Back of the Envelope ICA
32nd Annual GIRO Convention
R. A. Shaw
18-21 October 2005
The Imperial Hotel, Blackpool

Agenda
- Top Down Approach to Risk Modelling
- Linking Risk Assessment to Risk Quantification
- Examples – Credit Risk and Aggregation
- The Future (and Current)

Top Down Approach to Risk Modelling
Topics
- Overview
  - Purpose / Why / How
- Uncertainty
- Risk Categorisation
  - Main Risk Categories / How Many
- Total Balance Sheet Approach
- Business Plans
- Risk Algorithms
- Risk Aggregation
- What you Have vs What you Need
Top Down Approach to Risk Modelling

Overview

Purpose
- To "guesstimate" an ICA or DFA produced capital result
- How far can one get with a "Back of the Envelope" approach?
- Mechanism to Integrate ICA with Risk Mgt and Planning

Why
- Transparency – Ease of Understanding / Communication
- Enable Third Party Reasonableness Assessment:
  - Auditors / Investors / Rating Agencies
- Facilitate integration within the Decision Making process
- Business Planning in a Practical way
- Mirror some of the Solvency II formulaic developments

How
- A Series of 5 x 12-month Capital numbers (99.5%) – 5 years
  - Capital Risk Factors
    - Capital estimated separately for selected Risk Categories
    - 12-month Capital modelling – Company / Industry data
    - Using Stochastic, Closed-Form or Scenario approaches
  - Projected Capital (> 1 year)
    - Capital estimated by Risk Category for each future year
    - Projection of P&L, Balance Sheet and Cash-flow Financials
    - Application of Capital Risk Factors (as modified) to Financials
  - Aggregation
    - Allow for Company diversification between risk categories
    - Aggregation of Capital by Risk Category for each year

Top Down Approach to Risk Modelling

Overview

Risk Category 1
- 10,000
- 20,000
- 30,000
- 40,000
- 50,000
- 60,000

Year
- 1
- 2
- 3
- 4
- 5

Amount

Exposure

Capital

Top Down Approach to Risk Modelling

Overview

Risk Category 2
- 5,000
- 10,000
- 15,000
- 20,000
- 25,000
- 30,000

Year
- 1
- 2
- 3
- 4
- 5

Amount

Exposure

Capital

Total
- 20,000
- 40,000
- 60,000
- 80,000
- 100,000
- 120,000
- 140,000
- 160,000
- 180,000

Year
- 1
- 2
- 3
- 4
- 5

Amount

Equity

Capital
Top Down Approach to Risk Modelling

Uncertainty

- Uncertainty within any Multi-year Modelling:
  - Parameter Risk
    - Especially when compounding
  - Dependency Models
  - Parameter Penalties (Econometrics)
    - Over parameterisation
  - Model Risk
    - There are many variants before you even consider stochastic
    - Stochastic Risk
      - Do we get enough outcomes in the tails?

- Uncertainty increase over time:
  - More certainty at 99.5% over 1 year than 98.5% over 3 years
    - Little difference unless it influences decision now (capital raising)
  - More pronounced in the tails ~ Capital loss thresholds

Top Down Approach to Risk Modelling

Uncertainty

- How often do we get a 12-month Plan right
  - Let alone 3 or 5 years?
- How good were our ‘Best Estimate’ Reserves (12 mths)
- We are better placed to predict year 2 in 12-months

The Most Difficult Challenge is the Time Horizon (> 1 yr)

Top Down Approach to Risk Modelling

Uncertainty - Samples (50) - Pareto: MLE of \( \alpha \)
Top Down Approach to Risk Modelling
Uncertainty - Samples (50) - Pareto: Exp Loss

Top Down Approach to Risk Modelling
Uncertainty - Samples (50) - Pareto: 99%ile Loss

Top Down Approach to Risk Modelling
Uncertainty - Samples (50) - Pareto: Distribution

