The Actuarial Profession
making financial sense of the future

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

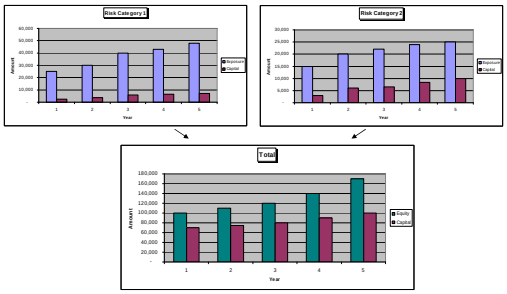
Top Down Approach to Risk Modelling Overview

- 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

Top Down Approach to Risk Modelling Overview

- 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



Top Down Approach to Risk Modelling Uncertainty

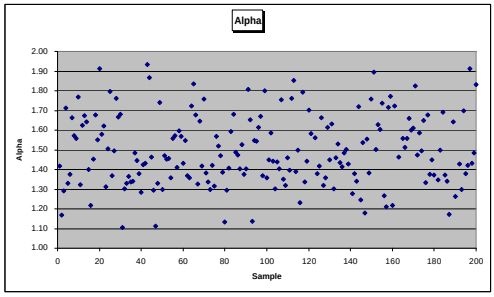
- Uncertainty within any Multi-year Modelling:
  - Parameter Risk
    - Especially when compounding → Dependency Models ?
    - Parameter Penalties (Econometrics) – Over parameterisation ?
  - Model Risk
    - There are many variants before you even consider stochastic
  - Stochastic Risk
    - Do we 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 influences decision now (capital raising)
- More pronounced in the tails ~ Capital loss thresholds

Top Down Approach to Risk Modelling Uncertainty

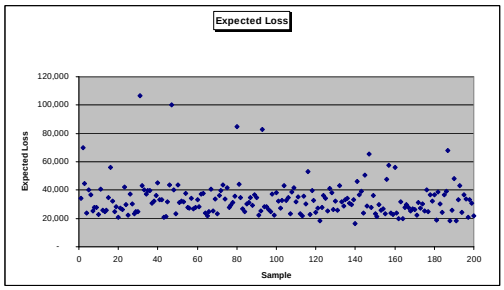
- How often do we get a 12-month Plan right
  - Let alone 3 or 5 years ?
- How good were our 'Best Estimate' Reserves (12 mths)
- We are better placed to predict year 2 in 12-months

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

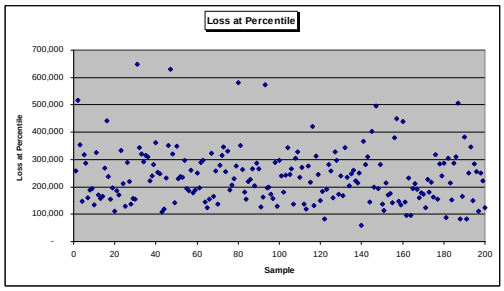
Top Down Approach to Risk Modelling Uncertainty - Samples (50) - Pareto: MLE of α



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

PARETO UNCERTAINTY MODEL

No.of Samples	**200**
Sample Size	**50**

PARETO PARAMETERS

α (Shape)	**1.50**
λ (Scale)	**10000.0**

Percentile	Expected Loss	Loss at 99% ile	Alpha
MODEL	**30,000**	**215,443**	**1.50**
Expected	**33,323**	**238,838**	**1.52**
1% ile	18,381	81,646	2.19
5% ile	20,980	111,351	1.91
10% ile	22,612	130,468	1.79
25% ile	25,389	163,028	1.65
50% ile	31,080	227,244	1.47
75% ile	37,060	288,629	1.37
90% ile	43,459	346,576	1.30
95% ile	53,067	419,872	1.23
99% ile	84,702	580,602	1.13

