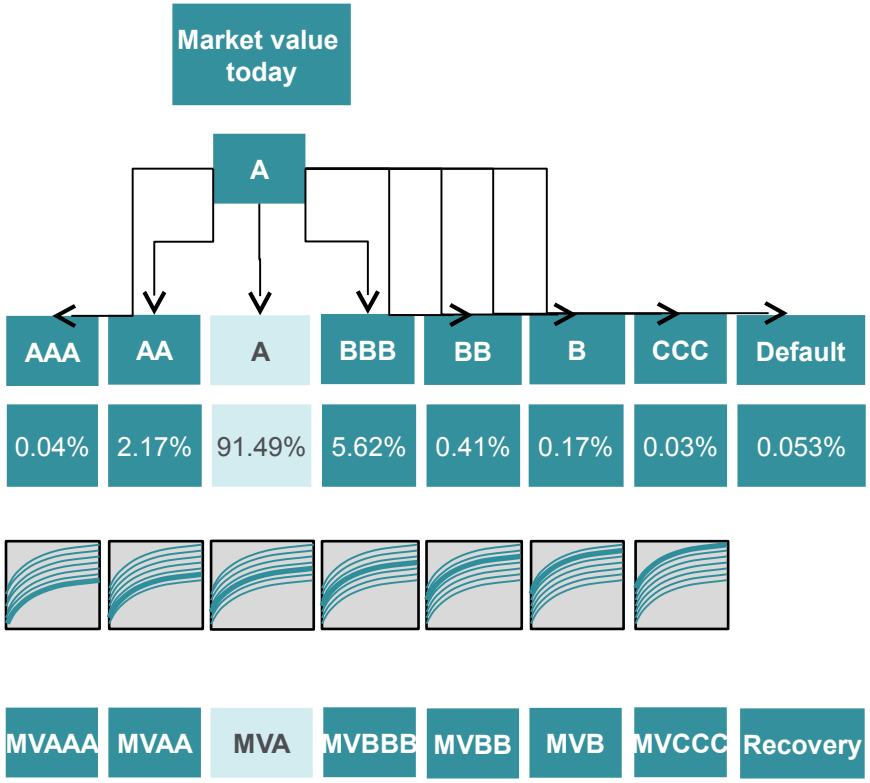
Credit risk modeling: Exposures from investments and other receivables considered

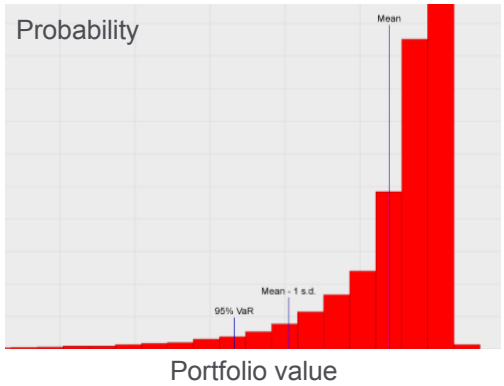
Market value and rating at the beginning of the one-year simulation horizon

Simulated credit quality in one year calibrated using transition probabilities

Revaluation using respective credit spread curves

Market value at the end of the simulation horizon





- Aggregated value distribution in one year
- Typically skewed distribution for credit risk
- Multitude of standard analysis available within the CreditManager

Life insurance risk

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One-year horizon: goal is to capture the full distribution of “change in value” over one-year

Change in value can be broken down into two parts:

(1) Experience variance = deviation in year 1 results

(2) Change in expectation of future = change in expectation of cash flows in t >1 after observing one year of experience

Change in embedded value = ΔPVNCF1 + E{ΔPVNCF2+ | Experience Year 1}

Life insurance risk

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Change in embedded value = ΔPVNCF1 + E{ΔPVNCF2+ | Experience Year 1}

Experience variance: ΔPVNCF1 easy to simulate:

- Generate one-year incidence, termination, and lapse shocks
- Then recalculate net cash flows

Change in expectation: E{ΔPVNCF2+ | Experience Year 1}

- Difficult to estimate: we are essentially trying to model the valuation actuary.
- Valuation function needs to be simple enough for reasonable run time.

