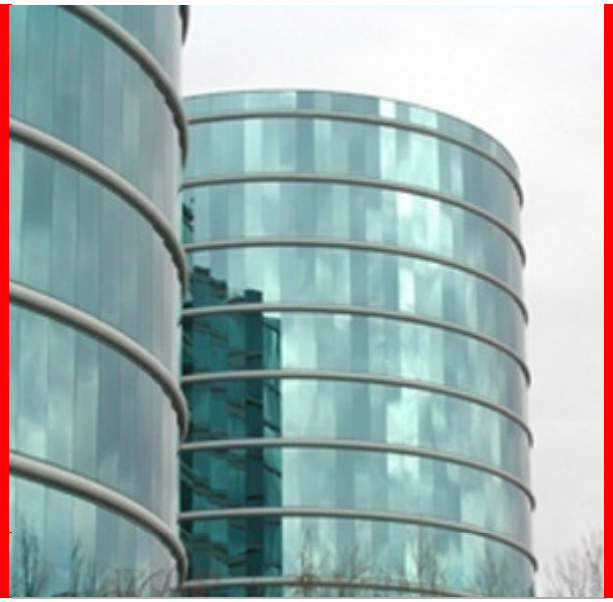

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12th GCA
Stress Testing in Insurance Industry

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About the Speaker

- Mohan is a trainer and regular speaker at various international forums on risk.
- Primary focus of Mohan and his team has been Basel II and Solvency II for the past many years.
- Mohan is busy writing his next 800 pages book “Handbook of Applied Risk Measurement” to be published by Wileys Finance Series in 2011
- His latest book “Introduction to Economic Capital” was published by Risk Books in May 2009. The book covered economic capital for Insurance Risk, Market, Credit, Operational and Liquidity.
- He is the founding co-editor of the Journal of Risk Model Validation since 2007
- In 2006, his book on credit risk was published by Risk Books London.

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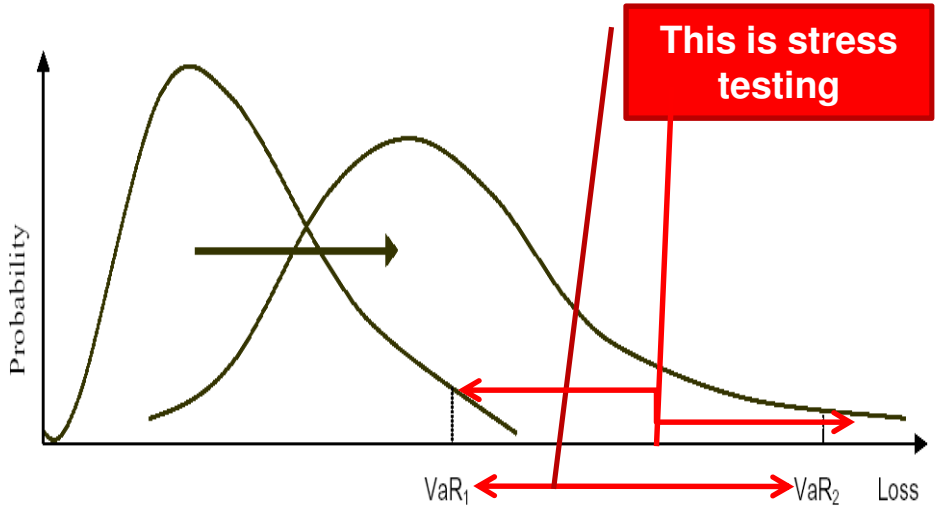
Agenda

- Stress Testing
- Risk and Model Types
- Scenario Selection
- Stress Testing Insurance Risk
- Uses of Stress Testing
- Case Study

Stress Testing

What is Stress Testing

- A stress test typically involves shifting the values of individual risk factors and determining the effect of such changes on its business.
- Changes in the loss distribution shape, VaR Losses, fat tails
- Identifies latent losses and exposures and previously unidentified risks.
- Quantum of loss identified are very high for increase in correlation, liquidity risk and breaking down of risk calibration



Stress testing is a risk management technique used to evaluate the potential effects on an institution's financial condition of a specific event and/or movement in a set of financial variables. The traditional focus of stress testing relates to exceptional but plausible events…

Committee of the global financial system, January 2005: Stress testing by large financial institutions: survey results and practice.

