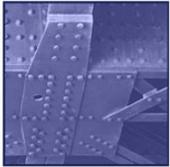


# Stress Testing: Credit Risk

*Joe Henbest*  
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Paper presented at the Expert Forum on Advanced Techniques on Stress Testing: Applications for Supervisors  
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# Stress Testing: Credit Risk

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- Basics of Credit Risk Stress Testing
- Testing Fundamental Credit Drivers
- Stress Testing at the Macro Portfolio Level
- Conclusions



- **Basics of Credit Risk Stress Testing**
- Testing Fundamental Credit Drivers
- Stress Testing at the Macro Portfolio Level
- Conclusions



- Stress testing is the process of determining the effect of a change to a portfolio or sub-portfolio due to extreme, realistic events
- Various levels of stress testing for credit risk across credit risk components and portfolio levels:
  - PDs for individual counterparty or sector
  - LGDs for specific facility types
  - Exposure estimates
  - Credit spreads
  - Portfolio capital, e.g. concentrations, correlations
- Need to define process around stress testing
  - Objectives and uses of outputs
  - Frequency that scenarios are updated
  - Use of static and / or bespoke scenarios
  - Strategies for adjusting portfolio given undesirable characteristics



- Sensitivity analyses
- Scenario analyses
  
- Historical scenarios
- Hypothetical scenarios
  
- Event-driven
- Portfolio-driven
  
- Macroeconomic events
- Market events
- Worst case / catastrophe events



- Sensitivity analyses
  - Involves the impact of a large movement on single factor or parameter of the model
  - Used to assess model risk, effectiveness of potential hedging strategies, etc.
- Scenario analyses
  - Full representations of possible future situations to which portfolio may be subjected
  - Involves simultaneous, extreme moves of a set of factors
  - Reflects individual effects and interactions between different risk factors, assuming a certain cause for the combined adverse movements
  - Used to assess particular scenarios (e.g., current forecast, worst-case) to gain better understanding of current situation
- Historical:
  - Based on observed events from the past = actual events
  - Less subjective but may be irrelevant
  - E.g. 9/11, Asian crisis
- Hypothetical:
  - Plausible events that are yet to be realized
  - More relevant
  - Requires expert judgment and analysis – sometimes difficult to link with underlying factors
  - E.g. Bird flu pandemic, default of a major firm



- Event-driven scenarios:
  - Scenario is based solely on a specific event independent of the portfolio characteristics
  - Identify risk sources/events that cause changes in market
  - Identify effects of these changes on the risk parameters
- Portfolio-driven scenarios:
  - Scenario is directly linked to the portfolio
  - Identify risk parameters changes that result in a portfolio change
  - Identify events that cause the parameters to change
  - May be drawn from expert analysis or quantitative techniques
- Macroeconomic scenarios
  - An shock to the entire economy that will affect industries to different degrees
  - Occurs external to a firm and develops over time
  - E.g. changes in unemployment in a region, movement towards a recession, etc.
- Market scenarios
  - A shock to the financial and capital markets
  - May be historical or hypothetical, though historic events help support the plausibility
  - E.g. stock market crash of early 2000s, change in interest rates, shock to credit spreads in a sector
- Worst case / catastrophe scenarios
  - Events are exogenous to the markets or economy, though impact arises through resulting changes
  - Often are tied to specific characteristics of portfolio or exposures
  - E.g. terrorist attack on major financial center, change in regulations or policies



- Even the most sophisticated analyses are only as good as the scenarios upon which they are based
- Constructing a good scenario involves both
  - Determining the overall impact by adjusting a set of variables that can influence the output
  - Estimating the probability of occurrence
- A useful scenario is:
  - Realistic
  - Corresponds to the approach and portfolio of exposures
  - Informative and valuable to risk management objectives



- Identify reaction of sectors to extreme events
- Assess the sensitivity of credit factors and approaches to extreme events to ensure appropriateness
- Identify “hidden” correlations within portfolio
- Support portfolio allocation decisions / strategy beyond normal current conditions
- Evaluate potential capital requirements on long-dated positions under possible future credit environments
- Identify a benchmark to create some awareness of the current market situation



- The impact of the stress events can be viewed through a number of outputs:
  - Change in Expected Loss or Value at Risk
  - Expected Shortfall given stress environment
  - Sensitivity of PD / LGD / Exposure
  - Stressed level of PD / LGD / Exposure
  - Change in average rating of portfolio / sub-portfolio



- Stress testing of credit spreads in trading books is relatively straightforward
  - Historical spread data is available, e.g. for swap spreads, corporate bond spreads, CDS spreads
  - Typically utilizes market risk stressing techniques
  - Supported by trading floor analytics and infrastructure
- However, loan portfolio stress testing is complicated by:
  - Difficulty in estimating effect on variables for a given scenario
  - Lack of historical data relevant to the portfolio characteristics
  - Differences in accounting regimes and treatment
  - Infrastructure problems