The mortality risk driver is built up from four components

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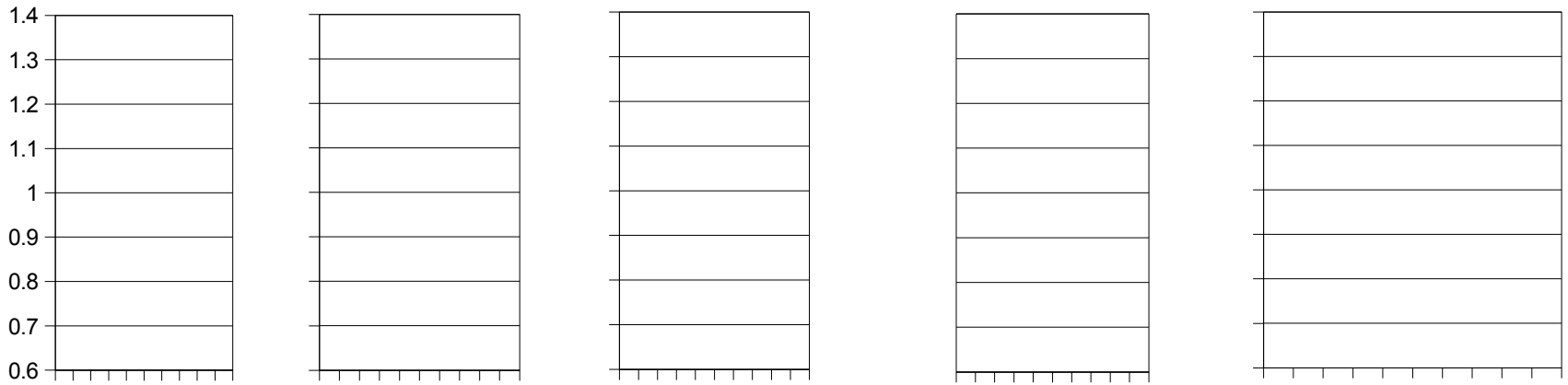
Process	Trend	Basis	Calamity	Total



Process risk:

Random fluctuation

Trend risk:

Long-term trends

Basis risk:

Future vs. experience used to develop assumptions

Calamity risk: (Additive Model)

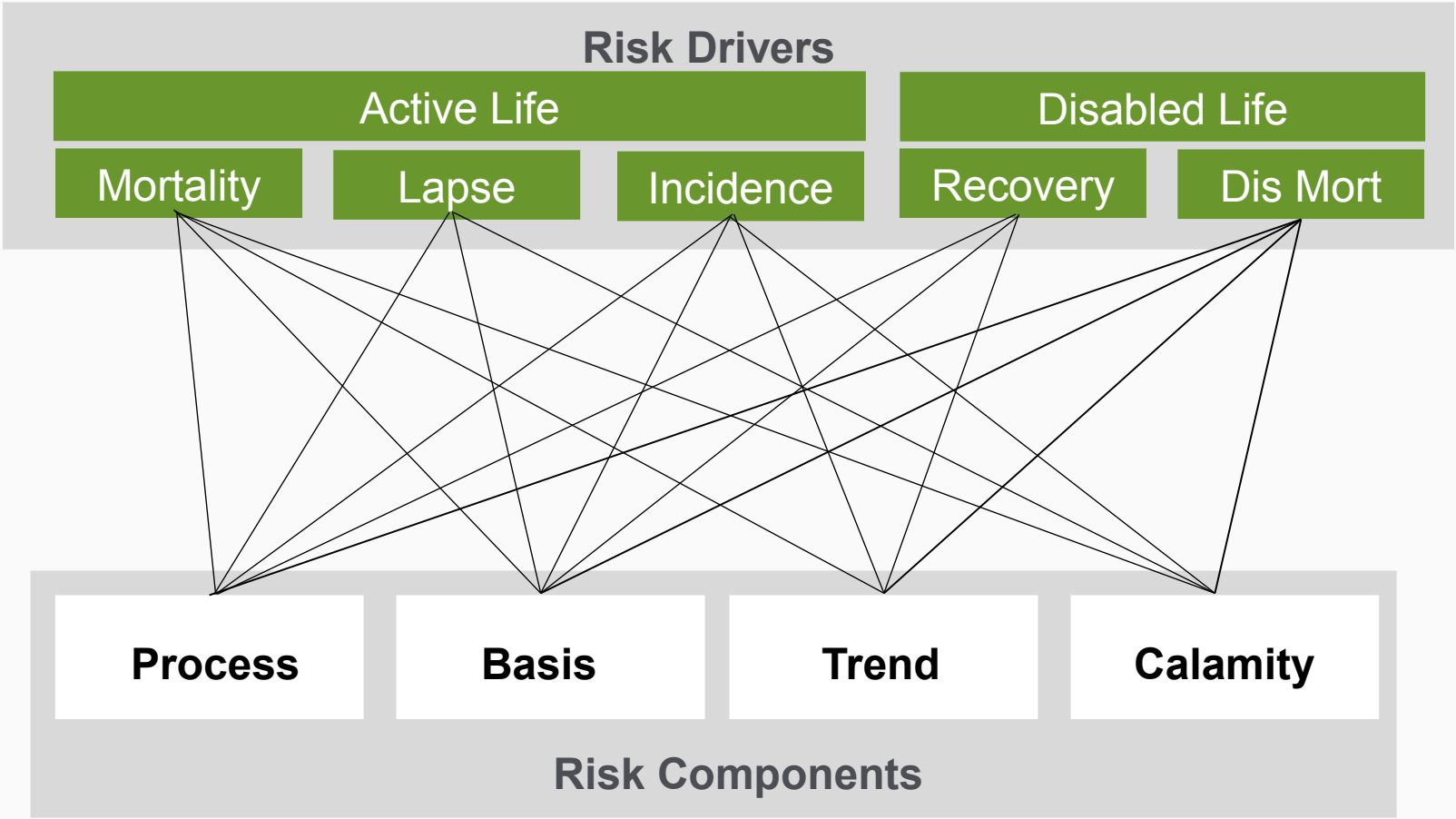
Infrequent, catastrophic loss events

Aggregation:

Assumed independence of risk components

Morbidity & Other risk drivers follow similar approach:

Built from a basket of up to four risk components



Example: Mortality risk driver is built up from four components

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Simulated_Mortality = P x B x T x **Best_Estimate_Mortality** + C

The process, basis, trend random variables have mean = 100%. The calamity random variable has a mean of 0.

So that E[Simulated Mortality] = Best Estimate Mortality

Simulate incidence, active life mortality, disabled life mortality, recovery, and lapse using Monte Carlo simulation (100,000+ iterations)

Example: Mortality risk driver is built up from four components

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Process Risk: Random Fluctuation

- Does not depend on results in previous time steps
- Calibrated to our current portfolio characteristics. (e.g. larger portfolio => smaller process risk; broader NAAR distribution => higher process risk)

Calamity: influenza pandemic, other infectious diseases, terrorism

- Event frequency is drawn from a discrete random variable
- Severities, given that an event has occurred, are drawn from parametric distributions.
- The parametric models are calibrated to our simulation-based pandemic and terrorism models

Example: Mortality risk driver is built up from four components

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Basis Risk (Bt) **:** Misestimation of the base assumption.

- Simulated values of Bt is dependent on the previous time step (Bt-1).
- Calibrated to MARC's and Munich Re's historical experience
- some expert judgment required as past experience is not always indicative of the future

Example: Mortality risk driver is built up from four components

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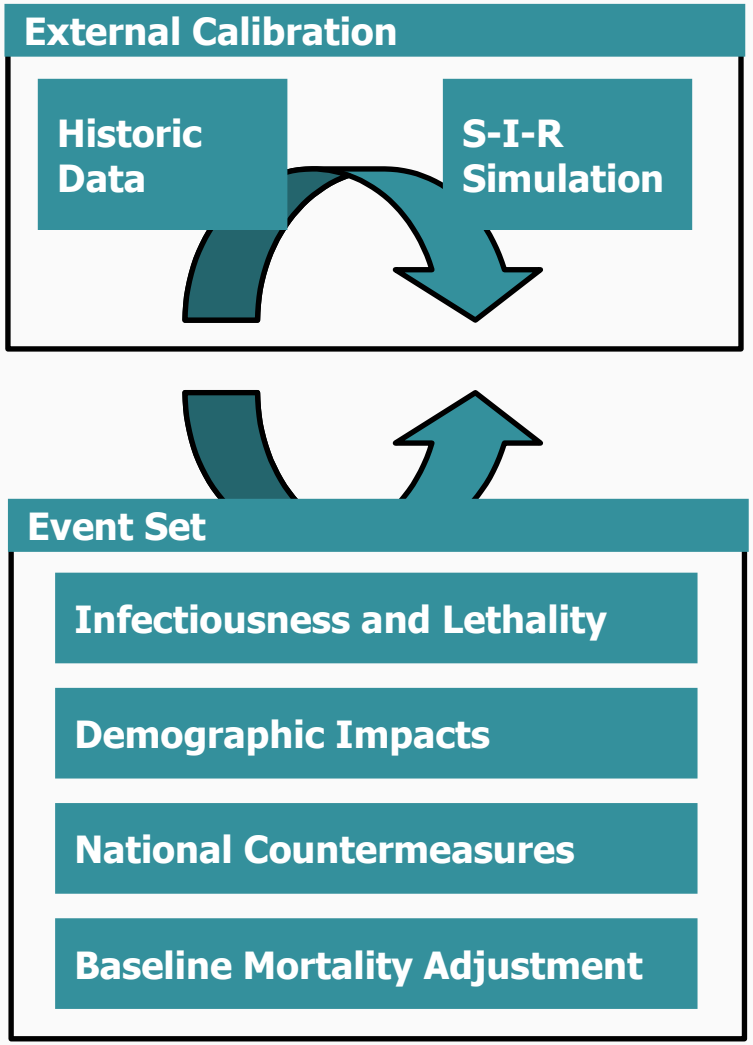
Trend Risk: Misestimation of the trend (e.g. mortality improvement) assumption.

- Based on the Lee-Carter model. Tt has a mean of 100% and depends on results from the previous time step (Tt-1).
- Calibrated to observed long-term population mortality trends + some expert judgment required as past experience is not always indicative of the future

The pandemic model



Munich Re produces an **event set** of about 4,000 pandemic scenarios representing both influenza (flu) and emerging infectious diseases (EIDs).

