

A Practical Framework for Credit Risk Stress Testing

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Credit Scoring and Credit Control XI conference

Overview



- **Introduction**
- Types of Stress Testing
 - ▣ Sensitivity Stress Testing
 - ▣ Scenario-based
 - Historical
 - Hypothetical
 - ▣ Concentration and correlation stress testing
- Measuring outcome of stress testing

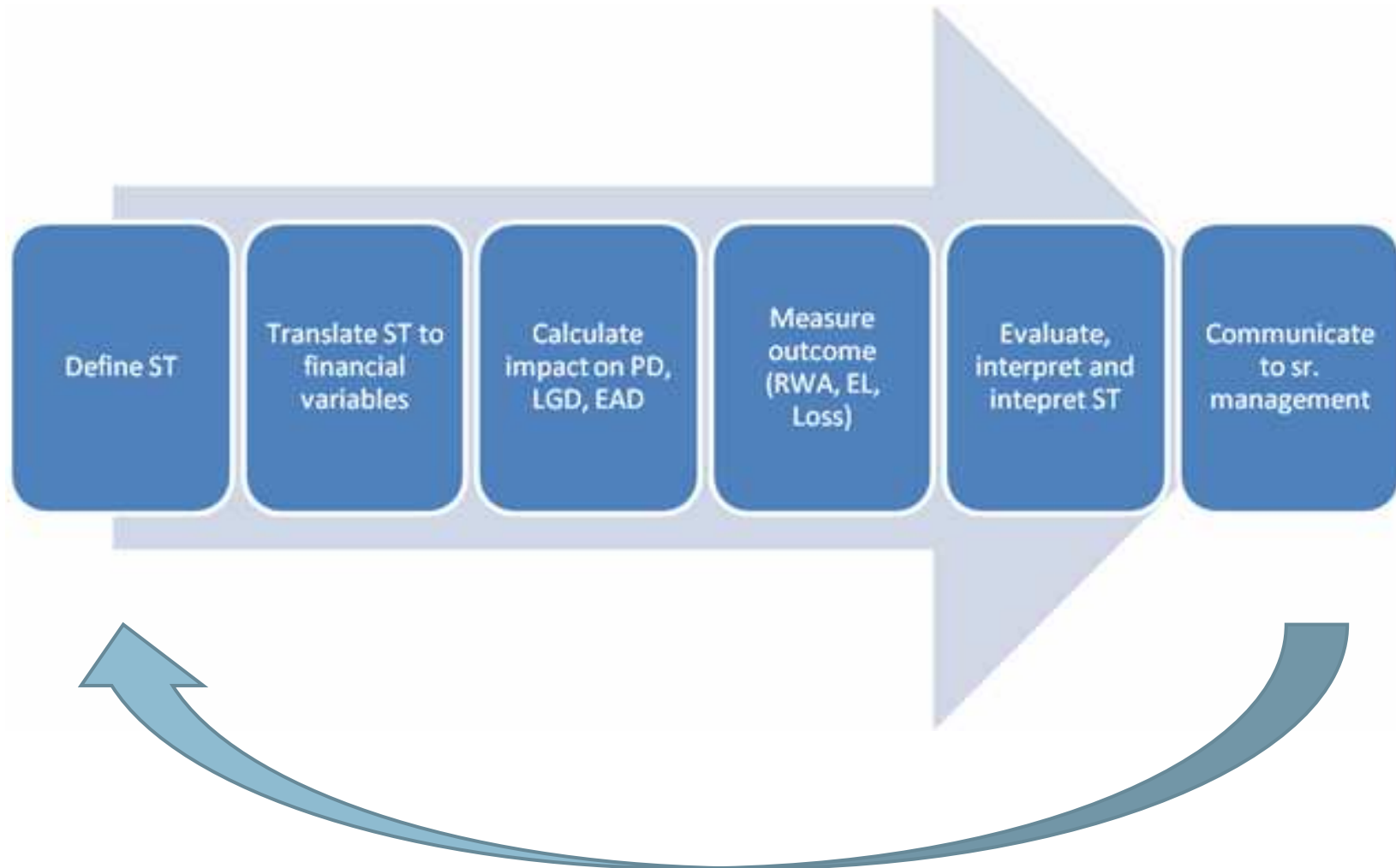
What Is Stress Testing?

Stress testing is a risk management tool used to evaluate the **potential** impact on a firm of **specific** events and/or movements in a set of **financial variables**.