<table>
<thead>
<tr>
<th>Percentile</th>
<th>Expected Loss</th>
<th>Loss at 99%ile</th>
<th>Alpha</th>
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<tr>
<td>Expected</td>
<td>33,323</td>
<td>238,059</td>
<td>1.50</td>
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<tr>
<td>1%</td>
<td>18,381</td>
<td>81,646</td>
<td>2.19</td>
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<tr>
<td>5%</td>
<td>20,980</td>
<td>111,351</td>
<td>1.91</td>
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<tr>
<td>10%</td>
<td>22,612</td>
<td>130,468</td>
<td>1.79</td>
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<tr>
<td>25%</td>
<td>25,389</td>
<td>163,028</td>
<td>1.65</td>
</tr>
<tr>
<td>50%</td>
<td>31,080</td>
<td>227,244</td>
<td>1.47</td>
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<tr>
<td>75%</td>
<td>37,060</td>
<td>288,629</td>
<td>1.37</td>
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<tr>
<td>90%</td>
<td>43,459</td>
<td>346,576</td>
<td>1.30</td>
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<tr>
<td>95%</td>
<td>53,067</td>
<td>419,872</td>
<td>1.23</td>
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<tr>
<td>99%</td>
<td>84,702</td>
<td>580,602</td>
<td>1.13</td>
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</table>
Top Down Approach to Risk Modelling
Total Balance Sheet Approach - Capital
- Assets and Liabilities on a PV Basis (Realistic)
  - Assets:
    - Invested Assets – Little Change (~ Market Value)
    - PV of Reinsurance Assets
    - RI Receivables, RI Recoveries, Losses on RI share of UPR
  - Liabilities:
    - Gross Claims Reserves
    - Expected Value (~ ‘Best’ Estimate) – Uncertainty ?
    - PV of Gross Claims Reserves
    - PV of Losses on Gross UPR

Top Down Approach to Risk Modelling
Business Plan – Projections
- Opening Balance Sheet 31/12/04
- 5-year Projections 2005 - 2010
- UK GAAP Accounts – Planning:
  - Insurance P&L – Aggregate / LOB
  - Profit and Loss Account
  - Balance Sheet
  - Cash-flow
- Enhanced Capital Requirement (ECR)
  - Ratios - FSA Returns vs UK GAAP Accounts
- Report and Accounts are good information sources
  - Notes to the Accounts are very important

Top Down Approach to Risk Modelling
Business Plan – Assets: Balance Sheet
XYZ Insurance Company
Balance Sheet
Date: 31/12/05

