Session 12

Stress testing
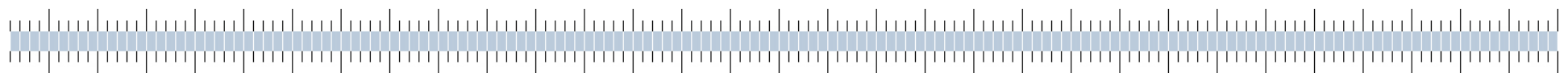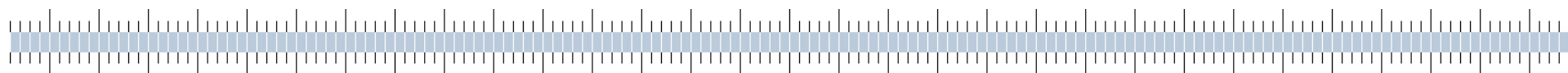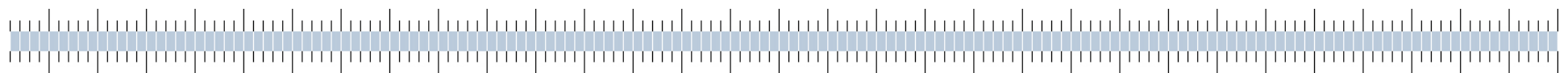
Agenda

■ **Motivation**

■ **Regulatory Requirements**

■ **Implementation**

■ **Risk Parameters for Stress Testing**

■ **Evaluating Stress Tests**

■ **Classifying Stress Tests**

■ **Conducting Stress Tests**

■ **Action Planning and Example**

■ **Summary**

MOTIVATION

Motivation

❚ **Blind trust in IRBA-models may lead to**

  ❚ Underestimation of latent risks

  ❚ Neglect of rare, but not unrealistic risk constellation.
These might be caused by abnormal economic conditions or dramatic events for the portfolio of

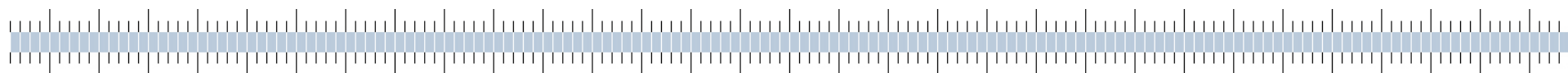   ❚ a single credit institute or

    ❚ a complete market.

❚ **To limit the impact of such sudden incidents, the study of fictional perturbations and shock testing the robustness / vulnerability of risk characteristics is required (stress testing).**

  ❚ Improvement of risk strategies

  ❚ Review of risk capacities

  ❚ Review of capital allocation

Purpose of stress testing

❚ Use stress tests to challange the regulatory and economic capital requirements determined by unexpected loss calculations

❚ Stress tests may lead to a better understanding of of explicit or implicit relation between unexpected loss and economic capital or regulatory capital.

❚ Unexpected loss should be covered by economic capital

❚ It is common, to regard the difference between expected loss and a chosen risk measure (Value-at-Risk, expected shortfall) as unexpected loss.

❚ One of the problems with this approach is that such an unexpected loss might not only be unexpected, but also quite unrealistic, as ist definition is purely of a statistical nature.

❚ It is therefore sensible to use stress tests to underscore which losses amongst the unexpected are plausible or to su the outcome of stress tests, instead of unexpected loss to determine economic capital.
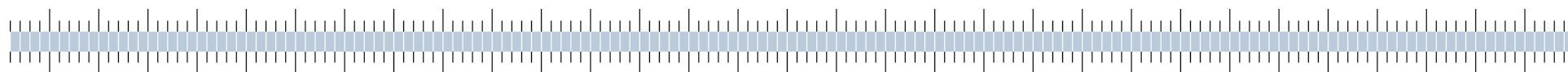
Stress tests and capital adequacy

- **Lack of reliable occurrence probabilities for stress events**
  - As it requires reliable occurrence probabilities for the stress tests.
  - Stress tests are, nevertheless, used to challange the regulatory and economic capital requirements determined by the unexpected loss calculations.
    - Simple test for the adequacy
    - Derive a capital buffer for exterme losses exceeding the unexpected losses
    - Define the risk appetite of a bank
- **Stress tests allow for combination of different types of risk**
  - Correlation between markets. Simultaneous increase in different types of risk
  - Realistic scenarios for various kinds of risk could lead to extreme losses, which could be of enormous risk importance for controlling risk and should be reflected in the capital requirements.
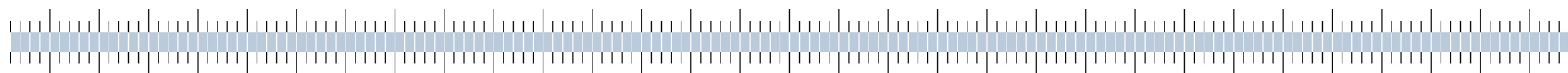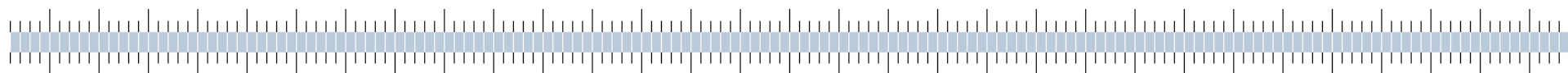
Use of stress test results