BIS working group report, January 2005

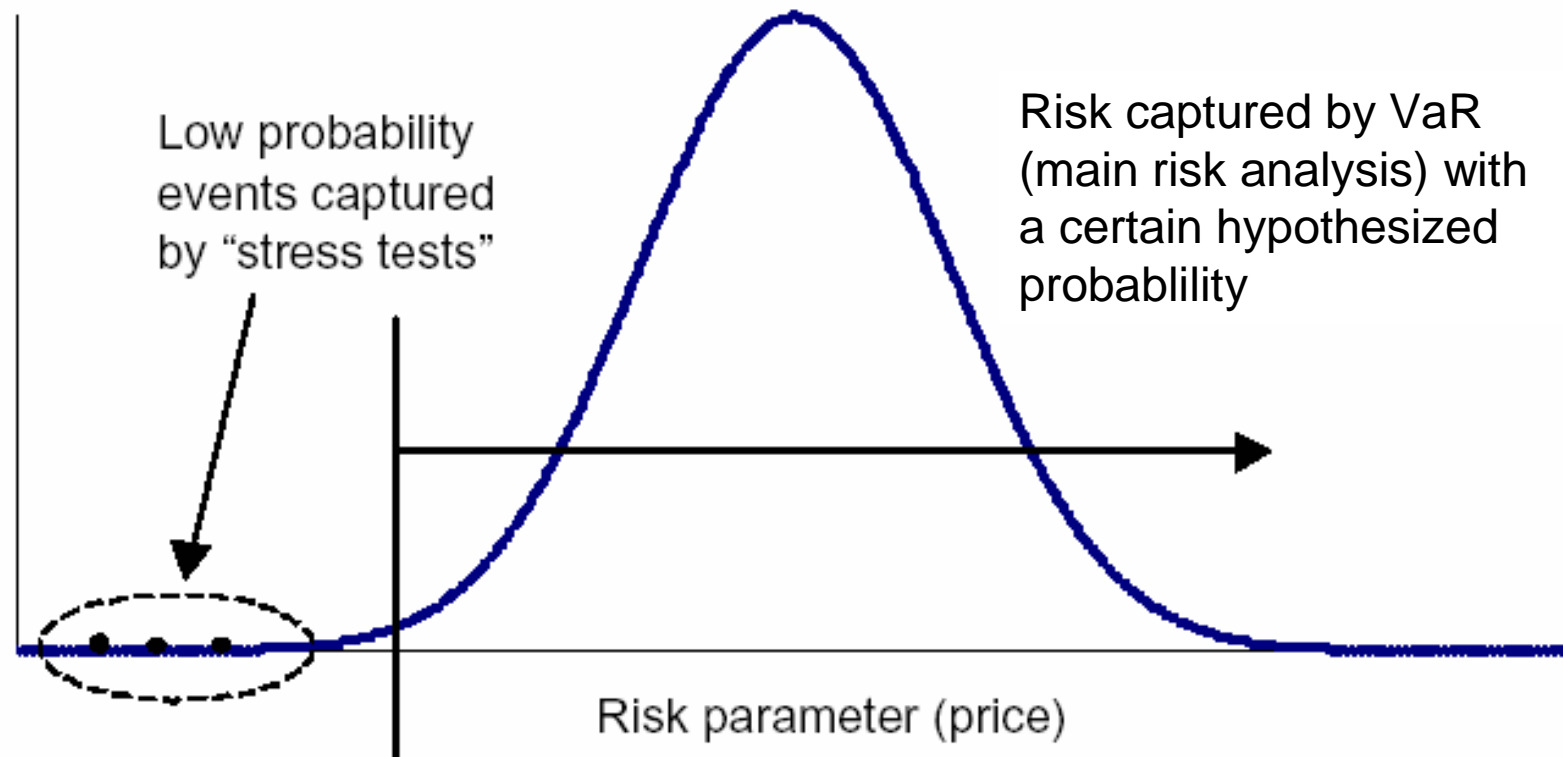
- ▣ Potential impact
- ▣ Specific situations
- ▣ Financial variables
- ▣ Used as an adjunct to statistical models such as Value at Risk to consider the very unusual events

Stress Test



Stress Testing

Stress tests capturing exceptional but plausible events



Why Use Stress Testing?

- **Business value as well as regulatory value**
- **BIS survey suggested some of the current uses**
 - ▣ In retail, forecasting used to set pricing and product features
 - ▣ Capturing impact of exceptional but plausible loss events
 - VaR reflects everyday markets, stress test abnormal markets
 - ▣ Understanding risk profile of firm
 - Aggregate risks
 - shocks in nonlinear instruments (credit facilities)
 - ▣ Capital allocation or verification of allocation
 - Stress tests used to set “soft limits”
 - ▣ Reduce pro-cyclicality
 - ▣ Evaluating business risks
 - The T of SWOT analysis

Basel II on Stress Testing

- **Who**
 - ▣ Every bank adopting IRB approach
- **Stress test setup**
 - ▣ Identify possible events or future changes in economic conditions that could have unfavorable effects on a bank's credit exposures
- **Severity of stress**
 - ▣ Mild recession scenarios. E.g. two consecutive quarters of zero growth
 - ▣ Typically, one considers a 1 out of 25 years event!
- **Risk parameters**
 - ▣ PD (LGD, EAD long-term)
- **Data**
 - ▣ First use internal data, external data as complement

Basel II on Stress Testing

- Current credit crisis
 - ▣ Basel Committee engaged with banking industry on ST
 - ▣ Consultative paper by BCBS (January 2009)
- Importance of integration in risk management
 - ▣ *“Stress testing should form an **integral part** of the overall governance and risk management culture of the bank. ... **Board and senior management** involvement in the stress testing programme is essential for its effective operation.”*
 - ▣ Explicit link: doing well during crisis and active involvement of sr. management in ST.