<table>
<thead>
<tr>
<th>Assets</th>
<th>2004</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
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<tr>
<td>Intangible Fixed Assets</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<tr>
<td>Investments</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Equities</td>
<td>241,403</td>
<td>769</td>
<td>804</td>
<td>840</td>
<td>878</td>
<td>917</td>
<td>959</td>
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<td>Government Bonds</td>
<td>822,206</td>
<td>1,503,407</td>
<td>1,579,460</td>
<td>1,795,315</td>
<td>2,013,840</td>
<td>2,219,619</td>
<td>2,407,094</td>
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<tr>
<td>Corporate Bonds</td>
<td>1,122,203</td>
<td>887,171</td>
<td>963,224</td>
<td>1,179,079</td>
<td>1,397,604</td>
<td>1,603,383</td>
<td>1,790,858</td>
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<tr>
<td>Property</td>
<td>5,441</td>
<td>5,192</td>
<td>5,192</td>
<td>5,192</td>
<td>5,192</td>
<td>5,192</td>
<td>5,192</td>
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<tr>
<td>Other</td>
<td>80,676</td>
<td>288,668</td>
<td>288,668</td>
<td>288,668</td>
<td>288,668</td>
<td>288,668</td>
<td>288,668</td>
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<tr>
<td>Intangible Fixed Assets</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<tr>
<td>Investments</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>2,271,929</td>
<td>2,685,208</td>
<td>2,837,348</td>
<td>3,269,094</td>
<td>3,706,183</td>
<td>4,117,779</td>
<td>4,492,771</td>
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<tr>
<td>Reinsurance share of Technical Provisions</td>
<td>160,000</td>
<td>172,570</td>
<td>152,253</td>
<td>116,995</td>
<td>122,817</td>
<td>123,785</td>
<td>126,261</td>
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<td>Provision for Unearned Premium</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Claims Outstanding</td>
<td>1,600,000</td>
<td>1,569,364</td>
<td>1,370,158</td>
<td>1,288,285</td>
<td>1,215,528</td>
<td>1,134,762</td>
<td>1,014,315</td>
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<td>Debtors</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Debtors - Direct Insurance Operations</td>
<td>687,778</td>
<td>310,432</td>
<td>465,291</td>
<td>549,627</td>
<td>581,106</td>
<td>603,995</td>
<td>614,854</td>
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<td>Debtors - Reinsurance Operations</td>
<td>302,604</td>
<td>490,256</td>
<td>342,539</td>
<td>322,071</td>
<td>303,882</td>
<td>283,690</td>
<td>253,579</td>
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<tr>
<td>Other Debtors and Assets incl Taxation</td>
<td>134,381</td>
<td>54,884</td>
<td>69,794</td>
<td>82,444</td>
<td>87,166</td>
<td>90,599</td>
<td>92,228</td>
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<tr>
<td>Other Assets</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Tangible Assets</td>
<td>8,696</td>
<td>9,994</td>
<td>11,632</td>
<td>13,741</td>
<td>14,528</td>
<td>15,100</td>
<td>15,371</td>
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<tr>
<td>Cash at bank and in hand</td>
<td>412,384</td>
<td>112,847</td>
<td>112,847</td>
<td>112,847</td>
<td>112,847</td>
<td>112,847</td>
<td>112,847</td>
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<tr>
<td>Prepayments and Accrued Income</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Accrued Interest and Rent</td>
<td>13,112</td>
<td>17,054</td>
<td>11,632</td>
<td>13,741</td>
<td>14,528</td>
<td>15,100</td>
<td>15,371</td>
</tr>
<tr>
<td>Prepaid and Deferred Expenses</td>
<td>12,662</td>
<td>6,108</td>
<td>11,632</td>
<td>13,741</td>
<td>14,528</td>
<td>15,100</td>
<td>15,371</td>
</tr>
<tr>
<td>Deferred Acquisition Costs</td>
<td>45,016</td>
<td>37,596</td>
<td>44,745</td>
<td>41,815</td>
<td>44,853</td>
<td>46,420</td>
<td>47,349</td>
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<td>Intangible Fixed Assets</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<tr>
<td>Investments</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>5,648,561</td>
<td>5,466,313</td>
<td>5,429,871</td>
<td>5,824,400</td>
<td>6,217,964</td>
<td>6,559,178</td>
<td>6,800,318</td>
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</table>
### Top Down Approach to Risk Modelling

**Business Plan – Cash-flow Model**

<table>
<thead>
<tr>
<th>Date</th>
<th>Amounts 000s</th>
</tr>
</thead>
<tbody>
<tr>
<td>31/12/05</td>
<td></td>
</tr>
</tbody>
</table>

