Economic Capital and Diversification at Group Level

Shaun Wang
Georgia State University
ERM-II Scientific Director

June 7, 2007
swang@ermii.org
Outline

1. Identify the Issue
   – Group Diversification
   – Solvency II, CRO Forum, IASB

2. Mathematical Measurement
   – Tail Correlation
   – Default correlation

3. Strategic Risk Diversification
   – Analysis of Business model
   – Costs and the Benefits
“Capital” Defines the Capacity for doing business

Small man lifts light weight

Big man lifts heavy weight
“Capital” defines Maneuver Room: don’t hit the wall!
Solvency II, Pillar I. Financial and Capital Requirements

- Principle based, rather than rule-based
- Economic value based approach
- 1-year time horizon, however, valuation reflects future multi-year time horizon
- Diversification across risks and risk mitigation
- Encourage development of internal risk model
Market-Consistent Valuations

Assets

- Available Capital
- Market Value of Assets
- Market Value Margin
- Minimal Capital Requirement

Liabilities

- Excess Capital
- Ladder
- MCR
- MVM
- Best Est Liability
- SCR: = Solvency Capital Requirement
- Market Value of Liabilities

June 7, 2007
swang@ermii.org
Three Tiers of Protection

MVM

MCR $\approx 2 \times \text{MVM}$

SCR $\approx 4 \times \text{MVM}$
4 Levels of Diversification

- **Level 1** -- Within risk types
- **Level 2** -- Across risk types
- **Level 3** -- Across entities, within a given geography
- **Level 4** -- Across geographies or jurisdictions

10 June 2005

A framework for incorporating diversification in the solvency assessment of insurers

The Chief Risk Officer Forum
The Issue

- How to reflect diversification across legal entities?
CRO Forum Finding #1: Ignoring diversification produces deadweight cost

Figure 7. The deadweight cost of excess capital

- Level 1 (within sub-classes only): 145%
- Levels 1 & 2, for operating entities): 100%
- Level 3, within a given country or regulatory region): 84%
- Level 4, total required capital for a group): 74%

45% additional cost if diversification within entities is not recognised
35% deadweight cost if diversification across entities is not recognised
CRO Forum Finding #2

• “Current regulatory solvency approaches for insurance do not adequately take diversification into account, and there are inconsistent approaches across jurisdictions.

• As a result, capital becomes ‘trapped’ in entities where diversification is not recognised, which leads to competitive distortions and a ‘deadweight loss’ to consumers.

• Moreover, it weakens the incentives for good risk management practices.”
CRO Forum Finding #3: Capital mobility and risk transfer should be recognised

Solo Entity level
• The diversification effects within that solo entity
• The formalised support provided by transferability of capital between a Group and the solo entity, or an external party and the solo entity

Insurance Group Level
• Assessed separately
• The diversification effects specific to that Group, taking any constraints to capital mobility into account
• The capital implications of both Group legal structure and any intra-group agreements

June 7, 2007
IASB Position on Risk Margin of Insurance Liabilities

1. Current exit value should be independent of the entity that holds the asset or liability.

2. Risk margins should be determined for each portfolio in isolation and should not consider diversification between portfolios.
Different Views of Supervision of Insurance Groups

**View #1**
- Treat an insurance group as a single economic entity
- Risks can be pooled and diversified.

**View #2**
- Treat the group as a collection of legal entities
- Risks are segregated at local legal entity level
UK FSA View on Supervision of groups

- Subsidiaries within a group should not be required locally to hold capital in excess of MCR.
- Rather, capital in excess of the MCR may be held at group level, for the benefit of subsidiaries.
- The group supervisor oversees the group’s guarantee of its subsidiaries, as well as meeting its SCR and Pillar 2 requirements.
Solvency II Parameters

Minimal Capital Requirement vs. Solvency Capital Requirement

<table>
<thead>
<tr>
<th></th>
<th>Threshold</th>
<th>Multiple</th>
</tr>
</thead>
<tbody>
<tr>
<td>MCR</td>
<td>90%</td>
<td>1.28</td>
</tr>
<tr>
<td>SCR</td>
<td>99.5%</td>
<td>2.58</td>
</tr>
</tbody>
</table>