Stress Testing

- Why
  - Financial Markets are volatile
  - Risk Models, risk parameters, assumptions, model calibrations and model validations
  - Solvency and liquidity, Profitability of institution
  - Scenarios prescribed by Regulators and stakeholders
  - Capital Adequacy and ICAAP requirements
- Types
  - Sensitivity Analysis- single factor
  - Scenario Analysis Multiple Risk Factors
  - Contagion Analysis- Common risk factors across risk types and exposures resulting into a large correlation
  - Bottom Up and Top Down

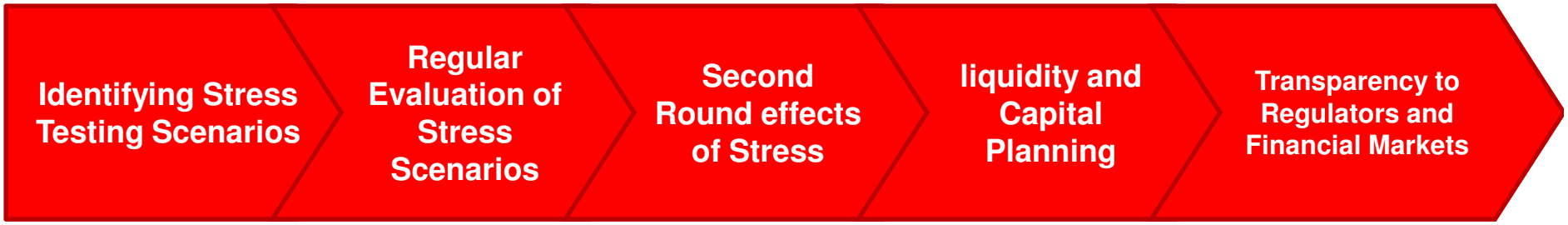
What is Stress Testing

- Comprehensive review by institutions of the nature and composition of their portfolios.
- Review of the external environment in which institutions are operating with a view to assessing the extent that this could affect their financial condition.
- Consider data specific to industries or sectors, macroeconomic variables which could affect for instance obligors' ratings, or data related to a specific country or region.
- Identification of appropriate risk factors is crucial to ensure the adequacy of the whole stress testing process.
- Identify their points of vulnerability in order to stress the relevant risk factors that may affect their earnings/profitability or solvency.
- Number of risk factors to be stressed depend on the complexity of the portfolio and the risks the institution is exposed to.

Reverse Stress Testing of the firm's business model vulnerabilities

- **Proposed by FSA, UK**
  - Identify and assess the scenarios most likely to cause its current business plan to become unviable.
  - Identify the tail risks, if they were to materialize will make counterparties and investors to lose confidence in the organization. This point reached well before the firm's regulatory capital is exhausted.

Stress Testing is a continuous Process



- Identifying Scenarios
  - Basel documents have prescribed scenarios
  - Regulators have prescribed Scenarios
  - Hypothetical Scenarios
  - Historical Scenarios
  - Reverse Stress Testing
- Identifying Risk Factors
  - Core and peripheral risk factors
- Regular Evaluation
  - In the second round, scenarios and sensitivity has to be changed
  - It can be benchmarked vs industry
- Second round effects
  - Changes in the portfolio, business models
- Liquidity and Capital Planning
- Disclosures to regulators and financial markets

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Hardest questions in stress testing

- Definition of Severe but plausible
- Historical vs Forward looking
  - Getting buying for forward looking is almost impossible…no one agreed for sub-prime like crisis……
- Bottom up…..very difficult, costly , resource intensive, requires commitment from the top management
- Agreement on Stress Testing Types
  - External Events – Macro Economic Factors
  - Model parameters – structural stresses
  - Internal events – systems failure, policy changes,
  - New Business – marketing plans, new products, collection policies
- Converge on the risk factors/ risk parameters/ risk components / loss distribution