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 Amounts	31/12/05 € 000s						
ASSETS	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
Intangible Fixed Assets	0	0	0	0	0	0	0
Investments							
Equities	241,403	769	804	840	878	917	959
Government Bonds	822,206	1,503,407	1,579,460	1,795,315	2,013,840	2,219,619	2,407,094
Corporate Bonds	1,122,203	887,171	963,224	1,179,979	1,397,604	1,603,383	1,790,858
Property	5,441	5,192	5,192	5,192	5,192	5,192	5,192
Other	80,676	288,669	288,669	288,669	288,669	288,669	288,669
Total	**2,271,929**	**2,685,208**	**2,837,348**	**3,269,094**	**3,706,183**	**4,117,779**	**4,492,771**
Reinsurance share of Technical Provisions							
Provision for Unearned Premium	160,000	172,570	152,253	116,995	122,817	123,785	126,261
Claims Outstanding	1,600,000	1,569,364	1,370,148	1,288,285	1,215,528	1,134,762	1,014,309
	1,760,000	**1,741,934**	**1,522,411**	**1,405,279**	**1,338,345**	**1,258,547**	**1,140,570**
Debtors							
Debtors - Direct Insurance Operations	687,778	310,432	485,291	549,627	581,106	603,995	614,854
Debtors - Reinsurance Operations	302,604	490,266	342,539	322,071	303,882	283,690	253,579
Other Debtors and Assets incl Taxation	124,381	54,884	69,794	82,444	87,166	90,599	92,228
	1,114,763	**855,572**	**877,624**	**954,142**	**972,153**	**978,285**	**960,661**
Other Assets							
Tangible Assets	8,696	9,994	11,632	13,741	14,528	15,100	15,371
Cash at bank and in hand	412,384	112,847	112,847	112,847	112,847	112,847	112,847
	421,080	**122,841**	**124,479**	**126,588**	**127,375**	**127,947**	**128,219**
Prepayments and Accrued Income							
Accrued Interest and Rent	13,112	17,054	11,632	13,741	14,528	15,100	15,371
Prepaid and Deferred Expenses	12,682	6,168	11,632	13,741	14,528	15,100	15,371
Defered Acquisition Costs	45,016	37,996	44,745	41,915	44,853	46,420	47,349
	70,790	**60,758**	**68,009**	**69,396**	**73,908**	**76,620**	**78,091**
TOTAL ASSETS	**5,648,561**	**5,466,313**	**5,429,871**	**5,824,400**	**6,217,964**	**6,559,178**	**6,800,318**

Top Down Approach to Risk Modelling Business Plan – Liabilities: Balance Sheet

XYZ Insurance Company
Balance Sheet
Date 31/12/05
Amounts € 000s

LIABILITIES	2004	2005	2006	2007	2008	2009	2010
Capital and Reserves							
Share Capital	518,314	518,315	518,315	518,315	518,315	518,315	518,315
Retained Profits	16,646	66,278	171,448	285,512	374,747	488,126	613,553
	534,960	**584,593**	**689,763**	**803,826**	**893,062**	**1,006,441**	**1,131,868**
Technical provisions							
Provisions for Unearned Premiums	666,000	638,294	647,766	616,393	658,486	667,115	680,458
Claims Outstanding	3,344,422	3,464,660	3,267,312	3,433,696	3,640,456	3,819,750	3,902,985
Equalisation Reserves	2,121	2,350	2,350	2,350	2,350	2,350	2,350
	4,012,543	**4,105,304**	**3,917,428**	**4,052,439**	**4,301,292**	**4,489,215**	**4,585,794**
Provision for Other Risks and Charges	12,352	0	0	0	0	0	0
Creditors							
Creditors - Direct Insurance Operations	144,381	89,259	116,323	137,407	145,276	150,999	153,714
Creditors - Reinsurance Operations	621,689	537,710	523,452	618,331	653,744	679,495	691,711
Other Creditors incl Taxation	216,752	86,392	145,403	171,759	181,596	188,749	192,142
	982,823	**713,361**	**785,178**	**927,496**	**980,616**	**1,019,242**	**1,037,567**
Accruals and deferred income							
Deferred Reinsurance Commisions	86,164	8,213	8,422	6,287	6,676	6,531	6,661
Accruals and Deferred Income	19,719	54,842	29,081	34,352	36,319	37,750	38,428
	105,883	**63,055**	**37,503**	**40,639**	**42,995**	**44,280**	**45,090**
TOTAL LIABILITIES	**5,648,561**	**5,466,313**	**5,429,871**	**5,824,400**	**6,217,964**	**6,559,178**	**6,800,318**