Unique events are further defined by other important factors such as demographic impacts, national countermeasures and underwriting quality.

Likelihoods are assigned to each event through a commonly used approach called a susceptible, infected, and recovered (S-I-R) model which calibrates the event set against historical data.

The flexible model structure allows for sensitivity analysis across the event set.

Lethality and infectiousness: the defining characteristics of a pandemic outbreak

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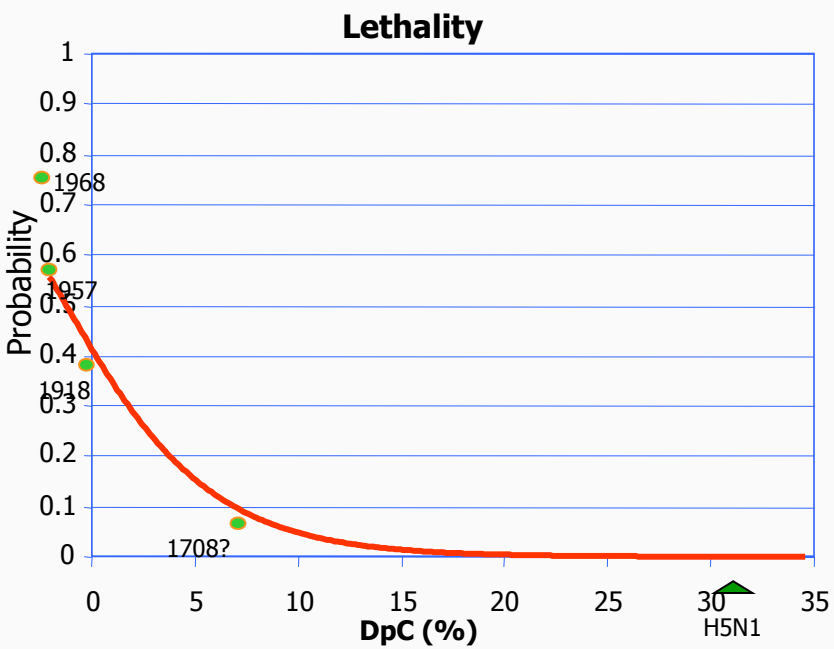
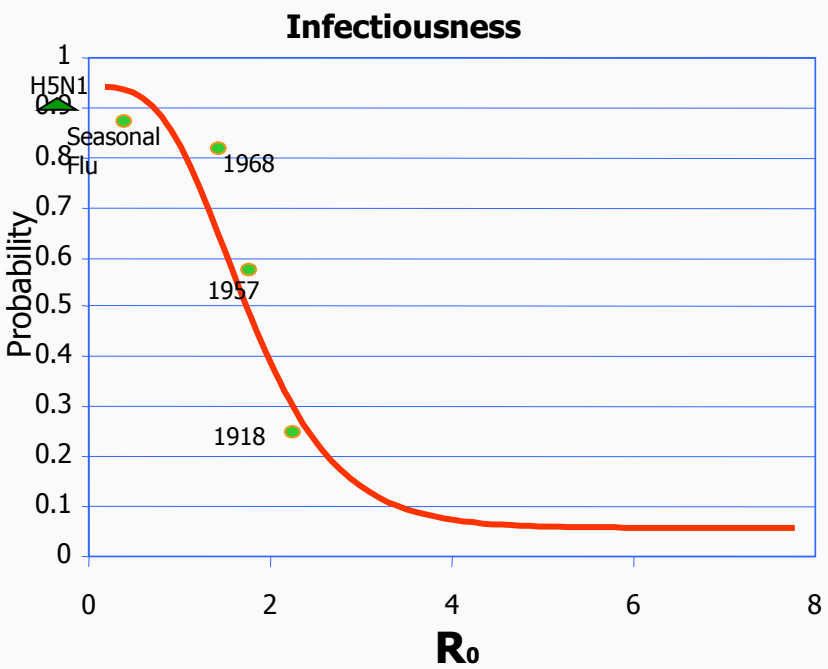
The ***lethality*** of a pandemic is measured by the deaths per case (DpC) the number of deaths given infection. DpC is typically calibrated to a Weibull distribution.

Infectiousness (R0) is the average number of people who are infected by an infected individual and are best fit with a lognormal distribution.

Combining the DpC and R0 reproduces historic pandemic events, i.e. the 1918 Spanish Influenza had (DpC, R0) of (2.5%, 2.25).