- Under Pillar II, banks are expected to perform...
  - *“Rigorous, forward-looking stress testing that identifies possible events or changes in market conditions that could adversely impact the bank”*
- Required to have a routine, robust process for stress testing and scenario analysis to support its measures of capital adequacy
  - Establish events or environmental changes that could lead to adverse development
  - Identify the impact of such events given current positions
  - Determine the strategy and processes for managing its portfolio given such events
- Process should cover such events as:
  - Economic or industry downturns
  - Market events
  - Increased illiquidity
- Under Pillar II, banks must be able to show that:
  - Current capital levels are sufficient to resist a 'range of severe but plausible' events
  - Different approaches are utilized in the measurement of the firm's overall capital



- Basics of Credit Risk Stress Testing
- **Testing Fundamental Credit Drivers**
- Testing at the Macro Portfolio Level
- Conclusions



- Useful analyses can be derived from stress testing at various levels of the portfolio:
  - Individual components or drivers – a bottom-up approach
  - Macro drivers across the portfolio
- For stressing individual components:
  - Objective is to evaluate the variability in sub-portfolios due to changes in fundamental variables
  - Variables being stressed will differ across portfolio segments and may include both quantitative and qualitative factors
  - Scenarios will be very different for specific segments
  - Outputs focus on components, such as ratings, PDs, and LGDs
  - Difficult to aggregate across the entire portfolio



- Segmenting the portfolio
- Identifying risk factors to be stressed
- Constructing the stress scenarios
- Translating scenarios into model drivers
- Analyzing outputs of stress analyses



- Understand the special features that characterize each portfolio segment:
  - Ensure that the scenarios are relevant to all portfolio entries per segment
  - Make scenarios more applicable and effective
- For example, a portfolio of asset finance deals can be further segmented according to the type of the asset:
  - Shipping
  - Aircraft
  - Leasing
- Create scenario for each segment



- Exhaustive list of all the risk factors that influence each segment of the portfolio should be prepared
  - Risk factors may appear in more than one segment or can be uniquely identified as sector-specific
  - Identifying these factors is a key challenge, as it effectively determines the performance of the stress test
  - E.g. for aviation = jet fuel prices, revenue passenger miles, tourism measures, political events (war in Iraq), growth in GDP, aircraft collateral values, air cargo demand, etc.
- Once the risk factors influencing each category have been identified, they should be ordered by importance and grouped on the basis of similarity
- When stress tests are designed, such groups will ensure that when individual risk factors are shocked, other relevant stress factors are not left unstressed
  - For example, if interest rates are stressed, we can refer to the group of risk factors that interest rates belong to (such a group may include exchange rates) and then ensure that the test stresses exchange rates as well. This process of ordering and grouping risk factors helps to ensure that the most important risk factors, as well as those related to them, are stressed.



- After completing the selection process of risk factors, the next step is to construct the actual stress scenarios, which requires:
  - Researching prior situations and industry trends
  - Determining appropriate and realistic events
  - Evaluating which drivers are affected under the event
  - Prioritizing amongst the numerous scenarios possible
- Use bottom-up analysis
  - General macroeconomic analysis
  - Industry specific trends
  - Company specific trends
- E.g. for aviation: sensitivity to jet fuel prices, scenarios for Flu pandemic, recession and related impact on cargo demand



- Scenarios must be translated into the model drivers
- Requires a determination of the impact of each scenario on each component within the model
- Impact should be parameterized as best as possible to ensure that the event is accurately represented in the ‘stressed’ output
- E.g. for insurance: decrease in financial ratios (solvency, technical reserves, loss ratio), portfolio asset quality change, etc.



- Lastly, the stress event is applied to the portfolio to determine “stressed” outputs
  - Calculate credit risk stressed distribution (ratings / PDs / LGDs)
- Analysis of the output requires:
  - Compare with original distribution
  - Conclude if the model reacted reasonably to the adverse economic trends
  - Identify limitations/ sensitivities
  - Look for credit sense



- Sourcing appropriate information and actual impact on factors under historic scenarios
- Designing scenarios at the appropriate sector level
- Capturing the correlation between factors within the ratings methodology – in both expert judgment and quantitative model approaches
- Given the estimation / rating approach, the impact of a scenario may not be captured adequately
- Distinguishing between the impact from the stress event itself and the approach used to evaluate the creditworthiness
- Complexity of the client base and the related ease of representing the scenarios onto a firm
- Ability to access data for underlying drivers across portfolio
- Bottom up analyses are difficult to aggregate