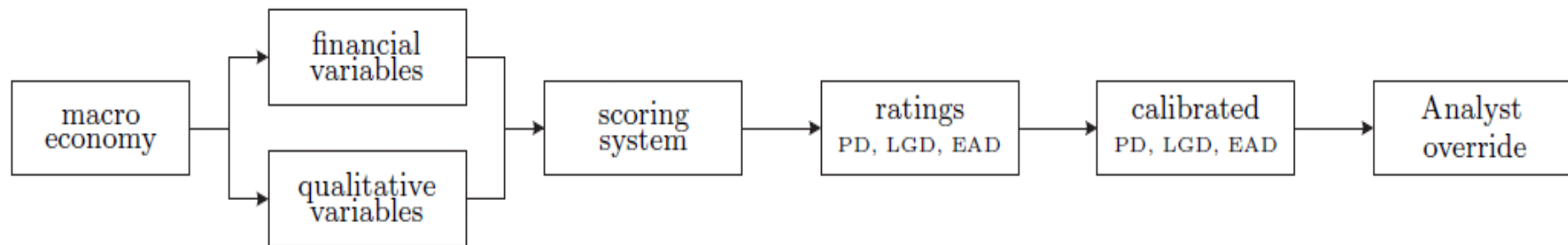
Current Uses of Stress Testing



- Both FSA and BIS have recently done **surveys** of use of stress testing in financial organizations

- FSA
 - “Stress testing most developed for **market risk**”
 - “Stress tests for **credit risk** less advanced”
 - “Surprisingly little evidence firms develop credit risk stress testing methodology”

Levels of Stress Testing



Overview



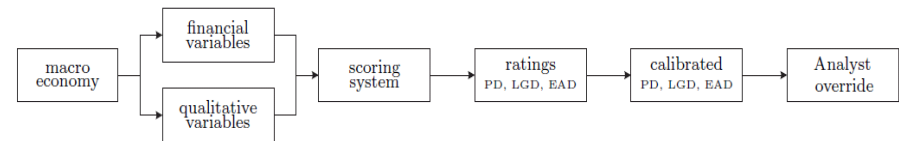
- Introduction
- **Types of Stress Testing**
 - **Sensitivity Stress Testing**
 - Scenario-based
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Sensitivity stress testing



- Static approaches
- Do not take into account external (macro-economic) information
- Very popular for market risk
 - ▣ Example single factor stress tests
 - Yield curve shifts by 100 basis points
 - Decrease in £:\$ exchange rate of 5%

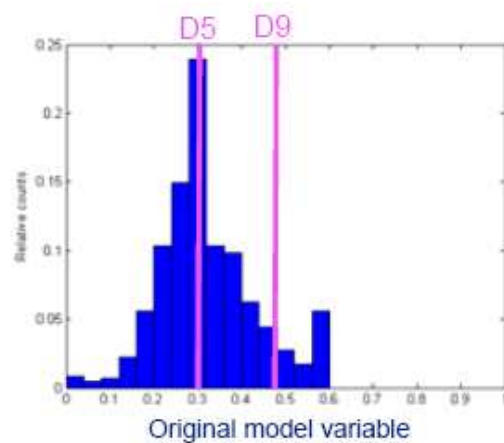
Sensitivity stress testing



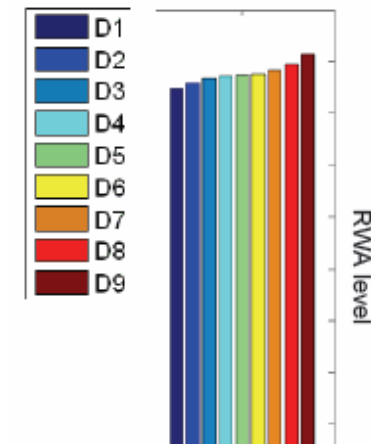
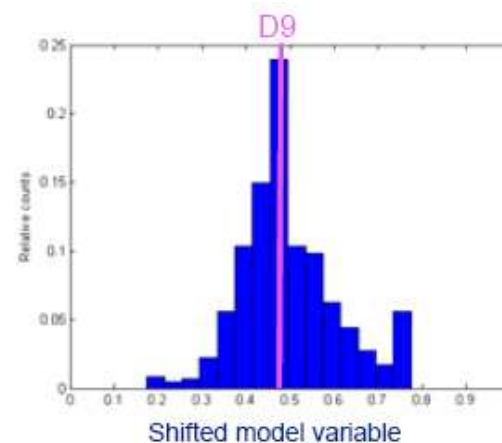
- Sensitivity stress testing:
 - ▣ Level 0 - Input parameter sensitivity stress testing
 - *Decrease in income levels of 10%*
 - ▣ Level 1 – Score
 - *Decrease in the application/behavioural scores of 10%*
 - ▣ Level 2 - Risk level sensitivity: change in PD, LGD by x%
 - Also used by the IMF
 - Calibrated risk parameters
 - *Calibrated PD/LGD values increase by 100%/50%*
 - Rating
 - *Two-notch downgrade of 50% of all exposures*
 - *Six-notch downgrade of 10% of all exposures*

Sensitivity stress testing

- Sensitivity stress testing:
 - Level 0 - Input parameter sensitivity stress testing
 - Stress test model variables one by one
 - Calculate deciles of variable distribution: D1, ..., D9
 - Shift variable x reference levels to the right (+) or left (-)