#### PREMIUMS, CLAIMS AND EXPENSES

<table>
<thead>
<tr>
<th>Year</th>
<th>Gross Written Premium</th>
<th>RI Written Premium</th>
<th>Gross Paid</th>
<th>RI Paid</th>
<th>Gross Commission</th>
<th>Administration Expenses</th>
<th>RI Commission</th>
<th>Investment Expenses and Charges</th>
<th>Other Income and Expenses (Insurance P&amp;L)</th>
<th>Other Income and Expenses (P&amp;L Account)</th>
<th>Premiums, Claims and Expenses</th>
</tr>
</thead>
<tbody>
<tr>
<td>2006</td>
<td>1,659,241</td>
<td>(466,225)</td>
<td>(1,236,780)</td>
<td>452,854</td>
<td>(164,586)</td>
<td>(209,798)</td>
<td>18,294</td>
<td>(3,735)</td>
<td>(128)</td>
<td>0</td>
<td>49,136</td>
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<tr>
<td>2007</td>
<td>1,753,539</td>
<td>(375,585)</td>
<td>(1,091,443)</td>
<td>364,504</td>
<td>(155,644)</td>
<td>(233,124)</td>
<td>18,428</td>
<td>(3,960)</td>
<td>5,857</td>
<td>0</td>
<td>282,572</td>
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<tr>
<td>2008</td>
<td>1,889,129</td>
<td>(400,095)</td>
<td>(1,157,207)</td>
<td>352,800</td>
<td>(166,766)</td>
<td>(250,281)</td>
<td>19,676</td>
<td>(4,598)</td>
<td>3,362</td>
<td>0</td>
<td>286,021</td>
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<tr>
<td>2009</td>
<td>1,923,976</td>
<td>(406,326)</td>
<td>(1,232,153)</td>
<td>371,025</td>
<td>(172,045)</td>
<td>(253,331)</td>
<td>19,513</td>
<td>(5,245)</td>
<td>6,422</td>
<td>0</td>
<td>251,836</td>
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<td>2010</td>
<td>1,962,456</td>
<td>(414,453)</td>
<td>(1,354,087)</td>
<td>415,871</td>
<td>(175,486)</td>
<td>(258,398)</td>
<td>19,903</td>
<td>(5,853)</td>
<td>6,550</td>
<td>0</td>
<td>196,502</td>
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#### INVESTMENT INCOME

<table>
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<tr>
<th>Asset Class</th>
<th>Amounts 000s</th>
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<tbody>
<tr>
<td>Equities</td>
<td>25 - 30</td>
</tr>
<tr>
<td>Government Bonds ( &lt; 5 years)</td>
<td>38,968 - 52,844</td>
</tr>
<tr>
<td>Government Bonds ( &gt;= 5 years)</td>
<td>25,510 - 43,863</td>
</tr>
<tr>
<td>Corporate Bonds ( &lt; 5 years)</td>
<td>15,698 - 34,579</td>
</tr>
<tr>
<td>Corporate Bonds ( &gt;= 5 years)</td>
<td>32,091 - 51,587</td>
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<tr>
<td>Property</td>
<td>156</td>
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<tr>
<td>Other</td>
<td>8,660</td>
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#### Cashflow Model

<table>
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<th>Date</th>
<th>Amounts 000s</th>
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</thead>
<tbody>
<tr>
<td>31/12/05</td>
<td></td>
</tr>
</tbody>
</table>

#### Top Down Approach to Risk Modelling

**Risk Categorisation**

- **Main Risk Categories:**
  - Insurance Risk – U/W, Reserving and Cat Risk
  - Credit Risk – Insurance and Investment related
  - Market Risk
  - Operational Risk
  - Liquidity Risk

- **How Many:**
  - Enough to capture risk dynamics
  - Insurance – Broad Definitions of Lines of Business
  - Avoid the use of too many

**Risk Algorithms – Insurance Risk (LOB)**

- **Underwriting Risk**
  - Adritional and Large Losses (excluding Nat CAT)
  - Gross and Net Modelling → Net Loss Distribution
  - Stochastic (with Scenario modification)
  - Capital Number (VaR)
  - Exposure – Net premium

- **Reserving Risk**
  - Bootstrapping or Other → Net Loss Distribution → VaR
  - Exposure – Net Reserves

**Catastrophe Risk**

- RMS or other Output → Capital Number (VaR)
  - Exposure – Net premium
Top Down Approach to Risk Modelling
Risk Algorithms – Insurance Risk (LOB)
  • Correlation
    • Underwriting Risk
    • Reserving Risk
    • Catastrophe Risk