Top Down Approach to Risk Modelling Business Plan – Insurance P&L

XYZ Insurance Company
P&L for: All Lines of Business
Date 31/12/05
Amounts € 000s

EARNED PREMIUMS, NET OF REINSURANCE	2005	2006	2007	2008	2009	2010
Gross Written Premium		1,659,241	1,753,539	1,889,129	1,923,976	1,962,456
Ceded Written Premium		(466,225)	(375,585)	(400,095)	(406,326)	(414,453)
Net Written Premium		**1,193,015**	**1,377,954**	**1,489,035**	**1,517,650**	**1,548,003**
Change in the Provisions for Unearned Premiums						
Gross UPR		(9,472)	31,373	(42,093)	(8,629)	(13,343)
Prepaid RI Premium Reserve		(20,317)	(35,258)	5,822	968	2,476
Change in Net UPR		**(29,789)**	**(3,886)**	**(36,271)**	**(7,661)**	**(10,867)**
Net Earned Premiums		**1,163,226**	**1,374,068**	**1,452,764**	**1,509,988**	**1,537,136**
CLAIMS INCURRED, NET OF REINSURANCE						
Claims Paid						
Gross Paid		(1,236,780)	(1,091,443)	(1,157,207)	(1,232,153)	(1,354,087)
RI Paid		452,854	364,504	352,800	371,025	415,871
Net Paid Claims		**(783,926)**	**(726,939)**	**(804,407)**	**(861,127)**	**(938,217)**
Change in the Provisions for Claims						
Gross Reserves		197,348	(166,384)	(206,760)	(179,294)	(83,236)
RI Reserves		(199,206)	(81,873)	(72,756)	(80,766)	(120,447)
Net Reserves		**(1,858)**	**(248,257)**	**(279,517)**	**(260,060)**	**(203,683)**
Net Claims Incurred		**(785,784)**	**(975,196)**	**(1,083,924)**	**(1,121,187)**	**(1,141,899)**
NET COMMISSION AND EXPENSES						
Paid Commission and Expenses						
Gross Commission		(164,586)	(155,644)	(166,766)	(172,045)	(175,486)
Administration Expenses		(209,798)	(233,124)	(250,281)	(253,331)	(258,398)
RI Commission		18,294	18,428	19,676	19,513	19,903
Net Commission and Expenses		**(356,090)**	**(370,340)**	**(397,371)**	**(405,864)**	**(413,981)**
Change in the Provisions for Commission and Expenses						
Gross Commission		7,149	(2,930)	3,039	1,567	928
RI Commission		(209)	2,135	(389)	145	(131)
Net Commission and Expense Reserves		**6,940**	**(795)**	**2,650**	**1,712**	**798**
Net Earned Commission and Expenses		**(349,149)**	**(371,136)**	**(394,721)**	**(404,152)**	**(413,183)**
OTHER INCOME AND EXPENSES						
Other Income		0	5,710	6,296	6,422	6,550
Other Expenses		(128)	147	(2,934)	0	0
Other Income and Expenses		**(128)**	**5,857**	**3,362**	**6,422**	**6,550**
Change in Equalisation Provision						
UNDERWRITING RESULT						
Underwriting Result		**28,164**	**33,594**	**(22,519)**	**(8,929)**	**(11,397)**