❚ Use of quantative stress test results

　❚ Determine risk buffers and / or test risk buffers against extreme losses

　❚ Determine risk capacity or test against extreme losses

　❚ Limits for sub-portfolios can be fixed to avoid given amounts of extreme losses

　❚ Risk policy, risk tolerance and risk appetite can be tested by visualising the risk / return under abnormal market conditions

❚ Approaches for focusing on quantitative results might be of particular interest for sub-portfolios, where the historic volatility of the respective loans is low, but drastic changes in risk relevant parameters cannot be excluded.
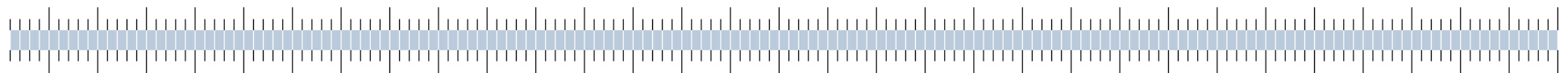
Purpose of stress testing

❚Use of qualitative results

 ❚ Identify potential risks and locate the weak spots of a portfolio

 ❚ Study effects of new intricate credit products

 ❚ Guide discussion on unfavourable developments (crises, market conditions)

 ❚ Help monitor important sub-portfolios exhibiting large exposures or extreme vulnerability to changes in the market

 ❚ Derive some need for action to reduce the risk of extreme losses and hence economic capital, and mitigate the vulnerability to important risk relevant effects

 ❚ Test portfolio diversification by introducing additional correlations

 ❚ Question bank's atitude towards risk
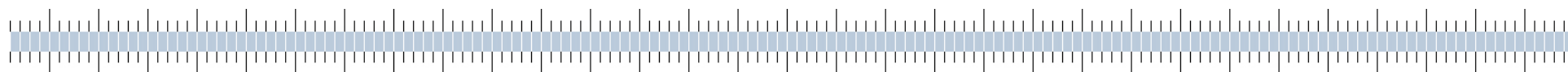
REGULATORY REQUIREMENTS

Regulatory requirements

▌**Task**

  ▌Conduct stress tests to assess capital adequacy in a reasonable way

 ▌Integrate stress tests in the internal capital adequacy process

▌**Intention**

  ▌Ensure capital adequacy to meet regulatory capital requirements even in the case of stress

▌**Requirements**

  ▌Banks should identify possible events and future changes in economic conditions, which could have disadvantageous effects on their credit exposure

  ▌Asses the bank's ability to withstand these unfavourable impairments

▌**Design**

  ▌Quantification of the impact on the parameters PD, LGD, and EAD

 ▌Rating migrations should be taken into account
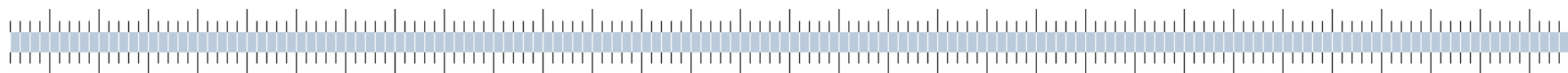
German Implementation of IRBA Stress tests

▌Use of stress tests in assessing risk bearing capacity

   ▌The insitute must have in place solid stress tests for assessing it's risk bearing capacity

   ▌Stresstests must identify possible events or future changes in economic conditions that may adversely effect the credit risk position of the institute.

   ▌Stresstests must as well include the institute's assessment to withstand such situations / conditions.

   ▌Stresstests must be conducted in regular intervals

   ▌Stress test is subject to acknowledgement by BaFin.

   ▌Stress test must be conservative and include at least a scenario of mild recession

   ▌Stress tests must include migrations

   ▌Stress tests must include the majority of the portfolios in the IRBA approach

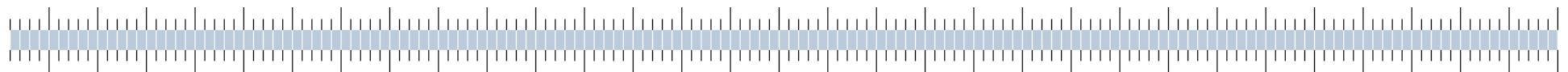   ▌Stress tests must include the creditworthiness of guarantors (under certain conditions)
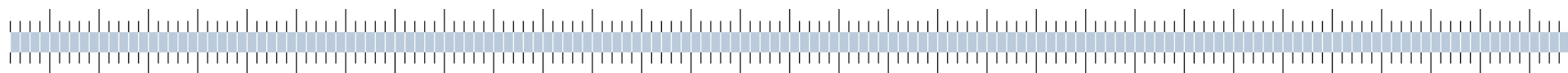
German Implementation of IRBA Stress tests

Risk-reporting

- Risk-reports include risk-profile of the institute.
- Adressee is senior management
- Reports must contain stress test results.

German ICAAP-Regulation

❚Additional requirements via ICAAP stress tests

❚The most of them were recently introduced explicitly, although all of them were required implicitly before.

