

11th Capacity Building Seminar on General Insurance 19th December, 2024

RBC – Risk Calibration Techniques (Part 1)



Prasun Sarkar
Appointed Actuary and Chief Actuarial Officer, ICICI Lombard

Manoj Gatram, Ritu Kotnala and Harsh Shah
Actuarial Team, ICICI Lombard

Agenda



- Introduction to Risk Based Capital (RBC)
- Reserve Risk - Calibration Techniques
- Premium Risk - Calibration Techniques
- CAT Risk - Calibration Techniques

Introduction to Risk Based Capital (RBC)



Risk Based Capital (RBC)

Introduction



Definition

- RBC is a method used to assess the solvency and financial stability of insurance companies
- It is based on the idea that the insurance companies should determine and hold the capital consistent with amount of risk it has assumed in its operations

Objective

- To ensure that insurers have sufficient capital to pay claims and remain financially stable, **even under adverse market conditions**
- Tool to monitor the financial health of insurance companies and to take action if a company's capital falls below the required levels

Flat Minimum

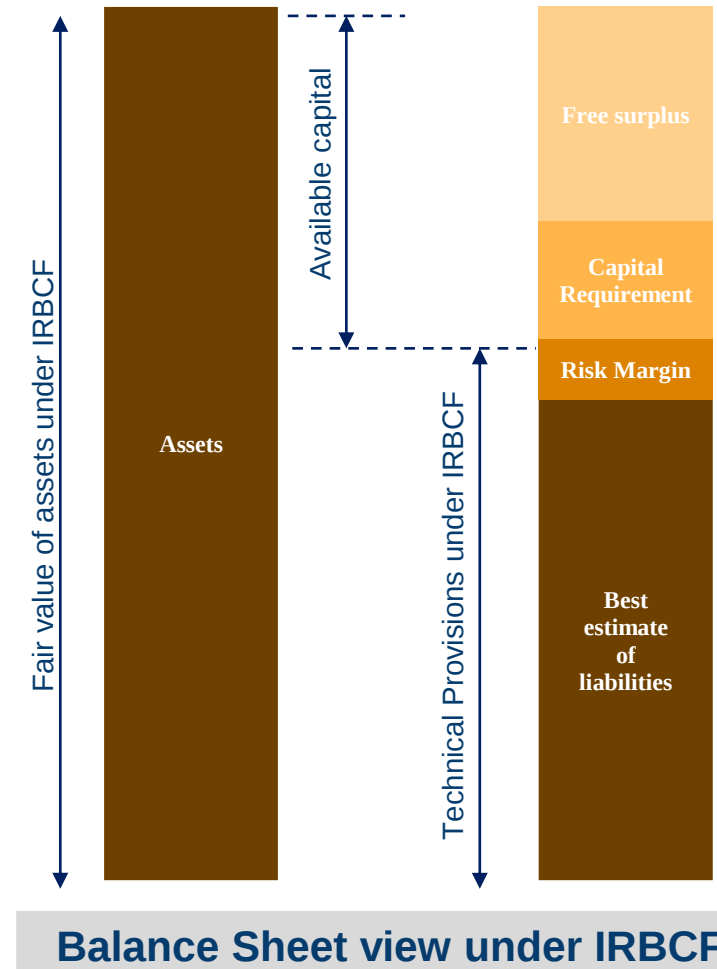


Risk Based Capital (RBC)

IRBCF | Total Balance Sheet Approach



- Includes all assets & liabilities and recognizes the interdependency b/w assets, liabilities, assessments of risks and capital requirements
- Valuation and recognition of all assets/liabilities as per IRBCF principles
- The impact of relevant material risks are required to be recognized adequately



Risk Based Capital (RBC)

IRBCF (QIS-1) | Valuation of Assets and Liabilities



Valued on a market-consistent basis, assets and liabilities are assessed at amounts they could be exchanged for between informed, willing parties in a fair transaction.

Valuation of Assets:

Asset Type	Valuation basis
Traded in Active Market	Market value basis
Unlisted, Property etc.	Fair value basis as per IndAS 113
Reinsurance Recoverable (est. RI recovery against OS/IBNR)	Positive RI recoverable to be regarded as assets • Treaties with net negative RI recoverable to be regarded as liabilities • To be valued at (discounted) best estimate basis
Goodwill & intangible assets	To be valued at zero

Valuation of Non-insurance Liabilities:

Liability Type	Valuation basis
Contingent liabilities	Recognized as per IndAS 37; Valued at discounted probability weighted basis
Others	Fair value basis as per IndAS 113

Risk Based Capital (RBC)

IRBCF (QIS-1) | Valuation of Assets and Liabilities



Valuation of Insurance Liabilities (Technical Provisions):

$$\text{Technical Provisions} = \text{Best Estimate Liability} + \text{Risk Margin}$$

- Risk Margin: additional margin for liability against volatility in actuals against best estimate
 - To be calculated as prescribed in IRBCF
- Best Estimate Liability (BEL):
 - Gross and RI to be presented in liabilities and assets respectively
 - Outwards RI recoverable should be exclude recoverable from any know material counter party risk
 - Components of BEL and valuation basis are tabulated below:

Component of BEL	Valuation basis
Outstanding claim liabilities	• Present value (PV) of probability weighted cashflows • Provisions include claim losses and ULAE as well • Effect of discounting provided only against claim losses
Unexpired in-force premiums	• PV of URR cashflows subject to flooring of current Unexpired Premium Reserve (UPR) • URR to include all forms of expected expenses such as claim loss, policy maintenance, future reinsurance costs etc. • URR and UPR calculations to consider future installments as well
BBNI premiums	

Note: Bound But Not Incepted (BBNI) Policies are policies which are not incepted yet. For e.g. – Motor Long term (3Yr & 5Yr), which are considered as premium advance, will be considered as part of BEL now.

Risk Based Capital (RBC)

IRBCF (QIS-1) | Brief Description of Risks

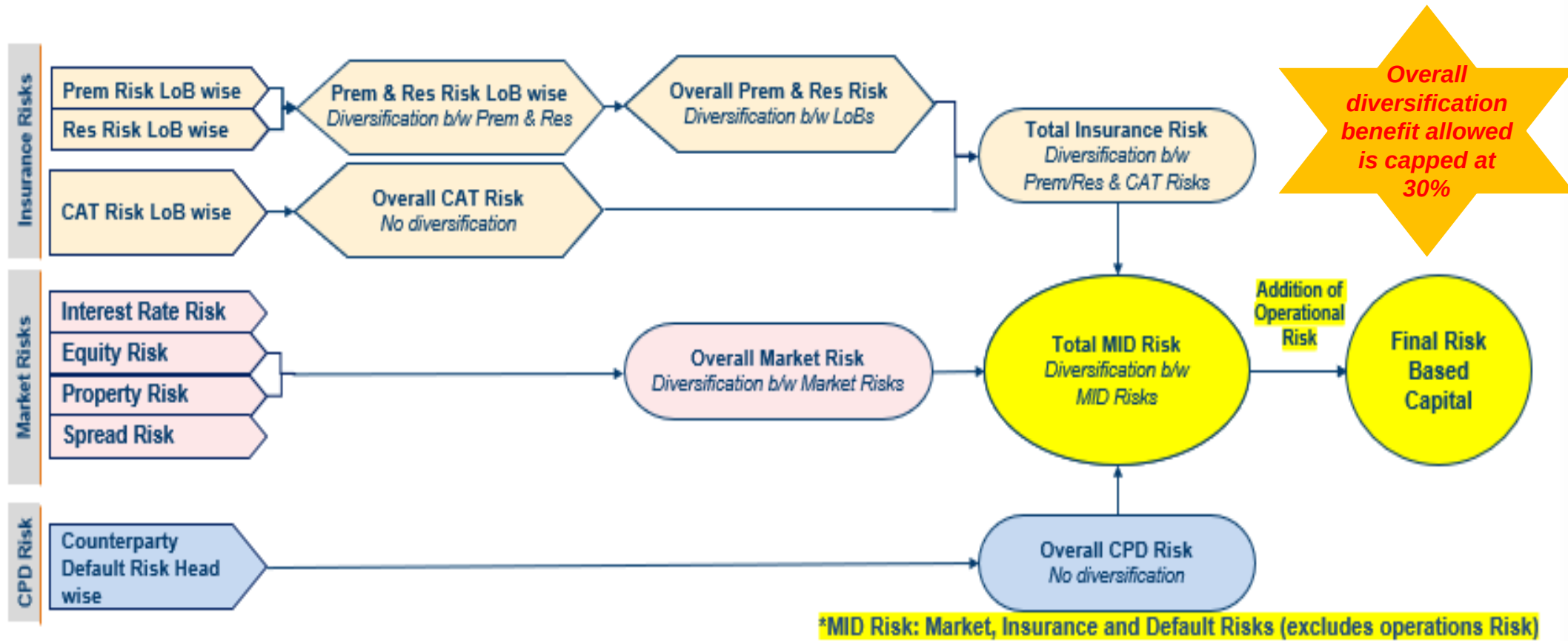


Category	Risk	Description of need for charge
Insurance Risk	Reserve Risk	Adverse movements in estimates of expected future payments for already incurred events (OS + IBNR).
	Premium Risk	Volatility in pricing assumptions (freq, sev etc.) for UPR as well as premium to be written in next 1 year.
	Catastrophe Risk	Adverse impact due to occurrence of low frequency and high severity events.
Market Risk	Interest Rate Risk	Volatility of risk-free interest rates.
	Equity Risk	Volatility of market prices of equities.
	Property Risk	Volatility in market/selling price of properties or timing of cash-flows from investments in real estate.
	Spread Risk	Volatility of spreads over the risk-free interest rate term structure.
Counterparty Default Risk	Reinsurance Recoverable	Adverse impacts due to defaults of recoverable/receivable from reinsurers/coinsurers, policyholders etc. along with deterioration of counterparty's creditworthiness.
	Reinsurance Receivable	
	Outstanding Premium	
	Coinsurance Balances etc.	
Operational Risk	Operational Risk	Adverse impacts due to operational events including inadequate or failed internal processes etc.

Risk Based Capital (RBC)

IRBCF (QIS-1) | Aggregation & Calibration of Risks

Flow chart for the aggregation of risks in RBC



Risk Based Capital (RBC)

IRBCF | Risk Charge Calibration



Standard Approach – Fundamentals

Calibration of each risk charge: The risk charges are calibrated with an objective to achieve 99.5% confidence level in 1-yr horizon

- **Factor based approach**: Capital is calculated by multiplying the prescribed factor with defined exposure against a risk
- **Stress based approach**: The assumptions (such as interest rate) are stressed basis prescription on assets and liabilities. The maximum value of change in net asset value is considered as risk charge
- Calibrating the risk charge factor in Indian context requires sufficient credible data, but the growing insurance industry faces challenges due to limited historical data.
- Standard risk charge factors reflect the average industry risk profile, but large-scale/multi-line insurers may be subjected to higher capital charges than required.

Reserve Risk - Calibration Techniques



Insurance Risk – Reserve Risk

Introduction



Background

- Reserve risk refers to the potential for an insurer's failure due to adverse deviations in expected future payments related to the technical reserves established for past exposures, such as IBNR or case reserves
- The IRBCF or any typical solvency regime considers the value at risk over a one-year horizon only
 - Therefore, models that calibrate volatility using a one-year view are explored
- The sources of reserve risk can be broadly grouped into two categories:
 - (i) **Process variance:-** Refers to the variability or uncertainty in the outcome of a process due to inherent fluctuations or pure randomness in the system
 - (i) **Parameter variance:-** Refers to uncertainty arising from differences between estimated and true unknown parameters, affecting the results based on the calibration approach and data used

Further details discussed in subsequent slide.