Stress Testing shocks

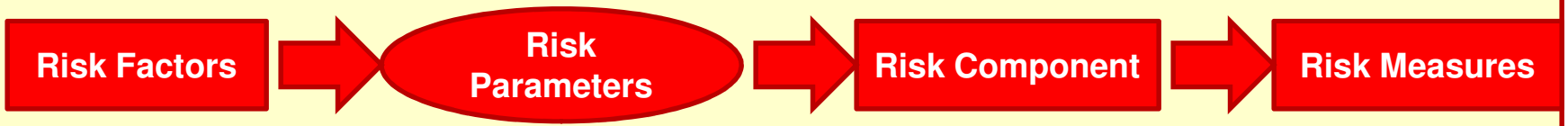
Shocks	Risk Factors/ Risk Parameters/ Risk Components
Macro Economic changes	Changes in the Risk Factors
Changes in Losses and NPL	Changes in expected losses and unexpected losses
Industry / Sectoral Shocks	Changes in the risk factors
Concentration Risk	Changes in the correlation
Changes in the interest rates	Repricing, gap, basis risk
Changes in the yield curve	Repricing risk, yield curve risk, basis risk, pre-payment and embedded options
Changes in the Foreign Exchange Rates	Impact on the net open position , this is one of the macro economic factor
Changes in the Liquidity	Cash-flow volatility and activity and volume measures in the assets markets
Changes in the insurance factors	Volatility, catastrophe
Changes in the risk event and their correlation	Volatility, extreme events, risk across products and customers, previously unidentified risks

Conducting Stress Testing on Factor Model

- There are two approaches
  - Discard the existing dependency structure and build a new dependency structure. This is required for a major shock…..
  - Expand the existing dependency structure to include the new values of systemic variables. Here not all risk factors need to change. This also can help identifying correlated impact due to stress. Advantage of this approach
    - The existing model can be re-used and users are familiar with the model.
    - The model can be used for stressed and non-stressed conditions
    - Computational effect can be minimized.

Risk and Model Types

Measuring Risk



Examples- Commercial Credit, Hybrid Models, Country Risk Models, Structural Models, Risk Factors based VaR models, liquidity risk models, life underwriting models.
Risk Factors- Mostly historical- Macro Economic, Industry, Financial variables, idiosyncratic attributes,

Examples- Reduced form credit risk models, operational risk models, market risk models, credit derivatives, P&C models, and most of the derivative models, etc

Risk Measures include, assets values, accounting profits and loss, economic profit and loss, regulatory capital or risk weighted assets, economic capital, liquidity and funding gaps

Risk and Model types

Model Types	Risk Factors	Risk Parameters	Risk Components	Risk Measures
Credit Rating	Customer Behavior, Industry and macroeconomic factors, Country Risk	Cash Flow, Ratings, Rating Migration	Ratings, Rating Migration	External Ratings, migration matrices, industry ratings, Economic loss
PD-Structural	Assets values, Customer behaviors, Financial variables, Industry and macro economic variables recovery	Diffusion process, jump process, distance to default	Default process, distance to default	Assets values, economic loss
Reduced Form	Recovery, default intensity, macro economic and industry variable, financial variable	Spreads, risk premium, default process	Spreads, risk premium	Bond price, spreads, interest rates, volatility, implied volatility, economic loss
Facilities Rating & LGD	Quality of collateral, loan structure, seniority, leverage, industry variables,	Recovery tables, Workout LGD, Market LGD, Implied LGD	Recovery ratings, Downturn ratings	Accounting losses, economic losses
EAD	Customer behavior, product characteristics, fixed or floating rates, covenants	Unused commitments, CCFs	Drawdown, Credit conversion factors	Regulatory Capital, Economic loss
Counterparty Risk	Volatility, liquid horizon, macro economic and industry variables, financial variables, exposure, collateral values	Potential future exposure	Exposure volatility, decay with time	Economic losses, margin with collaterals
Country Risk	Political risks, economic structures, fiscal flexibility, monetary flexibility, external liquidity, macro economic variables	Local currency ratings, Fx ratings	Exposure credit support, Collateral, Third party support	Regulatory Capital

