Society of Actuaries in Ireland

Introduction to Operational Risk Modelling

21 September 2015

Disclaimer

The views expressed in this presentation are those of the presenters and not necessarily of the Society of Actuaries in Ireland

Agenda

- Scope, Context, Basel II and Solvency II
- Some observations on UK experience
- Advanced Measurement Approach
- Operational risk modelling in Insurance
- Example of Loss Distribution Approach
- Other considerations

Context

“We made too many wrong mistakes” –
Lawrence ‘Yogi’ Berra NY Yankees

People : Systems : Processes : External Events

- Operational risk events can damage/destroy a company
- Good Governance, Control and Avoidance of op risk is the first remedy
- Assessing exposure and capital is important
  - Operational risk modeling is about more than just that

Scope

- What's in a model?
  - Internal Model
  - Standard formula/approach
  - Risk Scores
  - Scenario input/output
- Why Model….
  - Manage Monitor Rank Risks Risk Appetites/Mandates
  - Set Capital/Reserves
  - Assess and manage (Re) Insurance needs
  - Assess suitability of Standard Formula under Solvency II
  - Regulatory requirement/pressure for line of business

So many papers….Where to Start???

An Operational Risk Profile: The Experience of British Firms Imad Moosa and Li Larry

Operational risk management – a statistical perspective
Francesca Ieva; Anna Maria Paganoni; Stefano Ziller

Operational Risk Management for Insurers
Torre-Enciso, Maria Isabel Martínez; Barros, Rafael Hernandez

Operational Risks in Financial Sectors
E. Karam; F. Planchet

Information asymmetry around operational risk announcements
Barakat, Ahmed; Chernobai, Anna; Wahrenburg, Mark

Operational risk Jarrow, Robert A

THIS IS JUST A SAMPLE!!

Operational risk quantification: a risk flow approach
Finke, Gandolf R; Singh, Mahender; Rachev, Svetlozar T

Principles for the Sound Management of Operational Risk - final document
Bank for International Settlement

Review of the Principles for the Sound Management of Operational Risk
Bank for International Settlement
October 2014

Principles for effective risk data aggregation and risk reporting
Basel Committee of Banking Supervision

Operational Risk – Supervisory Guidelines for the Advanced Measurement Approaches
Basel Committee of Banking Supervision

Scenario analysis in the measurement of operational risk capital: a change of measure approach
Dutta, Kabir K; Babbel, David F

A Theoretical Framework for Incorporating Scenarios into Operational Risk Modelling
Bakhodir A. Ergashev

Combining scenario analysis with loss data in operational risk quantification
Cope, Eric W

Modelling operational risk in financial institutions using hybrid dynamic Bayesian network
Martin Neil, Lasse B, Andersen, David Hager

Scenario analysis for modelling operational losses in the absence of data: the Spanish bank in perspective
Jiménez-Rodríguez, Enrique José; Feria-Domínguez, José Manuel; Martín-Marín, José Luis

Basel II Op Risk Capital Charge

BASIC INDICATOR APPROACH

Σ avg 3 yr Gross income x α

α is 15%

STANDARDISED APPROACH

Σ avg 3 yr Gross income x β

β for each business line is

Corporate Finance Trading and Sales Payment And Settlement	18%
Commercial Banking Agency Services	15%
Retail Banking Retail Brokerage Asset Management	12%

ADVANCED MEASUREMENT APPROACH

Regulator approved internal risk model requiring these inputs

Internal Loss Data
External Loss Data
Scenario Analysis
Business Environment Internal Control Factors

Revisions proposed Oct 2014 not reflected above

Basel II Calibration

So how did they come up with the α and β factors?