❚Assumptions concerning risk diversification and risk concentration

❚Definition of stress test is identical in ICAAP, but scenarios have to be of

❚historical nature, as well as

❚hypothetical nature.

❚Inverse stresstests
Analyse, which events endanger the ability to survive, i.e. the current business model is no longer applicable

❚Scenario of severe economic downturn is demanded

❚Inclusion of results in risk bearing capacity considerations is mandatory, but not necessarily a deduction from risk bearing capacity.
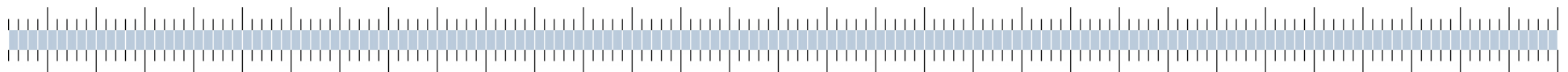
Stress tests in German IRBA-Examination

▌**No requirement for banks to have running stress tests at point of time of assessment**

> ▌Concession in order to improve transition to IRBA

> ▌Concept for stress testing had to be supplied in the application

> ▌Examination focused on the concept for stress testing. This was sufficient to judge, whether banks can adjust to variable capital requirements unter IRBA-regime.

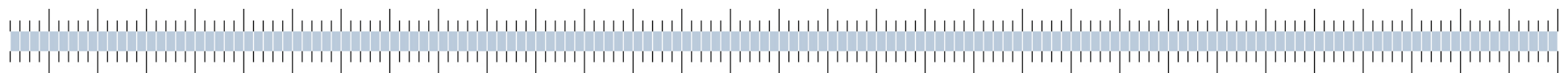> ▌Stress tests were a key topic in assessments made after IRBA approval
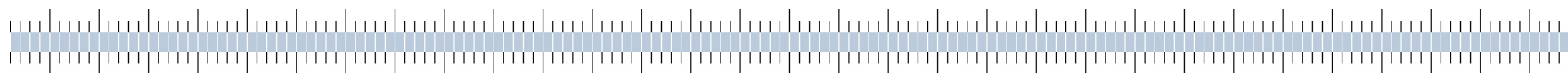
IMPLEMENTATION

Implementation thoughts

▌**Use of scenarios**

  ▌Economic or industry downturn

  ▌Market-risk events

  ▌Liquidity shortage

▌**Recession scenarios should be considered, worst-case scenarios are not necessarily required**

▌**Banks should use their own data for estimating rating migrations and integrate the insight of rating migrations in external ratings**

▌**Banks should build their stress testing also in the study of the impact of smaller deterioration in the credit environment**

▌**Use stress testing as a guidance to risk policy**

▌**Stress tests should not be treated as an ammendment to the VaR-caluations for credit portfolios, but as a complementary method, which contrasts the purely statistical approach of VaR-methods by including causally determined considerations for unexpected losses**
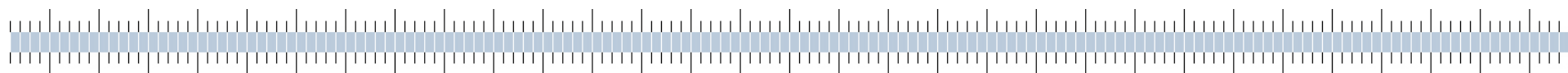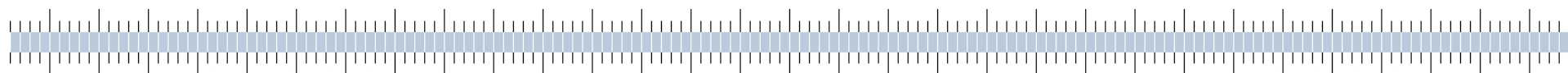
Connection to Pillar II

| Though requirements for stress testing are mainly contained in Pillar I of Basel II, the method is a fundamental part of Pillar II, since it is an important way of assessing capital adquacy.

| This explains the lack of extensive regulations for stress testing in Basel II, as Pillar II acknowledges the ability to judge risk and use the right means for this procedure.

| As another consequence, not only regulatory capital should be the focus of stress tests, but also economic capital as the counterpart of the portfolio risk as seen by the bank.

Summary

❚ Stress tests

  ❚ should consider extreme deviations from normal developments and hence should invoke plausible situations with low probability of occurrence

  ❚ Stress tests should consider constellations wich might occur in future and which have not yet been observed

  ❚ Institutes should use stress testing to become aware of their risk profile and challange their business plans, target portfolios, risk politics etc.