Results of pandemic model are incorporated into the current economic risk capital (ERC) framework

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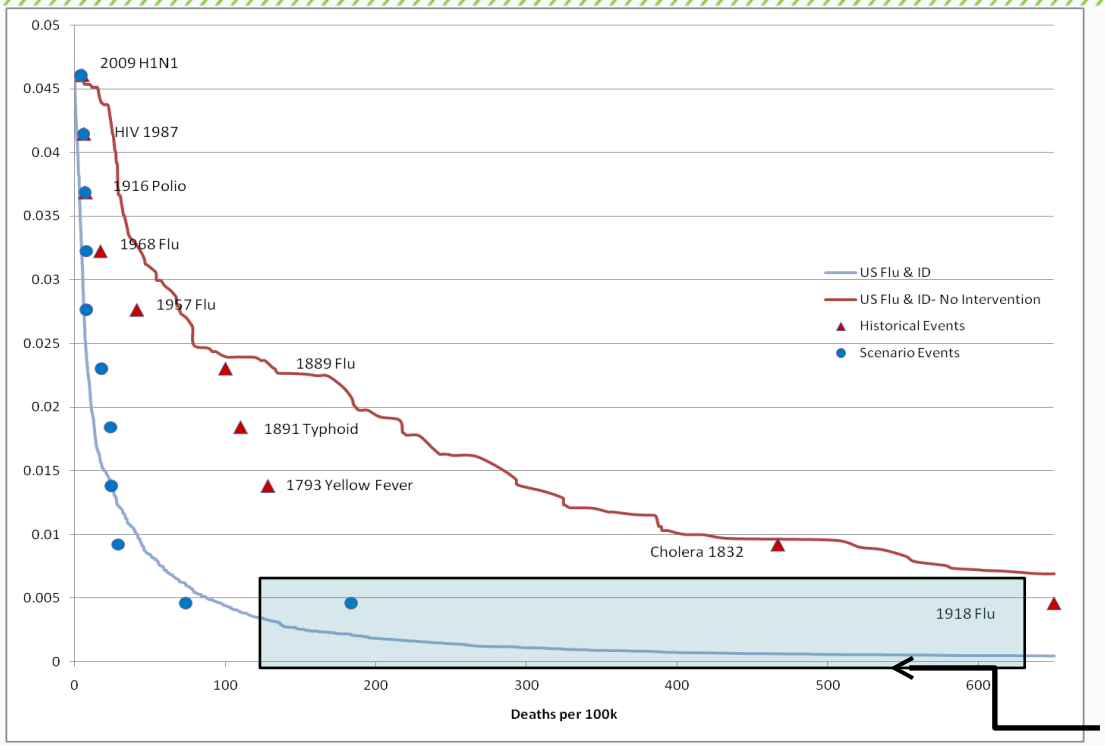


The models derive a total excess mortality - exceedence probability curve for each major business unit.

In order to compute required capital, the tail of the exceedence probability curve is fit to a Pareto distribution.

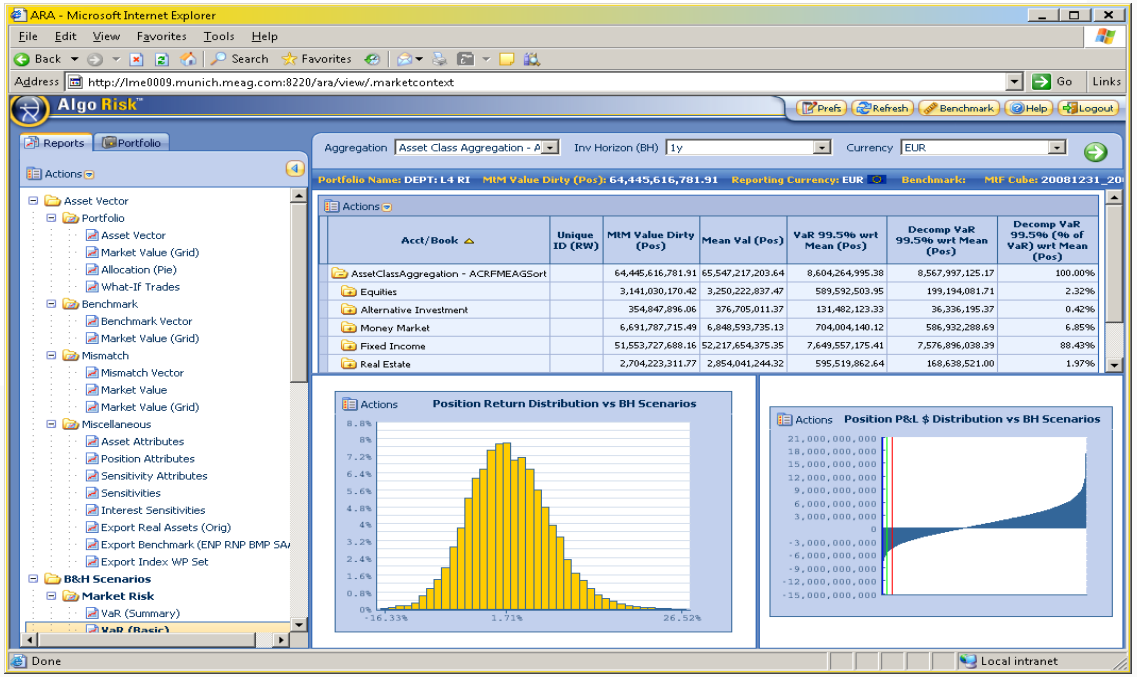
The nature of the Munich Re ERC model incorporates the pandemic model directly for each business unit and product line.