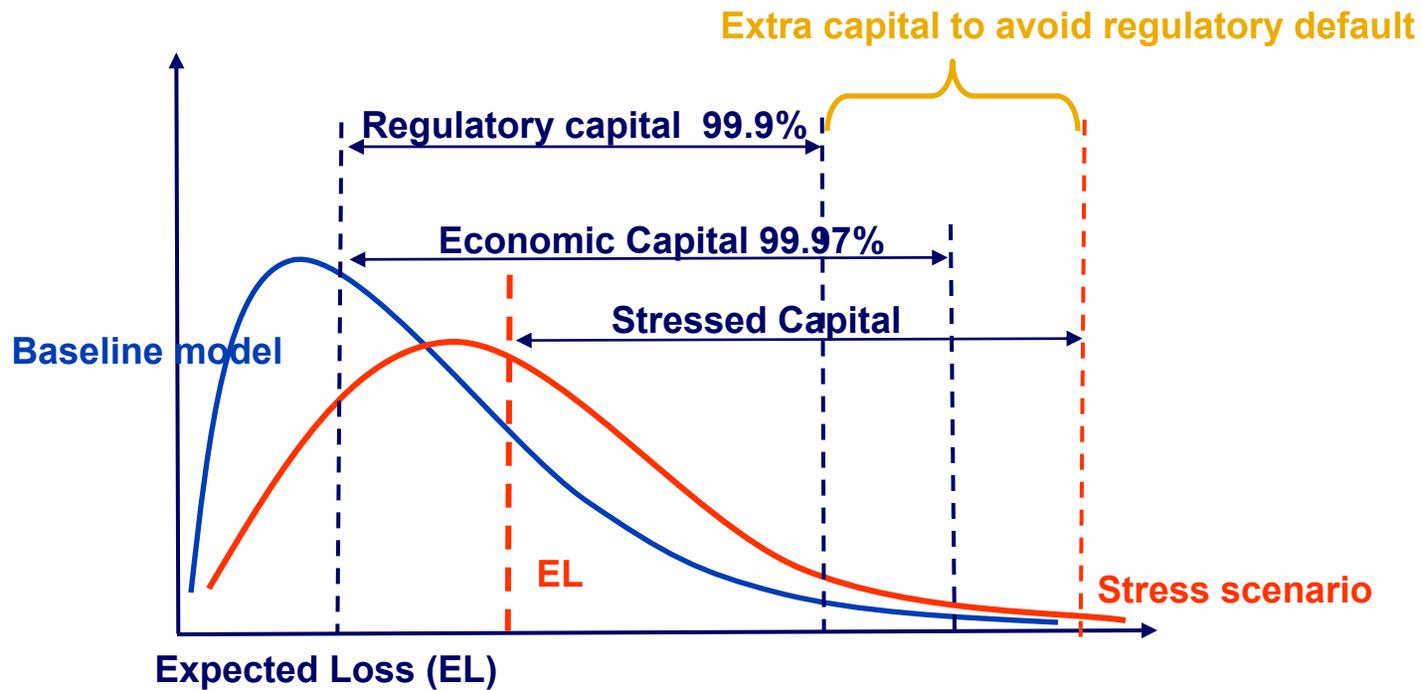
- Basics of Credit Risk Stress Testing
- Testing Fundamental Credit Drivers
- **Stress Testing at the Macro Portfolio Level**
- Conclusions



- Dependent on the portfolio methodology employed
- Steps to develop and apply the scenarios is similar to that at the component level
- Objective is to identify name or sector concentrations, hidden correlations within the portfolio, capital survival, etc.
- Seek to design consistent scenarios such that the impact is observable across multiple parts of the portfolio
- Some industries, segments, etc. may not be affected
- Focus often is on systematic drivers as opposed to underlying variables
- Variables to be stressed may be based on expert judgment of relevant factors or through quantitative techniques (identifying most heavily weighted drivers in portfolio)
- Outputs are generally capital / VaR based