Top Down Approach to Risk Modelling
Risk Algorithms – Credit Risk
  • Reinsurance Asset Related
    • Stochastic Model (Default based) → Capital Number (VaR)
    • Combined with Scenarios of particular reinsurer defaults
    • Exposure – RI Receivables, RI Recoveries, Loss RI UPR
  • Invested Assets Related (Bonds)
    • Stochastic Model:
      • Credit risk due to defaults
      • Credit risk due to Credit Migrations and Changes in Spread
    • Exposure – Value of Bonds

Top Down Approach to Risk Modelling
Risk Algorithms – Market Risk
  • Investment Assets
    • Stochastic Asset Model (e.g. 3rd Party)
      • Some models are only extrapolating most recent past
      • Underestimating volatility
    • Scenarios
      • Risk from large movement in yield curve - non-parallel
      • Drop in Equity Values
    • Capital Number (VaR)
    • Exposure – Value of Invested Assets:
      • Value of Bonds – Bond VaR
      • Value of Equities – Equity VaR
Top Down Approach to Risk Modelling

Risk Algorithms – Operational Risk

- Operational Risk
  - Scenarios:
    - Ground-Up approach – Individual event types (~ RMF)
    - Causes, Risk drivers and Behavioural patterns
    - Controls and Risk mitigation practices in place
    - Combine – assuming say independent (or low correlation)
  - Loading or Factor:
    - Benchmark – as modified by above
  - Exposure – Total Capital, Premium or Balance Sheet item

Top Down Approach to Risk Modelling

Risk Algorithms – Liquidity Risk

- Liquidity Risk
  - Scenario based – Projected Cash-flows by year
  - If Negative Cash-flow:
    - Compare with Available Invested Assets (Bonds)
    - Assume covered by Selling Bonds (very low transaction costs)
    - Capital Number (VaR)
  - Exposure – Size of Negative Cash-flow

Top Down Approach to Risk Modelling

Risk Aggregation

- Dependency Modelling:
  - Risks often exhibit co-movement / dependencies
    - Structural
    - Loss variables are driven by common variables
    - Empirical
      - Observed without any known relationships
  - Normal vs Stressed Situations:
    - Correlations in Stressed Situations → Larger
    - Does Aggregating Capital numbers (VaR) mean higher values
    - Tail Dependency – Copulas
      - Aggregation process needs to recognise this
      - Not an ‘Exact’ Science / Sensitivity Testing
Top Down Approach to Risk Modelling

Risk Aggregation – For year each of 5 years

<table>
<thead>
<tr>
<th>LOB / Risk Type</th>
<th>Risk Category</th>
<th>Before</th>
<th>After</th>
</tr>
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<tbody>
<tr>
<td>Credit Risk</td>
<td>Credit</td>
<td>50,000</td>
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<tr>
<td>Investments</td>
<td>Credit</td>
<td>15,000</td>
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</tr>
<tr>
<td>Investments</td>
<td>Market</td>
<td>25,000</td>
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<tr>
<td>Line of Business 1</td>
<td>Insurance</td>
<td>20,000</td>
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<tr>
<td>Line of Business 2</td>
<td>Insurance</td>
<td>25,000</td>
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</tr>
<tr>
<td>Line of Business 3</td>
<td>Insurance</td>
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</tr>
<tr>
<td>Line of Business 4</td>
<td>Insurance</td>
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</tr>
<tr>
<td>Line of Business 5</td>
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<td>30,000</td>
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</tr>
<tr>
<td>Line of Business 6</td>
<td>Insurance</td>
<td>20,000</td>
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</tr>
<tr>
<td>Line of Business 7</td>
<td>Insurance</td>
<td>10,000</td>
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<tr>
<td>Line of Business 8</td>
<td>Insurance</td>
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</tr>
<tr>
<td>Line of Business 9</td>
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<tr>
<td>Operational Risk</td>
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<tr>
<td>Liquidity Risk</td>
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<tr>
<td>Diversified Capital</td>
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<td>326,000</td>
<td>270,000</td>
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<tr>
<td>Economic Equity</td>
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<td>450,000</td>
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Linking Risk Assessment to Risk Quantification