Insurance Risk – Reserve Risk

Introduction



Sources of volatility in reserving – One-year view

Estimation @Mar24:

AY	Development Year wise Cumulative Paid					Cumulative Paid (CP)	Ultimate Estimate (CP*LDF)	Expected Paid in Next Year [CP*(ATA-1)]
	1	2	3	4	5			
2020	100	200	350	400	425	425	425	0
2021	80	180	260	320		320	340	20
2022	150	300	420			420	527	76
2023	200	400				400	760	206
2024	250					250	968	259

Incremental ATA	2.04	1.51	1.18	1.06	1.00
Cumulative LDF	3.87	1.90	1.25	1.06	1.00

Estimation @Mar25:

AY	Development Year wise Cumulative Paid						Cumulative Paid (CP)	Ultimate Estimate (CP*LDF)	Actual Paid during the Year
	1	2	3	4	5	6			
2020	100	200	350	400	425	450	450	450	25
2021	80	180	260	320	370		370	392	50
2022	150	300	420	620			450	526	30
2023	200	400	430				620	823	220
2024	250	400					400	812	150

Incremental ATA	1.90	1.53	1.14	1.10	1.06	1.00
Cumulative LDF	3.85	2.03	1.33	1.17	1.06	1.00

Consider a hypothetical scenario using a simple CLM to estimate of ultimate, the change in ultimate between Mar24 and Mar25 is driven by below two 'loosely' defined factors:

- Change in actual paid vs expected in FY25:** This variability stems from the underlying volatility of claims development.
 - This component may be attributable to the process variance
- Change in actual paid in FY25 as compared to the expected:** This variability is driven from the revision in the ATAs as per the estimation process.

Driven by parameter variance plus some component combination of both parameter and process variance as well		
Driven by process variance		
Total Variation		
Change in Ultimate (A) (Ult @mar25 – Ult @Mar24)	Change in Ultimate if ATAs are not revised (B)	Residual Change in Ultimate (C) (A – B)
25	25	0
52	30	22
-1	-49	48
64	18	46
-156	-208	52

Insurance Risk – Reserve Risk

Introduction



Sources of volatility in reserving – Ultimate view

Estimation @Mar24 (projected bottom triangle):

AY	Development Year wise Cumulative Paid						Cumulative Paid (CP)	Ultimate Estimate (CP*LDF)
	1	2	3	4	5	6		
2020	100	200	350	400	425	425	450	450
2021	80	180	260	320	340	340	370	392
2022	150	300	420	496	527	527	450	526
2023	200	400	606	715	760	760	620	823
2024	250	509	772	911	968	968	400	812

Incremental ATA	2.04	1.51	1.18	1.06	1.00	2.04
Cumulative LDF	3.87	1.90	1.25	1.06	1.00	3.87

Triangle after ultimate state is achieved @ Mar29 (bottom triangle actualized):

AY	Development Year wise Cumulative Paid						Cumulative Paid	Ultimate Estimate
	1	2	3	4	5	6		
2020	100	200	350	400	425	450	450	450
2021	80	180	260	320	370	395	395	395
2022	150	300	420	620	730	780	780	780
2023	200	400	430	590	685	740	740	740
2024	250	400	440	615	740	840	840	840

Consider the same scenario where we look at the triangle @Mar24 and @Mar29 when the triangle has presumably reached its ultimate state.

- The variable represents the difference due to deviations in payments observed across all financial years, including those beyond FY25, which will be considered as part of the ultimate view
- This variability can arise from both process variance as well as parameter variance due to error in current ATA estimates
- Mack model has provided as framework which recursively evaluates the volatility associated with

(i) **Process variance:** By assuming the current ATA estimates to be constant and calculating the variance associate with all future development periods

(ii) **Parameter variance:** By studying the volatility of ATA estimates within the observed triangle

Insurance Risk – Reserve Risk

Approaches in Various Jurisdictions

Approaches in various jurisdictions

Jurisdiction	Item	Approach
IRBCF (QIS-1)	Formula Used	$RBC_{Reserve Risk,lob i} = Volume Measure * Standard Premium Risk Charge Factor_{lob i}$
	Volume Measure	Includes the best estimate of net claim outstanding (IBNR + Case reserves) Should exclude any implicit margins carried under reserves and on discounted basis
Solvency II	Formula Used	$RBC_{Reserve Risk,lob i} = Volume Measure * Standard Premium Risk Charge Factor_{lob i}$
	Volume Measure	Same of in IRBCF QIS-1
NAIC RBC	Formula Used	$RBC_{Reserve Risk,lob i}$ $= [Net Reserves + Other discounts not in reserves]$ $* [[Company Reserve Risk Factor + 1] * Adjustment for Investment Income - 1]$
	Volume measure	Net reserves adjusted for discounting (should be as per the carried financials)
	Unique features	The <i>Company Reserve Risk Factor</i> is calculated as the average of the risk charge from the company's reserve triangle and the standard risk charge factor from industry data. The methodology using the company's reserve triangle is prescriptive, analyzing ultimate movements over time.

Insurance Risk – Reserve Risk Risk Charge Calibration Approach

Merz-Wüthrich formula

➤ Introduction:

- Referred for Solvency II Reserve Risk calibration as well
- **Objective:** Calibrate the reserve risk charge factor using industry data at a 99.5% confidence level over a one-year horizon, with the best estimate reserve liability as the volume measure
- Merz-Wüthrich formula Works within the Mack's model and gives one year view
 - Mack model evaluates risk on ultimate view
 - Stochastic approach based on distribution free Chain Ladder Method (CLM) technique
 - Provides analytical formula for mean squared error of prediction (MSEP)
 - Requires at least on run-off AY
- **Data Format:** Cumulative incurred or paid triangles
 - Requires at least on run-off AY

Insurance Risk – Reserve Risk Risk Charge Calibration Approach

Merz-Wüthrich formula

➤ Fundamental Assumptions:

- (i) Cumulative payments $C_{i,j}$ in different AYs are independent
- (ii) The development of cumulative payments follow a Markov and there exists factors f_j and σ_j such that
 - $E[C_{i,j} \mid C_{i,j-1}] = f_{j-1} C_{j-1}$
 - $V[C_{i,j} \mid C_{i,j-1}] = \sigma_{j-1}^2 C_{j-1}$

Accident year, i	Cumulative Paid across Development Period, j				
	0	1	...	J-1	J
0	$C_{0,0}$	$C_{0,2}$	...	$C_{0,J-1}$	C_J
1	$C_{1,0}$	$C_{1,2}$	...	$C_{1,J-1}$	
...	...	...	...		
I-1	$C_{I-1,0}$	$C_{I-1,2}$			
I	$C_{I-1,0}$				

The set of data points available at time I are defined as D_I .
 $\Rightarrow D_I = \{C_{i,j}; i + j \leq I \text{ and } i \leq I\}$

- Assuming J is runoff development period, the expected value of ultimate claim can be derived as
 - $C_{i,J} = E[C_{i,J} \mid D_I] = C_{i,I-i} * \prod_{j=I-i}^{J-1} f_j$

Can be intuitively understood as cumulative LDF

Insurance Risk – Reserve Risk Risk Charge Calibration Approach

Merz-Wüthrich formula

➤ Estimators of the parameters:

Accident year, i	Cumulative Paid across Development Period, j				
	0	1	...	J-1	J
0	$C_{0,0}$	$C_{0,2}$	...	$C_{0,J-1}$	C_J
1	$C_{1,0}$	$C_{1,2}$	...	$C_{1,J-1}$	
...	...	...	...		
I-1	$C_{I-1,0}$	$C_{I-1,2}$			
I	$C_{I-1,0}$				

In the above illustration, $\hat{f}_0^I$ will be equal to sum of cells highlighted within green divided by sum of the cells highlighted in red...

$$\hat{f}_j^I = \frac{\sum_{i=0}^{I-j-1} C_{i,j+1}}{\sum_{i=0}^{I-j-1} C_{i,j}}$$

$$\hat{\sigma}_j^2 = \frac{1}{I-j-1} \sum_{i=0}^{I-j-1} C_{i,j} \left(\frac{C_{i,j+1}}{C_{i,j}} - \hat{f}_j \right)^2$$

This component intuitively represents the difference between the actual development and estimated development, $\hat{f}_j$ for an AY

➤ Estimators of ultimate: The above setup naturally implies

$$\hat{C}_{i,J} = C_{i,I-i} * \prod_{j=I-i}^{J-1} \hat{f}_j$$

Insurance Risk – Reserve Risk Risk Charge Calibration Approach

Merz-Wüthrich formula

➤ Claims Development Result (CDR) and Mean Squared Error of Prediction (MSEP) single AY:

Item	Observable CDR (A)	True CDR (B)	Difference b/w A and B (C)
Definition	$\hat{CDR}_i(I+1) = \hat{C}_{i,J}^{I+1} - \hat{C}_{i,J}^I$	$CDR_i(I+1) = C_{i,J}^{I+1} - C_{i,J}^I$	$\hat{CDR}_i(I+1) - CDR_i(I+1)$
Interpretation	Change in the total <u>estimates of ultimate</u> . Total impact on P&L from a solvency perspective.	Change in ultimate upon <u>known</u> (constant) parameters. Loosely related to <u>process variance</u> .	Loosely related to <u>parameter variance</u> .
Conditional MSEP	$MSEP_A = E[(\hat{CDR}_i(I+1) - 0)^2 D_I]$	$MSEP_B = V[CDR_i(I+1) D_I]$	$MSEP_C = E[(CDR_i(I+1) - \hat{CDR}_i(I+1))^2 D_I]$
Estimator of MSEP in Merz-Wüthrich	$M\hat{SEP}_A = M\hat{SEP}_B + M\hat{SEP}_C$	$M\hat{SEP}_B = \hat{C}_{i,J}^I{}^2 * \frac{\hat{\sigma}_{I-i}^2}{\hat{f}_{I-i}^2 * C_{i,I-i}}$	$M\hat{SEP}_C = \hat{C}_{i,J}^I{}^2 * \left[\lambda_{I-i} + \sum_{j=I-i+1}^{J-1} \frac{C_{I-j,j}}{S_j^I} \lambda_j \right]$
Estimator of MSEP in Mack	$M\hat{SEP}_A = M\hat{SEP}_B + M\hat{SEP}_C$	$M\hat{SEP}_B = \hat{C}_{i,J}^I{}^2 * \sum_{I-i}^{J-1} \frac{\hat{\sigma}_j^2}{\hat{f}_j^2 * C_{i,j}}$	$M\hat{SEP}_C = \hat{C}_{i,J}^I{}^2 * \left[\lambda_{I-i} + \sum_{j=I-i+1}^{J-1} \lambda_j \right]$
Comparison of Merz-Wüthrich with Mack	-	Only first term of Mack is present in Merz-Wüthrich as the remaining terms pertain to volatility associated with development periods beyond one-year.	All other terms other than first term are scaled down in case of Merz-Wüthrich.

Note: $\lambda_j = \hat{\sigma}^2 / (\hat{f}_j^2 * S_j^I)$; $S_j^I = \sum_{i=0}^{I-j} C_{i,j}$

Insurance Risk – Reserve Risk Risk Charge Calibration Approach

Merz-Wüthrich formula

- Aggregation over previous accident years:

$$\text{Aggregate } M\hat{SEP} = \sum_i M\hat{SEP} \text{ of Observable } CDR_i + 2 \underbrace{\sum_{k>i>0} \hat{C}_{i,J}^I \hat{C}_{k,J}^I (\lambda_{I-i} + \sum_{j=I-i+1}^{J-1} \frac{C_{I-j,j}}{S_j^I} \lambda_j)}_{\text{Introduces component related to the covariance terms across AYs}}$$

Where $\lambda_j = \hat{\sigma}^2 / (\hat{f}_j^2 * S_j^I)$ and $S_j^I = \sum_{i=0}^{I-j} C_{i,j}$

Introduces component related to the covariance terms across AYs

The lambda term for the covariance is identical to the lambda term for the parameter error. This is logical, as the correlation between the estimates arises solely from the shared parameters used.

Insurance Risk – Reserve Risk Risk Charge Calibration Approach

Merz-Wüthrich formula

➤ Goodness-of-fit diagnostics:

- **Definition of a residual:**

- A residual pertaining to a cell in the triangle is defined as:

- $Residual(C_{i,j}) = C_{i,j+1} - C_{i,j} * \hat{f}_j$

- Residuals are scaled for the purpose of diagnostic test:

- $Residual_{scaled}(C_{i,j}) = \frac{Residual(C_{i,j})}{Standard\ error} = \frac{(C_{i,j+1} - C_{i,j} * \hat{f}_j)}{C_{i,j} * \hat{\sigma}^2}$

- The residuals collected for each company's triangle can be consolidated and analyzed using scatter plots to assess the validity of various assumptions.