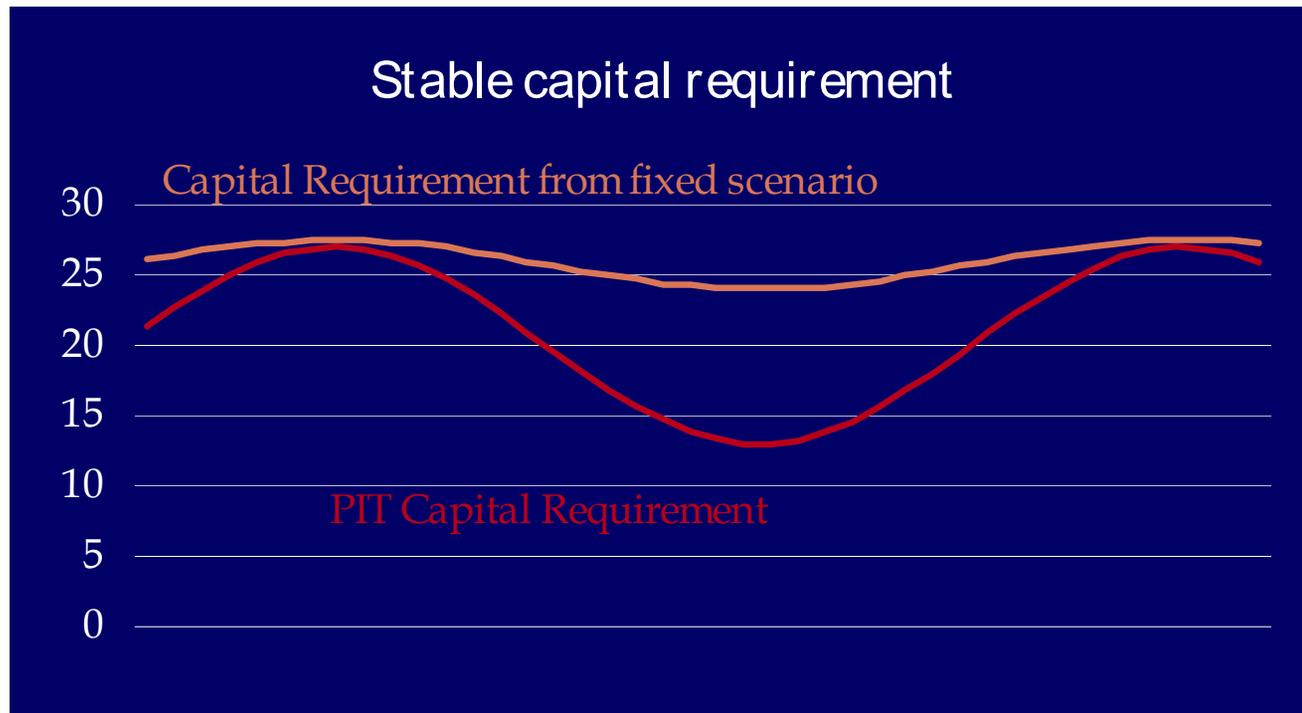


- Must have a multi-factor credit portfolio model
  - Rich correlation and risk factor structure
  - Factors must be relatable to economic / macro drivers
  - Captures individual exposures
- Translation of stress to model
  - Defined moves in particular factors due to systematic drivers
  - Adjustment to distribution of factors
  - Constraining the distribution
- Limited number of factors are adjusted
- Effect on other, unstressed factors is captured through correlation structure



Stress testing could facilitate the internal and regulatory discussions on how much capital to hold in excess of the Pillar I regulatory capital requirement.

Source: Sune Visti Petersen, Danske Bank, ARC 2006



For example:

- Define a scenario that is the worst that can be expected over 3 to 5 years
- The main target is to have sufficient capital to go through this scenario
- Provides a stable capital requirement as long as our expectations of the future are unchanged
- Currently, do not expect anything worse than a normal recession

Source: Sune Visti Petersen, Danske Bank, ARC 2006



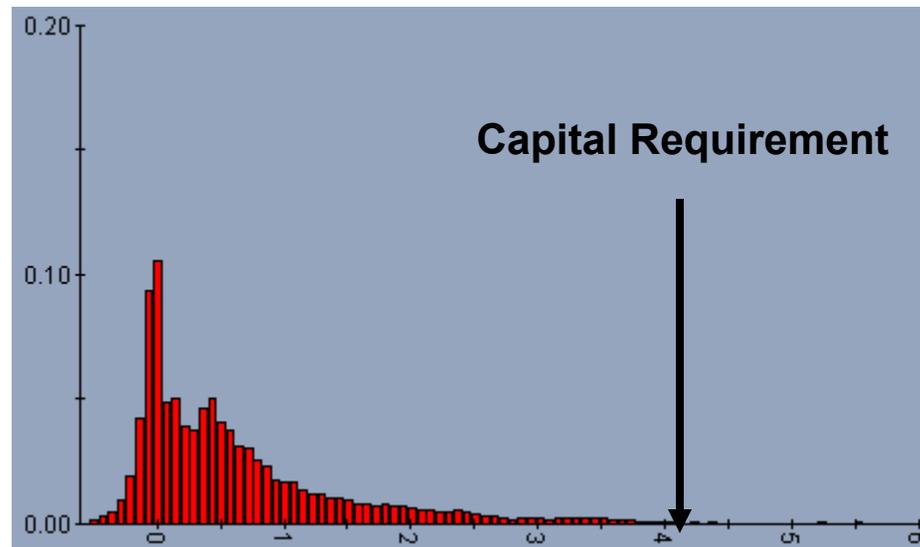
- **Definition:**
  - Sudden, significant change in the economic environment followed after a relatively short period by a recovery to a state similar to the current one
- **Goal:**
  - Survive the shock for a (relatively) short period until the economy ‘bounces back’
- **Implication / Interpretation:**
  - Bank has the opportunity to use capital to survive the crisis without resorting to an increase in capital during the period of upheaval
- **Measure:**
  - Survival Probability - estimating the probability that the current capital level of the firm is sufficient to survive the scenario



- **Definition:**
  - Sudden, significant change in the economic environment that persists indefinitely or for a considerable period
- **Goal:**
  - Make the transition to a new reality and continue doing business in it indefinitely
- **Implication / Interpretation:**
  - Bank may use capital to survive the initial crisis, but this must be replenished and capital requirements (calculated) met under the new conditions
- **Measure:**
  - (New) economic capital measure (e.g., CVaR)