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Risk and Model types

Model Types	Risk Factors	Risk Parameters	Risk Components	Risk Measures
Financial Variables Interest Rates	Macro economic factors, market observed rates	Spot and forward, drift, diffusion, jump, mean diversion	Level, slope and curvature of yield curve, volatility	Interest rates and indices in bond and derivatives market
Financial Variables Equity/FX/Commodities	Macro economic factors, market observed rates	Price/return, volatility, time variation	Drift, diffusion, jump, time variation	Equity prices and indices in cash and derivatives market
Funding Liquidity	Financial variables, customer behavior, assets quality migration, customer behavior	Source analysis, cost of funds, collaterals	Cash flow volatility	Changes in financial variables, assets quality, contingent liquidity, funding behavior
Market liquidity	Activity in assets market, bid and offer spreads	Assets quality	Volume and spread measures	Turnover, settlement and changes data Contingent liquidity
Life Insurance	Trend, level, volatility, catastrophe, insured behavior/loss experience	Mortality, morbidity, longevity, claims, expenses, lapse	Volatility	Life tables
P&C Insurance	Trend, level, volatility, catastrophe	Premium, claims, expenses	Trend, level, volatility of claims	External claims data
Operational Risk	Business environment and internal controls factors, external losses, internal losses	Extreme values, severity distribution	Event types, line of business	External losses

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Risk and Model types

Models	Macro Economic	Industry Behavior	Client/Behavior	Financial Variables	Loss experience
Credit Rating	*	*	*		* Self + Industry
Structural Form			*	*	* Self + Industry
Reduced Form				*	* Self + Industry
LGD		*			* Self + Industry
EAD			*		* Self
Counterparty Exposure			Product Behaviour	*	
Country	*	*		*	* Industry
Financial Variables Interest Rates	*				* Industry
Financial Variables Market/FX/Commodities	*				* Industry
Funding Liquidity			Product Behaviour	*	
Market liquidity	*		Volumes & activities	*	* Industry
Life Insurance			*		* Self + Industry
P&C Insurance					* Self + Industry
Operational Risk					* Self + Industry