Topics
- Scenarios
- Implicit and Explicit Modelling
- Integration of Scenario and Stochastic pieces
Linking Risk Assessment to Risk Quantification
Scenarios – Top Down vs Ground Up

- Risk Capital 1
- Risk Capital 2
- Risk Capital 3
- Risk Capital 4

Linking Risk Assessment to Risk Quantification
Scenarios – Why

- Fill in any Gaps in the modelling process
- Sense Check of the Top-Down Approach:
  - Are Individual Scenarios consistent for extreme events
  - Different modelling perspective to Maths based approach
  - Greater level of Granularity
- Business Decision Making:
  - Financial Impact and Likelihood of threats to the business
  - Management Information for Risk Owners (Heat Maps)
- Input to more sophisticated modelling approaches:
  - Refinement of Assumptions
  - Dependencies – Causes & Effects
  - Correlation between risks

Linking Risk Assessment to Risk Quantification
Scenarios – Heat Map (Market Risk)

- Financial Market Residual Heatmap
- 1:1 Relationships which do not hold - Ranges
Linking Risk Assessment to Risk Quantification
Implicit and Explicit Modelling

- Risk Factors → Implicitly / Explicitly captured
- Implicit Modelling:
  - Some risks are implicitly captured in the modelling
  - E.g. Errors in Claims processing → Reserve Estimation
- Explicit Modelling:
  - Some risks are directly (explicitly) captured in the modelling
  - E.g. Loss from Natural CAT Events

Linking Risk Assessment to Risk Quantification
Integration of Scenario and Stochastic pieces

RISK MAPPINGS

<table>
<thead>
<tr>
<th>Risk Category</th>
<th>RMF or FSA Risks</th>
<th>Scenarios</th>
<th>Stochastic</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Insurance Risk</td>
<td>RMF</td>
<td>Scenario 1</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Scenario 2</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Scenario 3</td>
<td>4</td>
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</tr>
<tr>
<td></td>
<td></td>
<td>Scenario 4</td>
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</tr>
<tr>
<td>Market Risk</td>
<td>RMF</td>
<td>Scenario 1</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Scenario 2</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Credit Risk</td>
<td>RMF</td>
<td>Scenario 1</td>
<td>8</td>
<td></td>
</tr>
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<td></td>
<td></td>
<td>Scenario 2</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Operational Risk</td>
<td>RMF</td>
<td>Scenario 1</td>
<td>8</td>
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</tr>
<tr>
<td></td>
<td></td>
<td>Scenario 2</td>
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<td></td>
</tr>
<tr>
<td>Liquidity Risk</td>
<td>RMF</td>
<td>Scenario 1</td>
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</tr>
<tr>
<td></td>
<td></td>
<td>Scenario 2</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

RMF = Risk Management Framework (Company Risk Assessment)

Examples
Topics
- Credit Risk
- Aggregation
Examples
Credit Risk – Results Summary

<table>
<thead>
<tr>
<th>CREDIT RISK SUMMARY</th>
<th>A</th>
<th>BB</th>
<th>BBB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Expected Loss</td>
<td>776</td>
<td>1,282</td>
<td>15,798</td>
</tr>
<tr>
<td>VaR @ 99.5%</td>
<td>65,224</td>
<td>76,718</td>
<td>230,202</td>
</tr>
<tr>
<td>TVaR @ 99.5%</td>
<td>80,074</td>
<td>97,958</td>
<td>290,322</td>
</tr>
<tr>
<td>Exposure</td>
<td>950,000</td>
<td>950,000</td>
<td>950,000</td>
</tr>
<tr>
<td>VaR @ 99.5% / Exposure</td>
<td>6.9%</td>
<td>8.1%</td>
<td>24.2%</td>
</tr>
<tr>
<td>No. of Reinsurers</td>
<td>10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. of Simulations</td>
<td>100,000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reinsurer Correlation</td>
<td>35%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Examples
Credit Risk – Observations
- Exposure over 12-months – weighted average of
  - Run-off of BS Values plus RI Exposure from new business
  - Exposure - Deterministic or Stochastic (Gross Losses)
- Large Credit Risk contribution from BS run-off
  - Larger exposure / Some ratings below new business criteria
  - IBNR Allocation by Reinsurer – Uncertainty
- Complexities:
  - RI Prob of Default / LGD – Data / Static / Variable
  - Defaults ~ Economic / Insurance Conditions
  - Large Insurance Loss → Credit Risk (Dependency)
    - Increased RI Exposure → Increased Default Probs → Loss
  - “Willingness to Pay” → A New Issue