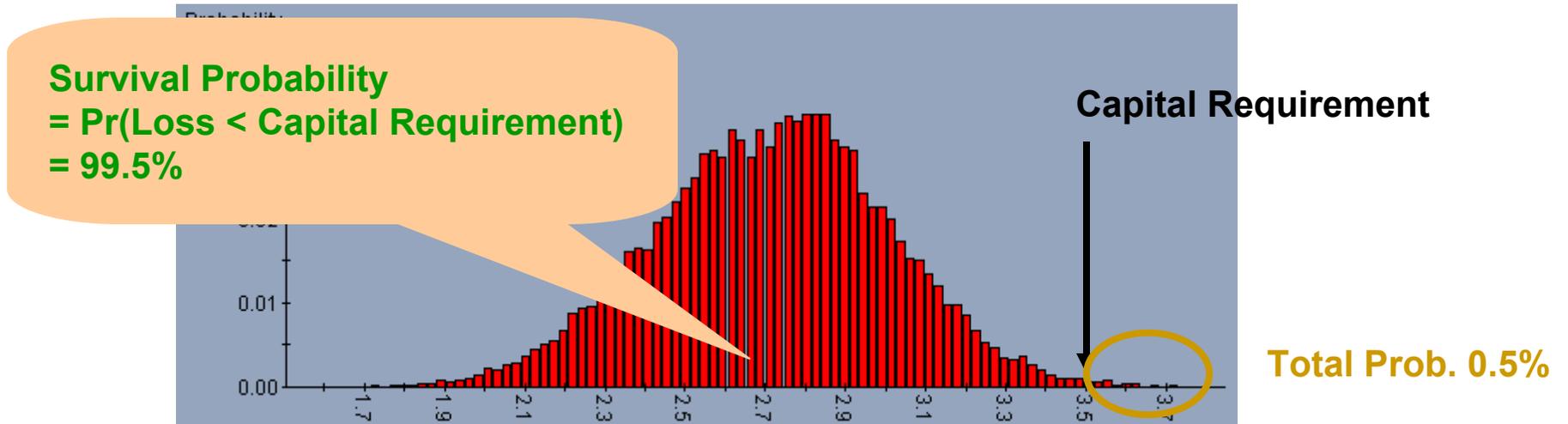
- **Definition:**
  - The probability that current capital is sufficient to weather the crisis / market conditions embodied in the scenario.
- **Example:**
  - Current Capital Requirement = \$3.5bn
  - Current Capital Level = \$7bn
  - Capitalization Ratio = 200%





- Suppose there is a decline in the economy
- The conditional distribution of loss is:

MSCI-Banks	0.7
MSCI-Electric Utilities	0.8
MSCI-Forest Products	0.85
MSCI-Heavy Construction	0.9
MSCI-Industrial Diversified	0.65
MSCI-Lodging	0.55
MSCI-Real Estate	0.6
MSCI-Retailers Specialty	0.75
MSCI-Sweden OMX	0.8
MSCI-Trucking	0.7



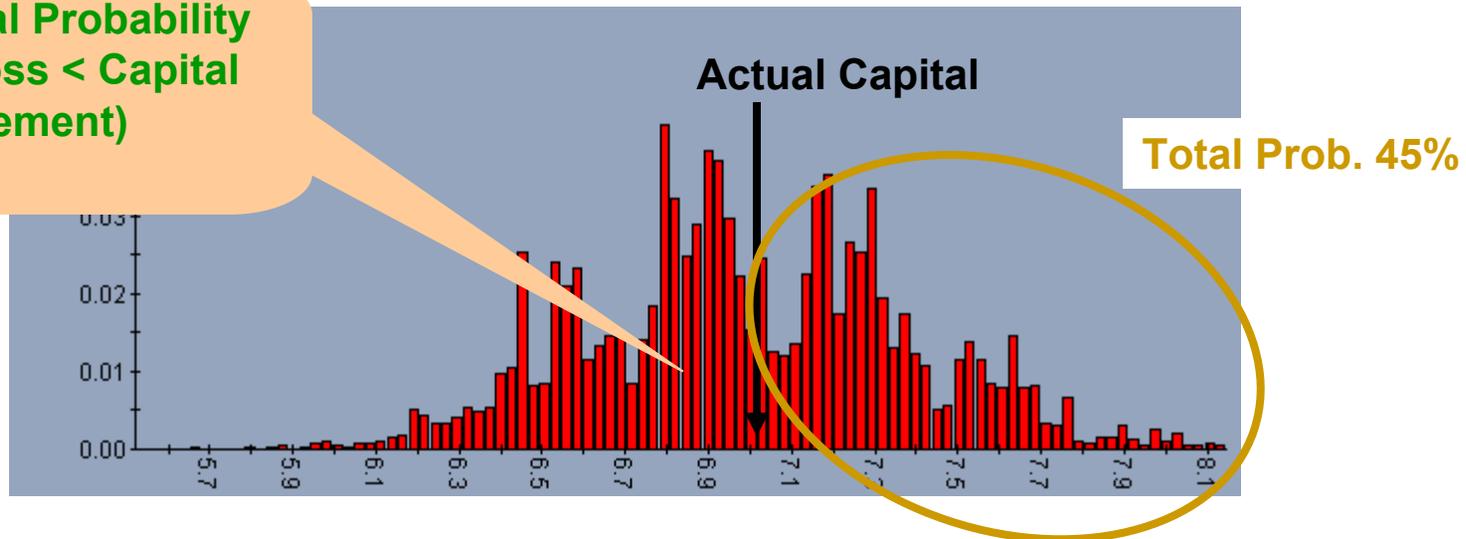


- Suppose there is a catastrophic event:

MSCI-Banks	0.3
MSCI-Electric Utilities	0.4
MSCI-Forest Products	0.45
MSCI-Heavy Construction	0.35
MSCI-Industrial Diversified	0.35
MSCI-Lodging	0.3
MSCI-Real Estate	0.35
MSCI-Retailers Specialty	0.4
MSCI-Sweden OMX	0.45
MSCI-Trucking	0.4

- The conditional distribution of loss is:

**Survival Probability**  
**= Pr(Loss < Capital Requirement)**  
**= 55%**





## Describe a 'Mild Recession' scenario

*The scenario is based on CAD3, which mentions two quarters' zero growth as basis for a stress test.*

**Scenario:** Zero growth in two consecutive quarters. Growth then returns to its long-term trend for the remaining two quarters of the year. The following years, growth will be as in base case.

**Macro:** As in a traditional recession, it is assumed that the industrial sector experiences a stronger growth slowdown than the economy as a whole. It is also assumed that labour hoarding prevails and that unemployment reacts to low growth with a lag, and, similarly, when growth picks up again.

The slacker activity puts a slight pressure on inflation, after which it returns to its original level. However, the price level is lower than in base case, and corporate sector margins are therefore lower. This results in lower corporate earnings and a slightly lower credit quality.

**Monetary policy and fixed-income markets:** Monetary policy is sustained, and long-term interest rates remain unchanged, as this is a short-lived slowdown, and inflation is not affected to any significant extent.

**Credit spread:** Credit spreads remain unchanged as the deterioration of credit quality is insignificant.

**Equity markets:** Declining earnings and sales trigger a small price fall. Part of the fall will be regained in the years ahead.

**Property prices:** Higher unemployment triggers lower prices of residential property. As unemployment continues to increase in the second year, residential property prices will once again show a small fall. The commercial property market witnesses a similar fall, caused by increasing idleness.

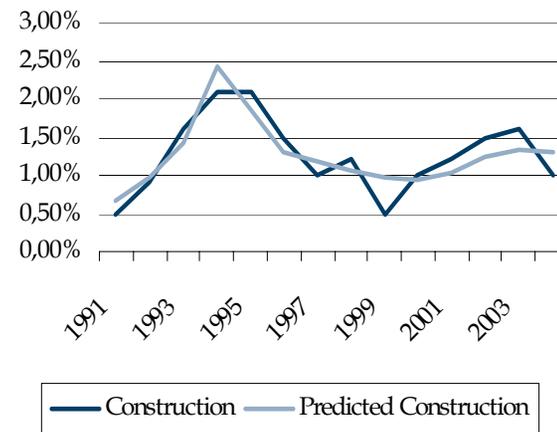
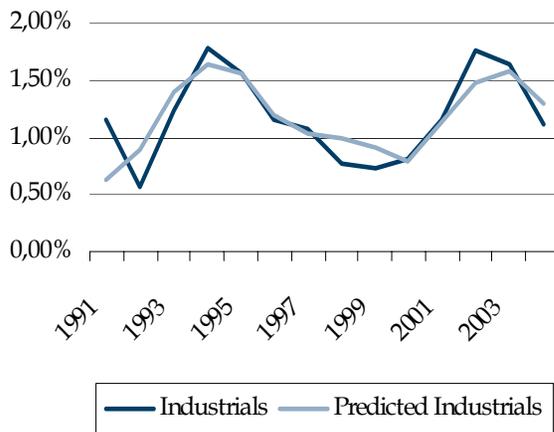
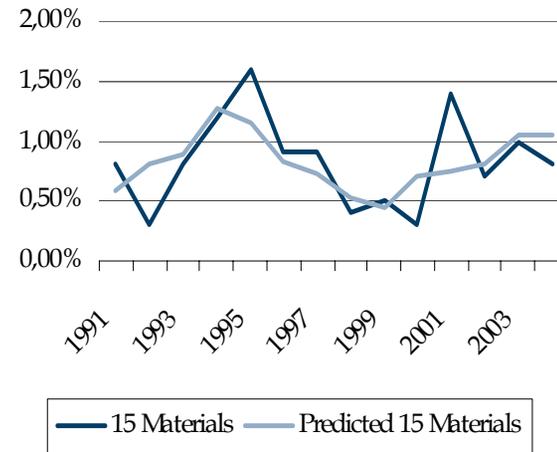
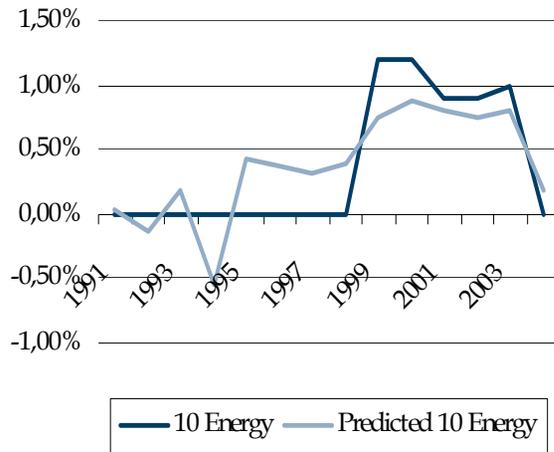
**Business-related reaction:** For the banking sector it is business as usual.