Top Down Approach to Risk Modelling Business Plan – Profit and Loss Account

XYZ Insurance Company
P&L: Non-Technical Account
Date 31/12/05
Amounts € 000s

UNDERWRITING RESULT	2005	2006	2007	2008	2009	2010
Underwriting Result (Insurance P&L)	**28,314**	**28,164**	**33,594**	**(22,519)**	**(8,929)**	**(11,397)**
INVESTMENT RETURNS						
Investment Income	38,434	124,493	131,992	153,273	174,817	195,105
Capital Gains / (Losses) on Investments	(2,102)	35	36	38	40	41
Investment Expenses and Charges	(1,478)	(3,735)	(3,960)	(4,598)	(5,245)	(5,853)
Investment Returns	**34,854**	**120,793**	**128,068**	**148,712**	**169,612**	**189,293**
OTHER INCOME NET OF OTHER CHARGES						
Foreign Exchange Gains / (Losses)	53,806	0	0	0	0	0
Other Income, net of other charges	(972)	0	0	0	0	0
Other Income, Net of Other Charges	**52,834**	**0**	**0**	**0**	**0**	**0**
TAX						
Profit / (Loss) before Tax	**116,002**	**148,957**	**161,662**	**126,194**	**160,684**	**177,897**
Tax Deductible items	(69,148)	(3,000)	(3,000)	(3,000)	(3,000)	(3,000)
Taxable Losses brought forward	0	0	0	0	0	0
Taxable Profit	46,854	145,957	158,662	123,194	157,684	174,897
Tax (Profit) / Credit (Loss)	(7,028)	**0**	**0**	**0**	**0**	**0**
PROFIT / (LOSS) AND RETAINED PROFIT						
Profit / (Loss) after Tax	**101,946**	**105,170**	**114,063**	**89,236**	**113,379**	**125,428**
Extraordinary items	0	0	0	0	0	0
Dividends	0	0	0	0	0	0
Retained Profit after Tax	**101,946**	**105,170**	**114,063**	**89,236**	**113,379**	**125,428**

Top Down Approach to Risk Modelling
Business Plan – Cash-flow Model

XYZ Insurance Company
Cashflow Model
Date 31/12/05
Amounts € 000s

Year	2006	2007	2008	2009	2010
PREMIUMS, CLAIMS AND EXPENSES					
Gross Written Premium	1,659,241	1,753,539	1,889,129	1,923,976	1,962,456
RI Written Premium	(466,225)	(375,585)	(400,095)	(406,326)	(414,453)
Gross Paid	(1,236,780)	(1,091,443)	(1,157,207)	(1,232,153)	(1,354,087)
RI Paid	452,854	364,504	352,800	371,025	415,871
Gross Commission	(164,586)	(155,644)	(166,766)	(172,045)	(175,486)
Administration Expenses	(209,798)	(233,124)	(250,281)	(253,331)	(258,398)
RI Commission	18,294	18,428	19,676	19,513	19,903
Investment Expenses and Charges	(3,735)	(3,960)	(4,598)	(5,245)	(5,853)
Other Income and Expenses (Insurance P&L)	(128)	5,857	3,362	6,422	6,550
Other Income and Expenses (P&L Account)	0	0	0	0	0
Premiums, Claims and Expenses	**49,136**	**282,572**	**286,021**	**251,836**	**196,502**
INVESTMENT INCOME					
Equities	25	27	28	29	30
Government Bonds (< 5 years)	38,968	40,442	44,624	48,857	52,844
Government Bonds (>= 5 years)	25,510	27,458	32,990	38,589	43,863
Corporate Bonds (< 5 years)	15,698	17,703	23,393	29,154	34,579
Corporate Bonds (>= 5 years)	32,091	34,161	40,037	45,986	51,587
Property	156	156	156	156	156
Other	8,660	8,660	8,660	8,660	8,660
Cash	3,385	3,385	3,385	3,385	3,385
Investment Income	**124,493**	**131,992**	**153,273**	**174,817**	**195,105**
BALANCE SHEET MOVEMENTS					
(Increase in Intangible Fixed Assets)	0	0	0	0	0
(Increase in Debtors)	(22,052)	(76,519)	(18,011)	(6,132)	17,624
(Increase in Other Assets)	(1,638)	(2,108)	(787)	(572)	(271)
(Increase in Accrued Income and Prepayments)	(103)	(4,217)	(1,574)	(1,144)	(543)
Increase in Creditors	71,817	142,318	53,120	38,626	18,324
Increase in Accruals and Deferred Income	(25,761)	5,271	1,967	1,431	679
Tax	(43,787)	(47,599)	(36,958)	(47,305)	(52,469)
Extraordinary items	0	0	0	0	0
Dividends	0	0	0	0	0
Capital Injections	0	0	0	0	0
Balance Sheet Movements	**(21,524)**	**17,146**	**(2,243)**	**(15,096)**	**(16,656)**
Cashflow	**152,105**	**431,710**	**437,051**	**411,557**	**374,951**