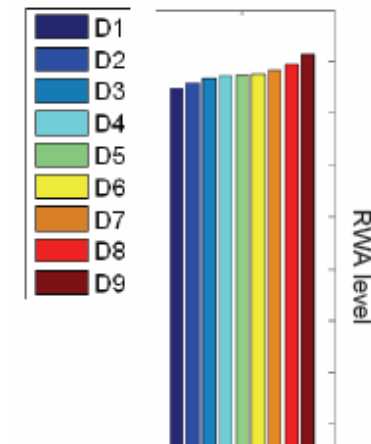
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(Van Gestel, 2009)

Sensitivity stress testing

- Sensitivity stress testing:
 - Level 0 - Input parameter sensitivity stress testing
 - Resulting outcome is compared across different model inputs
 - Biggest impact from model inputs with
 - high weight
 - impacting the full portfolio
 - The results give an indication of the RWA volatility across the drivers and the portfolios



(Van Gestel, 2009)

Sensitivity stress testing



- Relatively easy to implement and understand
- Better understanding of how model works
- Hard to defend connection with changes in economic conditions
- Multi-factor seeks to stress “all factors”
 - ▣ Really becomes a scenario type test and critical issue is correlation between factors

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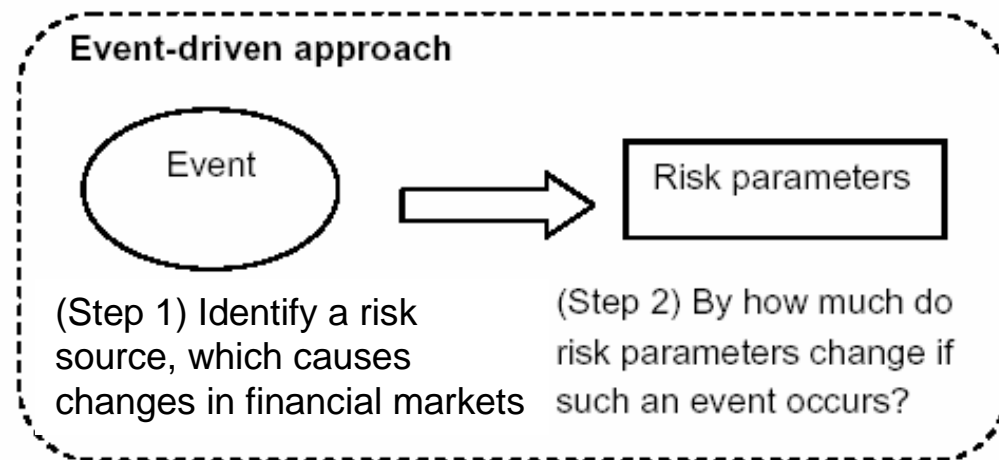
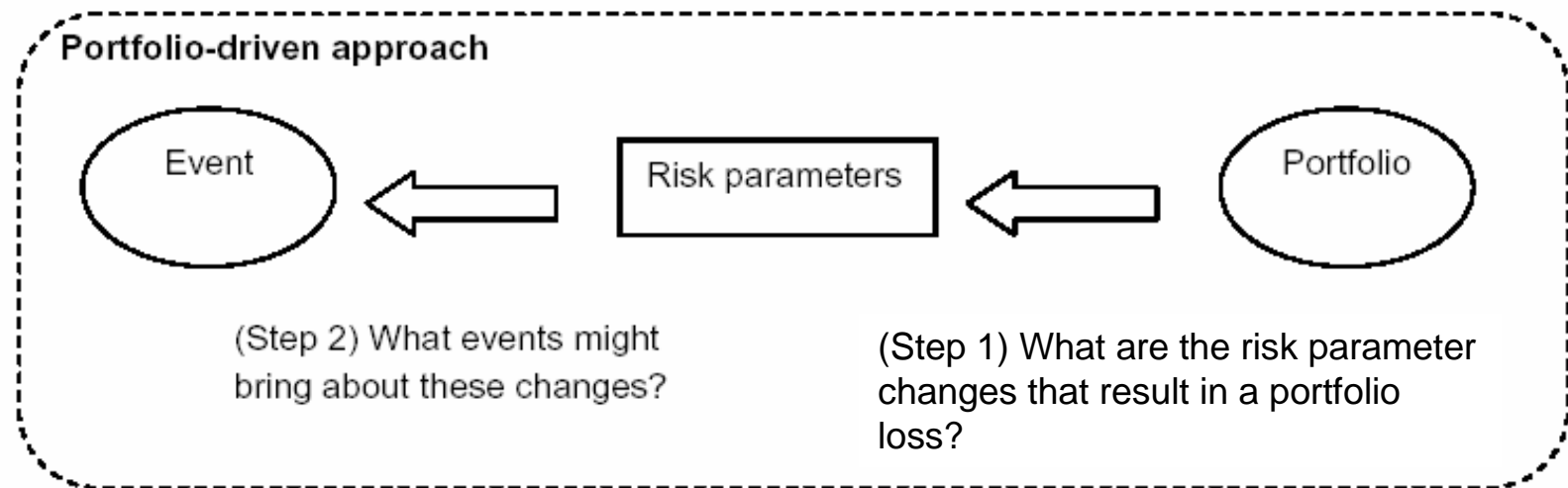
Scenario Tests