Examples
Aggregation – 2 Risks – Risk A and Risk B

<table>
<thead>
<tr>
<th>Expected</th>
<th>Risk A</th>
<th>Risk B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loss</td>
<td>1,000</td>
<td>1,000</td>
</tr>
<tr>
<td>Std Dev</td>
<td>250</td>
<td>500</td>
</tr>
<tr>
<td>Variance</td>
<td>62,500</td>
<td>250,000</td>
</tr>
<tr>
<td>CV</td>
<td>25%</td>
<td>50%</td>
</tr>
<tr>
<td>Mu</td>
<td>6.8774</td>
<td>6.7962</td>
</tr>
<tr>
<td>Sigma</td>
<td>0.2460</td>
<td>0.4724</td>
</tr>
</tbody>
</table>

- Investigate different implied correlations given:
  - Pair-wise Correlation Coefficients
  - Simulations using different Copulas
- Different Copulas
  - T-Copula – 5 d.f.
  - HRT (Heavy Right-hand Tailed Copula)
  - Partially Comonotonic
Examples
Aggregation – 50% Corr; T-Copula; 10,000 pts

Examples
Aggregation – Implied Correlation (20%)

Examples
Aggregation – Implied Correlation (50%)
Top Down Approach to Risk Modelling

**Aggregation – Observations**

- **Tail Dependency**
  - Higher Correlation in tails at 99% and 99.5% levels
  - Lower Correlation for VaR (Capital) aggregation
  - Subtracting Expected (100% correlated) from 99% / 99.5% Loss

- **Rather than re-run for different Copulas**
  - Input different correlation amounts at the 99.5% Loss
  - Hypothetical results of different copulas
  - Derive Implied Correlations between VaR amounts
  - Investigate:
    - 2x Risk A – CVs of 25%
    - 1x Risk A + 1x Risk B – CVs of 25% and 50%
    - 2x Risk B – CVs of 25%

---

**Examples**

**Aggregation – Implied Correlation (2x 'A')**

<table>
<thead>
<tr>
<th>Correlation</th>
<th>Risk 1</th>
<th>Risk 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Expected</td>
<td>1,000</td>
<td>1,000</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>250</td>
<td>250</td>
</tr>
<tr>
<td>CV</td>
<td>20.0%</td>
<td>20.0%</td>
</tr>
<tr>
<td>Mu</td>
<td>6.8774</td>
<td>6.8774</td>
</tr>
<tr>
<td>Sigma</td>
<td>0.2462</td>
<td>0.2462</td>
</tr>
<tr>
<td>Percentiles</td>
<td></td>
<td></td>
</tr>
<tr>
<td>90% 95%</td>
<td>1,455</td>
<td>1,455</td>
</tr>
<tr>
<td>95% 99%</td>
<td>1,720</td>
<td>1,720</td>
</tr>
<tr>
<td>99% 99.5%</td>
<td>1,829</td>
<td>1,829</td>
</tr>
<tr>
<td>Value of Risk</td>
<td></td>
<td></td>
</tr>
<tr>
<td>90% 95%</td>
<td>455</td>
<td>455</td>
</tr>
<tr>
<td>95% 99%</td>
<td>720</td>
<td>720</td>
</tr>
<tr>
<td>99% 99.5%</td>
<td>829</td>
<td>829</td>
</tr>
</tbody>
</table>