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

Top Down Approach to Risk Modelling
Risk Algorithms – Insurance Risk (LOB)

- Underwriting Risk
  - Attritional 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
    - Understating 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

Capital by Risk Category

LOB / Risk Type	Risk Category	Diversification Before	Diversification After
Credit Risk	Credit	50,000	
Investments	Credit	15,000	
Investments	Market	25,000	
Line of Business 1	Insurance	20,000	
Line of Business 2	Insurance	25,000	
Line of Business 3	Insurance	5,000	
Line of Business 4	Insurance	45,000	
Line of Business 5	Insurance	30,000	
Line of Business 6	Insurance	20,000	
Line of Business 7	Insurance	10,000	
Line of Business 8	Insurance	15,000	
Line of Business 9	Insurance	20,000	
Operational Risk	Operational	25,000	
Liquidity Risk	Liquidity	1,000	
Diversified Capital		**306,000**	**270,000**
Economic Equity			**450,000**

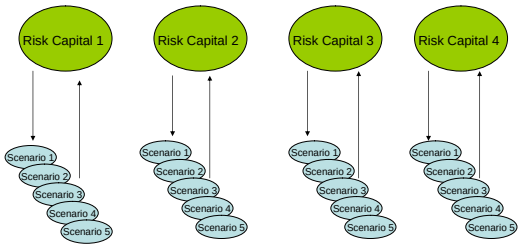
Top Down Approach to Risk Modelling
What you Have vs What you Need

- Not the GAAP Equity or Net Asset Value
  - Economic Equity = PV Assets – PV Liabilities
- What you Have:
  - GAAP Equity (~ Assets – Liabilities)
  - Value of Reserve Discount
    - 'Double Counting' of Reserve Risk Capital
  - Claims Equalisation Reserve ("Capital")
  - Present Value of Future Profits (Modelling Period)
- Comparison Easier over 1 year
- What you Need
  - ICA
- Timeframes Needs to be Consistent

Linking Risk Assessment to Risk Quantification Topics

- Scenarios
- Implicit and Explicit Modelling
- Integration of Scenario and Stochastic pieces

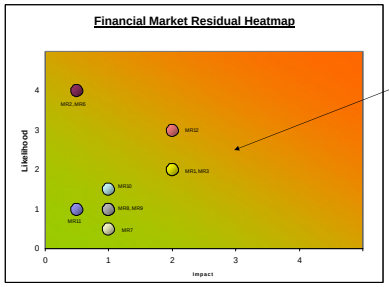
Linking Risk Assessment to Risk Quantification Scenarios – Top Down vs Ground Up



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)



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

Risk Category	RMF or FSA Risks	Scenarios	Stochastic	Comments
Insurance Risk				
	Description 1	E		
	Description 2		E	
	Description 3	E	I	
	Description 4		I	
Market Risk				
	Description 1			
	Description 2	E		
Credit Risk				
	Description 1	I	I	
	Description 2			
Opearional Risk				
	Description 1	E		
	Description 2			
Liquidity Risk				
	Description 1			
	Description 2			

RMF = Risk Management Framework (Company Risk Assessment)

Examples
Topics

- Credit Risk
- Aggregation

Examples
Credit Risk – Capital (Reinsurers ‘A’ Rated)

CREDIT RISK CAPITAL MODEL

No. of Simulations	100,000
No. of Reinsurers	10
Asset Correlation	35%
Confidence Level	99.5%

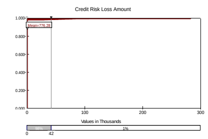
OUTPUTS	CREDIT LOSS Amount	Number
Minimum	0	0
Maximum	216,000	4
Expected	**776**	**0.01**
Std Deviation	7,585	0.13
Skewness	11.74	11.04
Kurtosis	171.03	153.58
VaR @ 99.5%	**65,224**	**0.99**
TailVaR @ 99.5%	**86,074**	**1.25**