Working Paper on the Regulatory Treatment of Operational Risk

Sept 2001 BIS.org

- Considered Median Ratio of op risk economic capital to overall economic capital c 15% and minimum regulatory capital 12.8% (MRC=8 % of reported risk-weighted assets)

Basel II Calibration Basic Indicator Approach

- Assume capital charge 12% minimum regulatory capital
- QIS data MRC and Gross income (GI) for bank j time t (1998-2000) 355 banks
- $\alpha j,t = 0.12 * MRCj,t / GIj,t$
- => α range 17-20%

Basel II Calibration Standardized Approach

- Assume capital charge 12% minimum regulatory capital, allocate to Lines of Business
- $\beta j,i = 0.12 * MRCj * OpRiskSharej,I / GI\ j,i$
- OpRiskSharej,i is the share of bank j's operational risk economic capital allocated to business line i
- GIj,i is the volume of gross income in business line i for bank j
- <30 banks

Solvency II $SCR_{operational}$

STANDARD FORMULA

Article 204 Delegated Acts:-

$$SCR_{Operational} = \min(0.3 \cdot BSCR; Op) + 0.25 \cdot Exp_{ul}$$

$$Op = \max(Op_{premiums}; Op_{provisions})$$

$$Op_{premiums} \quad 0.04 \cdot (Earn_{life} - Earn_{life\text{-}ul}) + 0.03 \cdot Earn_{non\text{-}life} + \max(0; 0.04 \cdot (Earn_{life} - 1.2 \cdot pEarn_{life} - (Earn_{life\text{-}ul} - 1.2 \cdot pEarn_{life\text{-}ul}))) + \max(0; 0.03 \cdot (Earn_{non\text{-}life} - 1.2 \cdot pEarn_{non\text{-}life}))$$

$$Op_{provisions} \quad 0.0045 \bullet \max(0; TP_{life} - TP_{life\text{-}ul}) + 0.03 \bullet \max(0; TP_{non\text{-}life})$$

No diversification against other Risk Categories

INTERNAL MODEL

Chapter VI Delegated Acts:-

Use test

Statistical quality standards

Calibration standards

Integration of partial internal models

Profit and loss attribution

Validation standards

Documentation standards

External models and data

Proportionality, Expert judgement, Materiality/Approximations

Diversifcation within and across risk categories possible

Solvency II Calibration

- CEIOPS-SEC-40-10 , 15 April 2010
- 4 Analyses/References considered, all indicated QIS4 factors too low

1. Internal model data from 32 entities, 5 EU countries -> pre diversification charge
2. CRO Forum Study => double QIS4 parameters
3. ABI study -> QIS4, ICA 7 life 6 non-life, extensive spread of data including for example #FTE
4. FSA -> ICA data from 15 life 13 non-life

Solvency II Calibration

- Analysis 1 output (CEIOPS recommended)

Measure	Factor	PreDiv 50% percentile	CEIOPS Recommendation	S2 Final Parameter
Premiums	Plife_f	5.44%	5.50%	4.00%
	Pnl_f	3.80%	3.80%	3.00%
Technical Provisions	TPlife_f	0.59%	0.60%	0.45%
	TPnl_f	3.55%	3.60%	3.00%
UL Expense	UL_f	n/a	25.00%	25.00%
BSCR Cap			30.00%	30.00%

Potentially useful observations

"You can observe a lot just by watching" –
Yogi Berra NY Yankees

Some Observations from UK Firms' experience

- 163 major op losses 1999-2008

1. **Loss Severity and frequency depend on business line and entity type**
2. The decline in the market value of a firm following the announcement of an operational loss may or may not be greater than the loss amount.
3. Loss severity and the decline in market value relative to the loss amount are not necessarily greater when the loss results from internal fraud.
4. Loss severity does not depend on the announcing firm's size.
5. The decline in market value does not depend on the loss amount.
6. The decline in market value relative to the loss amount is unrelated to leverage but it is positively related to size.