Level 2 Correlation Matrix

MCR does not have Default

<table>
<thead>
<tr>
<th></th>
<th>Market</th>
<th>Default</th>
<th>Life</th>
<th>Health</th>
<th>NonLife</th>
</tr>
</thead>
<tbody>
<tr>
<td>Market</td>
<td>100%</td>
<td>25%</td>
<td>25%</td>
<td>25%</td>
<td>25%</td>
</tr>
<tr>
<td>Default</td>
<td>25%</td>
<td>100%</td>
<td>25%</td>
<td>25%</td>
<td>50%</td>
</tr>
<tr>
<td>Life</td>
<td>25%</td>
<td>25%</td>
<td>100%</td>
<td>25%</td>
<td>0%</td>
</tr>
<tr>
<td>Health</td>
<td>25%</td>
<td>25%</td>
<td>25%</td>
<td>100%</td>
<td>0%</td>
</tr>
<tr>
<td>NonLife</td>
<td>25%</td>
<td>50%</td>
<td>0%</td>
<td>0%</td>
<td>100%</td>
</tr>
</tbody>
</table>
## Level 1 -- Market Risk Aggregation for SCR

<table>
<thead>
<tr>
<th></th>
<th>Interest Rate</th>
<th>Equity</th>
<th>Property</th>
<th>Spread</th>
<th>Concentration</th>
<th>Foreign Exchange</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interest Rate</td>
<td>100%</td>
<td>0%</td>
<td>50%</td>
<td>25%</td>
<td>0%</td>
<td>25%</td>
</tr>
<tr>
<td>Equity</td>
<td>0%</td>
<td>100%</td>
<td>75%</td>
<td>25%</td>
<td>0%</td>
<td>25%</td>
</tr>
<tr>
<td>Property</td>
<td>50%</td>
<td>75%</td>
<td>100%</td>
<td>25%</td>
<td>0%</td>
<td>25%</td>
</tr>
<tr>
<td>Spread</td>
<td>25%</td>
<td>25%</td>
<td>25%</td>
<td>100%</td>
<td>0%</td>
<td>25%</td>
</tr>
<tr>
<td>Concentration</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>100%</td>
<td>0%</td>
</tr>
<tr>
<td>Foreign Exchange</td>
<td>25%</td>
<td>25%</td>
<td>25%</td>
<td>25%</td>
<td>0%</td>
<td>100%</td>
</tr>
</tbody>
</table>
Level 1 -- Life Insurance Risk Correlation (for SCR)

<table>
<thead>
<tr>
<th>Life.Corr</th>
<th>Mortality</th>
<th>Longevity</th>
<th>Disability</th>
<th>Lapse</th>
<th>Expenses</th>
<th>Revision</th>
<th>CAT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mortality</td>
<td>100%</td>
<td>0%</td>
<td>50%</td>
<td>0%</td>
<td>25%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Longevity</td>
<td>0%</td>
<td>100%</td>
<td>0%</td>
<td>25%</td>
<td>25%</td>
<td>25%</td>
<td>0%</td>
</tr>
<tr>
<td>Disability</td>
<td>50%</td>
<td>0%</td>
<td>100%</td>
<td>0%</td>
<td>50%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Lapse</td>
<td>0%</td>
<td>25%</td>
<td>0%</td>
<td>100%</td>
<td>50%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Expenses</td>
<td>25%</td>
<td>25%</td>
<td>50%</td>
<td>50%</td>
<td>100%</td>
<td>25%</td>
<td>0%</td>
</tr>
<tr>
<td>Revision</td>
<td>0%</td>
<td>25%</td>
<td>0%</td>
<td>0%</td>
<td>25%</td>
<td>100%</td>
<td>0%</td>
</tr>
<tr>
<td>CAT</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>100%</td>
</tr>
</tbody>
</table>
## Level 1 -- Non-Life Correlation Matrix (for SCR)