- Source of shock well-defined as are parameters affected (there might be lags before affected)
 - Portfolio driven or event driven
 - Historical Scenarios
 - actual events so fewer judgments
 - still relevant if changes in portfolio/operations?
 - Hypothetical Scenarios
 - potentially more relevant
 - very labor intensive
 - need lots of expert judgment
 - Always a trade-off between realism and comprehensibility

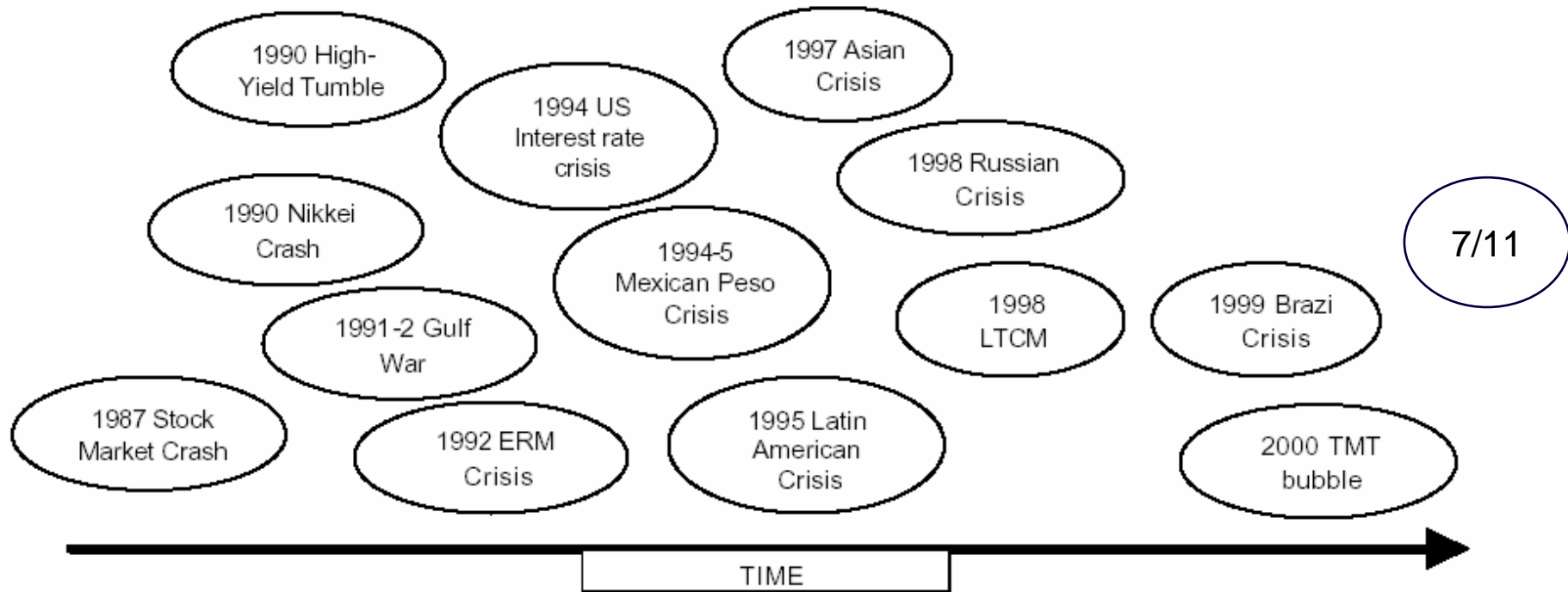
Portfolio Driven versus Event Driven

Approaches to scenario formulation



Reverse stress testing!

Historical Scenarios



MAS Credit Stress Testing

 Historical scenarios mainly affect trading portfolios.

Historical Scenarios



- Expert-based: scenario from past
- Data-based methodology
 - ▣ Determine worst year
 - ▣ Apply observed stress of worst year
- Easy if enough data is available (stress of 1/25 years)

Historical Scenarios

- Determine worst year
 - Downgrade kappa summarizes stress of migration matrix
 - Downgrades add to kappa
 - Upgrades lower kappa
 - Highest stress: kappa = 1
 - Lowest stress: kappa = -1
 - Even (or diagonal matrix): kappa = 0

$$\kappa = \sum_{i=1}^k \sum_{j=1}^k w_{ij} p_{ij}$$

$$w_{ij} = -\frac{i-j}{k-1}$$

Data-driven historical Stress of 1/25 years

year 1 – year 2

	nobs	A	B	C	D	E	F
A	287	100%	0%	0%	0%	0%	0%
B	332	0%	88%	2%	4%	0%	0%
C	96	2%	0%	70%	18%	4%	0%
D	47	0%	0%	9%	87%	2%	2%
E	46	0%	0%	0%	17%	83%	0%
F	5	0%	0%	0%	0%	0%	100%



Downgrade $\kappa = -0,013$

year 2 – year 3

	nobs	A	B	C	D	E	F
A	78	97%	3%	0%	0%	0%	0%
B	107	1%	98%	1%	0%	0%	0%
C	62	0%	3%	89%	2%	0%	2%
D	17	0%	0%	6%	94%	0%	0%
E	8	0%	0%	0%	0%	88%	12%
F	1	0%	0%	0%	0%	0%	100%