Source An Operational Risk Profile: The Experience of British Firms
Imad Moosa and Li Larry 2013

Some Observations from UK insurance experience

- #Events is proportional to Entity Size
- #Events is proportional to GWP
  - GWP up by Stn deviation (£3.7bln) => E(N) up by 25%
  - Low GWP=> p(N>9) 4%
  - High GWP=> p(N>9) 12%
- Severity is proportional to Entity Size
- Severity is proportional to FTE
  - 1% rise in FTE => 0.8% increase in E(X)

Source ABI Research Paper No. 16.pdf 2009

Basel II Advanced Measurement Approach

1. Internal Data
2. External Data
3. Scenario Analysis
4. Business Environment Internal Control Factors (BEICF)

- Requirements
  - Data period (5+ years)
  - 99.9% 1 year confidence interval
  - Rules & Cap on insurance mitigation
  - Other mitigation rules
  - Governance frameworks, independent audit

Supervisory Guidelines for
the Advanced Measurement Approaches (Basel Committee, 2011)

AMA: Internal Loss Data

- Estimation of loss frequencies
- Inform the severity distribution(s) to the extent possible
- Input into scenario analysis
- Limited tail events => external /scenario

AMA: External Loss Data

- Complement internal data to model severity
- More tail info
- Input into scenario analysis

AMA: Scenario Analysis

- Inputs include
  - Internal data
  - External data
  - BEICFS
- Forward looking view of op risk exposures
- Requires scenario framework
- Deal with Bias – e.g. anchoring

AMA: Business Environment & Internal Control Factors

- Internal/External data retrospective
- BEICF are operational risk management indicators
- Provide forward-looking assessments of
  - business risk factors
  - internal control environment
- To assist parameterization
- Inform Ex-post adjustments
- Serve as inputs into Scenario Analysis
- Judgement

Basel II Insurance options

Some Options

- Bankers Blanket Bond
- Commercial General Liability
- Computer Crime
- Cyber
- D&O
- Electronic Insurance
- Keyman
- Kidnap & Ransom
- Professional Indemnity/Civil Liability
- Property
- Terrorism
- Unauthorised Trading

AMA requirements

- Policy term minimum 12 months
- Cancellation period not less than 90 days
- No exclusions triggered by supervisory/receiver's/liquidator's actions
- Claims paying ability of "A" or equivalent
- [Clear cancellation and non-renewal periods]
- Policy coverage mapped to the actual operational risk exposure being modelled
- Coverage by 3rd parties.

Mitigation allowance capped 20% capital

Insurance Modelling Approaches

Ninety percent of this game is half-mental –

Yogi Berra NY Yankees

Modelling Approaches

- Hybrid Models -> Scenario Analysis combined with loss data analysis
- Solely Scenarios
- Solely Loss Data Analysis based model
- Single loss estimate (sum of scenario loss estimates)
- Bayesian Networks (address dependency issues)

Back to data

Loss Data

- Internal loss database
- External
  - Consortium based
    - ORIC (insurers UK, mostly Life)
    - ORX (banks mostly)
  - Vended databases (public, proprietary)
  - Publicly available data

Loss Data Issues

- Internal loss database
  - Limited data
  - Bias
- External
  - Truncated data (losses below threshold not recorded e.g. ORIC £10k)
  - Mix of risk profiles not matching Firm's
  - Scaling issues
  - Selection biases
  - Classification inconsistencies

Data Adjustments & Scaling

- Internal
  - Inflation
  - Changes to business
  - Changes to control framework impacting on incidence/severity
  - Classification changes
  - Consistency treatments for groups e.g. currency
- External
  - Scaling for Entity size
  - Inflation
  - Risk Profile of entity

Some Distributions

- Frequency
  - **Poisson**
  - Negative Binomial
  - Others – Binomial etc
- Severity
  - **LogNormal**
  - Exponential
  - Gamma
  - Weibull
  - Empirical
  - **Generalised Pareto**
  - Generalised Beta
  - Parent (body)
  - Child (heavy tail) EVT

Loss Distribution Approach

- Discrete frequency distribution
- Conditional severity distribution
- Convolution to put them together

LDA how to

1. Fit distributions to loss data and decide on parameters
    1. Freq
    2. Severity
2. Decide on simulation count e.g. 100k
3. Get random numbers
4. Inverse transform functions for Freq and Severity from random number set
5. Model outcomes for each sim
6. Take stats