  ❚ Stress testng shoould not only be addressed to check the capital adequacy, but also used to determine and question limits for awarding credit

  ❚ Stress testing should not be treated only as an amendment to the VaR-evaluatioins for credit portfolios, but as a complimentary method, whch contrasts the purely statistical approach of VaR-methods by including causally determined considerations for unexplected losses. In particlular, it can be used to specify extreme losses in a qualitative and quantitative way.
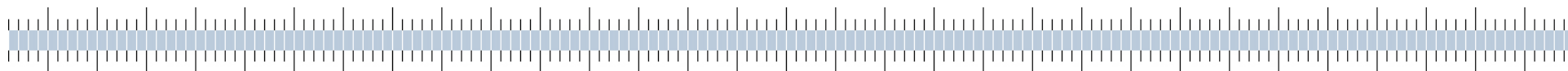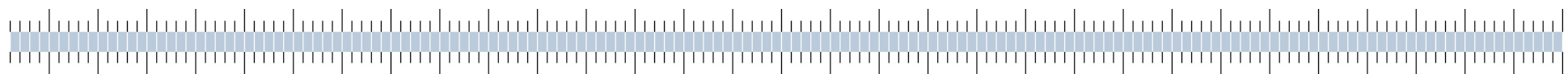
RISK PARAMETERS FOR STRESS TESTING
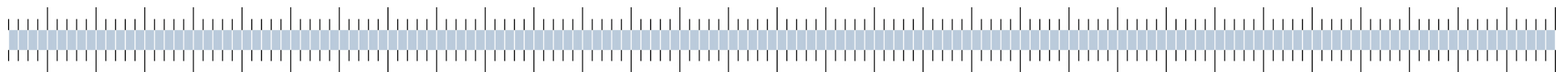
Stress testing EAD

▌**Already conditioned to disadvantageous situations**

▌**Exogenous risk factors affecting EAD might be of interest if they also have an impact on the other risk parameters**
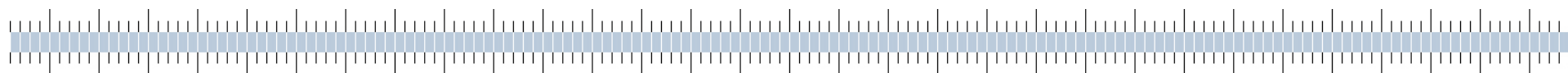
Stress testing LGD

▎**Already conditioned to disadvantageous situations**

▎**Possible variances for LGD depend on the procedure used to determine LGD**

  ▎Determine variations that might arise from the estimation methods

  ▎Determine parts of the process that might depend on economic conditions

▎**Evaluation of collateral**

Stress testing PD

▌**Assignment of an obligor to a rating grade might change due to altered inputs for the rating process**

  ▌Allow for inclusion of transitions to non-performing loans

  ▌Investigate the possibilities of variances and the sensitivity of the input for the rating process based on historic data as well as expert opinions

▌**Realised default rates of the rating grades itsef might change (for various reasons, e.g. because of modified economic conditions)**

▌**While it is sensible to to estimate the volatility of PDs in a first step and use the outcome of this procedure for tests on regulatory capital, the differentiation of the effects of systematic and idiosyncratic risk on PD deviations should be considered in a second step. Tis will lead to more advanced and realistic stress tests, in particular on economic capital.**
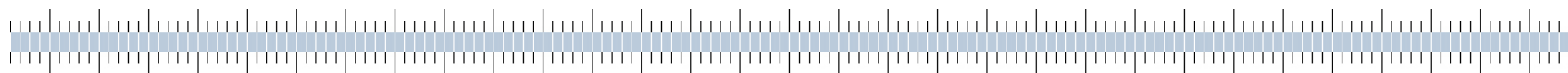
Stress testing PD

▌**An analysis of the transition structure for rating grades might also be used to determine PDs under stress conditions. The advantage of modifying PDs against modifying the assignment of rating grades is a greater variaty for the choices of changes; the disadvantages is the absence of a modified assignment to the performing and non-portfolio. This has to take place on top of te modificatioin of PDs.**
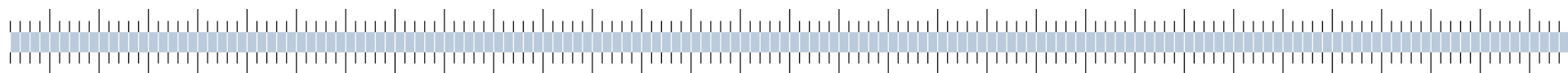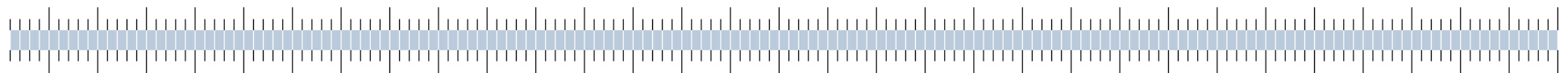
Stress testing other parameters

▌Factors displaying portfolio effects, including correlations between the loans or the common dependence on risk drivers are needed

▌Investigation on historic crises show that risk concentration exhibit huge deviations in these circumstances. Variations of risk correlation and risk concentration should be considered in stress tests with portfolio models.

▌Protfolio models (e.g. CreditMetrics™) not only consider the default of loans, but also the change of value by using migration probabilities. Migration probabilities should be stressed in the same wa as PDs.