This flexibility allows detailed analysis of total pandemic risk at a the group level, and for each new deal.

Market risks: Analyzed in Algorithmics based on replicating portfolios

Group-wide consistent measurement of all capital market risks (assets and liabilities) in one system:

- Consistent modelling of all capital market risks
- “Use Test“ by applying identical methods and portfolios in risk modelling and steering by MEAG during the period guaranteed
- Implementation in the software “Algorithmics“, which is available on the market and which is about to become a standard product (used by Allianz, AXA, ING, Zürich et al.)
- Group-wide access to the system for asset manager (MEAG), risk manager (IRM), and CIO functions (ALM)
- Transparency with respect to portfolios and methods used
- Numerous evaluations for different purposes available
- Partly based on proprietary data and methods (e.g. modeling of risk drivers, valuation functions)



Market risk modeling: Stochastic risk drivers and valuation function in Algorithmics

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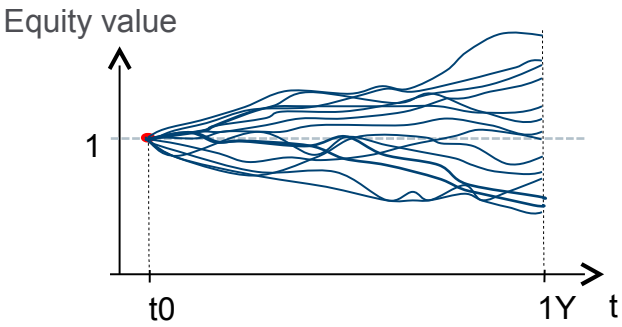
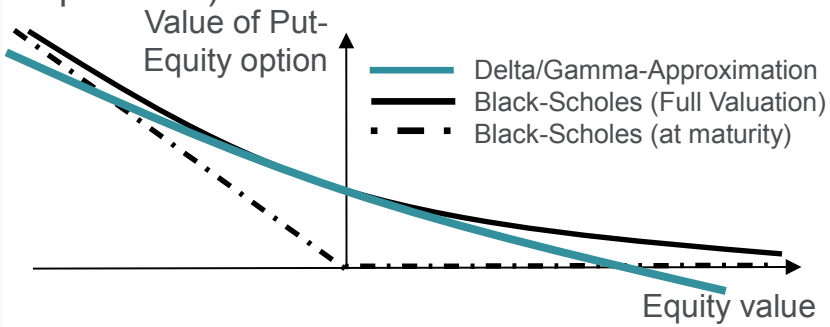
Risk drivers

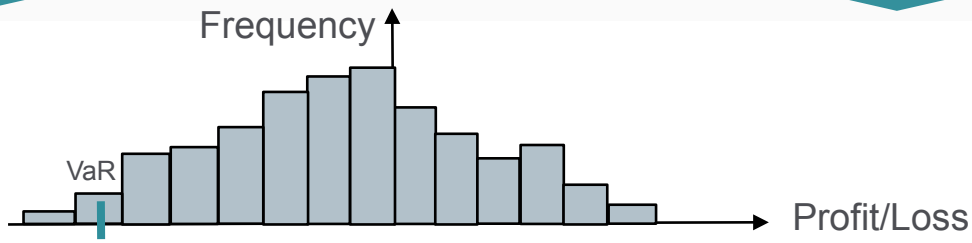
- Determination of type and number of risk drivers over all portfolios
- Stochastic modeling of risk drivers over a time horizon of one year considering the correlation structure



Valuation function

- Previously first and second order approximation used
- Step-wise migration to “full valuation” mode from Q2-2010 onwards (especially important for with-profits business in life and all derivative positions)





Operational risk: Representation within the MRCM

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Process to determine ERC for operational risks

Risk categorization	Scenario development and evaluation	Stochastic modelling	ERC-determination and allocation
• Separation in primary and reinsurance segment due to the different business models • Categorization based on business processes • Based on ORIC1-categories	• Development of representative scenarios based on the chosen categorisation (materiality) • Setting probabilities and severities for the scenarios (expert estimates) • In the future: Link to ICS	• Refinement of critical scenarios (M&A, antitrust, business interruption ERGO) through techniques from property / casualty modelling • Use of Bernoulli-models2 for the other scenarios	• Scenarios within RI and PI deemed uncorrelated • Assumption of a 50% correlation between RI and PI • Tail-dependency between technical and operational risks

The evaluation of operational risk within the MRCM proceeds along the corresponding business processes.