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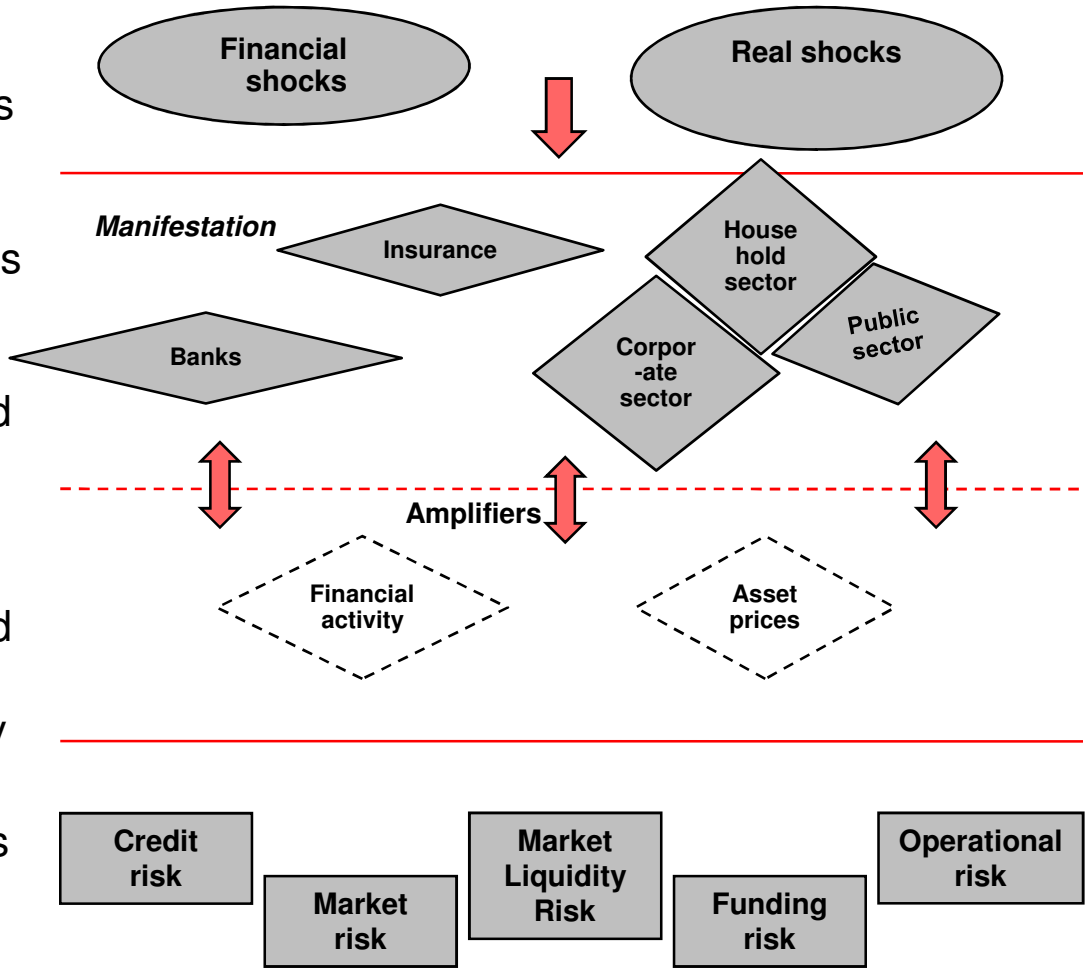
Factor Models

- Macro Economic Factors
  - Examples state, systemic factors, GDP, Recession, systemic risk, etc.
  - Basel II credit risk model is a single macro economic factor model
  - Regulators have been performing Macro Economic Stress Testing
- Types of Models
  - Credit (credit ratings) and Market risk (financial variables) Country and market liquidity models macro economic factor models.
  - Structural form, reduced form, counter-party risk, funding models are extended macro economic factor models through financial variables modeling.
  - Credit risk, LGD and country risk models are industry factor models.
- Factor Models building blocks
  - Techniques generally used are regression, time series, volatility, time variation in volatility, changes in the mean as a measure of risk.
  - Multi Factor model means different sensitivities to different factors.
  - What happens under stress conditions
    - Factors themselves may not be representing the risks being modeled
    - Regression and time series model may not hold good (parameters change, historical data and model is no more valid)
    - Correlation and Volatility change drastically
    - Volatility clustering and time variation changes
    - Assumptions of either constant or deterministic risk component no longer holds true (LGD/ EAD)
    - Stochastic behavior (PD/ IR/ FX/ Equity) modeled through drift, diffusion, jump changes drastically
    - There may be regime shift (changes in the volatility, volatility clustering, time variation)

Risk Transmission

- All institutions and all risks are exposed to the same / similar risk factors. Changes in the risk factors change risks across risk types, across the exposures, across the markets and product types. This creates a major impact on risk measures and is also called correlation.
- Under Stress conditions the relationship between risk factors, risk components and risk measures change rapidly and can dramatically amplify the changes.
- Extreme reaction and events occur rarely so carry little weights in models.