Downgrade $\kappa = -0,692$

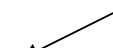
year 3 – year 4

	nobs	A	B	C	D	E	F
A	168	97%	3%	0%	0%	0%	0%
B	463	2%	92%	5%	1%	0%	0%
C	348	0%	2%	96%	2%	0%	0%
D	376	0%	1%	10%	84%	0%	0%
E	458	0%	0%	1%	3%	85%	0%
F	97	0%	0%	0%	2%	0%	92%



Downgrade $\kappa = 0,234$

Maximal



year 4 – year 5

	nobs	A	B	C	D	E	F
A	191	97%	2%	2%	0%	0%	0%
B	169	2%	95%	1%	2%	0%	0%
C	140	0%	3%	90%	2%	0%	0%
D	44	0%	0%	7%	84%	9%	0%
E	20	0%	0%	0%	45%	55%	0%
F	1	0%	0%	0%	0%	0%	100%



Downgrade $\kappa = 0,185$

...

year 24 – year 25

	nobs	A	B	C	D	E	F
A	19	58%	26%	16%	0%	0%	0%
B	50	0%	80%	20%	0%	0%	0%
C	79	0%	3%	95%	3%	0%	0%
D	28	0%	0%	21%	75%	4%	0%
E	18	0%	0%	0%	28%	72%	0%
F	3	0%	0%	0%	0%	0%	100%



Downgrade $\kappa = 0,094$

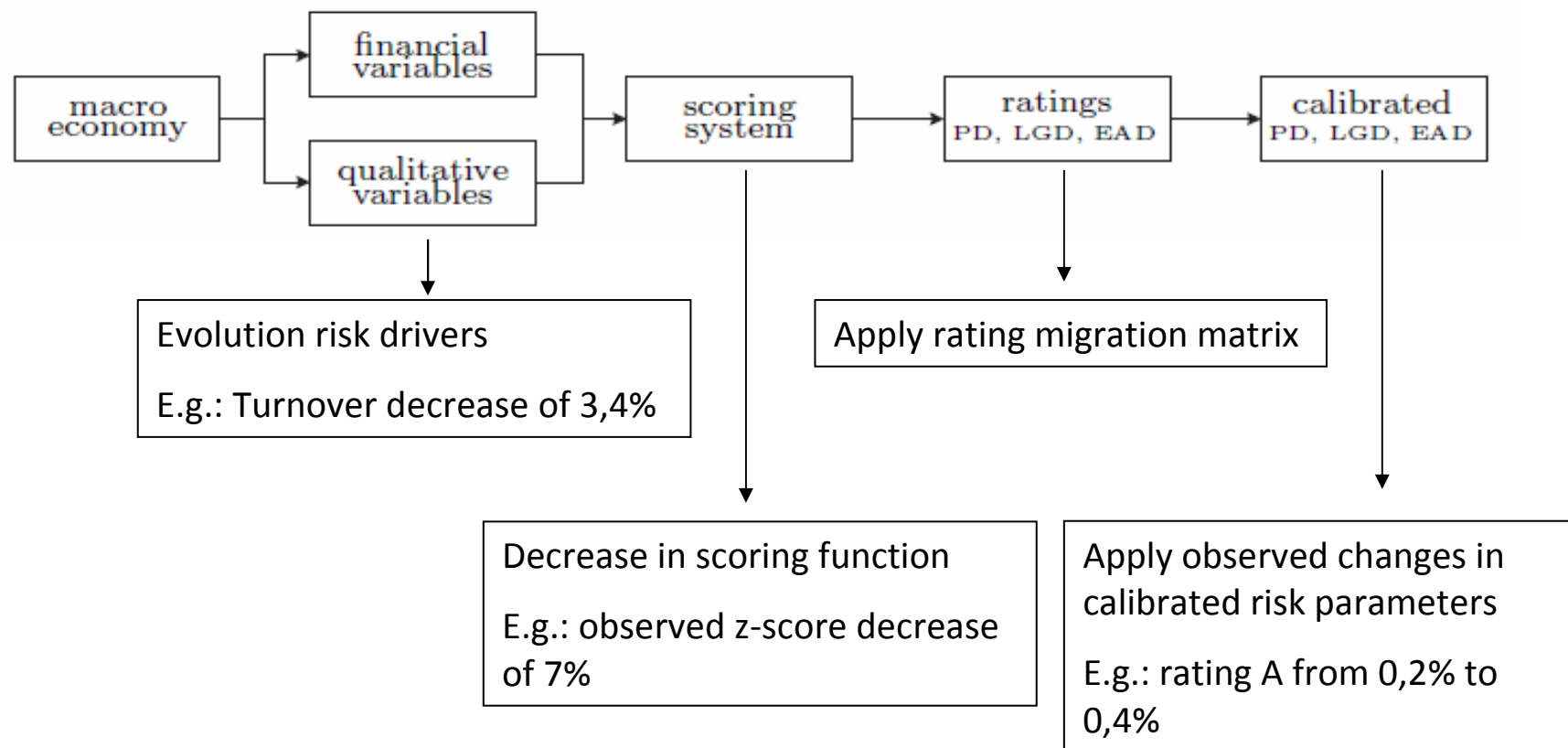
Data-driven historical scenarios

Apply observed stress of worst year

Levels of stress testing

year 3 – year 4

	nobs	A	B	C	D	E	F
A	163	97%	3%	0%	0%	0%	0%
B	463	2%	92%	5%	1%	0%	0%
C	343	0%	2%	96%	2%	0%	0%
D	376	0%	1%	10%	84%	0%	0%
E	453	0%	0%	1%	8%	85%	0%
F	97	0%	0%	0%	2%	0%	92%