▌Stress test parts of the portfolio and adjust for different sensitivities of parts of the portfolio to different sensitivities (concentration risk, diversification)
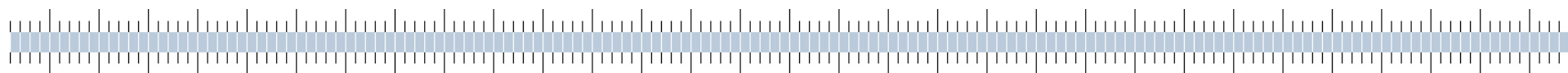
EVALUATING STRESS TESTS

Evaluating stress tests

I **There should be an understanding of how to use the outcome of stress tests for controling and managing portfolio risk.**

I **Starting point should be the regulatory and economic capital as output of the underlying stress tests.**

  I Check if capital to cover requirements in stress situation are sufficient

  I Review limits, buffers and policies

  I The tools used in stress testing might be applicable to different portfolios levels, so they should be checked in detail
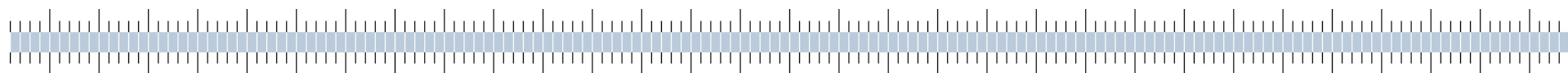
Evaluating stress tests

I **The concept of stress testing would be incomplete without knowing when action has to be considered as a result of the outcome of tests.**

I **To this purpose, define indicators and thresholds suggesting when**

  I to inform management about potential critical developments

  I to develop guidelines for new business in order to avoid extension of existing risky constellations

  I to reduce risk for portfolio / sub-portfolios with the help of securitisation and syndication

  I to readjust an existing limit management system and capital buffer for credit risk

  I to re-think risk policy and risk tolerance

Evaluating stress tests

❚Possible indicators for the call of actions

  ❚Increase of risk indicators (EL, UL, ...) over a threshold or by a specified factor
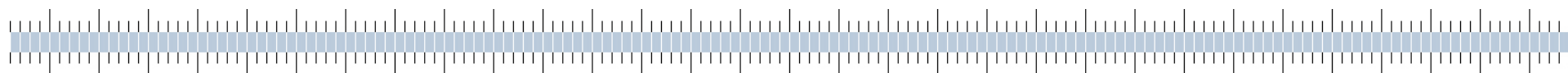
  ❚Increase of capital requirements over a threshold or by a specified factor

  ❚Solvency ratio of capital and capital requirements under a threshold

  ❚Low solvency level for meeting the economic capital requirements under stress

  ❚Specified quantile of the loss distribution for the portfolio under stress conditions does not lie within a specified quantile of the loss distribution for the original portfolio

  ❚EL for the portfolio under stress conditions overlaps the standard risk costs by a specified cator or gets too close to the unexpected loss for the unstressed portfolio

  ❚Risk-return-ratio above specified threshold
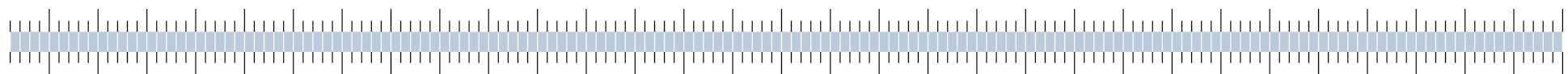
Evaluating stress tests

I **The interpretation of the outcome of stress tests on economic capital can easily lead to misapprehensions, in particular if the capital requirement is estimated on the basis of a VaR for a rather large confidence level.**

I **Motivation for a VaR approach is the avoidance of insolvency by holding enonough capital, except for some very rare stress events**

I **Stress tests might simulate situations coming quite close to these rare events.**

CLASSIFYING STRESS TESTS
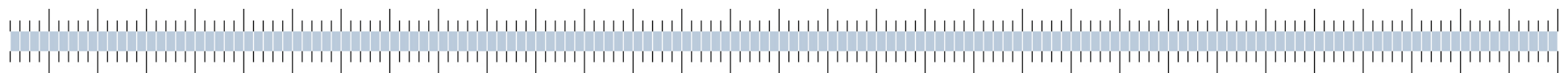
Classifying stress tests

▮For non-performing loans, loss provisions have to be made. Thus one has to consider the following cases for stress tests:

- ▮A performing loan gets downgraded, but remains a performing loan.
  - ▮Estimation of economic capital involves updated risk parameters
- ▮A performing loan gets downgraded and becomes a non-performing loan.
  - ▮Provisions have to be estimated involving the net exposures calculated with the LGD
- ▮A non-performing loan deteriorates.
  - ▮The provisions have to be increased on the basis of a declined LGD

▮Defaults can be included in stress tests via a worsened assignment to rating grades.

▮If Stress tests focus on PDs rather than rating grades, then stress rates for the transition of performing to non-performing loans are required. Ideally, they depend on ratings, branches, economic states etc. and are applied to the portfolio after stressing the PDs.

▮The methodology of the method to determine the volume of the provision for a defaulted credit should be considered.

Classifying stress tests

❚ **Technology**

   ❚ Statistical methods – model based methods

      ❚ Model based: modelling economic variances

      ❚ Statistical methods: sensitivity analysis

   ❚ Common basis for all these specifications is the elementary requirement for stress tests to perturb the risk parameters.