Scenario Selection

Scenarios Selection

- Forward looking
- At different level of granularity
  - Single Risk Factor
  - Multiple Risk Factors
  - Multiple Risk Factors across multiple risk types, institutions, customers, markets, assets types
- Relationship and calibration breaks down during crisis.
- Different Scenario time horizon for different types of risks, risk factors, assets and markets

- Stress scenarios
  - stochastic models or historical events,
  - and can be developed with varying degrees of precision, depth and severity
  - Very difficult to achieve coherency between different risk types and scenario time horizon
  - Assess the risks and risk factors across the different types of risks and portfolios
- All assets, institutions, customers, are linked to each other through market liquidity. Any factor or shock impacting market liquidity will have amplified impact on all types of risks
- Multiple scenarios vs. multiple risk factors

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Scenarios Selection

- **Complexity of Stress testing**
  - the nature, scale and mix of future activities; and
  - the behavior of counterparties, including the exercise of choices (e.g. options embedded in financial instruments or contracts of insurance)
- **Scenario Time Horizon**
  - Time horizon is the time for which stress is likely to continue. Time for which adverse, conditional risk factors and risk parameters need to be considered
  - For each scenario there can be multiple time horizon
  - Coherency between different risk types
- **Frequency of Stress Testing**
  - Stress Testing is cost intensive exercise. Cost goes up exponentially with frequency. Frequency can be between 1 day to 1 year. Frequency of stress testing is a broad measurement for the level of commitment from the top management and complexities of the environment and products.
  - The quickness with which events and circumstances can be identified leading to losses and how quickly can the risk mitigation be applied.
  - The extent to which there is a regular, open, liquid and transparent market in those assets, which would allow valuation of assets under normal and stress conditions.
  - Hypothetical scenarios is deemed more difficult, given the time necessary to gather data for instance,
  - Significant changes in the external environment or in the risk profile of institutions
  - Ad-hoc stress tests

Scenarios prescribed by Basel II and Regulators

Credit Risk	Market Risk	Liquidity Risk
• Macro economic movement of different degrees. Once in 25 years recession. • Market Risk and liquidity Events • Realization of collaterals, quality of protection providers • Credit risk concentration • Expected loss, EAD and LGD estimates for downturn • Illiquidity of lower quality assets	• Market risk events co-dependent on the movements in economic conditions. • Concentrated position • Non linear products/ deep out of money products • Simultaneous influence of individual stresses upon counterparty exposure, position and aggregate amount of margin calls	• Illiquidity or gapping of pricing of assets, interest rates, foreign exchange rates • Drying up of market liquidity • severe reduction in secured and unsecured funding • restrictions on currency convertibility; • Severe disruptions affecting one or more payment or settlement systems. • Covers complexities of business , products and funding sources

Operational Risk	Insurance Risk
• Stress tests and scenarios appropriate to the risks of the firms. • Check input, out put and accuracy of the AMA Model • Insert scenarios into AMA models	Volatility and assumptions

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Scenarios – Risk Factors

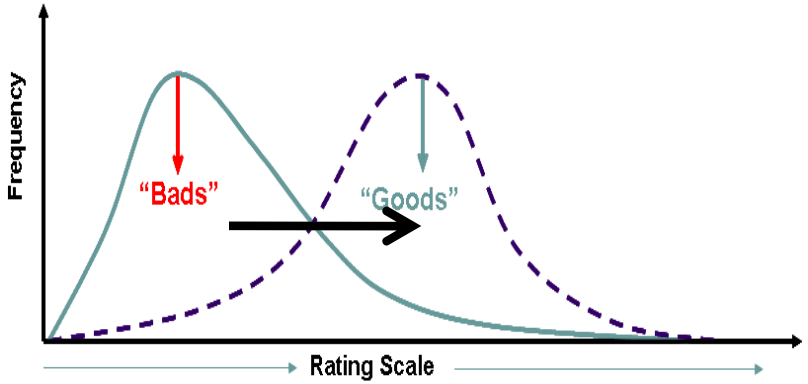
- Each scenarios may mean tens of risk factors getting impacted ….
- Just identify the risk factor most relevant for the portfolio, exposures and models. Most relevant risk factors are those with highest maximum loss contribution.
- Stress tests for standard and historical scenario may nourish a false illusion of safety.
- Subjective worst case scenarios are often too implausible to trigger management action.