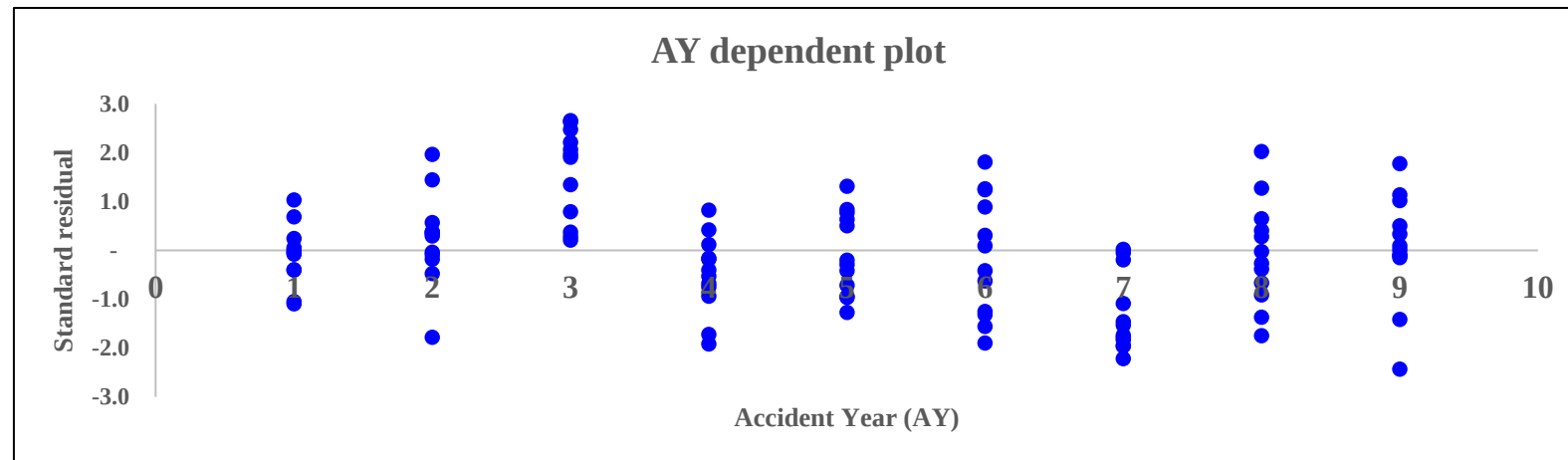
Insurance Risk – Reserve Risk Risk Charge Calibration Approach

Merz-Wüthrich formula

➤ Goodness-of-fit diagnostics continued:

(i) Check for independency across AY:

- Scatter plot of scaled residuals across AY
- Expected to be scattered as per model assumptions



(ii) Similar scatter plots of residuals are also created for financial/diagonal year and development period to evaluate assumptions related to independence across these dimensions.

Insurance Risk – Reserve Risk Risk Charge Calibration Approach

Derivation of Risk Charge Factor

➤ Derivation of company wise risk charge factor:

- The square root of the MSEP is divided by the best estimate liability reserves to calculate the Relative Root Mean Squared Error of Prediction (RRMSEP)
 - This RRMSEP is consistent with the risk charge definition, treating BEL as a volume measure
- The final risk charge factor is derived as the 99.5th percentile value based on the estimated standard deviation (RRMSEP) and assumed distribution for each company

MSEP from Merz-Wüthrich
formula

$$\text{RRMSEP} = \sqrt{\text{MSEP}} / \text{BEL}_{\text{claim reserves}}$$

Risk Charge Factor = $\text{VaR}_{99.5\%}$
@standard deviation = RRMSEP

➤ Selection of standard charge factor under a standard model-based approach:

- Risk charge factor is derived based on each company's triangle separately. Therefore, a single factor must be chosen based on prudence criteria in the standard model approach.

S. No.	Criteria
1	Weighted average of company wise risk charge factors derived using BEL of reserves as weight
2	Median of the company wise risk charge factors derived
3	Selecting a risk charge factor such that the company-specific risk charges of a desired percentage of companies are lower than the selection
4	Selecting a risk charge factor so that company-specific charges for companies representing the desired percentage of industry reserve volumes are lower

Insurance Risk – Reserve Risk

Other Key Aspects of Calibration



Other Key Aspects

- The model does not account for changes in claim development patterns over time, such as those arising from changes in claim settlement practices
- The model only calibrates the standard error of reserves and is distribution-free
 - Assumptions are required to be made about the distribution to derive the final risk charge factor
- Model requires at least one run-off AY
 - Extrapolation methods may be needed for long-tailed lines of business
- The risk charge formula does not allow for each company's reserve volatility, as a standard factor is applied uniformly
 - An approach similar to the NAIC's may be adopted over time
- Other calibration techniques that may be explored
 - Bootstrapped ODP and Bootstrapped Mack models adjusted to calibrate one year volatility
 - Emergence patterns etc.

Premium Risk - Calibration Techniques



Insurance Risk – Premium Risk

Introduction

Background

- Premium risk refers to the potential for insurer's failure resulting from adverse deviations in the underlying assumptions related to frequency and severity etc. related to future events over a one-year horizon.
- Sources of premium risk over the next following one-year:

S. No.	Exposure Type	Definition of Premium Risk
1.	Exposure already recognized at the time of valuation: (i) Unexpired Premium Reserve (UPR) (ii) Bound But Not Incepted (BBNI)	Risk of insufficiency of provisions against premium liabilities created in the current RBC balance sheet.
2.	New Business expected to be written in the following 12-months	Risk of insufficiency in premiums collected to pay for claims and provide for provisions for new business over the next year.

- New business is also included within the scope of the RBC, with the objective of providing protection on a going concern basis, rather than a gone concern basis.

Insurance Risk – Premium Risk

Approaches in Various Jurisdictions

Approaches in various jurisdictions

Jurisdiction	Item	Approach
IRBCF (QIS-1)	Formula Used	$RBC_{Premium Risk,lob i} = Volume Measure * Premium Risk Charge Factor_{lob i}$
	Volume Measure	- Includes premium from UPR, BBNI as well as New Business - Includes premium earned beyond the following one-year period
	Risk Charge	A uniform risk charge factor is applied to all types of premiums
Solvency II	Formula Used	$RBC_{Premium Risk,lob i} = Volume Measure * Premium Risk Charge Factor_{lob i}$
	Volume Measure	- Includes premium from UPR, BBNI as well as New Business - Includes premium earned beyond the following one-year period
	Risk Charge	- A lower risk charge factor is applied to premium earned beyond 12 months - Does not include capital charges for volatility associated with policy expenses - This is based on the assumption that they are deterministic percentage of premium and hence do not contribute to the overall volatility of the results

Insurance Risk – Premium Risk

Approaches in Various Jurisdictions

Approaches in various jurisdictions

Jurisdiction	Item	Approach
US NAIC RBC	Formula Used	$RBC_{Premium Risk,lob i} = NWP_{current year} * [Company Loss Ratio * Adjustment for Investment Income + Company Underwriting Expense Ratio_{current year} - 1]$
	Volume Measure	- Includes New Written Premium from current year - Designed to derive capital for premiums to be written in the upcoming year - Does not considered UPR and BBNI premiums - NAIC requires valuation of UPR and BBNI floored @100% of UPR, while acquisition expenses are recognized upfront - This conservative treatment of prepaid expenses at zero and the existing UPR at 100% is expected to already account for the associated risk
	Risk Charge	- A uniform risk charge factor is applied to all types of premiums - Does not include capital charges for volatility associated with policy expenses - Allows for investment income to exclude prudence in loss ratio factor which is on undiscounted basis - Calculates capital charges based on potential premium deficiencies from adverse claims, factoring in policy expenses

Insurance Risk – Premium Risk Risk Charge Calibration Approach



Fundamentals of calibration techniques

- **Reference:** Solvency II Calibration paper
- **Objective:** To calibrate premium risk charge factor industry data at a 99.5% confidence level, based on earned premiums as volume measure
- Intuitively, the techniques are intended to analyze and understand the fluctuations in best estimate of loss ratios over different accident years
- To avoid double counting the risk charge with the CAT module, calibration should exclude losses from natural catastrophes and pandemics
- The methodology developed looks into only claim volatility and does not account for expense volatility
- **Data Format:** The data required is consistent across all models
 - Includes company-wise, AY-wise earned premiums and the best estimate ULRs

Insurance Risk – Premium Risk Risk Charge Calibration Approach



Overview of Solvency II techniques considered before 2011

- Below is an overview of the four calibration techniques used before 2011, some of which influenced our current Economic Capital framework.

Details	Method 1	Method 2	Method 3	Method 4
Distribution of loss	Normal	Log Normal	Log Normal	Log Normal
Relationship b/w loss variance and premium	Variance is proportional to square of premium	Variance is proportional to premium	Variance is proportional to premium	Variance is proportional to square of premium
Formulation of loss distribution, $U_{C,Y,lob}$	$\sim V_{C,Y,lob}\mu_{lob} + V_{C,Y,lob}\beta_{lob}\epsilon_{C,Y,lob}$	$\sim V_{C,Y,lob}\mu_{C,lob} + \sqrt{V_{C,Y,lob}}\beta_{lob}\epsilon_{C,Y,lob}$	$\sim V_{C,Y,lob}\mu_{lob} + \sqrt{V_{C,Y,lob}}\beta_{lob}\epsilon_{C,Y,lob}$	$\sim V_{C,Y,lob}\mu_{lob} + V_{C,Y,lob}\beta_{lob}\epsilon_{C,Y,lob}$
Expected loss ratio parameter, μ	Assumed constant over time but varying across companies	Assumed constant over time but varying across companies	Assumed constant over time and also same across companies	Assumed constant over time but varying across companies
Standard deviation of loss ratio, β	Assumed constant over time but varying across companies	Assumed constant over time and same across companies	Assumed constant over time and same across companies	Assumed constant over time and same across companies
Parameter estimation method	Least Squares	Maximum Likelihood Estimation (MLE)	Maximum Likelihood Estimation (MLE)	Maximum Likelihood Estimation (MLE)
Company wise loss ratio std deviation, σ	$\sigma_{C,lob} = \beta_{C,lob}$	$\sigma_{C,lob} = \beta_{C,lob}/\sqrt{V_{C,lob}}$	$\sigma_{C,lob} = \beta_{C,lob}/\sqrt{V_{C,lob}}$	$\sigma_{C,lob} = \beta_{C,lob}$
Derivation of Final Risk Charge	Weighted average of company wise σ using average premium observed for each company as weight. This Final risk charge factor is used under the standard formula which derives final risk charge factor by assuming Log Normal distribution of losses.			
Key remarks	- Chances of overfitting - Bias towards large companies - Distributional assumptions differ from standard formula	- Lower chances of overfitting - Bias towards large companies - Lacks statistical backup	- Oversimplified assumptions - Bias towards large companies - Lacks statistical backup	- Lower chances of overfitting - Bias towards large companies - Lacks statistical backup

Insurance Risk – Premium Risk Risk Charge Calibration Approach

Final Solvency II techniques considered in 2011 paper

➤ Details of model specifications:

S. No.	Distributional assumption of losses	Specification of loss ratio expectation, q	Variance specification of loss ratio, q*	Implied variance of losses, y
1	Normal	$E(q) = \beta$	$V(q) = \sigma^2((1 - \delta)\bar{x}x^{-1} + \delta)$	$V(y) = \sigma^2((1 - \delta)\bar{x}x + \delta x^2)$
2			$V(q) = \beta^2\sigma^2((1 - \delta)\bar{x}x^{-1} + \delta)$	$V(y) = \beta^2\sigma^2((1 - \delta)\bar{x}x + \delta x^2)$
3	Log Normal		$V(q) = \sigma^2((1 - \delta)\bar{x}x^{-1} + \delta)$	$V(y) = \sigma^2((1 - \delta)\bar{x}x + \delta x^2)$
4			$V(q) = \beta^2\sigma^2((1 - \delta)\bar{x}x^{-1} + \delta)$	$V(y) = \beta^2\sigma^2((1 - \delta)\bar{x}x + \delta x^2)$

* x represents NEP for the AY while $\bar{x}$ represents average NEP observed across time and companies in the industry.