   ❚ These can be the basic risk parameters (EAD, LGD, PD) of the loans

   ❚ These can also be parameters used in a portfolio model like asset correlations or dependencies on systematic risk drivers
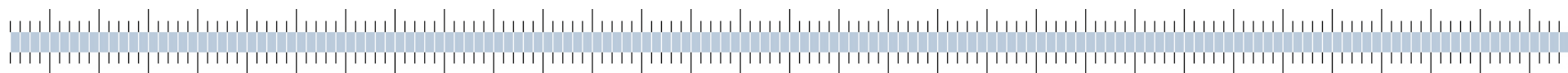
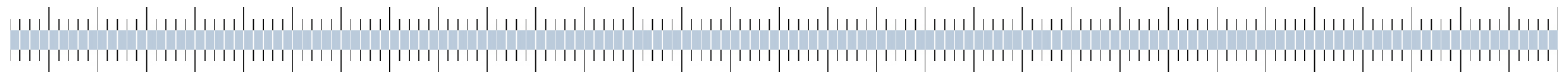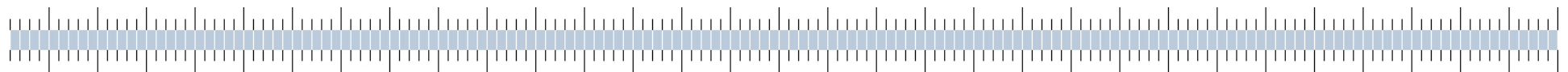# Classifying stress tests

▊**Techniques**

  ▊Direct modification of risk factors (univariate / multivariate)

  ▊Bottom-up / top-down

  ▊Historical scenarios / statistically determined scenarios

  ▊Hypothetical scenarios

CONDUCTING STRESS TESTS

Uniform stress tests

▌The most popular stress tests in banks are uniform stress tests, in particular for the PDs.

▌Intention is to use increased PDs for the calculation of economic or regulatory capital.

▌In the easiest case, there is a flat increase rate for all PDs of obligors or/and countries, but in general the change might depend on rating grades, branches, countries, regions etc.

▌Ways to derive stress PDs:

   ▌Analyse default data with respect to the dependence on rating grades, brances etc.

   ▌Migration rates

Uniform stress tests

❚ **Analyse default data with resprect to dependence on rating grades, branches, countries, regions etc.**

 ❚ Determine deviations of the default rates from PD

  ❚ Determine spreads for respective credit derivatives

  ❚ Calculate stressed $PD = PD + \Phi$

    ❚ Φ: standard deviation, quantile, other relevant characteristic of the deviation distribution

❚ **Migration rates to determine transitions between rating grades**

  ❚ Migrations might depende on Branches, countries, etc

  ❚ In an intermediate step, stressed migration matrices can be generated by omitting of rating upgrades, conditioning on economic downturns, uniformly increasing downgrade rates at the expense of uniformly decreasing the upgrade rates, time series

  ❚ Quantiles or other characteristics of the transition probabilities

  ❚ Stress depending on rating grade

  ❚ Stressed migration rates
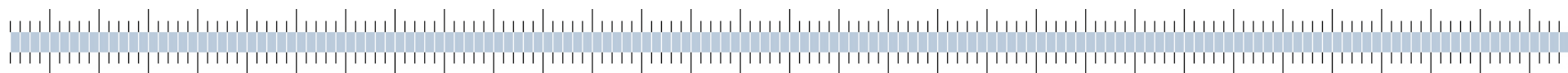
Uniform stress tests

▌**The decision which option should be chosen for determining the stress PD should depend on the data which is available for statistical analysis.**

  ▌Expert opinions could be a part of the process to generate the stress PDs.

  ▌It makes sense to study the deviations that can be caused by the rating process due to sensitive dependence on input parameters.

▌**Choice for stressing PDs vs stressing rating grades should depend on the possibilities of realising the stress tests.**

  ▌Ragarding a portfolio model, the dependence of a PD on a branch or country in a rating grade could represent a problem.

  ▌Inclusion possibility to include defaults could be a criterion to favour stressing of rating grades. Such a stressing might lead to assignments of loans to grades belonging to the non-performing portfolio.

  ▌In case of stressing PDs one should first consider the stressing of the PDs in the portfolio and then the stressing of transition rates to the non-performing part of the portfolio. Monte-Carlo simulations could be used in this context.
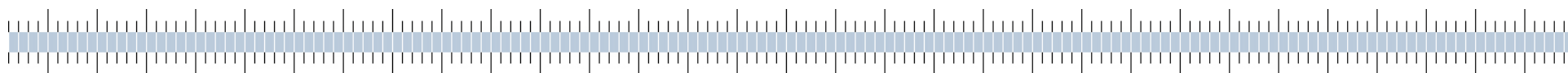
Uniform stress tests

- Transition rates to the non-performing portfolio, usually corresponding to default rates, can bes stressed in the same form and with the same methods as the PDs.

- The same holds for migration rates between rating grades which are used in some portfolio models.

- Flat stress tests for LGDs could be derived analogously to flat stress tests for PDs.

- Deviations in EAD mainly depend on individual properties of the loans. So uniform stressing of EAD is often not relevant. The variation of factors like exchange rates, that may have an influence, should be investigated separately.