Hypothetical Scenarios



- Use hypothetical when no historic scenario appropriate
 - ▣ Portfolio changed or new risks identified
- Ensure no risk factors omitted
- Combined changes in each risk factor make economic sense
- Factors that might cause stress:
 - ▣ Macro-economic downturns
 - Mostly considered by institutions nowadays (FSA, October 2006)
 - ▣ Deterioration in reputation
 - ▣ Adverse change in competitive position
 - ▣ Failure of a market counterparty
 - ▣ Liquidity conditions

Types of Hypothetical Scenarios

- Worst-off: look at most adverse movement in each risk factor.
 - ▣ Least plausible – ignores correlations between risk factors
 - ▣ Very common
- Subjective: factors stressed using expert input
 - ▣ Only as good as the experts
 - ▣ Allow for proactive scenarios

continued...

Macro-economic models

- ▣ Look at historical connections between
 - default rates for different types of loan portfolios
 - and economic conditions (for example, GDP, unemployment rate, inflation, ...)
- ▣ Use these connections to relate economic conditions to changes in default rates in different segments/portfolios.
- ▣ Correlated trend analysis
 - $PD_A = \beta_0 + \beta_1 \cdot GDP$ (single-factor model)
 - $PD_A = \beta_0 + \beta_1 \cdot GDP + \beta_2 \cdot inflation$ (multivariate model)
- ▣ Which economic variables to use?
- ▣ Concern that “normal” correlations break down in stressed times – the very times that need to be modelled
- ▣ Is the next recession like the last?

Macro-economic models



- Multivariate macro-economic models from governments or agencies
 - ▣ Evaluate impact of economic recession
 - ▣ Migration matrices based on economic drivers
 - E.g. Moody's rating migration predictions

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Outcome of ST

□ Measuring impact of ST

□ Δ RWA

- Basel II formula

$$RWA = 12.5 \times EAD \times K$$

$$K = LGD \times \left(\Phi \left(\sqrt{\frac{1}{1-\rho}} \Phi^{-1}(PD) + \sqrt{\frac{\rho}{1-\rho}} \Phi^{-1}(0.999) \right) - PD \right)$$

□ Δ Expected Loss

- PD x LGD x EAD

□ Δ Loss (defaults)

□ Migration matrix probability

- Downgrade kappa

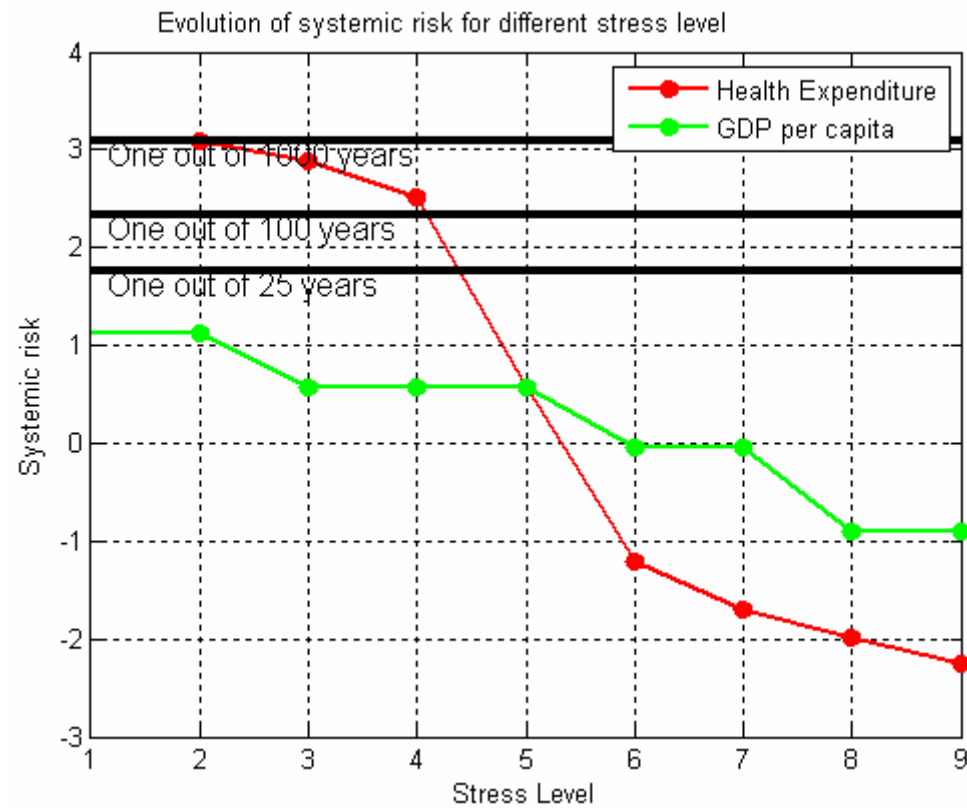
□ Systemic risk

- Use Basel II formula to evaluate the impact of $z = \text{norminv}(0.96)$ corresponding to 1/25 year event

$$\alpha^* = N \left[\frac{N^{-1}(PD) + \sqrt{\rho} N^{-1}(0.96)}{\sqrt{1-\rho}} \right]$$

