ECONOMIC RISK CAPITAL

November 2011  Tony Green FSA, CERA, MAAA

Agenda

Enterprise Risk Management
- Risk Strategy
- Risk modeling
  - Credit risk
  - Insurance (aka Biometric) risk
  - Pandemic risk
  - Market risk
  - Operational risk
- Risk Results & Opportunities
  - 2010 ERC Results
  - Risk & Solvency Consulting
# Munich Re's Risk Strategy

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

**Risk steering**
- Risk triggers, limits and measures facilitate accountable management action

**Risk identification and early warnings**
- Necessity of a panoramic vision with focus on core areas

**Risk strategy**
- Set explicit limits
- Clear internal and external signalling effect
- Define framework for operative activities

**Comprehensive risk governance and effective risk management functions**

**ERM-cycle**
- "Risk adequate" incentives and sustainable responsibility

**Risk management culture as a solid foundation**
Quantitative Risk Modelling - based on Economic Balance Sheet concept

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.

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

Economic Risk Capital (ERC) = 175% VaR(99.5%)

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%)
All risks are separately analysed and aggregated using the underlying risk drivers.

<table>
<thead>
<tr>
<th>RISK</th>
<th>Credit</th>
<th>P&amp;C basic Risk</th>
<th>P&amp;C large losses</th>
<th>Life &amp; Health</th>
<th>Market</th>
<th>Operational</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Corporate bonds</td>
<td>Premium risk</td>
<td>NatCat Terror Further large losses</td>
<td>Mortality Lapse Incidence Recovery Dis. Mortality Calamity</td>
<td>Equities Real estate Interest rates Exchange rates Implied volatilities</td>
<td>Fraud Business interruption Reporting IT risks Legal risks</td>
</tr>
</tbody>
</table>

Individual modelling of all risk drivers

Credit risk – portfolio models

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 modelling – Exposures from investments and other receivables considered

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

The Mortality Risk Driver is built up from four components

- 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

- Volatility
- Misestimation
- Catastrophe
- Mortality Risk
Other Risk Drivers follow a similar approach – Built from a basket of up to 4 Risk Components

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

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** ($R_0$) 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 $R_0$ reproduces historic pandemic events, i.e. the 1918 Spanish Influenza had (DpC, $R_0$) of (2.5%, 2.25).

Results of Pandemic model are incorporated into the current Economic Risk Capital (ERC) Framework

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 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. modelling of risk drivers, valuation functions)

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

Risk drivers
- Determination of type and number of risk drivers over all portfolios
- Stochastic modelling 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)

Value of Put-Equity option

Equity value vs. Equity option

Frequency vs. Profit/Loss
### Operational risk - representation within the MRCM

#### Process to determine ERC for operational risks

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

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

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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)

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### RISK RESULTS & OPPORTUNITIES
Munich Re: A leading global (re)insurer

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

Premium breakdown by segment 2010

<table>
<thead>
<tr>
<th>Segment</th>
<th>Total Q1–4 2010</th>
<th>Property-casualty</th>
<th>Life</th>
<th>Reinsurance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reinsurance</td>
<td>€45.5bn</td>
<td>15.4 (34%)</td>
<td>5.4</td>
<td>3.4 (7%)</td>
</tr>
<tr>
<td>Primary Insurance</td>
<td></td>
<td></td>
<td>6.4</td>
<td></td>
</tr>
<tr>
<td>Munich Health</td>
<td></td>
<td>5.0 (11%)</td>
<td>5.5</td>
<td></td>
</tr>
</tbody>
</table>

Premium breakdown by geography 2010

<table>
<thead>
<tr>
<th>Region</th>
<th>Total Q1–4 2010</th>
<th>Property-casualty</th>
<th>Life</th>
<th>Reinsurance</th>
</tr>
</thead>
<tbody>
<tr>
<td>North America</td>
<td>12.1 (26%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Europe</td>
<td>27.2 (60%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Asia and</td>
<td>Africa, Near and Middle East 4.2 (9%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Latin America</td>
<td>1.1 (3%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Africa, Near and Middle East</td>
<td>0.9 (2%)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1 Consolidated figures.
2 2010 compared to 2009.

Breakdown of Group required economic risk capital (ERC)