- For uniform stressing of parameters used in portfolio models, it seems to be the best to rely on expert opinions, as it is difficult to detect and statistically verify the effect of these parameters on the deviations from expected or predicted values of defaults and losses.
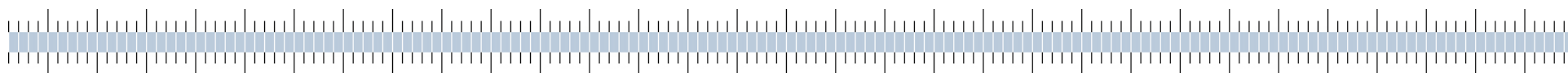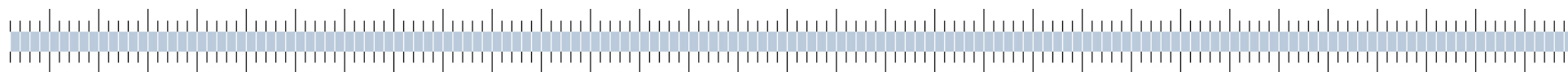
Sensitivity analysis for risk factors

❚ **These kind of scenarios are popular for market risk, where risk factors can easily be identified, but it is also used as a basis for scenario analysis.**

❚ **This is due to the crurial task of recognising suitable risk factors and introducing a valid macroeconomic model for the dependence of risk parameters on the risk factors representing the state of the business cycle.**

❚ **Popular risk factors**

  ❚ Usual suspects (interest rates, inflation rates, stoch marktet indices, credit spreads, growth in GDP...)

  ❚ Portfolio specific, depending on bank's policy

  ❚ Detection of risk parameters typically via time series

    ❚ One should try to develop a macroeconomic model and determine those factors suitable to describe the evolution of risk parameters.

    ❚ Impact of stress on the risk parameter or irectly on credit loss characteristics is modelled using linear regression. Problem: restrict risk factors to allow a feasible model
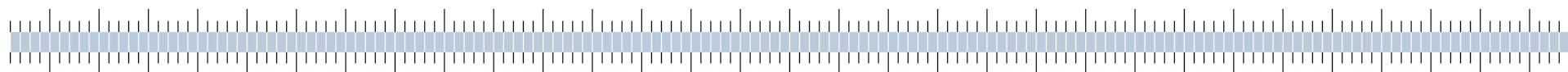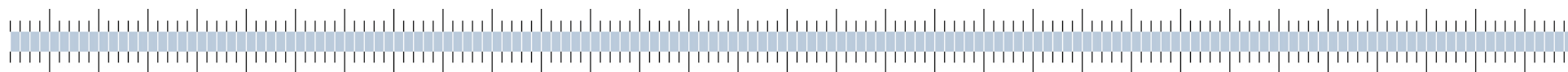
Sensitivity analysis for risk factors

❚Discovering which risk factors have the biggest impact on the portfolio risk in terms of the VaR or whatever is used for the evaluation of unexpected losses, is the target and the benefit of sensitivity analysis.

❚Stressing is analogous to the uniform stress test on risk parameters. Stress values for a single risk factor are fixed on the basis of statistical analysis or expert opinion. The consequences for the risk parameters are calculated with the help of the macroeconomic model and the modified values for the risk parameters are finally used for evaluating capital requirements.

❚Risk factors which have an impact on several risk parameters and which also play a role for stress testing market risk, might be of particular interest.

Sensitivity analysis for risk factors

Sensitivity analysis could also be used to verify the uniform stress testing by checking whether the range of parameter changes due to sensitivity analysis is also covered by the flat stress tests.

Morevover, it can be seen as a way to pre-select secenarions: only those historical or hypothetical scenarios which involve risk factors showing some essential effects in the sensitivity analysis are worth considering.
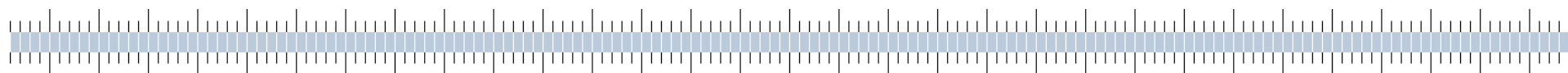
Historical scenarios

I Historical scenarios are easy to implement, as one only has to transfer the values of risk factors corresponding to a historic event to the current situation. In most cases, it does not make sense to copy the value of the risk factors, but to determine the change of value (either in absolute or in relative form) which is accompanied by the insertion of the event and assume it also applies to the actual evaluation.

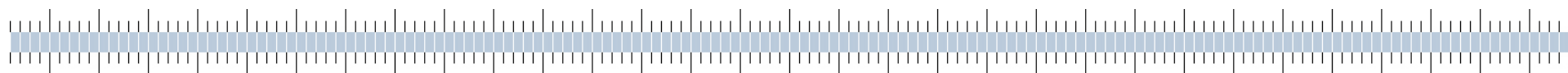I Popular scenarios

I Oil crisis 1973/74

I Stock market crash (1987, 1994, 1998)

I Terrorist attacks (2001, 2004) / wars (1990, 2003)

I Currency crisis (1992, 1994, 1997)

I Emerging market crisis

I LTCM / Russia crisis (1998)

Historical scenarios

I Represent ‚real' accident – probability of occurrence would have been seen too low to look at them