LDA simulation kernel: frequency

- For each simulation…

Frequency: Poisson

m	2
F(x)	x
0	0
0.13533528	1
0.40600585	2
0.67667642	3
0.85712346	4
0.94734698	5
0.98343639	6
0.99546619	7
0.99890328	8
0.99976255	9
0.9999535	10
0.99999169	11
0.99999864	12
0.99999979	13
0.99999997	14
1.0000000	15
1.0000000	16
1.0000000	17
1.0000000	18

Lookup the frequency by referencing the CDF using the uniformly distributed random number generated for that Simulation iteration

Say the random number is .54

This corresponds with a frequency of 2 -> it's between F(2) .406 and F(3) .676

So we need to simulate the severities for 2 losses

LDA simulation kernel: severity

- We have 2 losses for this simulation
- Inverse transform on a new random number to generate the loss in each case
  - Bit more complicated than the frequency part

Severity: LogNormal		*Parameters*	
Mean	10000	->LogMean	9.18544
Std Dev	5000	->LogSD	0.22314
Min	6000	->ln(min)	8.69951
Max	20000	->ln(max)	9.90349
		qMin	0.01472
		qMax	0.99935
		DeltaQ	0.98464
Loss Generator Function		Exp(LogMean + LogSD * NORMSINV(qMin + DeltaQ*RAND()))	

LDA simulation kernel: severity

- Record and sum the 2 losses to get the result for that simulation

Sim #	Result	Simulated Number of losses	Simulated Loss for each Simulated Loss Event			
			1	2	3	4
1	20,156.35	2	10,217	9,940		

- Repeat for number of simulations…

Sim #	Result	Simulated Number of losses	Simulated Loss for each Simulated Loss Event					
			1	2	3	4	5	6
1	20,156.35	2	10,217	9,940				
2	49,905.68	5	9,867	9,866	9,941	10,214	10,018	
3	59,731.38	6	9,937	9,928	10,022	9,983	9,953	9,908
4	9,735.72	1	9,736					
5	10,132.43	1	10,132					
6	10,034.23	1	10,034					
7	-	0						
8	9,917.16	1	9,917					

LDA: Results + validation

CTE0	20,165
%ile	Result
50.0	18,693
90.0	40,026
95.0	47,067
99.5	67,437
99.9	79,605
100.0	113,489

Average #	2.004
Max # Losses from any Sim	11
Min Loss	6,000
Max Loss	19,993
S Results	2,016,499,582
S # Losses	200,406
Mean Loss	10,062

Frequency: Poisson

m	2
F(x)	x
0	0
0.13533528	1
0.40600585	2
0.67667642	3
0.85712346	4
0.94734698	5
0.98343639	6
0.99546619	7
0.99890328	8
0.99976255	9
0.9999535	10
0.99999169	11
0.99999864	12
0.99999979	13
0.99999997	14
1.0000000	15
1.0000000	16
1.0000000	17
1.0000000	18