<table>
<thead>
<tr>
<th>SCR.NonLife.Corr</th>
<th>Worker compensation</th>
<th>Complementary health</th>
<th>Accident and health/default</th>
<th>Motor, third party liability</th>
<th>Motor, other classes</th>
<th>Marine, aviation and transport</th>
<th>Fire and other damage to property</th>
<th>Third-party liability</th>
<th>Credit and suretyship</th>
<th>Legal expenses</th>
<th>Assistanc e</th>
<th>Miscellaneous non-life insurance</th>
<th>NP reins property</th>
<th>NP reins casualty</th>
<th>NP reins MAT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Worker compensation</td>
<td>100%</td>
<td>50%</td>
<td>50%</td>
<td>25%</td>
<td>25%</td>
<td>25%</td>
<td>25%</td>
<td>50%</td>
<td>25%</td>
<td>50%</td>
<td>25%</td>
<td>25%</td>
<td>25%</td>
<td>25%</td>
<td>25%</td>
</tr>
<tr>
<td>Complementary health</td>
<td>50%</td>
<td>100%</td>
<td>50%</td>
<td>25%</td>
<td>25%</td>
<td>25%</td>
<td>25%</td>
<td>50%</td>
<td>25%</td>
<td>50%</td>
<td>25%</td>
<td>25%</td>
<td>25%</td>
<td>25%</td>
<td>25%</td>
</tr>
<tr>
<td>Accident and health/default</td>
<td>50%</td>
<td>50%</td>
<td>100%</td>
<td>25%</td>
<td>25%</td>
<td>25%</td>
<td>25%</td>
<td>50%</td>
<td>25%</td>
<td>50%</td>
<td>25%</td>
<td>25%</td>
<td>25%</td>
<td>25%</td>
<td>25%</td>
</tr>
<tr>
<td>Motor, third party liability</td>
<td>25%</td>
<td>25%</td>
<td>25%</td>
<td>100%</td>
<td>50%</td>
<td>50%</td>
<td>25%</td>
<td>50%</td>
<td>25%</td>
<td>50%</td>
<td>25%</td>
<td>25%</td>
<td>25%</td>
<td>50%</td>
<td>50%</td>
</tr>
<tr>
<td>Motor, other classes</td>
<td>25%</td>
<td>25%</td>
<td>25%</td>
<td>50%</td>
<td>100%</td>
<td>25%</td>
<td>25%</td>
<td>25%</td>
<td>50%</td>
<td>50%</td>
<td>50%</td>
<td>50%</td>
<td>25%</td>
<td>25%</td>
<td>25%</td>
</tr>
<tr>
<td>Marine, aviation and transport</td>
<td>25%</td>
<td>25%</td>
<td>25%</td>
<td>50%</td>
<td>25%</td>
<td>100%</td>
<td>25%</td>
<td>25%</td>
<td>25%</td>
<td>50%</td>
<td>50%</td>
<td>50%</td>
<td>25%</td>
<td>25%</td>
<td>50%</td>
</tr>
<tr>
<td>Fire and other damage to property</td>
<td>25%</td>
<td>25%</td>
<td>25%</td>
<td>25%</td>
<td>25%</td>
<td>25%</td>
<td>100%</td>
<td>25%</td>
<td>25%</td>
<td>50%</td>
<td>50%</td>
<td>50%</td>
<td>25%</td>
<td>50%</td>
<td>50%</td>
</tr>
<tr>
<td>Third-party liability</td>
<td>50%</td>
<td>25%</td>
<td>25%</td>
<td>50%</td>
<td>25%</td>
<td>25%</td>
<td>25%</td>
<td>100%</td>
<td>50%</td>
<td>50%</td>
<td>25%</td>
<td>25%</td>
<td>50%</td>
<td>50%</td>
<td>25%</td>
</tr>
<tr>
<td>Credit and suretyship</td>
<td>25%</td>
<td>25%</td>
<td>25%</td>
<td>25%</td>
<td>25%</td>
<td>25%</td>
<td>25%</td>
<td>50%</td>
<td>100%</td>
<td>50%</td>
<td>25%</td>
<td>25%</td>
<td>50%</td>
<td>50%</td>
<td>50%</td>
</tr>
<tr>
<td>Legal expenses</td>
<td>50%</td>
<td>25%</td>
<td>50%</td>
<td>50%</td>
<td>50%</td>
<td>25%</td>
<td>25%</td>
<td>50%</td>
<td>50%</td>
<td>100%</td>
<td>25%</td>
<td>50%</td>
<td>50%</td>
<td>50%</td>
<td>50%</td>
</tr>
<tr>
<td>Assistance</td>
<td>25%</td>
<td>25%</td>
<td>25%</td>
<td>25%</td>
<td>50%</td>
<td>50%</td>
<td>50%</td>
<td>25%</td>
<td>25%</td>
<td>25%</td>
<td>100%</td>
<td>50%</td>
<td>50%</td>
<td>50%</td>
<td>25%</td>
</tr>
<tr>
<td>Miscellaneous non-life insurance</td>
<td>50%</td>
<td>50%</td>
<td>50%</td>
<td>50%</td>
<td>50%</td>
<td>50%</td>
<td>50%</td>
<td>50%</td>
<td>50%</td>
<td>50%</td>
<td>50%</td>
<td>100%</td>
<td>25%</td>
<td>25%</td>
<td>50%</td>
</tr>
<tr>
<td>NP reins property</td>
<td>25%</td>
<td>25%</td>
<td>25%</td>
<td>25%</td>
<td>25%</td>
<td>25%</td>
<td>50%</td>
<td>25%</td>
<td>25%</td>
<td>25%</td>
<td>25%</td>
<td>25%</td>
<td>50%</td>
<td>50%</td>
<td>25%</td>
</tr>
<tr>
<td>NP reins casualty</td>
<td>25%</td>
<td>25%</td>
<td>25%</td>
<td>25%</td>
<td>25%</td>
<td>25%</td>
<td>50%</td>
<td>50%</td>
<td>50%</td>
<td>50%</td>
<td>25%</td>
<td>25%</td>
<td>25%</td>
<td>25%</td>
<td>100%</td>
</tr>
<tr>
<td>NP reins MAT</td>
<td>25%</td>
<td>25%</td>
<td>25%</td>
<td>25%</td>
<td>25%</td>
<td>50%</td>
<td>50%</td>
<td>25%</td>
<td>25%</td>
<td>25%</td>
<td>25%</td>
<td>25%</td>
<td>25%</td>
<td>25%</td>
<td>100%</td>
</tr>
</tbody>
</table>
Correlation between daily Stock Return and Stock Volatility