1 ORIC = Operational Risk Insurance Consortium
2 Bernoulli-model: Model with a deterministic loss, which can occur with a specific probability exactly once (0-1-situation)

Risk-Based pricing: Profitability metrics

Munich Re uses a collection of profit metrics and other analyses to measure the inherent profitability of new business, including:

1. IRR Spread
2. Return on Risk Adjusted Capital
3. Profit Margin
4. Pandemic Exposure & Impact
5. Both 1 & 2 using Rating Agency Capital
6. Credit Risk analysis

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Risk results & Opportunities

Munich Re: A leading global (re)insurer

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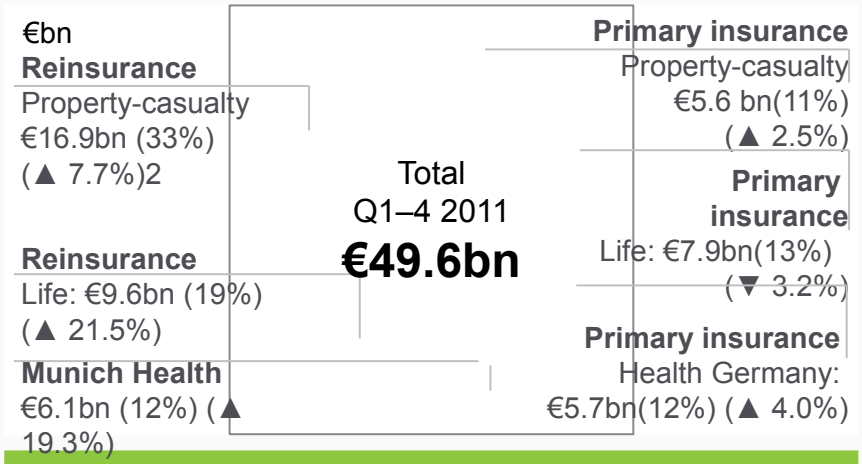
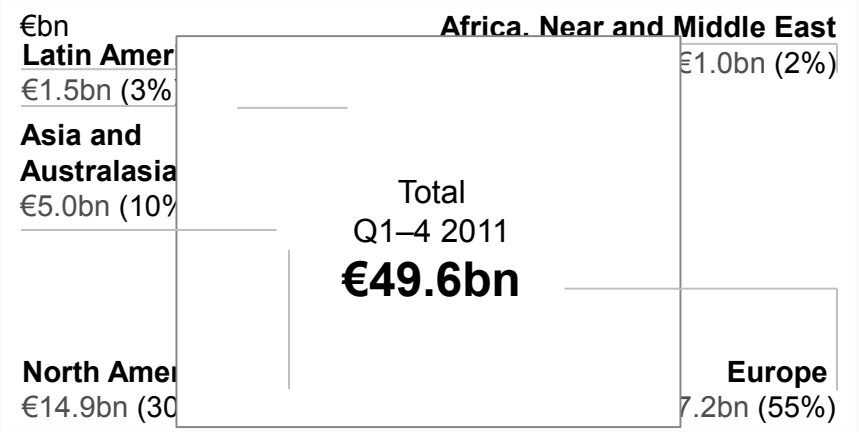
Premium breakdown by segment 20111



Premium breakdown by geography 20111



Key business segments

Reinsurance

- Leading expertise worldwide for 130 years
- Full range of products: From traditional reinsurance to alternative risk financing
- Diversification – A key success factor

Primary Insurance

- Germany-based with presence in attractive growth markets in Eastern Europe and Asia
- Offers P-C, life and German health insurance
- Multi-channel sales strategy and a powerful new brand

Munich Health

- A leading specialised risk carrier in selected international health markets
- Unique selling proposition: Flexible combination of business models and products across healthcare sector value chain

1 Consolidated figures.
2 2011 compared to 2010.

Breakdown of group required economic risk capital (ERC)

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Risk category[1]	Group		RI	PI	MH	Div.	Explanation
Year end	2010	**2011**	2011	2011	2011	2011	
€bn							
Property-casualty2	8.9	**9.5**	9.4	0.6	–	–0.5	Slightly higher exposure in natural catastrophes scenarios (partly driven by model enhancements)
Life and health	5.1	**6.6**	4.8	2.5	0.6	–1.3	Lower interest rate environment
Market	9.9	**11.4**	5.7	8.5	–	–2.8	Increase mainly driven by lower interest rates and higher implied volatility
Credit3	4.5	**6.7**	4.5	2.2	–	–	Strong increase mainly driven by lower interest rates, downgrades of counterparties
Operational risk	1.6	**1.2**	0.9	0.6	0.1	–0.4	Refinement of operational risk scenario set
Simple sum	**30.0**	**35.4**	**25.3**	**14.4**	**0.7**	**–5.0**	
Diversification effect4	–9.3	**–11.0**	– 8.8	–3.1	–	–	Slightly higher diversification due to increases in risk exposures
Total ERC	**20.7**	**24.4**	**16.5**	**11.3**	**0.7**	**–4.1**	

Change in interest rate environment main driver of ERC increase

1 Risk categories broadly based on refined "Fischer II" risk categories recommended for standardised industry disclosures.
2 Credit (re)insurance included. 3 Default and migration risk.
4 The measured diversification effect depends on the risk categories considered and the explicit modelling of fungibility constraints.