Severity: LogNormal *Parameters*

Mean	10000	->LogMean	9.18544
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Min	6000	->ln(min)	8.69951
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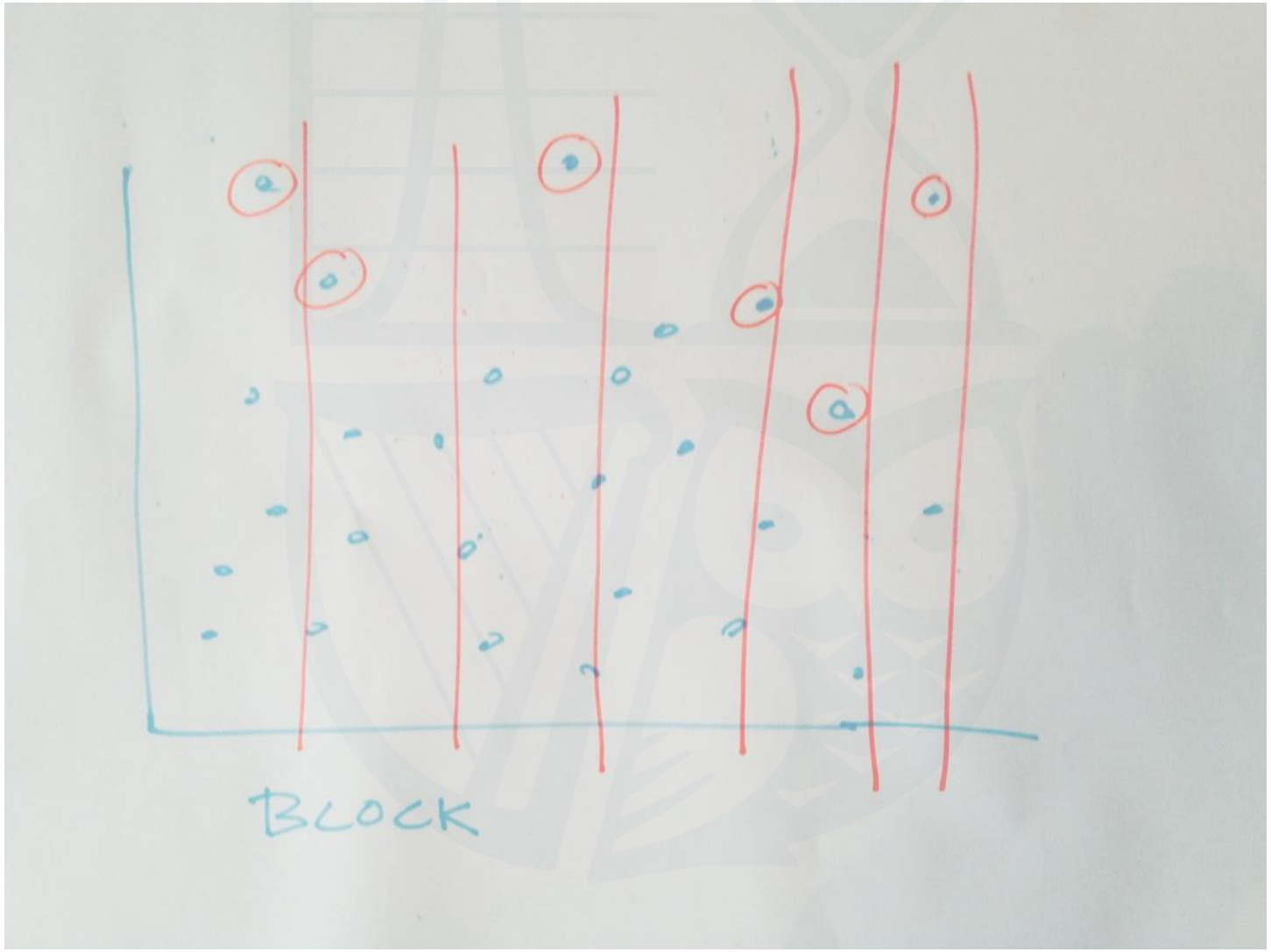
		qMin	0.01472
		qMax	0.99935
		DeltaQ	0.98464

Loss Generator Function Exp(LogMean + LogSD * NORMSINV(qMin + DeltaQ*RAND()))