<table>
<thead>
<tr>
<th>Risk category</th>
<th>Year end</th>
<th>Group 2009</th>
<th>RI 2010</th>
<th>PI 2010</th>
<th>MH 2010</th>
<th>Div. 2010</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>€bn</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Property-casualty</td>
<td>7.6</td>
<td>8.9</td>
<td>8.8</td>
<td>0.6</td>
<td>0.0</td>
<td>–0.5</td>
<td>Slightly higher exposure in natural catastrophes scenarios, weaker euro, change of external protection</td>
</tr>
<tr>
<td>Life and Incurrs</td>
<td>3.7</td>
<td>5.1</td>
<td>3.9</td>
<td>1.3</td>
<td>0.7</td>
<td>–0.8</td>
<td>Weaker euro (mainly affecting reinsurance portfolio) and higher interest rates</td>
</tr>
<tr>
<td>Market</td>
<td>6.8</td>
<td>9.9</td>
<td>5.5</td>
<td>7.0</td>
<td>0.0</td>
<td>–3.5</td>
<td>Strong increase due to higher equity positions and increased interest rates</td>
</tr>
<tr>
<td>Credit</td>
<td>3.1</td>
<td>4.5</td>
<td>3.4</td>
<td>1.2</td>
<td>0.0</td>
<td>–0.1</td>
<td>Spread risk above average, Issuer yield changes, downgrades of counterparties</td>
</tr>
<tr>
<td>Operational risk</td>
<td>1.5</td>
<td>1.6</td>
<td>1.3</td>
<td>0.5</td>
<td>0.1</td>
<td>–0.3</td>
<td>Low increase due to higher exposure</td>
</tr>
<tr>
<td>Simple sum</td>
<td>22.7</td>
<td>30.0</td>
<td>22.9</td>
<td>11.5</td>
<td>0.8</td>
<td>–5.2</td>
<td></td>
</tr>
<tr>
<td>Diversification effect</td>
<td>–5.3</td>
<td>–9.3</td>
<td>–8.1</td>
<td>–2.0</td>
<td>0.0</td>
<td>–</td>
<td>Higher diversification due to increases in risk exposures and lower tail dependences</td>
</tr>
<tr>
<td>Total ERC</td>
<td>17.4</td>
<td>20.7</td>
<td>14.8</td>
<td>9.5</td>
<td>0.8</td>
<td>–4.4</td>
<td></td>
</tr>
</tbody>
</table>

Market 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

<table>
<thead>
<tr>
<th></th>
<th></th>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Economic risk capital</td>
<td>€bn</td>
<td>11.8</td>
<td>20.7</td>
</tr>
<tr>
<td>Economic capital buffer</td>
<td>€bn</td>
<td>4.1</td>
<td>8.9</td>
</tr>
<tr>
<td>Economic capital buffer after share buy-back and dividends</td>
<td>€bn</td>
<td>2.6</td>
<td>7.4</td>
</tr>
</tbody>
</table>

#### Capital strength maintained, despite higher risk exposures

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 2010 to be paid in April 2011 and €0.4bn outstanding share buy-back.

### Sensitivities of Munich Re Group's economic solvency ratio

#### Economic solvency ratio¹ – Sensitivity

<table>
<thead>
<tr>
<th>%</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Ratio as at 31.12.10</td>
<td>136</td>
<td></td>
</tr>
<tr>
<td>Interest-rate +100bps</td>
<td>148</td>
<td></td>
</tr>
<tr>
<td>Interest-rate –100bps</td>
<td>123</td>
<td></td>
</tr>
<tr>
<td>Equity markets +30%</td>
<td>139</td>
<td></td>
</tr>
<tr>
<td>Equity markets –30%</td>
<td>134</td>
<td></td>
</tr>
<tr>
<td>Interest-rates –100bps/</td>
<td>118</td>
<td></td>
</tr>
<tr>
<td>Equity markets –30%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Key observations

- Opposite interest-rate sensitivities in reinsurance and primary insurance mitigate sensitivity at Group level
- Moderate equity exposure leads to low sensitivity
- Economic solvency ratio after impact of combined interest-rate and equity market stress still high

1. Solvency ratio defined as Available Financial Resources (AFR) over capital requirement; AFR after announced dividend for 2010 of ~€1.1bn to be paid in April 2011 and €0.4bn outstanding share buy-back.
Reinsurer Credit Default Swap Spreads
Munich Re continues to enjoy a favorable credit outlook

<table>
<thead>
<tr>
<th>Company</th>
<th>5-Year April 2010</th>
<th>5-Year September 2011</th>
</tr>
</thead>
<tbody>
<tr>
<td>AEGON</td>
<td>150</td>
<td>304</td>
</tr>
<tr>
<td>Berk-Hath</td>
<td>107</td>
<td>199</td>
</tr>
<tr>
<td>Munich Re</td>
<td>69</td>
<td>99</td>
</tr>
<tr>
<td>RGA</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Swiss Re</td>
<td>116</td>
<td>203</td>
</tr>
</tbody>
</table>

April 2011 vs. April 2010

2010 highlights – Key achievements

- Again demonstrated strength of diversified activities as leading global (re)insurer
- 10% growth of gross premiums written in 2010
- Favourable net income of €2.4bn in challenging environment (high claims, low yields)
- Annualised RoRaC of 13.5%, RoE 10.4%
- ROI of 4.5% — solid returns within boundaries of moderate risk profile
- Group equity further strengthened to €23.0bn despite attractive dividend and share buy-backs
- Strong capitalisation by all relevant measures (regulatory, rating and internal model)
- Ability to further increase dividend for 2010 (+9%)
- Stable results despite major nat cat losses
- Enhanced utilization of Munich Re’s risk-bearing capacity to seize business opportunities
- Despite major claims, reinsurance remains dominant earnings contributor to the Group
- Cycle management: Underwrite tailor-made solutions – and cancel underpriced business
- ERGO confirms positive trend — net income at €355m more than doubled
- Successful introduction of new brand strategy
- Consolidation process well on track
- Expansion of health business model across selected areas