Scenarios Selection

Credit Risk	Market Risk	Liquidity Risk
• interest rates, exchange rates, • asset values, market liquidity, • transition matrices, credit spreads, • economic growth rates, inflation rates, or unemployment rates, housing prices, Industry and Sectorial variables	• Changes in the slope and shape of yield curve, • Changes in the relationship among key market rates, • Changes in the volatility and volatility clustering • Changes in the market liquidity. • Concentration and illiquid instruments.	• Drying up of market liquidity • severe reduction in secured and unsecured funding • restrictions on currency convertibility; • Severe disruptions affecting one or more payment or settlement systems. • Covers complexities of business , products and funding sources

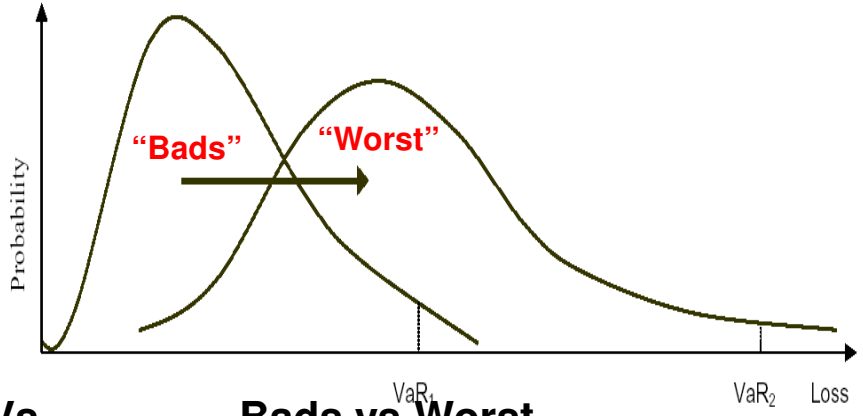
Operational Risk	Insurance Risk
Business Environment and Internal Control Factors and loss severity	Volatility and assumptions

Model Validation Techniques vs Stress Testing Techniques

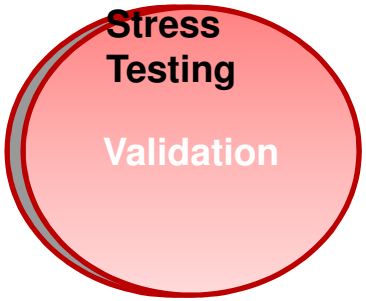


Bads vs Goods

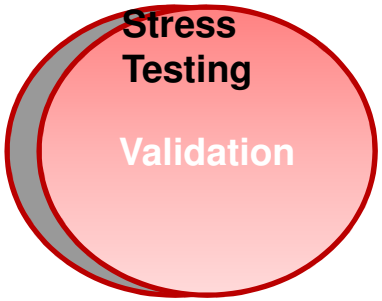
Vs.



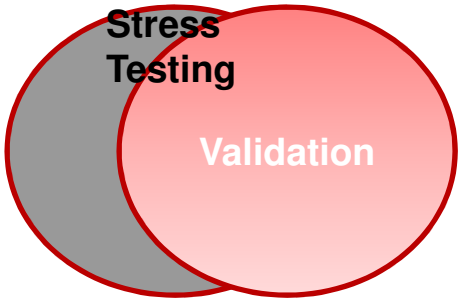
Bads vs Worst



Liquidity Risk **Operational Risk**



Insurance Risk



Credit Risk **Market Risk**

Stress testing model validation is largely concerned with verifying that the assumptions, structures and parameters incorporated into a model trained on historical data will persist far enough into the future and into extreme environments for the model to be useful.