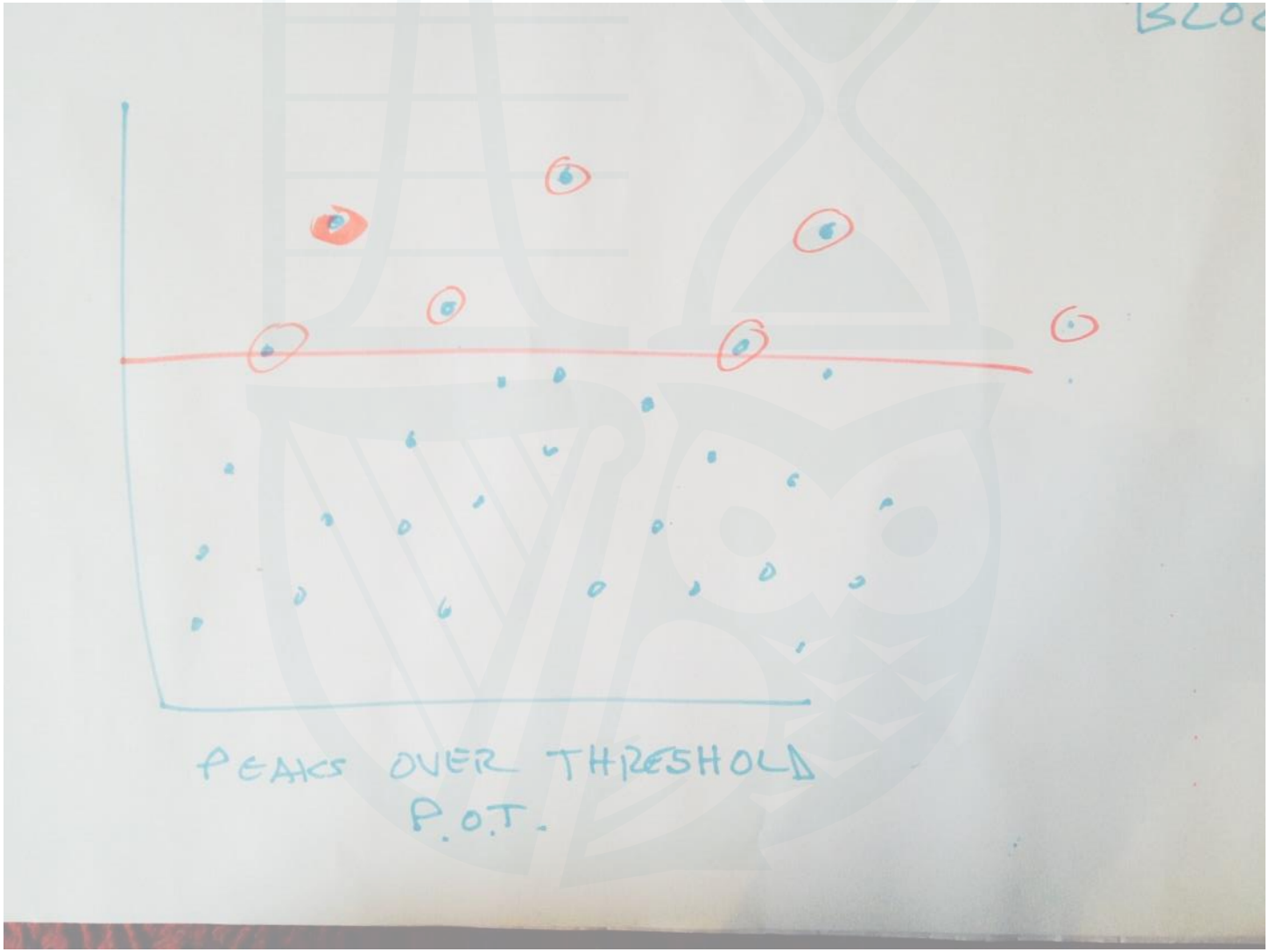
Tail ‘Child’ Distribution Extreme Value Theory (‘EVT’)

Binary Events: Low probability High impact

EVT: Blocks



EVT: Peaks Over Threshold



Checkpoint

We’re lost but we’re making good time –

Yogi Berra NY Yankees

Scenario Analysis

- Internally Generated Scenarios
  - Delphi
  - Interviews
- External
  - Group Scenario database
  - Regulator list of scenarios
  - 3rd party scenario database

Scenario Analysis

- Expert Risk Identification
  - Risk identification via workshops etc
  - ILD/ELD -> risk assessments
- Scenario Analysis
  - Frequency
  - Modal loss
  - Worst Case Loss
- Capital modelling based on Scenario Analysis
- Review and rework

Aggregation

- Var/covar
- Gaussian copula
- Sum
- T-copula
- Other (expert judgement hybrid methods)

Allocation

- Across Business lines
- Across Entities

- Scalar
- Risk adjusted (KRIs, RCSAs)

Validation Approaches

- Plausibility checks -> do results/changes in results tie up with what's happened to the business/in the world
- Sensitivity Analysis
- Back Testing
- Replication -> independent model /data to get similar results
- Expert Review

Questions?

If you ask me a question I don't know,

I'm not going to answer–

Yogi Berra NY Yankees

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