- Differs from previous models in that the variance is related to the premium in a quadratic form
- **A brief background of the specification:**
 - β represents long term mean loss ratio
 - σ represents loss ratio standard deviation of a portfolio with premium equal to industry average
 - $\sigma^2\delta$ represents to non-diversifiable sources of volatility
 - $\sigma^2(1 - \delta)\bar{x}x^{-1}$ represents diversifiable sources of volatility based on volumes
 - $\delta \rightarrow 0 \Rightarrow$ high reliance on portfolio size; $\delta \rightarrow 1 \Rightarrow$ low reliance on portfolio size

Insurance Risk – Premium Risk Risk Charge Calibration Approach

Final Solvency II techniques considered in 2011 paper

➤ Details of model specifications continued:

S. No.	Distributional assumption of losses	Specification of loss ratio expectation, q	Variance specification of loss ratio, q*	Implied variance of losses, y
1	Normal	$E(q) = \beta$	$V(q) = \sigma^2((1 - \delta)\bar{x}x^{-1} + \delta)$	$V(y) = \sigma^2((1 - \delta)\bar{x}x + \delta x^2)$
2			$V(q) = \beta^2\sigma^2((1 - \delta)\bar{x}x^{-1} + \delta)$	$V(y) = \beta^2\sigma^2((1 - \delta)\bar{x}x + \delta x^2)$
3	Log Normal		$V(q) = \sigma^2((1 - \delta)\bar{x}x^{-1} + \delta)$	$V(y) = \sigma^2((1 - \delta)\bar{x}x + \delta x^2)$
4			$V(q) = \beta^2\sigma^2((1 - \delta)\bar{x}x^{-1} + \delta)$	$V(y) = \beta^2\sigma^2((1 - \delta)\bar{x}x + \delta x^2)$

* x represents NEP for the AY while $\bar{x}$ represents average NEP observed across time and companies in the industry.

• **Keys aspects of estimation process:**

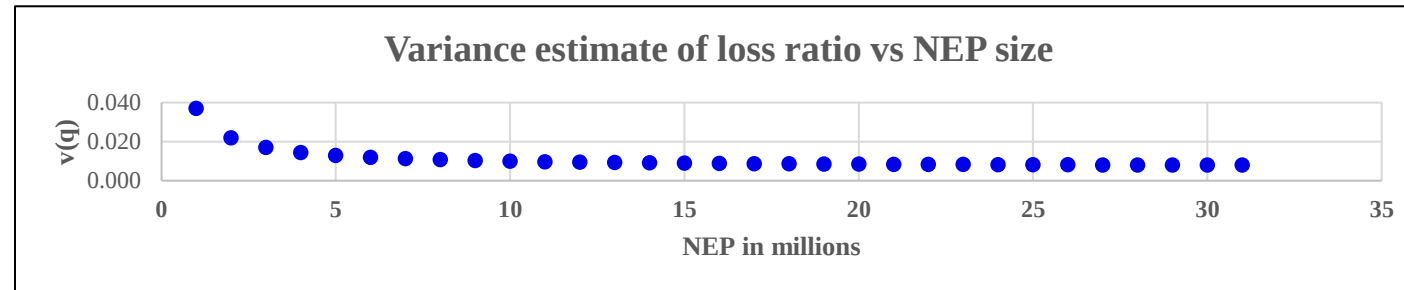
- Expected loss ratio parameter β assumed constant across time but differing across companies
- Volatility parameters σ and δ assumed to be constant over time and uniform across all companies
- Parameters are estimated based on Maximum Likelihood Estimation (MLE) process
- The final risk charge factor is derived as the 99.5th percentile value based on the estimated standard deviation and assumed distribution

Insurance Risk – Premium Risk Risk Charge Calibration Approach

Final Solvency II techniques considered in 2011 paper

➤ Selection of size invariant risk charge factor under a standard model-based approach:

- As per the specification, the model generates a risk charge factor based on portfolio size.
- Consider a scenario where $\delta = 0.7$, $\sigma = 0.1$, and the average industry NEP is 10 million. The following graph shows the loss ratio variance, $v(q)$, based on Method 1:



- Introducing portfolio size factors adds complexity to a standard model-based approach. To maintain simplicity, a single risk charge factor is chosen based on various prudence criteria, as outlined below.

S. No.	Criteria
1	Weighted average of company wise risk charge factors derived using NEP of latest AY as weight
2	Median of the company wise risk charge factors derived
3	Selecting a risk charge factor such that the company-specific risk charges of a desired percentage of companies are lower than the selection
4	Selecting a risk charge factor so that company-specific charges for companies representing the desired percentage of industry premium volumes are lower.

Insurance Risk – Premium Risk Risk Charge Calibration Approach

Final Solvency II techniques considered in 2011 paper

➤ Goodness-of-fit diagnostics:

• Definition of a residual:

• Key Aspects pertaining to Log Normal Models:

- $Y \sim \ln \Rightarrow \ln(Y) \sim N$
- Residuals of $\ln(Y)$ can be checked for normality to validate if Y follows log normal
- Also, mean and variance of $\ln(Y)$ will be

$$\Rightarrow E[\ln(Y)] = \ln(E[Y]) - \frac{1}{2} * V[\ln(Y)]$$

$$\Rightarrow V[\ln(Y)] = \ln\left(1 + \frac{V[Y]}{E[Y]}\right)$$

S. No.	Distributional assumption of losses	Expected Losses $E(Y_{c,i})$	Specification of variance of losses $V(Y_{c,i})$	Definition of Scaled Residual $Res_{c,i}$
1	Normal	$E(Y_{c,i}) = \beta * x_{c,i}$	$V(Y_{c,i}) = \sigma^2 \left((1 - \delta) \bar{x} x_{c,i} + \delta x_{c,i}^2 \right)$	$\frac{[y_{c,i} - E(Y_{c,i})]}{Standard\ error(Y_{c,i})}$
2			$V(Y_{c,i}) = \beta^2 \sigma^2 \left((1 - \delta) \bar{x} x_{c,i} + \delta x_{c,i}^2 \right)$	
3	Log Normal		$V(Y_{c,i}) = \sigma^2 \left((1 - \delta) \bar{x} x_{c,i} + \delta x_{c,i}^2 \right)$	$\frac{[\ln(y_{c,i}) - E(\ln(Y_{c,i}))]}{Standard\ error(\ln(Y_{c,i}))}$
4			$V(Y_{c,i}) = \beta^2 \sigma^2 \left((1 - \delta) \bar{x} x_{c,i} + \delta x_{c,i}^2 \right)$	

Insurance Risk – Premium Risk Risk Charge Calibration Approach



Final Solvency II techniques considered in 2011 paper

➤ Goodness-of-fit diagnostics:

(i) Check for fit in terms of distributional assumptions:

- As per the model assumptions, the scaled residuals are expected to follow standard normal distribution. Tests available:
 - **PP plot:**
 - Theoretical cumulative probabilities and Empirical cumulative probabilities, based on scaled residuals
 - Expected to follow straight line at 45% approximately if the assumptions hold
 - **Jarque Bera statistic-based test:**
 - Test statistic, $JB \sim \text{Chisquare with 2 degrees of freedom}$
Where:
$$JB = \frac{n}{4} [4S^2 + (K - 3)^2];$$
 S and K are skewness and kurtosis of scaled residuals respectively
 - **Null hypothesis:** Residuals follow normal distribution

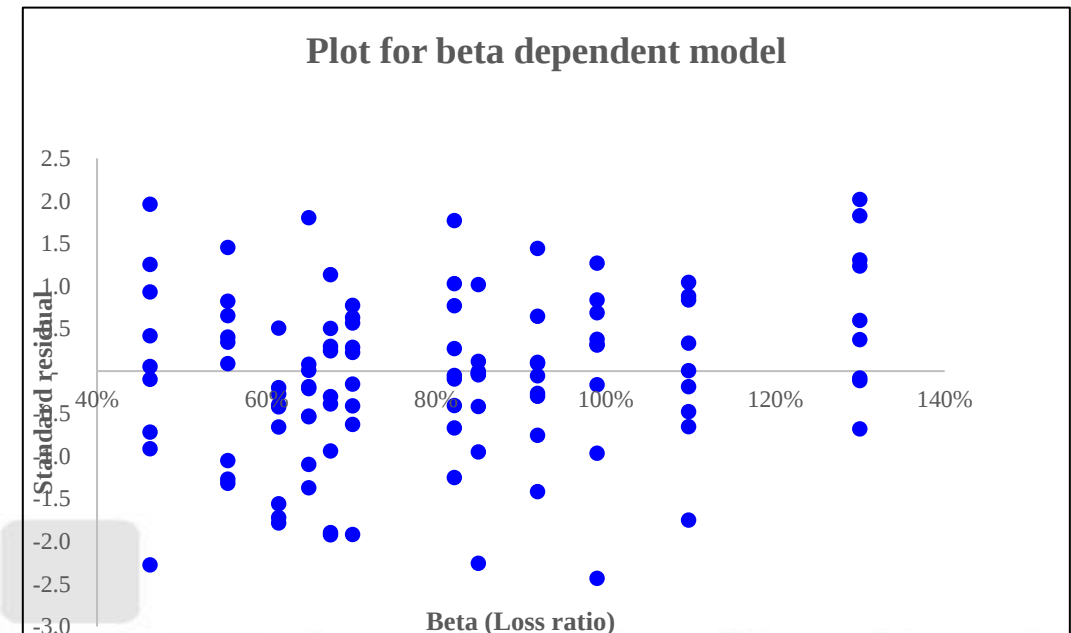
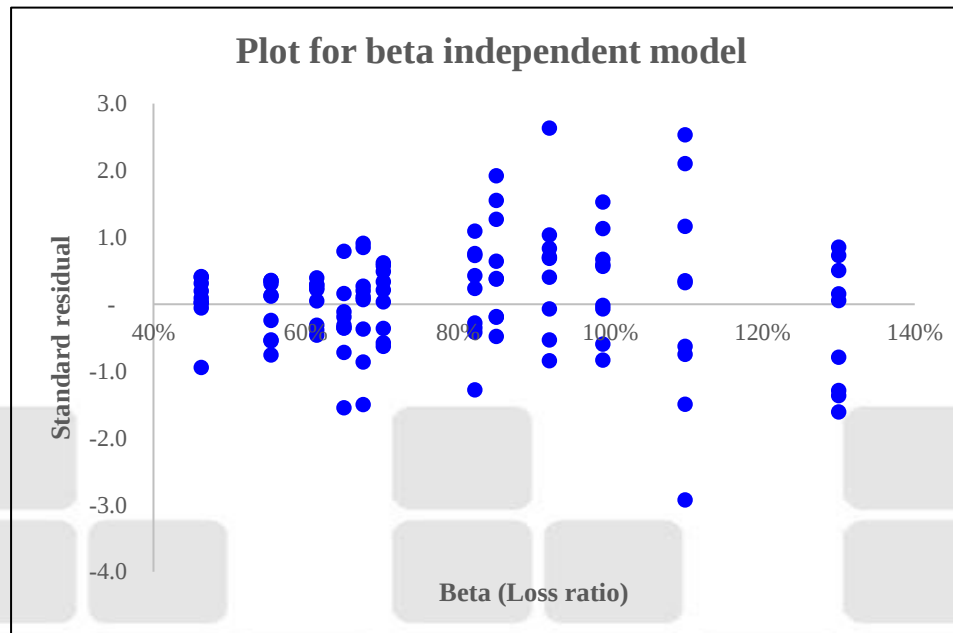
Insurance Risk – Premium Risk Risk Charge Calibration Approach

Final Solvency II techniques considered in 2011 paper

➤ Goodness-of-fit diagnostics continued:

(ii) Check for dependency on expected loss ratio parameter, β :

- Scatter plot of scaled residuals across company wise β estimate
- Expected to be scattered if model assumptions hold
- Below is a residuals plot from simulated data where the variance is influenced by a dependency on beta, β .