Percentiles	Amount	Number
5.0 %ile	-	-
10.0 %ile	-	-
15.0 %ile	-	-
20.0 %ile	-	-
25.0 %ile	-	-
30.0 %ile	-	-
35.0 %ile	-	-
40.0 %ile	-	-
45.0 %ile	-	-
50.0 %ile	-	-
55.0 %ile	-	-
60.0 %ile	-	-
65.0 %ile	-	-
70.0 %ile	-	-
75.0 %ile	-	-
80.0 %ile	-	-
85.0 %ile	-	-
90.0 %ile	-	-
95.0 %ile	-	-
99.0 %ile	**42,000**	**1**
99.1 %ile	42,000	1
99.2 %ile	48,000	1
99.3 %ile	54,000	1
99.4 %ile	60,000	1
99.5 %ile	**66,000**	**1**
99.6 %ile	72,000	1
99.7 %ile	78,000	1
99.8 %ile	84,000	1
99.9 %ile	90,000	2

REINSURANCE EXPOSURE

VaR @ 99.5%	**65,224**
% Credit Risk exposure	**6.9%**

No.	Reinsurer	Exposure	Rating	POD	LGD
1	A	50,000	A	0.136%	60.000%
2	B	60,000	A	0.136%	60.000%
3	C	70,000	A	0.136%	60.000%
4	D	80,000	A	0.136%	60.000%
5	E	90,000	A	0.136%	60.000%
6	F	100,000	A	0.136%	60.000%
7	G	110,000	A	0.136%	60.000%
8	H	120,000	A	0.136%	60.000%
9	I	130,000	A	0.136%	60.000%
10	J	140,000	A	0.136%	60.000%
Total		**950,000**			



Examples
Credit Risk – Capital (Reinsurers ‘BBB’ Rated)

CREDIT RISK CAPITAL MODEL

No. of Simulations	100,000
No. of Reinsurers	10
Asset Correlation	35%
Confidence Level	99.5%

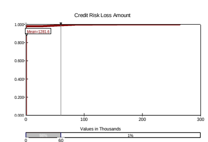
OUTPUTS	CREDIT LOSS Amount	Number
Minimum	0	0
Maximum	264,000	5
Expected	**1,282**	**0.02**
Std Deviation	9,836	0.17
Skewness	9.43	8.96
Kurtosis	114.48	107.61
VaR @ 99.5%	**76,718**	**0.98**
TailVaR @ 99.5%	**97,958**	**1.46**

Percentiles	Amount	Number
5.0 %ile	-	-
10.0 %ile	-	-
15.0 %ile	-	-
20.0 %ile	-	-
25.0 %ile	-	-
30.0 %ile	-	-
35.0 %ile	-	-
40.0 %ile	-	-
45.0 %ile	-	-
50.0 %ile	-	-
55.0 %ile	-	-
60.0 %ile	-	-
65.0 %ile	-	-
70.0 %ile	-	-
75.0 %ile	-	-
80.0 %ile	-	-
85.0 %ile	-	-
90.0 %ile	-	-
95.0 %ile	-	-
99.0 %ile	**60,000**	**1**
99.1 %ile	66,000	1
99.2 %ile	66,000	1
99.3 %ile	72,000	1
99.4 %ile	72,000	1
99.5 %ile	**78,000**	**1**
99.6 %ile	78,000	1
99.7 %ile	84,000	1
99.8 %ile	84,000	2
99.9 %ile	120,000	2

REINSURANCE EXPOSURE

VaR @ 99.5%	**76,718**
% Credit Risk exposure	**8.1%**

No.	Reinsurer	Exposure	Rating	POD	LGD
1	A	50,000	BBB	0.225%	60.000%
2	B	60,000	BBB	0.225%	60.000%
3	C	70,000	BBB	0.225%	60.000%
4	D	80,000	BBB	0.225%	60.000%
5	E	90,000	BBB	0.225%	60.000%
6	F	100,000	BBB	0.225%	60.000%
7	G	110,000	BBB	0.225%	60.000%
8	H	120,000	BBB	0.225%	60.000%
9	I	130,000	BBB	0.225%	60.000%
10	J	140,000	BBB	0.225%	60.000%
Total		**950,000**			



Examples
Credit Risk – Capital (Reinsurers ‘BB’ Rated)

CREDIT RISK CAPITAL MODEL

No. of Simulations	100,000
No. of Reinsurers	10
Asset Correlation	35%
Confidence Level	99.5%