Highest volatility & Worse return
Consider Two Bernoulli Risks

- Risk A: \( \Pr\{A=1\}=p_1, \quad \Pr\{A=0\}=1-p_1. \)
- Risk B: \( \Pr\{A=1\}=p_2, \quad \Pr\{A=0\}=1-p_2. \)
- \( E[AB] = \Pr\{A=1, B=1\} = p_{12} \)
  \[ = p_{12} - p_1 * p_2. \]
Define Default Correlation

\[ E[A] = p_1, \quad \sigma[A] = \sqrt{p_1 \times (1-p_1)} \]

\[ E[B] = p_2, \quad \sigma[B] = \sqrt{p_2 \times (1-p_2)} \]

\[
\rho_D = \frac{p_{12} - p_1 \cdot p_2}{\sqrt{p_1 \cdot (1-p_1)} \cdot \sqrt{p_2 \cdot (1-p_2)}}
\]

• The key quantity here is \( p_{12} \), which depends on joint tail probability
Definitions of Tail Dependence

1) Frey /McNeil/ Nyfeler tail correlation

\[ \theta = \lim_{\alpha \to 0^+} \Pr \left\{ X_1 < F_1^{-1}(\alpha) \mid X_2 < F_2^{-1}(\alpha) \right\} 0 \]

\[ p_{12}(\alpha) = \Pr \left\{ X_1 < F_1^{-1}(\alpha), X_2 < F_2^{-1}(\alpha) \right\} \theta \cdot \alpha \]

2) Venter’s tail correlation

\[ p_{12}(\alpha) = \Pr \left\{ X_1 < F_1^{-1}(\alpha), X_2 < F_2^{-1}(\alpha) \right\} L(\alpha) \cdot \alpha^2 \]
I Propose Definition of Corner Correlation

• Joint tail probability at corner \([0, \alpha) \times [0, \alpha)\) implies “Tail Correlation \(\rho(\alpha)\)” by solving

\[
p_{12}(\alpha) = \Phi_2 \left( \Phi^{-1}(\alpha), \Phi^{-1}(\alpha); \rho(\alpha) \right)
\]

• We can define this “Tail Correlation \(\rho(\alpha)\)” for the four corners
4 Corner Correlations as compared to average linear correlation