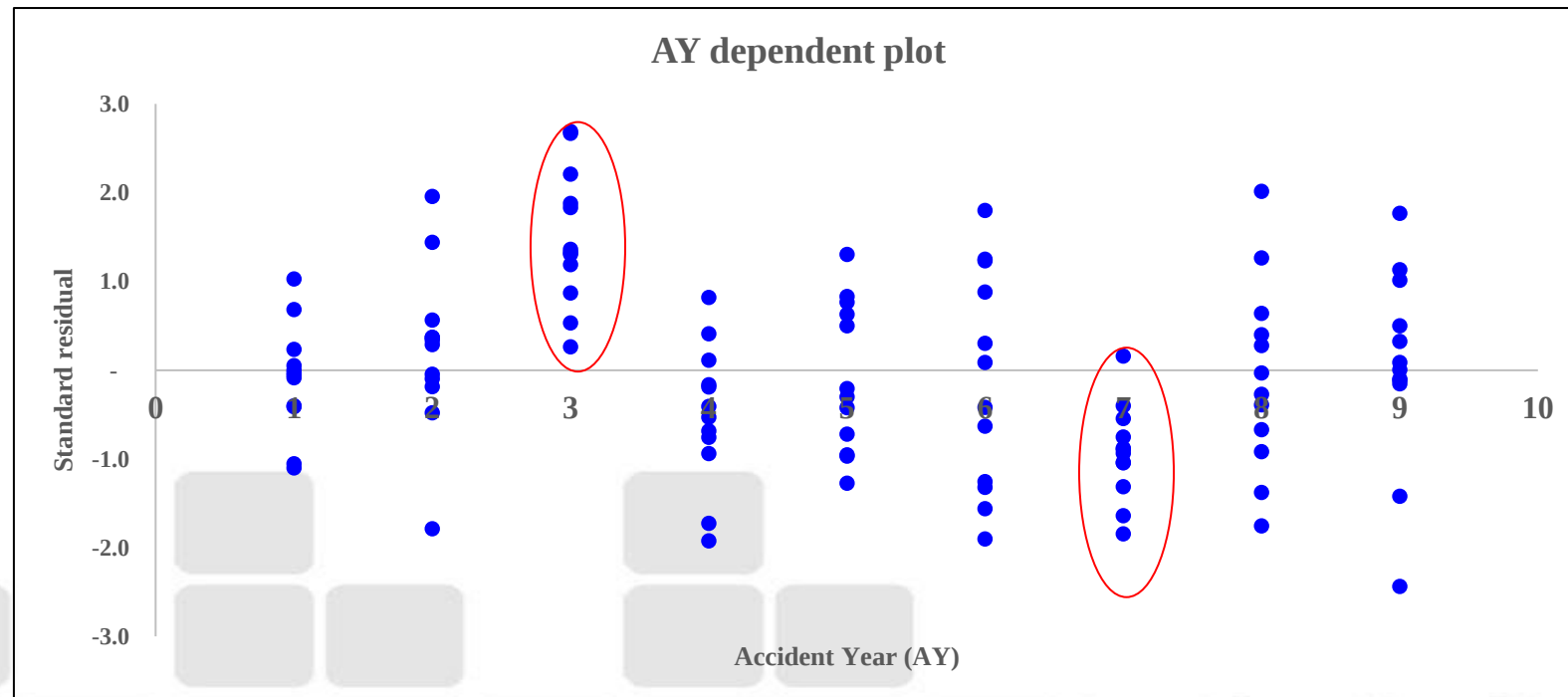
Insurance Risk – Premium Risk Risk Charge Calibration Approach

Final Solvency II techniques considered in 2011 paper

➤ Goodness-of-fit diagnostics continued:

(iii) Check for independency on AY:

- Scatter plot of scaled residuals across AY
- Expected to be scattered as per model assumptions



Insurance Risk – Premium Risk Risk Charge Calibration Approach

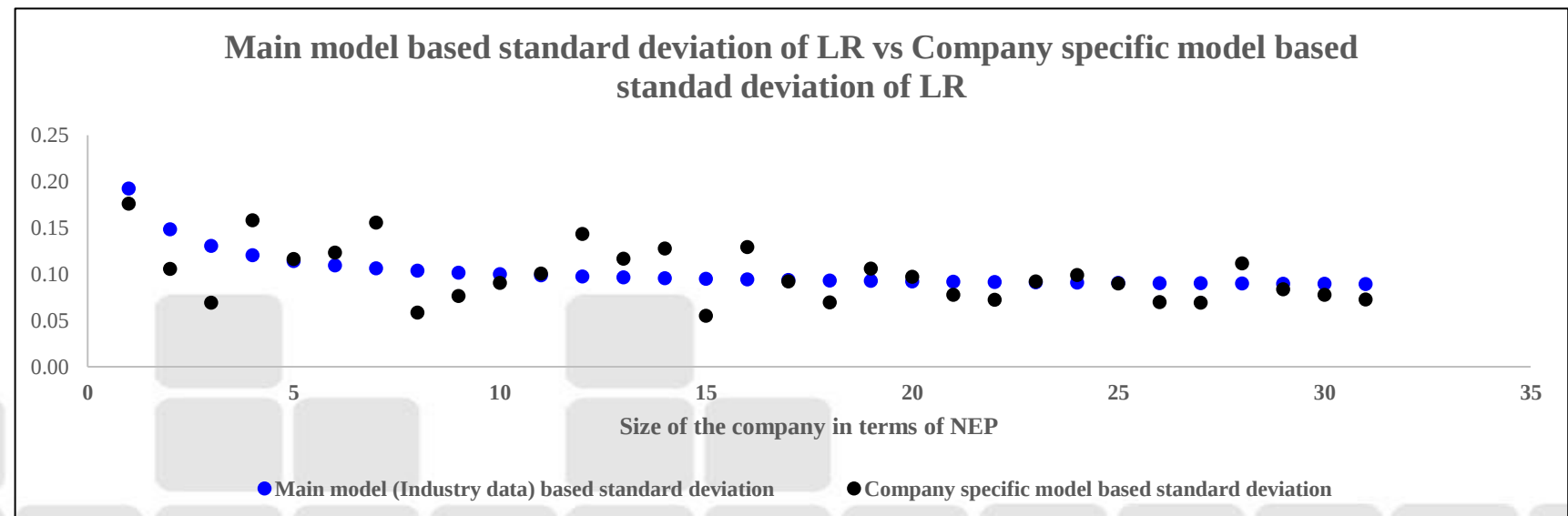
Final Solvency II techniques considered in 2011 paper

➤ Goodness-of-fit diagnostics continued:

(iv) Check for dependency on size of premium:

Company specific model:

- In addition to the industry model, company-specific models are built using respective data points to derive sigma estimates
- Volatility estimate from the company-specific model is plotted against those from the industry model, to check the goodness-of-fit in terms of dependency calibrated on premium volumes



Insurance Risk – Premium Risk

Other Key Aspects of Calibration



Other Key Aspects

- The methodology does not account for changes in risk margin under premium risk stress
 - A simpler assumption that the risk margin does not change was made in Solvency II calibration
- As the methodology derive the volatility in best estimate of loss ratios, it will be inconsistent with the valuation of URR liabilities which is floored at 100% of UPR
- Does not account for underwriting cycle induced by business cycles, tariff revisions etc.
- Premium is not a fully risk sensitive measure as it has many components which are driven by levers other than losses and losses volatility
- The factors represents capital charges for premium earned over the following one year. Need adjustments to prescribe corresponding to earnings beyond 12 months
 - Solvency II prescribes a reduction of capital charges by up to 70% for these premiums
 - This was proposed based on the assumptions that these exposures will not be impacted by unexpected temporary risks that might arise during the following year
 - In other simple words, there is unlikely to be another extreme event in the subsequent period beyond twelve months if there is already an extreme event within the next twelve months.

CAT Risk - Calibration Techniques



Concept of catastrophe risk under risk-based capital regime

Concept of catastrophe risk under risk-based capital regime



Definition

- Refers to financial losses from **rare, high-severity events** that cause significant damage to properties and human lives.
- Where, catastrophe risk covers:
 - a. The losses arising out of impact on properties and human lives due to natural disasters like Earthquake, Floods, Cyclones, etc.
 - b. Emerging pandemics (e.g., COVID-19) are now considered within catastrophe risk, where insurers are expected to maintain capital to handle large-scale health crises, modelled like other catastrophic risks.

Objective

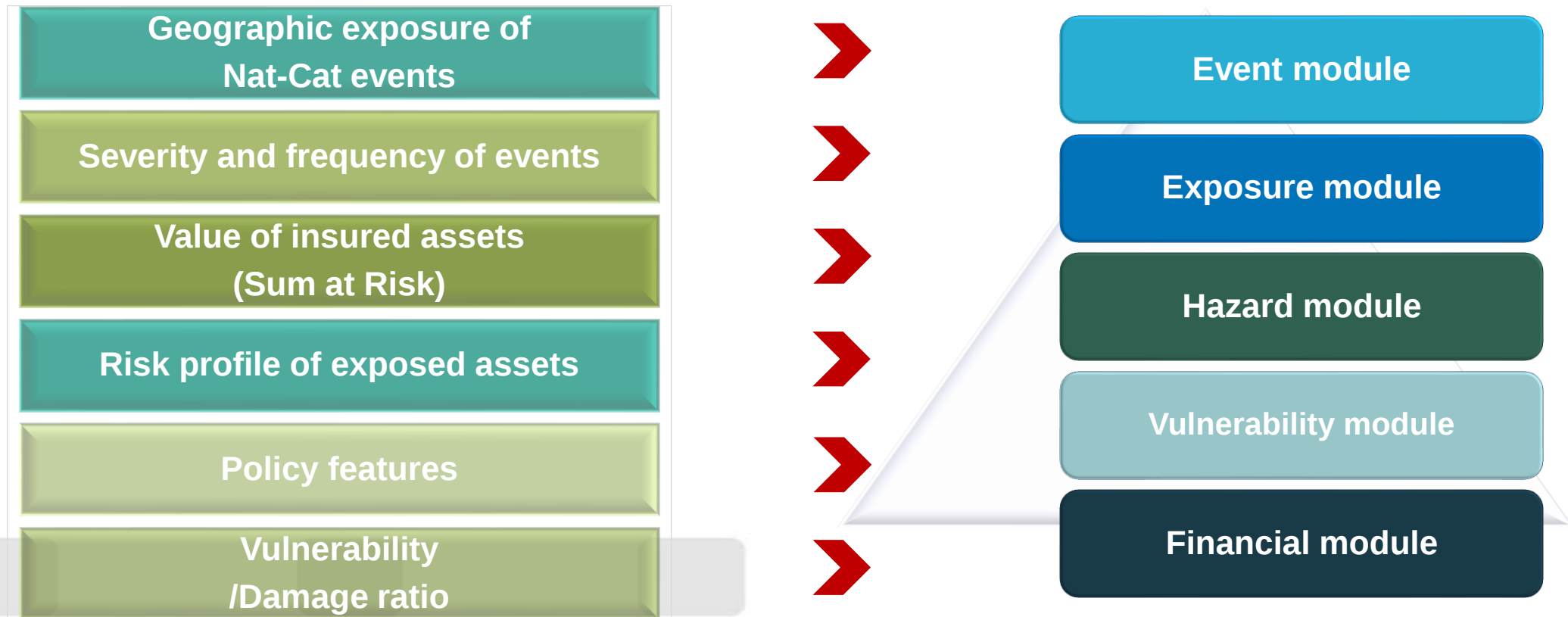
Under IRBCF, insurers and reinsurers are required to hold sufficient capital to cover potential losses from 1 in 200 years return period CAT events, thereby reducing the risk of insolvency and ensuring the insurer can meet its obligations towards policyholders.

IRBCF for natural catastrophes



Capital charge for natural catastrophe

- Capital charge for catastrophe risk is calculated using CAT models to estimate potential losses based on an insurer's exposure to NAT-CAT events. Factors considered are:



- Capital charge ***is then adjusted based on the insurer's reinsurance coverage***, to mitigate the financial impact of large-scale disasters.

Non-Life Catastrophe Risk module as per IRBCF QIS-1



Guidance of catastrophe risk charge under IRBCF QIS 1

- Cat risk charge includes cost of **individual major claim** as well as the **aggregation of multiple claims arising from a single event**. It aims to take into account the expected exposure over the next 12 months.
- IRBCR for catastrophe risk shall be calculated as

Net CAT losses (incl. reinstatement premium) + Counterparty Default Risk charge

Modelled for worst
in 200 years

For IRBSF QIS 1, working group also reviewed similar catastrophic risk modules used in different jurisdictions globally.