Stress Testing Insurance Risk

Stress Testing Insurance Risk

Risk Factors	Trend	Level	Volatility	Catastrophe			
LoBs	Insurance Risk Components						
Life	Mortality	Disability Morbidity	Longevity	Expenses	Lapse	Revision	Catastrophe
Health	Premium	Claims	Accumulation	Expenses	Standard deviation	Correlation	Catastrophe
Non Life	Premium	Claims	Reserves	Expenses	Standard deviation	Correlation	Catastrophe

Stress Testing Life Insurance

Mortality Risk	Volatility , Assumptions about mortality drawn from own and similar insurance population
Morbidity Risk	Volatility, increase in probability of illness incident by x%, change in degree of invalidity, increase in the duration of illness
Non-life annuities	Volatility and assumptions about mortality drawn from own and similar insurance population
Lapse Risk	Surrendering intensity, impact on insurance capital, impact on the recovery for expenses, loss of income
Expenses Risk	There is correlation (of say 50%) between mortality and morbidity. Change in both these have impact on Expenses Risk

Stress Testing General Insurance

Frequency and Severity of Claims	Volatility and Assumptions about claims drawn from own and similar insurance population
Premium Volume	Change in product mix, change in growth
Expenses	Assumptions about Expenses growth
Mis-estimation of policy liabilities	Assumptions about claims

Uses of Stress Testing

Why did stress tests failed

- Focus on metrics rather than fundamentals
- Siloed approach to risks ignored links in the chain of events
- Isolated treatment to Credit and Market risks – however they interact through liquidity risk
- Stress Testing and Solvency II see as a compliance requirement rather than managing risk effectively best practice
- Data, model, IT infrastructure constraints due to underinvestment (in high growth
- environment)
- VaR and other risk metrics were not “fit for purposes” or limitations misunderstood
- Concentrations risks not fully understood
- Business was not managed for these types of events…else business model itself is unviable…….

Case Study- failure of stress testing and risk governance

- UBS's Market Risk framework relies upon VaR and Stress Loss to set and monitor market risks at a portfolio level. Concentration is captured by Risk Factor Loss ("**RFL") measures,** Issuer Risk (exposure to individual or related entities) and Operational Limits. Within the Credit Risk Framework limits and monitoring are undertaken across a number of dimensions including portfolios (country ratings and sectors), business types of products and counterparty types.
  - The business growth plan did not consider the risk capacity (Market risk/ VaR and Stress Test Loss limits) as an important element in the business plan
  - Stress Test Losses were Modest and Stress Tests reports not circulated outside risk management deptt: para 5.3.3
  - Umbrella and aggregated limits. Stress limits were not allocated beyond business. 5.3.1
  - Stress Testing results were not available in time for many reasons including non availability of data, changing business priority and changing market environment 5.4
  - Changes in the stress testing methodology to make it favorable to increase exposure- resulting in the reduced stressed loss and increase in volume of exposure within the stress limits6.2.1
  - All basis risks and factor risks not identified. Portfolios were marked as Stress Testing Neutral Para . Stress Testing was not sufficiently robust. 6.2.3
  - Stress Data were historical five year. Over reliance on Stress and VaR tools though losses were increasing Para6.3.6.1
  - No comprehensive Stress Test Limits Framework in place para 6.3.6.2
  - No investment in the stress testing infrastructure. Para 6.3.6.4

How much to stress

- *"We are seeing things that were 25-standard deviation moves, several days in a row"*

Chief Financial Officer of Goldman Sachs, David Viniar, commented to the *Financial Times: August 2008*

- For a normal distribution, a 7.26-sigma daily loss would be expected to occur once every 13.7 billion or so years. That is roughly the estimated age of the universe.
- A 25-sigma event would be expected to occur once every life of the universe. Therefore, assumption of normal distribution is grossly wrong in most (all) cases.

And the final word

- All that this crisis indicate is risk was priced very cheap……the purpose of stress testing is test whether risk is priced appropriately.
- How to get stress testing accepted in the organization
  - Whether the same model is used for stress testing also? Using same model gives wider acceptability to the stress testing.
  - Clarity and robustness of base case
  - Clarity on external market/economic context
  - Scenario articulation
  - Sufficient severity
  - Transparency and understanding of results
  - Senior management involvement: evidence of process is important
  - Credibility and evidence for management actions
  - Simple and clear presentation of results
    - Impact on risk drivers
    - Impact on liquidity buffers
  - Role on Stress testing comes from
    - Regulatory compliance, disaster planning, product pricing, portfolio optimization

Thank you

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