Outcome of ST

□ Systemic risk example



Outcome of ST

- Aim: stress of once every 25 years
- Aiming for consistent stress levels accross portfolios
- How?
 - ▣ Input side
 - E.g.: worst migration matrix in 25 years
 - E.g.: worst house price evolution in 25 years
 - ▣ Output side
 - Evaluate probability of migration
 - Using matrix measures, such as e.g. kappa, or using systemic risk

Outcome of ST



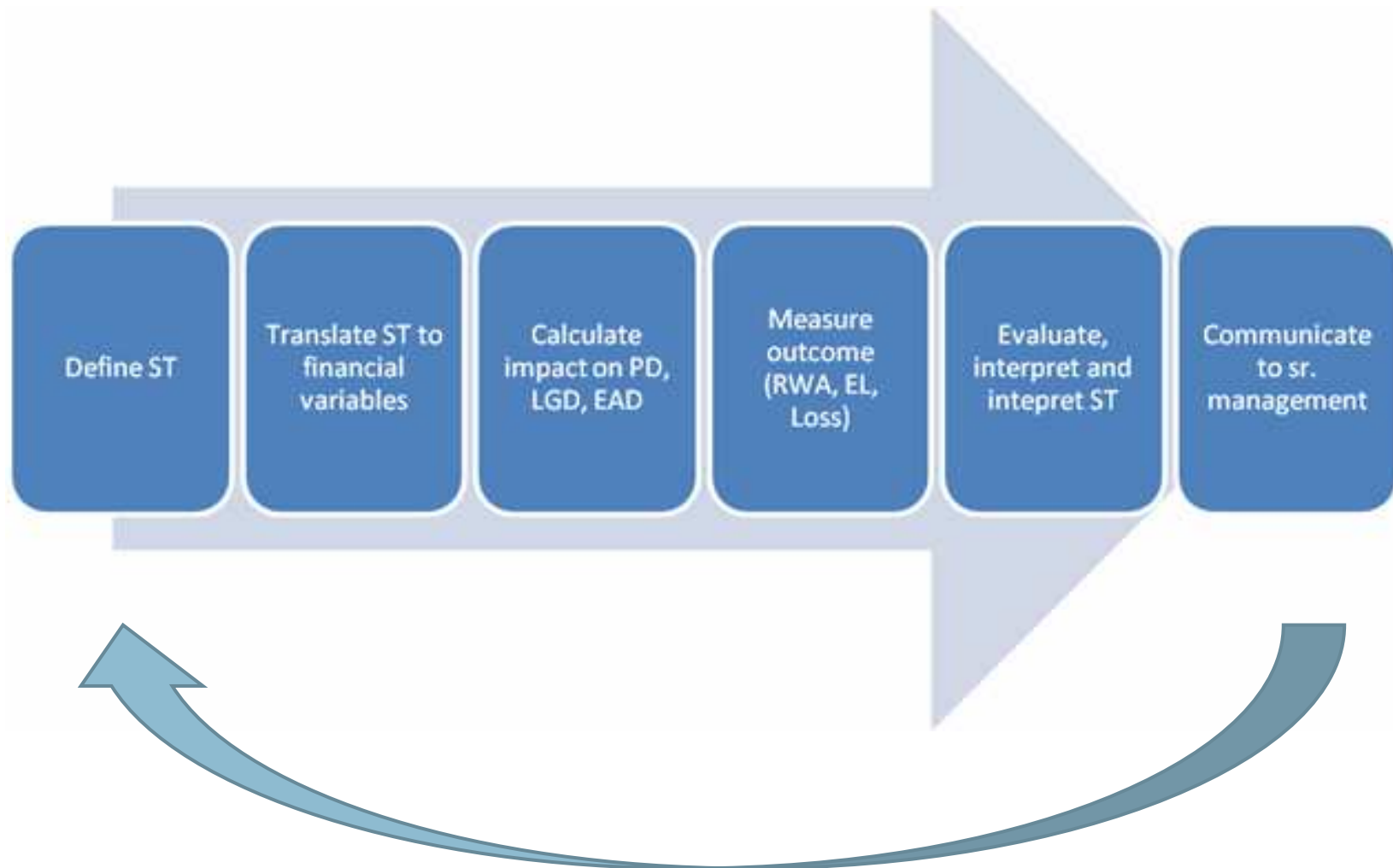
- Evaluate and interpret
 - ▣ Where highest most impact
 - ▣ Differences accross
 - Ratings
 - Issuers
 - Countries
 - Exposures
 - ...

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- **Conclusion**

Stress Test



Conclusion



- Limited practical stress test guidelines
- Several levels to stress
- Types of stress test
 - ▣ Sensitivity Stress Testing: decile shift
 - ▣ Scenario-based
 - Historical: scenarios from past or data-driven
 - Hypothetical: expert insight
- Importance **senior management**
- Importance **innovativeness**: plausible, yet high-impact

Contact Details

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