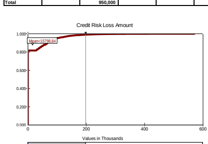
OUTPUTS	CREDIT LOSS Amount	Number
Minimum	0	0
Maximum	570,000	10
Expected	**15,798**	**0.28**
Std Deviation	41,423	0.71
Skewness	3.78	3.74
Kurtosis	22.34	22.25
VaR @ 99.5%	**230,202**	**3.72**
TailVaR @ 99.5%	**290,322**	**4.92**

Percentiles	Amount	Number
5.0 %ile	-	-
10.0 %ile	-	-
15.0 %ile	-	-
20.0 %ile	-	-
25.0 %ile	-	-
30.0 %ile	-	-
35.0 %ile	-	-
40.0 %ile	-	-
45.0 %ile	-	-
50.0 %ile	-	-
55.0 %ile	-	-
60.0 %ile	-	-
65.0 %ile	-	-
70.0 %ile	-	-
75.0 %ile	-	-
80.0 %ile	-	-
85.0 %ile	42,000	1
90.0 %ile	66,000	1
95.0 %ile	90,000	2
99.0 %ile	**198,000**	**3**
99.1 %ile	204,000	3
99.2 %ile	210,000	4
99.3 %ile	222,000	4
99.4 %ile	234,000	4
99.5 %ile	**246,000**	**4**
99.6 %ile	258,000	4
99.7 %ile	276,000	5
99.8 %ile	306,000	5
99.9 %ile	354,000	6

REINSURANCE EXPOSURE

VaR @ 99.5%	**230,202**
% Credit Risk exposure	**24.2%**

No.	Reinsurer	Exposure	Rating	POD	LGD
1	A	50,000	BB	2.772%	60.000%
2	B	60,000	BB	2.772%	60.000%
3	C	70,000	BB	2.772%	60.000%
4	D	80,000	BB	2.772%	60.000%
5	E	90,000	BB	2.772%	60.000%
6	F	100,000	BB	2.772%	60.000%
7	G	110,000	BB	2.772%	60.000%
8	H	120,000	BB	2.772%	60.000%
9	I	130,000	BB	2.772%	60.000%
10	J	140,000	BB	2.772%	60.000%
Total		**950,000**			



Examples
Credit Risk – Results Summary

CREDIT RISK SUMMARY

	A	BB	BBB
Expected Loss	776	1,282	15,798
VaR @ 99.5%	65,224	76,718	230,202
TVaR @ 99.5%	86,074	97,958	290,322
Exposure	950,000	950,000	950,000
VaR @ 99.5% / Exposure	**6.9%**	**8.1%**	**24.2%**

No. of Reinsurers	10
No.of Simulations	100,000
Reinsurer Correlation	35%

Examples
Credit Risk – Observations

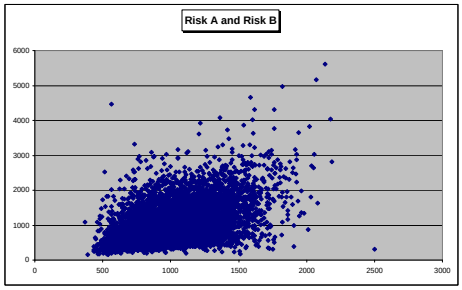
- Exposure over 12-months – weighted average of
  - Run-off of BS Values plus RI Exposure from new business
  - Exposure - Deterministic or Stochastic (Gross Losses)
- Large Credit Risk contribution from BS run-off
  - Larger exposure / Some ratings below new business criteria
  - IBNR Allocation by 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

LogNormal	Risk A	Risk B
Expected Loss	**1,000**	**1,000**
Std Dev	250	500
Variance	62,500	250,000
C.V.	**25%**	**50%**
Mu	6.8774	6.7962
Sigma	0.2462	0.4724

- 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%)

LogNormal	Risk A	Risk B	Total	Implied Correlation
Expected	1,000	1,000	2,000	
Standard Deviation	250	500	602	**20.0%**
CV	**25.0%**	**50.0%**	**30.1%**	
Skewness	0.7659	1.6339	1.3505	
Percentiles				
95% ile	1,453	1,946	3,103	
99% ile	1,719	2,684	3,943	**58.4%**
99.5% ile	1,828	3,022	4,334	**57.1%**
Value at Risk				
95% ile	453	946	1,103	
99% ile	719	1,684	1,943	**17.4%**
99.5% ile	828	2,022	2,334	**20.1%**
Correlation Coefficient	**20%**			
Copula:	**T-Copula 5 d.f.**			
Number of Simulations	**2,500,000**			