Mild recession (two quarters with zero growth)																
Year	GDP	Industrial output	Unemployment	Inflation	Consumer spending	Property prices		Interest rates		Interest margin	Equity price	Ex. rate	Lending	Output gap	Oil price	Commodities
						Residential	Commercial	3 mth.	10-year	(index)	USD/EUR	Growth	%	growth		
1	1,1	-0,5	5,7	0,8	2,3	1,6	-3,9	2,6	3,8	0,95	-2,0	123,0	15,6	-1,0	25,0	0,0
2	2,6	2,6	6,3	2,1	2,8	0,7	-3,0	2,9	4,2	0,95	11,0	120,0	0,1	-0,8	0,0	0,0
3	2,6	2,6	6,3	2,0	2,8	3,1	3,7	2,9	4,2	0,95	11,0	120,0	0,6	-0,6	0,0	0,0
Deviation from base case (%-point)																
Year	GDP	Industrial output	Unemployment	Inflation	Consumer spending	Property prices		Interest rates		Interest margin	Equity price	Ex. rate	Lending	Output gap	Oil price	Commodities
						Residential	Commercial	3 mth.	10-year	(index)	USD/EUR	Growth	%	growth		
1	-1,5	-3,1	0,8	-0,5	-1,2	-9,0	-10,5	0,0	0,0	-5,0	-9,0	0,0	1,7	-1,5	0,0	0,0
2	0,0	0,0	1,5	0,3	0,0	-2,4	-6,7	0,0	0,0	-5,0	4,0	0,0	-6,3	-1,5	0,0	0,0
3	0,0	0,0	1,5	0,3	0,0	0,0	0,0	0,0	0,0	-5,0	4,0	0,0	-4,1	-1,5	0,0	0,0