Jurisdictions studied & various calibration techniques

Australia



Insurance Concentration Risk Charge (Prudential Standard GPS 116)

Jurisdictions studied & various calibration techniques - UK



UK RBC Solvency II

- Under the Solvency II, catastrophe risk is calculated on both gross and net basis.
- Catastrophe risk mitigation effect is:
 - ☐ Difference between gross and net risk charges and
 - ☐ It is a measure of reinsurance credit risk used in the counterparty default risk calculation.
- Catastrophic risk charges are based on a combination of scenario and factor method.

Method 1 (Scenario Method)

Is considered for the calculation of the capital requirement for the NAT-CAT in the EEA (European Economic Area) using the recognized proprietary CAT models (1 in 200 year return period scenarios to be calibrated to 99.5% VaR requirement)

Method 2 (Factor Method)

Is considered for the calculation of capital requirement for the NAT-CAT **outside EEA, miscellaneous business and non-proportional reinsurance business**. For the factor method, the Standard Formula provides selected gross loss ratios by line of business.

Jurisdictions studied & various calibration techniques – UK (Cont.)

UK RBC Solvency II

- Capital required is calculated using method 1 and 2
- Net capital requirements are calculated using reinsurance programs - excess covers, proportional covers, excess retentions, reinstatement premiums and recoveries from any national pools.
- Aggregate capital requirement (net of reinsurance) for non-life (NL) NAT-CAT is determined as for each peril:

$$NL_{CAT}(C_k) = \sqrt{\{(Method\ 1)^2 + (Method\ 2)^2\}}$$

- Assumption: Method 1 and Method 2 apply to independent catastrophe exposures.
- Finally, the economic capital charges for all the CAT risks taken together is:

$$EC(CAT) = \sqrt{\sum_{k=1}^k c_k^2}$$

k denotes the numbers of catastrophic risk

Jurisdictions studied & various calibration techniques – US



US RBC

- Projected modeled losses are reported on an AEP basis
- Companies are permitted to report on an OEP basis if that is consistent with the company's internal risk management process.
- Additionally, a factor of **0.048** is applied to the modeled losses ceded under any reinsurance contracts to account for contingent credit risk from reinsurer defaults.
- Recoveries from certain categories of reinsurers are exempt from this charge, namely U.S. affiliates and mandatory pools
- Total catastrophe risk charge R_{cat} is calculated using the “sum of squares” approach, which assumes the two risks are independent, using the following formula:

$$R_{cat} = \sqrt{\{Total\ earthquake\ risk^2 + Total\ hurricane\ Risk^2\}}$$

AEP - Aggregate Exceedance Probability

OEP - Occurrence Exceedance Probability

Jurisdictions studied & various calibration techniques – Nepal

Nepal RBC

- Risk charge for catastrophic risks is calculated by multiplying factors that measure earthquake exposure and premiums.

$$\text{Earthquake risk charge} = (\text{EPR premium} + \text{ERE net retention}) \times 1.25$$

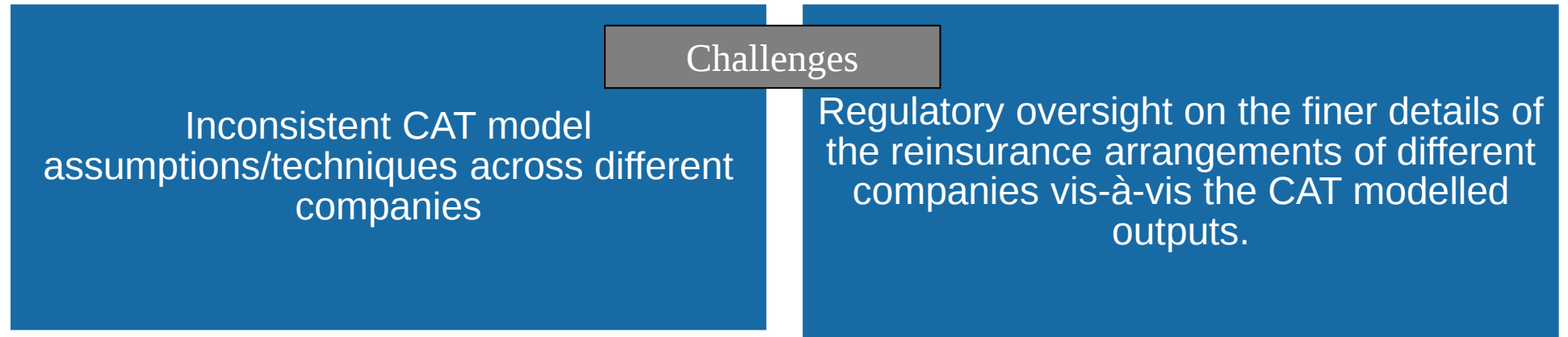
- PML basis numbers are first derived from exposures before CAT and other reinsurance protections and then adjusted for all the reinsurance covers including the CAT cover for estimating the ERE on net retained exposure basis.

- **EPR** - Earthquake Premium Reserve is the accumulation of earthquake premiums, net of reinsurance
- **ERE** - Earthquake Risk Exposure is the net retained exposure that the earthquake accumulations on PML basis over 250 years return periods
- **PML** - Probable Maximum Loss is the amount after deductibles but before catastrophic and other reinsurance protection



Final selection of jurisdiction & calibration technique

- CAT model outlined in IRBCF QIS 1 relies heavily on internal capital modelling capabilities.



- After thoroughly reviewing global risk-based capital frameworks, for the IRBCF, the **UK Solvency II catastrophe model framework** might be considered, which typically adheres to the standard factor-based approach removing the dependency on any internal capital modelling capabilities.

- UK Solvency II catastrophe model framework allows for risk-sensitive capital requirements, meaning insurers with higher exposure to catastrophe risk - such as those insuring properties in flood or earthquake-prone areas - must maintain more capital.

Final selection of jurisdiction and calibration technique (Continued)

- It is expected to help insurers assess the risk profiles of their exposures including the geographical distribution , in order to achieve optimal capital allocation.
- Approach encourages robust risk management by requiring insurers to manage and profile their exposures in a manner which aligns with the risk capital requirements of this standard factor based model which inherently incorporates factors like frequency, severity, vulnerability and potential correlation of extreme events.
- Additionally, UK Solvency II framework promotes financial stability by ensuring insurers are well-capitalized even in extreme conditions.
- In the UK based model natural catastrophes consist of windstorm, flood, earthquake, hail and subsidence. However, considering India's catastrophic risk landscape and history of cat events, we have considered only the following catastrophic events in our model:

Cyclonic Rain



Earthquake



Tropical Cyclone



Reason for adoption of proposed technique (Continued)

Limitations of the calibration technique chosen

Calibration technique chosen for catastrophe risk modelling is essential for determining capital charge. However, there are limitations in calibration process:

Data Limitations

Insufficient Historical Data

Geographical Variability

Model Assumptions and Uncertainty

Assumption Sensitivity

Climate Change

Emerging Risks

New Risks

Unknown Risks

Regulatory Calibration Constraints

Standardized Calibration

Tailored Approach

Input vector creation (Zonal grouping)

Most standard factor-based NAT-CAT model consist of risk zones for a peril and capital charge factors are prescribed against each of these risk zones including correlation factors among the various risk zones for aggregating the capital charges from the risk zones.

To identify right number of risk zones for a peril, exceedance probability outputs of an established CAT Model is used. This is to assess the relative hazard scores of identified risk zones.

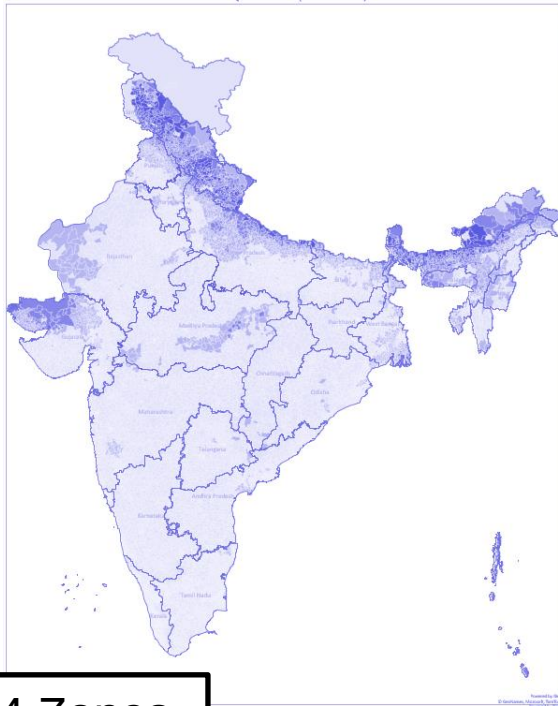
3 perils, namely Earthquake, Tropical Cyclone and Cyclonic rainfall, are considered.

Further risk zones are defined as a cluster of pin codes for a peril where the cluster of pin codes may be different for same risk/hazard zone for each peril.

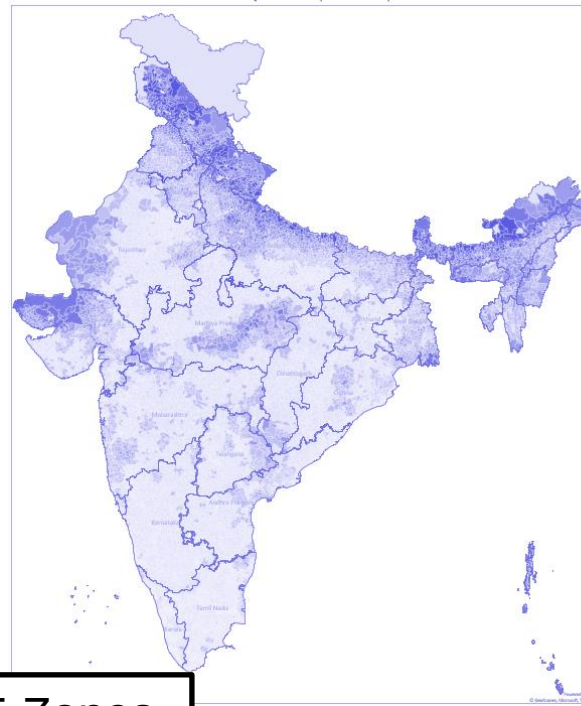
Considering various percentile points, we first created three formats, where the country was divided into 4 zones, 5 zones and 10 zones respectively to identify what level of grouping should be considered for this exercise

Zone selection process

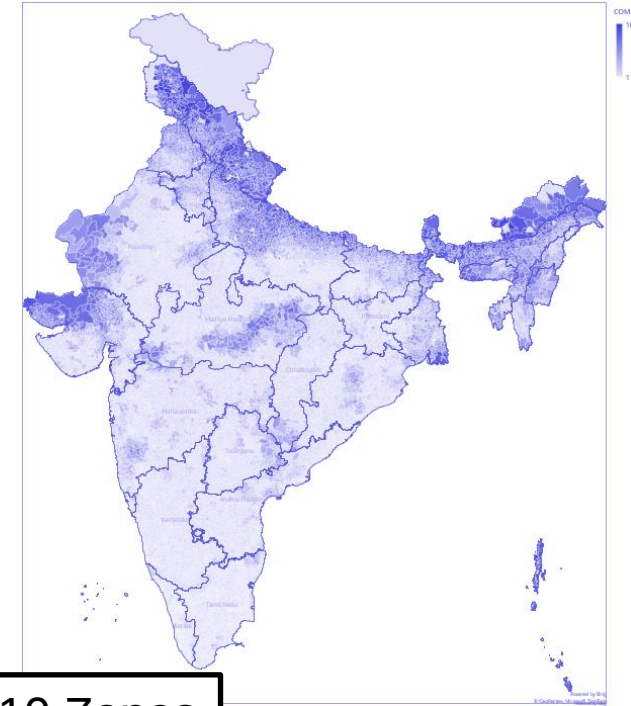
Heat map of earthquake peril for commercial occupancy type in India



4 Zones



5 Zones



10 Zones

Light color regions being least risky and dark color region being highly risky

Zone selection process (Continued)