Summary of economic capital disclosure

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Position as at 31 December 2011

€bn	31.12.2011	31.12.2010
Available financial resources (AFR)	**28.3**	**29.6**
Economic risk capital1	**24.4**	**20.7**
Economic capital buffer	**3.9**	**8.9**
Economic capital buffer after share buy-back and dividends2	**2.8**	**7.4**

Solvency II capital Hybrid capital

Solid capitalization in challenging times. Economic solvency ratio at 111% according to internal model3 and 194% at Solvency II calibration

1 Solvency II capital based on VaR 99.5%, Munich Re internal risk model based on 175% of Solvency II capital.
2 After announced dividend payout of ~€1.1bn for 2011 to be paid in April 2012. 3 Without recognition of the impact of restatement in the AFR at 105%

Sensitivities of Munich Re Group's economic solvency ratio

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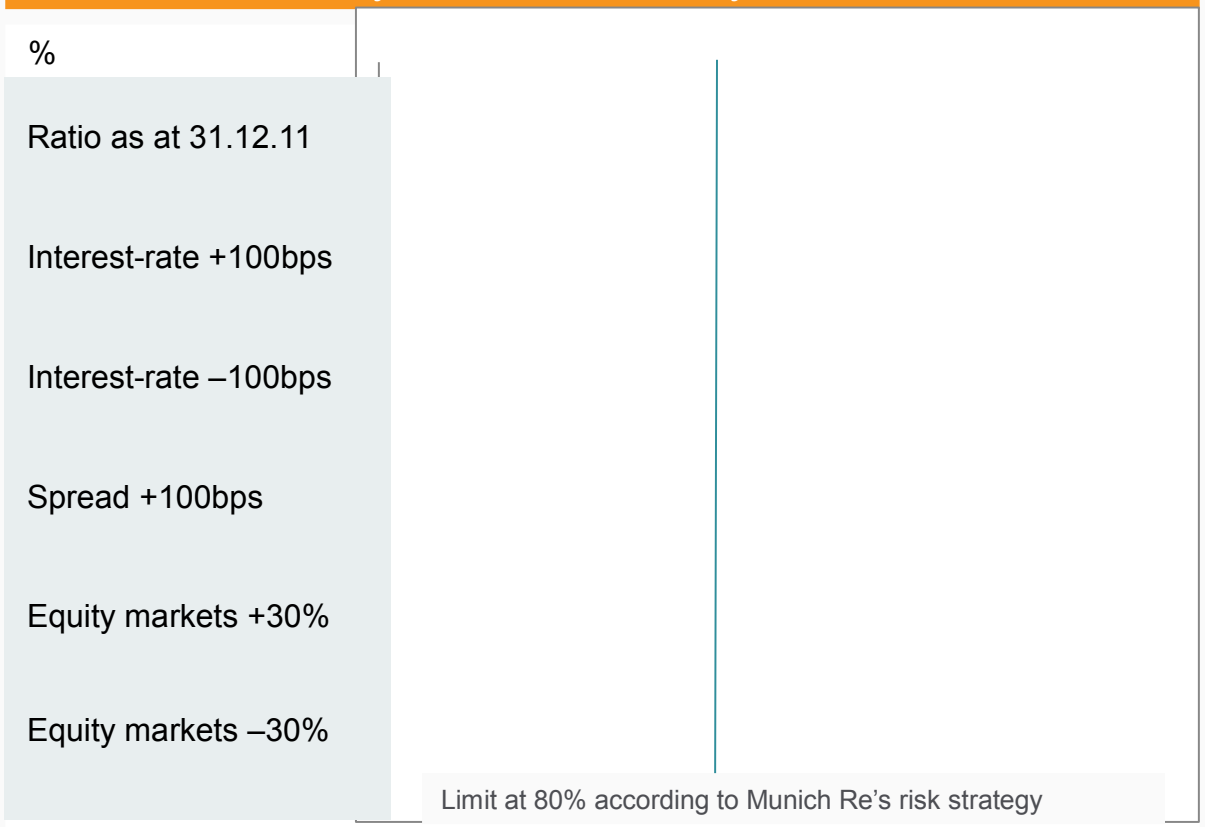
Economic solvency ratio1 – Sensitivity



Key observations

- Opposite interest-rate sensitivities in reinsurance and primary insurance mitigate sensitivity at Group level
- Even further deterioration of the interest rate environment would result in Group Solvency ratio well above the internal limit
- Moderate equity exposure leads to low sensitivity

Munich Re able to withstand further stress scenarios

1 Solvency ratio defined as Available Financial Resources (AFR) over capital requirement; AFR after announced dividend for 2011 of ~€1.1bn to be paid in April 2012

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Thank you