Corner "Rank" Correlations between "GM" and "GE" daily stock returns

June 7, 2007
swang@ermii.org
100\(\alpha\)% confidence interval for correlation coefficient \(\rho\)

\[
FISHER^{-1}\left( \frac{\ln \frac{1 + r_{xy}}{1 - r_{xy}} - \frac{z_{1-\alpha/2}}{\sqrt{n-3}}}{\frac{1}{2}} \right), \quad FISHER^{-1}\left( \frac{\ln \frac{1 + r_{xy}}{1 - r_{xy}} + \frac{z_{1-\alpha/2}}{\sqrt{n-3}}}{\frac{1}{2}} \right)
\]

\[
FISHER^{-1}(x) = \tanh(z) = \frac{\sinh(x)}{\cosh(x)} = \frac{e^x - e^{-x}}{e^x + e^{-x}} = \frac{e^{2z} - 1}{e^{2z} + 1}
\]

\[
z_{1-\alpha/2} = \Phi^{-1}\left( 1 - \frac{\alpha}{2} \right)
\]

June 7, 2007
swang@ermii.org
Confidence Bands of Correlation

\[ \rho^* = FISHER^{-1}\left( FISHER(\rho) + \frac{1}{\sqrt{n-3}} \cdot \Phi^{-1}\left(1 - \frac{\alpha}{2}\right) \right) \]

Correlation Confidence Intervals
95% Confidence Interval, sample size=15

June 7, 2007
swang@ermii.org
Corr(Equity, Gvt Bond)

Flight to quality: negative correlation

Contagion: positive correlation
Applications in Reinsurance

- Lower correlation across regions and lines of business
  - Uncorrelated individual risk underwriting/pricing
  - Excess layers show lower “linear correlations”
- Volatilities are higher (e.g. excess of loss layers)
- More subject to pricing cycle, unexpected inflation, and catastrophe accumulation
Well Established Diversification

**Assets**
- Money Flows drive value changes
- Asset Valuation: Sector Rotation

**Liabilities**
- Law of large numbers
- Diverse loss drivers
- The foundation of insurance

June 7, 2007
swang@ermii.org
How About Strategic Diversification?

• Analyze the business model
  – Synergy in production or delivery
  – Complexity and Diverted Management Focus

• Bifurcation results:
  – If managed poorly, an asset can turned into liability (diversification destroys value)
  – If managed well, a financial conglomerate can achieve compounding growth! (diversification creates value)
Two Examples of Focus/Diversification

Renaissance Re

• A Catastrophe Insurer in Bermuda
• Concentrate on the CAT business and does a good job at modeling CAT risks
• Diversify through pooling risk perils and geographic exposures

Allstate Insurance Co

• One of the largest personal lines (HO and Auto) insurer in the U.S.
• Focus on personal lines only
• Ceded CAT exposure at very high price
Examples Are Bountiful

• A consulting firm did an RAROC Analysis for an International Reinsurer:
  – Would adding a restaurant business further help the diversification?
• Many small mutual companies were urged to expand to multiple line and multiple states, ended up with massive losses
• European Reinsurers diversified to the US market and lost billions
Mega Transactions explained by business model synergy

Divorcing/Spinning Off

• Citigroup bought traveler’s, and sold after several years of trying to integrate
• General Electric sold Employers Re
• Credit Suisse Group sells Winterthur

New partners

• Travelers Property-Casualty acquired by St Paul
• Travelers Life unit acquired by MetLife
• Employers Re becomes part of Swiss Re
• Winterthur becomes part of AXA

June 7, 2007
swang@ermii.org
Diversification Theory Tested

• Some 20 years ago, a scholar made the following bold prediction:
  – “In 10-15 years time, there would be very few small companies.”

• This is equivalent to saying “In the jungle only tigers and lions can survive in the long run because they are big and strong”

• Such prediction turned out to be wrong!
Personal Auto Liability

Wide Company to company variations

June 7, 2007

swang@ermii.org
General Liability

Wide Company to company variations

CALLS FOR INTERNAL MODEL

June 7, 2007
swang@ermii.org
Regulation should recognize diversification & risk transfer

- Encourage growth of financial conglomerates
  - Revenue diversification in many market segments,
  - Scale of Economy
  - Brand recognition
  - Growth in emerging markets (participate in the wealth creation process)

- Recognize economic-driven risk transfer

- Free up locked capital while maintaining sound solvency
Harmonization: level playing field

Internal Market via Group Diversification

- Risk pooling agreements between subsidiaries
- Group guarantee serves as a stop-loss contract

External Market via Risk Transfer

- Allow for Company Internal Model approach that explicitly quantifies the effect of risk transfer
- Set MCR as the floor

June 7, 2007