Examples
Aggregation – Implied Correlation (50%)

LogNormal	Risk A	Risk B	Total	Implied Correlation
Expected	1,000	1,000	2,000	
Standard Deviation	250	500	659	**48.7%**
CV	**25.0%**	**50.0%**	**33.0%**	
Skewness	0.7659	1.6349	1.3398	
Percentiles				
95% ile	1,453	1,945	3,215	
99% ile	1,719	2,682	4,126	**74.4%**
99.5% ile	1,828	3,022	4,553	**74.7%**
Value at Risk				
95% ile	453	945	1,215	
99% ile	719	1,682	2,126	**48.2%**
99.5% ile	828	2,022	2,553	**52.1%**
Correlation Coefficient	**50%**			
Copula:	**T-Copula 5 d.f.**			
Number of Simulations	**2,500,000**			

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')

LogNormal	Risk 1	Risk 2
Expected	1,000	1,000
Standard Deviation	250	250
CV	**25.0%**	**25.0%**
Mu	6.8774	6.8774
Sigma	0.2462	0.2462
Percentiles		
95.0% ile	1,455	1,455
99.0% ile	1,720	1,720
99.5% ile	1,829	1,829
Value at Risk		
95.0% ile	455	455
99.0% ile	720	720
99.5% ile	829	829

Correlation for Loss @ 99.5%	Amount of Loss @ 99.5%	Correlation for VaR @ 99.5%	Amount of VaR @ 99.5%
50.0%	3,168	**(0.7%)**	1,168
55.0%	3,221	**8.4%**	1,221
60.0%	3,272	**17.7%**	1,272
65.0%	3,323	**27.3%**	1,323
70.0%	3,373	**37.1%**	1,373
75.0%	3,422	**47.1%**	1,422
80.0%	3,471	**57.3%**	1,471

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

LogNormal	Risk 1	Risk 2
Expected	1,000	1,000
Standard Deviation	250	500
CV	**25.0%**	**50.0%**
Mu	6.8774	6.7962
Sigma	0.2462	0.4724
Percentiles		
95.0% ile	1,455	1,945
99.0% ile	1,720	2,684
99.5% ile	1,829	3,020
Value at Risk		
95.0% ile	455	945
99.0% ile	720	1,684
99.5% ile	829	2,020

Correlation for Loss @ 99.5%	Amount of Loss @ 99.5%	Correlation for VaR @ 99.5%	Amount of VaR @ 99.5%
50.0%	4,241	**7.7%**	2,241
55.0%	4,306	**16.4%**	2,306
60.0%	4,370	**25.3%**	2,370
65.0%	4,432	**34.3%**	2,432
70.0%	4,494	**43.4%**	2,494
75.0%	4,555	**52.6%**	2,555
80.0%	4,616	**61.9%**	2,616

Examples
Aggregation – Implied Correlation (2x 'B')

LogNormal	Risk 1	Risk 2
Expected	1,000	1,000
Standard Deviation	500	500
CV	**50.0%**	**50.0%**
Mu	6.7962	6.7962
Sigma	0.4724	0.4724
Percentiles		
95.0% ile	1,945	1,945
99.0% ile	2,684	2,684
99.5% ile	3,020	3,020
Value at Risk		
95.0% ile	945	945
99.0% ile	1,684	1,684
99.5% ile	2,020	2,020

Correlation for Loss @ 99.5%	Amount of Loss @ 99.5%	Correlation for VaR @ 99.5%	Amount of VaR @ 99.5%
50.0%	5,230	**27.9%**	3,230
55.0%	5,317	**34.8%**	3,317
60.0%	5,402	**41.8%**	3,402
65.0%	5,486	**48.9%**	3,486
70.0%	5,568	**56.0%**	3,568
75.0%	5,650	**63.2%**	3,650
80.0%	5,730	**70.5%**	3,730

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