Source: Sune Visti Petersen, Danske Bank, ARC 2006



## Models fit historical loss data



Source: Sune Visti Petersen, Danske Bank, ARC 2006

# A scenario example (step 3)



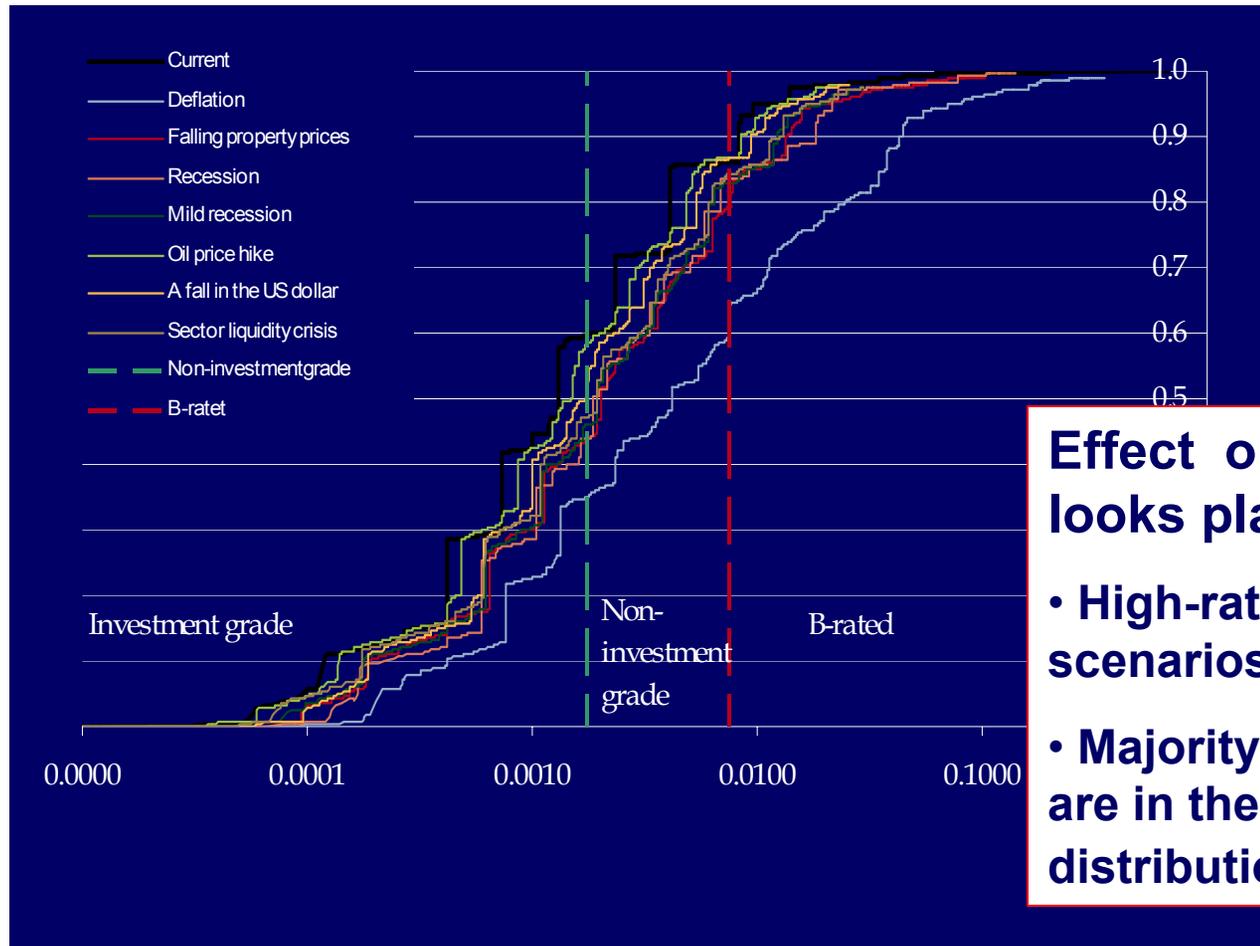
## Coefficient matrix

	01 Government	10 Energy	15 Materials	20 Industrials	201030 Construction & Engineering	25 Consumer Discretionary	30 Consumer Staples	35 Health Care	40 Financials	45 Information Technology	55 Utilities	60 Household	65 Non profit organisation	Fisheries	Agriculture	Grand Total
Intercept	0.00%	1.14%	0.82%	2.09%	1.73%	1.98%	2.38%	0.21%	-0.75%	0.66%	0.51%	1.51%	1.43%	1.67%	0.31%	0.92%
Lagged output gap	0.00%	0.00%	-0.11%	-0.44%	-0.51%	-0.44%	-0.50%	0.00%	0.00%	-0.35%	0.00%	-0.14%	-0.15%	-0.83%	-0.29%	-0.28%
Output gap	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	-0.45%	-0.21%	-0.19%	0.00%	0.00%	0.00%
GDP	0.00%	0.00%	0.00%	-0.15%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Unemployment	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.06%	0.21%	0.00%	0.00%	0.08%	0.04%	0.00%	0.00%	0.00%
Consumer spending	0.00%	-0.18%	0.00%	0.00%	0.00%	0.00%	-0.10%	-0.03%	0.00%	-0.14%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Change in real housing prices	0.00%	0.00%	0.00%	0.00%	0.00%	-0.04%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
3-month rate	0.00%	-0.08%	0.00%	-0.11%	-0.08%	-0.11%	-0.14%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.05%
5-year rate	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	-0.08%	0.00%	0.00%	0.00%	-0.04%	0.00%	0.00%	0.00%	0.00%
Yield gap	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.14%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
KFX Index	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Exchange rate	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	-0.02%	0.00%	0.00%	0.00%	0.00%	0.00%	-0.01%
Commodities	0.00%	0.00%	0.02%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Oil price	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Lagged frequency	-	-	-	-	-	-	-	-	-	1%	0%	-1%	-1%	0%	0%	-

Source: Sune Visti Petersen, Danske Bank, ARC 2006



## Stress shifts distribution to the right



**Effect on distributions looks plausible:**

- High-rated clients in all scenarios
- Majority of the changes are in the middle of the distribution

Source: Sune Visti Petersen, Danske Bank, ARC 2006



- Difficult to stress portfolio and concentration risks given the IRB quantitative framework
- But it is an important aspect of the stress testing and capital planning processes
- One approach: Utilize information from fundamental or economic capital stress tests
  - Calibrate factors in BIS calculations using the stressed PDs / LGDs from underlying models or portfolio model
  - Re-estimate BIS II capital values
  - Produces a forecast of the required regulatory capital given the event or combination of events



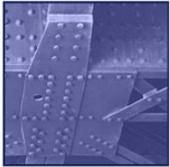
- Challenges
  - Available / implemented credit risk portfolio tool that is capable of adequate stress testing
  - Portfolios are complex, and thus, the definition and parameterization of a scenario can be difficult
  - May require need to estimate the likelihood that multiple extreme events were to occur simultaneously
  - Multiple sources of credit risk (bonds, credit derivatives, CDOs, etc.) have different profiles that must be accommodated
  - Need for computational efficiency across large, diverse portfolios



- Basics of Credit Risk Stress Testing
- Stress Testing Fundamental Credit Drivers
- Stress Testing at the Macro Portfolio Level
- **Conclusions**



- Stress testing for credit is still being developed, with both fundamental and portfolio analyses being driven by Basel II requirements
- There are challenges at both levels, particularly in deriving the appropriate and consistent scenarios and impact on observable factors
- Given the often complex and opaque nature that credit risk is present in the portfolio, requires a significant involvement of credit risk experts with firm understanding of the portfolio / sub-portfolio
- Requires sufficient technological infrastructure to support effective assessments



# Stress Testing: Credit Risk

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