---

**Examples**

**Aggregation – Implied Correlation (1x 'A', 1x'B')**

<table>
<thead>
<tr>
<th>Correlation</th>
<th>Risk 1</th>
<th>Risk 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Expected</td>
<td>1,000</td>
<td>1,000</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>250</td>
<td>500</td>
</tr>
<tr>
<td>CV</td>
<td>20.0%</td>
<td>25.0%</td>
</tr>
<tr>
<td>Mu</td>
<td>6.8774</td>
<td>6.7962</td>
</tr>
<tr>
<td>Sigma</td>
<td>0.2462</td>
<td>0.4724</td>
</tr>
<tr>
<td>Percentiles</td>
<td></td>
<td></td>
</tr>
<tr>
<td>90% 95%</td>
<td>1,455</td>
<td>1,945</td>
</tr>
<tr>
<td>95% 99%</td>
<td>1,720</td>
<td>2,684</td>
</tr>
<tr>
<td>99% 99.5%</td>
<td>1,829</td>
<td>3,020</td>
</tr>
<tr>
<td>Value of Risk</td>
<td></td>
<td></td>
</tr>
<tr>
<td>90% 95%</td>
<td>455</td>
<td>945</td>
</tr>
<tr>
<td>95% 99%</td>
<td>720</td>
<td>1,684</td>
</tr>
<tr>
<td>99% 99.5%</td>
<td>829</td>
<td>2,020</td>
</tr>
</tbody>
</table>

---

**Correlation for Amount of Loss @ 99.5%**

<table>
<thead>
<tr>
<th>Correlation</th>
<th>Amount of Loss @ 99.5%</th>
</tr>
</thead>
<tbody>
<tr>
<td>50.0%</td>
<td>3,168 $(0.7%)$</td>
</tr>
<tr>
<td>55.0%</td>
<td>3,221 8.4%</td>
</tr>
<tr>
<td>60.0%</td>
<td>3,272 17.7%</td>
</tr>
<tr>
<td>65.0%</td>
<td>3,323 27.3%</td>
</tr>
<tr>
<td>70.0%</td>
<td>3,373 37.1%</td>
</tr>
<tr>
<td>75.0%</td>
<td>3,422 47.1%</td>
</tr>
<tr>
<td>80.0%</td>
<td>3,471 57.3%</td>
</tr>
</tbody>
</table>
Examples
Aggregation – Implied Correlation (2x 'B')

<table>
<thead>
<tr>
<th>Probability</th>
<th>Risk 1</th>
<th>Risk 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>50.0%</td>
<td>1,000</td>
<td>1,000</td>
</tr>
<tr>
<td>60.0%</td>
<td>2,000</td>
<td>2,000</td>
</tr>
<tr>
<td>70.0%</td>
<td>3,000</td>
<td>3,000</td>
</tr>
</tbody>
</table>

The Future (and Current)

- More Scientific approach to Insurance Management
  - This is already happening:
    - UK: ICA World / Solvency II - Continental Europe (2009 / 10)
- Business Planning:
  - Improvements in Planning Models
  - Consideration of Balance Sheet Impacts – Not Just P&L
  - Returns on Economic Capital (Move from Combined Ratio)
  - Consideration of different Risk / Return Trade-Offs
- Reappraisal of Corporate and Strategic Objectives
- Risk Measures and Capital Allocation
  - Industry in its own right
- Pricing (Risk and Capital Loads)

The Future (and Current)

- Performance Measurement – Compensation Packages
- Refinement of Models and Approaches
- Further Work on Sources of Uncertainty
  - Parameter / Model / Stochastic Risks over time
- The Actuary as Chief Risk Officer
  - Chief Risk Officer an established Role within the UK
  - Responsibility for all risks – not just Insurance
  - Juggling many Balls – Insurance, Market, Credit ……
  - Understanding of Micro → Advise at Strategic Level