- 4-zone grouping *fails to adequately capture the **heterogeneity*** and varying risk levels across different regions. Selecting model based on 4 zones can result into **cross subsidy** and result into lower capital requirement of insurers writing business in high risk zones.
- 5-zone grouping are very similar to those from the more granular 10-zone grouping, as seen in the third map.
- As a result, 5-risk zone grouping can be considered for each risk type. Where, 5 risk zones are selected using annual loss cost for each occupancy and risk type as given below:
 - Source of data – NAT CAT Model output
 - Zone defined based on percentile of loss cost (AAL) for each risk and occupancy type (Table in the next slide)

AAL percentile points considered for zone selection

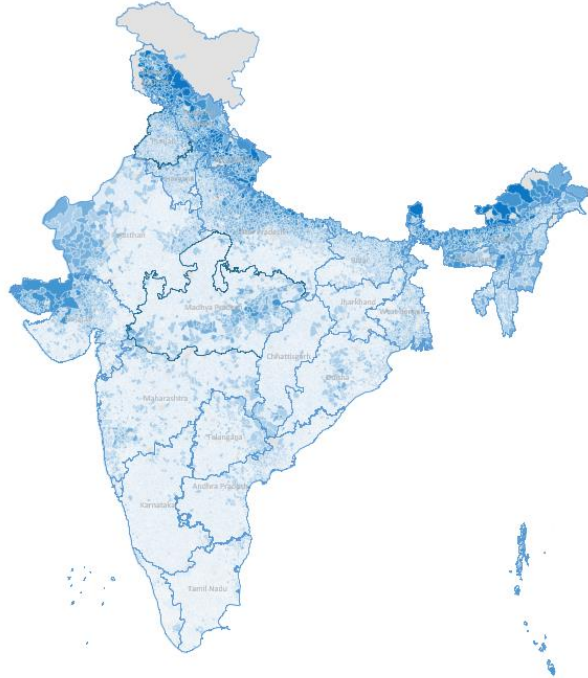
Occupancy-->		COM	RES	IND	COM	RES	IND	COM	RES	IND
Zone	Percentile	EQ_LC_AAL			TC_LC_AAL			PF_LC_AAL		
1	50%	0.01726	0.01748	0.01839	0.00044	0.00193	0.00303	0.01543	0.02155	0.02351
2	75%	0.06698	0.06790	0.07151	0.00707	0.02556	0.04041	0.05335	0.07450	0.08127
3	90%	0.21306	0.21615	0.22698	0.07380	0.25083	0.39277	0.10088	0.14087	0.15366
4	95.0%	0.59653	0.60314	0.62996	0.18294	0.62037	0.97334	0.14030	0.19592	0.21372
5	95.0%+	0.59653+	0.60314+	0.62996+	0.18294+	0.62037+	0.97334+	0.14030+	0.19592+	0.21372+
Where, maximum and average value of annual loss cost (AAL) for each risk and occupancy is given below										
	Maximum	3.12985	3.16126	3.28526	2.70164	9.74843	14.06459	0.45121	0.63001	0.68723
	Average	0.10134	0.10252	0.10728	0.03130	0.10904	0.16804	0.03514	0.04907	0.05353

Since we observed that the risk zones remain consistent across different occupancy types, hence final geographical grouping can also be independent of occupancy type **i.e. same number and size of risk zones for all three occupancies (Industrial, Commercial and Residential)**

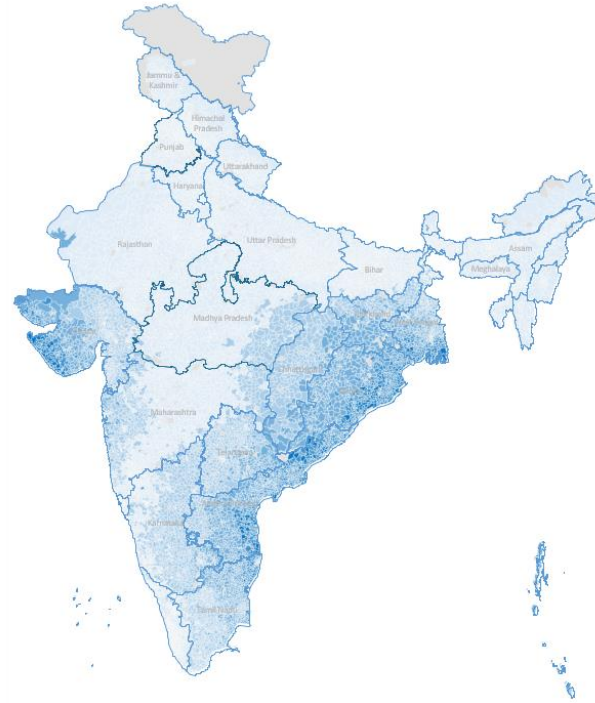
Peril wise heat map of final zone selection

Heat map of different perils based on 5 zone grouping

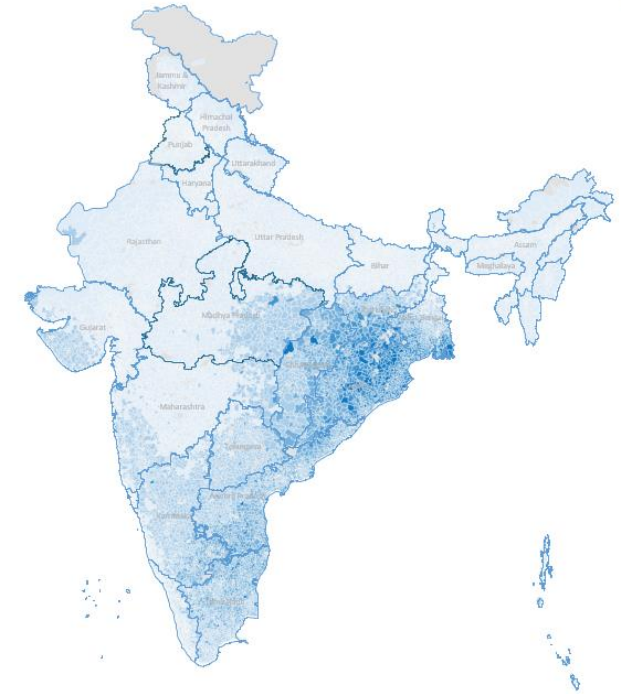
Earthquake



Tropical Cyclone



Cyclonic Rain



Light color regions being least risky and dark color region being highly risky



1 being least risky and 5 highest

Input vector

Output is used to create 5 input vectors for 5 risk zones separately for a particular peril.
Each input vector contains assumptions that are fed in to CAT model during a simulation to calculate the associated CAT costs for a particular risk zone and for the particular peril.

For each peril and risk zone, input vector further included details such as:

- Construction type (kutcha vs pukka)
- Distribution of Industrial/ Non-industrial/ Residential
- Pin codes within the zone
- Simplified equal distribution of Sum Insured across pin codes

Capital charge factor for a risk zone and for a particular peril is then expressed as:

$$\text{Capital Charge Factor} = \text{CAT Cost} \div \text{Sum Insured exposure}$$

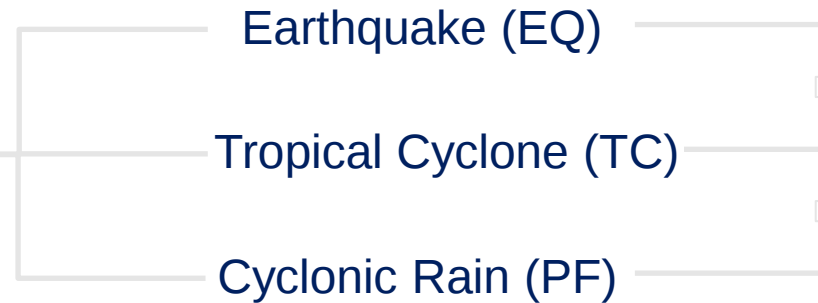
Model outcome

IRBCF for natural catastrophes

Data (Formats/Collection/Checks/Challenges) (Continued)



The IRBCF natural catastrophe risk module shall consist of the following sub-modules



$$SCR_{NatCat} = \sqrt{\sum_i SCR_i^2}$$

SCR_i denotes the capital requirement for sub-module for peril i

Capital requirement of earthquake risk sub-module will be calculated as per the formula given below:

$$SCR_{EQ} = \sqrt{\left(\sum_{(r,s)} CorrEQ_{(r,s)} \times SCR_{(EQ,r)} \times SCR_{(EQ,s)} \right)}$$

$CorrEQ_{(r,s)}$ denotes correlation coefficient for earthquake peril for risk zone r and risk zone s

$SCR_{(EQ,r)}$ and $SCR_{(EQ,s)}$ denote capital requirements for earthquake peril in risk zone r and risk zone s respectively;

Sum includes all possible combinations (r,s) of the 5 zones

IRBCF for natural catastrophes

Data (Formats/Collection/Checks/Challenges) (Continued)



- Capital requirement for earthquake peril in a particular risk zone r shall be equal to the loss in basic own funds of insurance and reinsurance undertakings that would result from an instantaneous loss of an amount that, without deduction of the amounts recoverable from reinsurance contracts and special purpose vehicles, is equal to the following amount:

$$L_{(EQ,r)} = Q_{(EQ,r)} \times WSI_{(EQ,r)}$$

$Q_{(EQ,r)}$ denotes the earthquake peril capital charge factor for risk zone r

$WSI_{(EQ,r)}$ denotes the weighted sums insured for earthquake peril in risk zone r

- Weighted sum insured for earthquake risk in a particular earthquake zone r shall be equal to the following:

$$WSI_{(EQ,r)} = W_{(EQ,r)} \times SI_{(EQ,r)}$$

$W_{(EQ,r)}$ denotes the risk weight for earthquake peril in risk zone r

$SI_{(EQ,r)}$ denotes the sum insured for earthquake peril in risk zone r

Expected Model output (Earthquake)

Peril wise, risk zone combination wise correlation factors are given below:

Risk Zone combination	EQ Correlation
1_1	Complete
1_2	Strong
1_3	Moderate
1_4	Weak
1_5	Weak
2_2	Complete
2_3	Moderate
2_4	Weak
2_5	Weak
3_3	Complete
3_4	Moderate
3_5	Weak
4_4	Complete
4_5	Strong
5_5	Complete

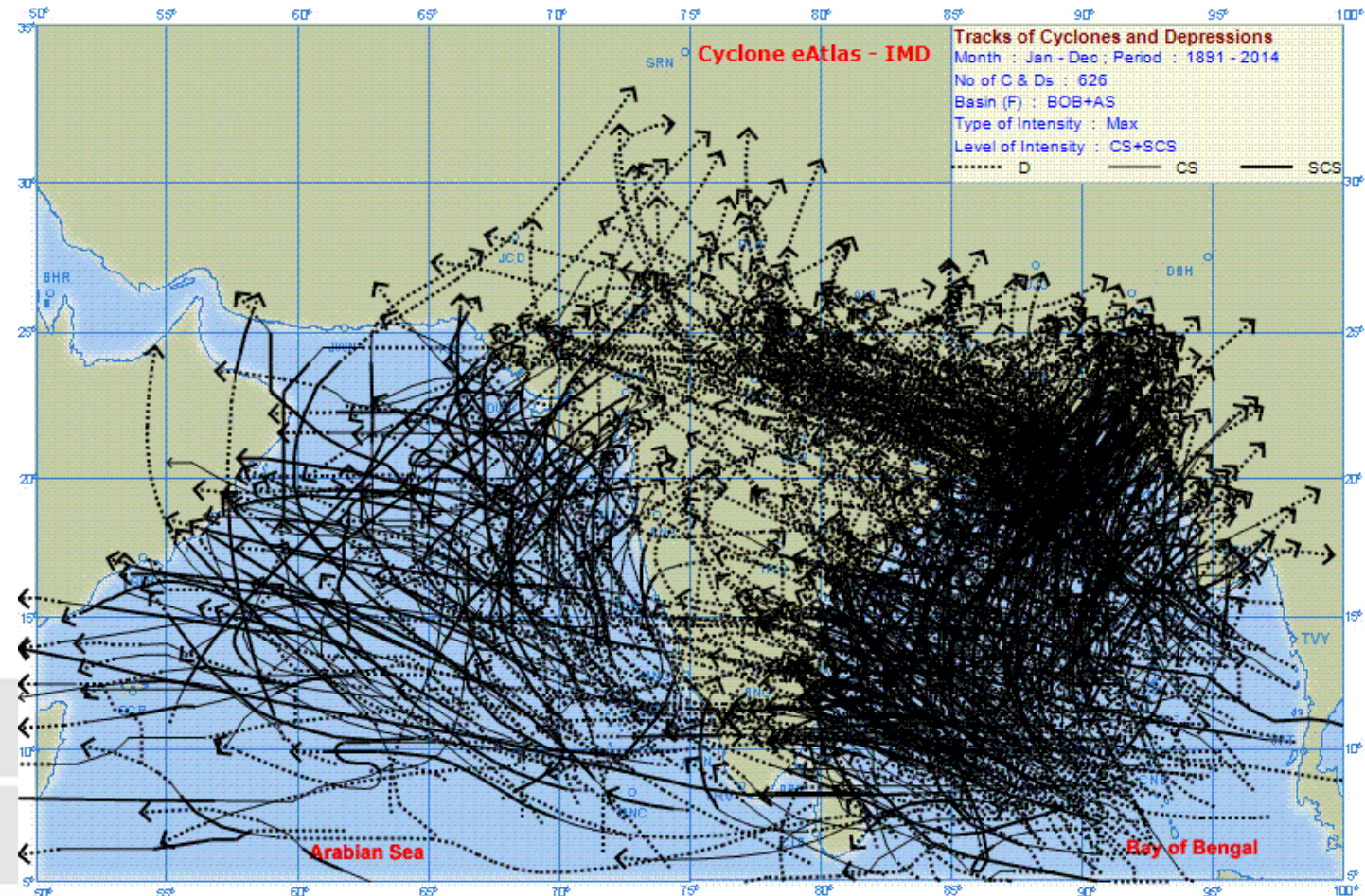


- A large shift in tectonic plate resulting into a large event is expected to result into subsequent shocks for nearby risk zones. However, this might not necessarily result into an event in low risk zones.
- Under extreme Earthquake scenario, correlation of lower risk zones with highest risk zones is observed to be negative (zone 1_4,1_5 and 2_5).

Expected Model output (Tropical Cyclone)

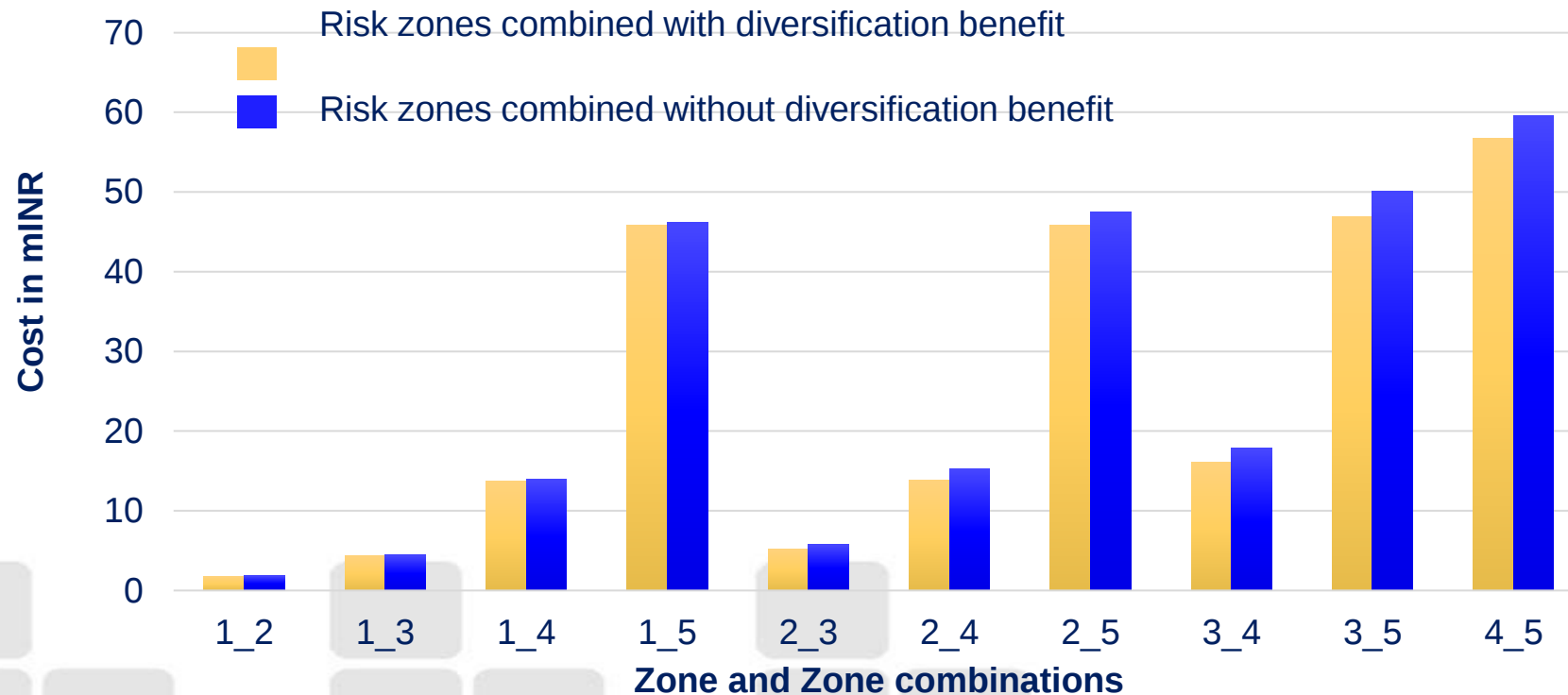
Spatial distribution of different risk zones of tropical cyclone are relatively closer and adjacent to each other and hence observed correlation factors are expected to decrease gradually as the distance between risk zones increases.

Risk Zone combination	TC Correlation
1_1	
1_2	
1_3	
1_4	
1_5	
2_2	
2_3	
2_4	
2_5	
3_3	
3_4	
3_5	
4_4	
4_5	
5_5	



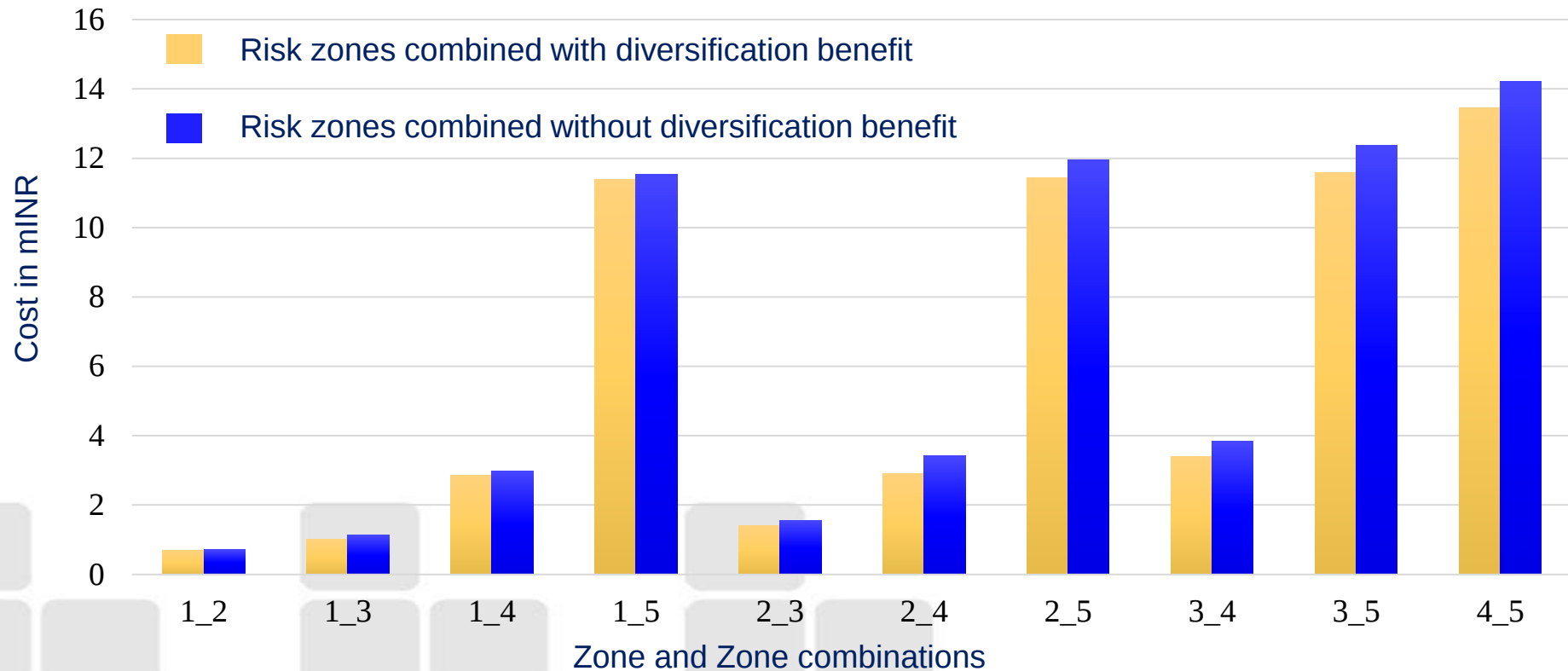
Capital requirement- Earthquake

Below is a graphical representation of the cost relativity (with and without diversification benefit) for 1-in-200 year events across individual risk zones and various risk zone combinations, assuming an equal sum insured (INR 100 Cr) in each risk zone for **Earthquake** :



Capital requirement- Tropical Cyclone

Below is a graphical representation of the cost relativity (with and without diversification benefit) for 1-in-200 year events across individual risk zones and various risk zone combinations, assuming an equal sum insured (INR 100 Cr) in each risk zone for **Tropical Cyclone** :



IRBCF for Pandemics (Health LoB)



Institute of Actuaries of India

Capital Charge for Pandemics/ NAT CAT disasters on Health LOBs

- Under Health and Personal Accident Insurance LOBs, Nat-Cat disasters like Floods, Earthquake, Cyclones can result in to following insured events:



Accidental Death



Permanent or Partial Disability



Medical Treatment

Aggregated multiple claims, which might result into large losses

Capital Charge for Pandemic/ NAT CAT Disasters (Health LOB) - as per Solvency II UK

The capital requirement for the health catastrophe risk sub-module shall be equal to the following:

$$SCR_{\text{healthCAT}} = \sqrt{\underbrace{(SCR_{ma}^2 + SCR_{ac}^2 + SCR_p^2)}_{\sqrt{\sum SCR_{(ma,s)}^2}}}$$

$SCR_{(ma,s)}$ denotes the capital requirement for mass accident risk of country s .

SCR_{ma} , SCR_{ac} , and SCR_p denotes the capital requirement of the mass accident, accident concentration and pandemic risk sub-modules, respectively.

Mass Accident and Pandemic risk sub modules apply to health insurance & reinsurance obligations other than Workers' Compensation insurance.

Accident Concentration risk sub module applies to workers' compensation and group income protection insurance & reinsurance obligations.

Capital Charge for Pandemic/ NAT CAT Disasters (Health LOB) - as per Solvency II UK (Contd..)

Approach to calculate capital requirement for Mass Accident and Accident Concentration risk sub-modules is calculated as:

$$L(ma, s) = rs \times \sum xe \times E(e, s)$$

rs Percentage of people affected by accident in country s.

xe Percentage of people receive benefits of event (Accidental Permanent Disability and Treatment) or Death, Partial Medical

$E(e, s)$ Total value of benefits payable by insurance and reinsurance undertakings for event type e in country s

Capital requirement is direct relation to the people affected. The more people are affected, the higher the capital requirement.

Capital Charge for Pandemic/ NAT CAT Disasters (Health LOB) - as per Solvency II UK (Contd..)



Capital requirement (loss) for the Pandemic risk sub-module, is calculated as follows:

$$L_p = 0.000075 \times E + 0.4 \times \sum N_c \times M_c$$

E income protection pandemic exposure.

N_c the number of insured persons covered by medical expense insurance or reinsurance obligations (other than workers' compensation).

M_c the expected average amount payable per insured person in case of a pandemic

This formula calculates the required capital to cover income protection and medical expenses in the event of a pandemic.

Thank you

Q and A?