I Provide evidence of coincidence

I Can be used to check the validity of the uniform stress tests and sensitivity analysis

I Offer the possibility of learning about the joint occurrence of major changes to different risk factors and the interaction of several typse of risks. It can thus also be used to design hypothetical scenarios
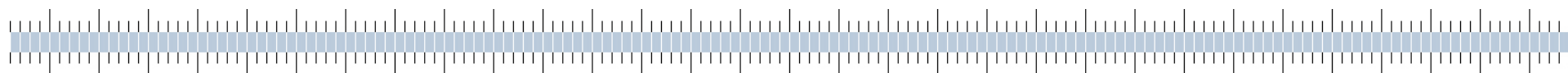
Statistically determined scenarios

- Chosen on the basis of risk factor distributions
- No direct relationship to the other types of scenario analysis
- Historical distributions might be inferior to distributions conditioned to the situation applying at the time of stress testing
- Reliability of the factor distribution is essential
- If EL conditioned to a quantile are evaluated in order to interpret them as UL and treat them as economic capital requirement, then the risk factor distribution should also be conditioned to the given economic situation.
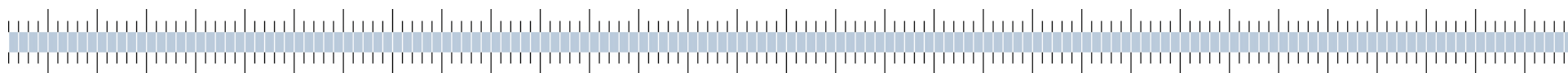
Hypothetical scenarios

▌Historical Scenarios is the most advanced means of stress testing in risk management.

▌Should combine experience in analysing risk relevant events with expert opinion on the portfolio, as well as the economic conditions and statistical competency

▌Derived from historical data and expert opinion
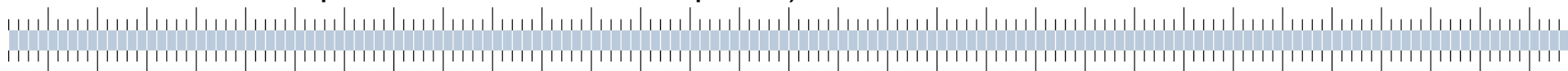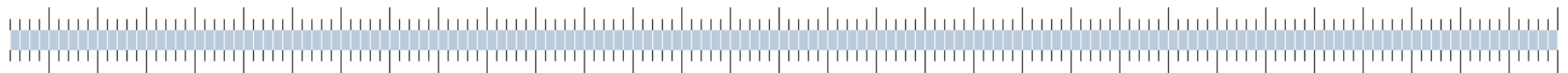
▌Implementation is analogous to historical scenarios

Hypothetical scenarios

▌**Scenarios should reflect the focus of the portfolio for which the stress test is conducted and should have the most vulnerable parts of it as the target**

▌**Advantage of hypothetical scenarios is that they can take into account recent developments, events, news and prospects**

▌**Common scenarios:**

  ▌Significant rise in commodity prices (oil price, reduced annual growth in GDP, indices describing increased consumer prices)

  ▌Major increase in interest rates (indices describing the volatility of financial markets, increase spreads, reduced annual growth in GDP, volatility of exchange rates, consumer indices)

  ▌Drop in global demand (reduced annual growth in GDP, stock market indices, consumer indices)

  ▌Emerging market crisis (reduced annual growth in GDP, widened sovereign credit spreads, decline in stock prices)

ACTION PLANNING

Development of stress test

Decide upon stress scenarios

↓

Estimate risk parameters

↓

Simulate contribution to Credit risk (market risk...)

↓

Calculate contribution per rating grade

↓

Calculate new PD, LGD, EAD

↓

Calculate credit risk in that scenario

↓

Risk aggregation / risk bearing capacity
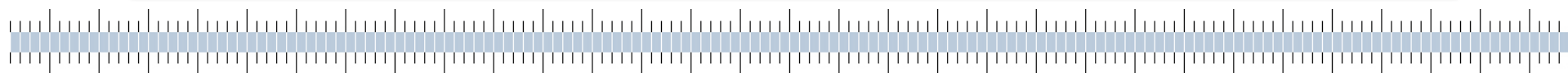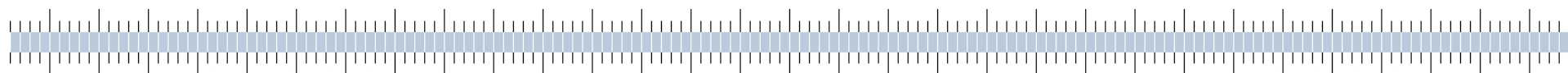
Statistical analysis and research

▎**Risk parameter determination w.r.t. possibilities for deviations**

▎**Default and loss data w.r.t possibilities for deviations of risk parameters**

  ▎Dependece of risk parameter deviations on risk factors

    ▎Determine risk factors and their possible deciations relevant to the portfolio and stress testing

    ▎Historic events with high impact on portfolio risk

  ▎Macroeconomic model for dependece of risk parameters on risk factors

  ▎Distribution for the (historic) deviations of the relevant risk factors

▎**Interplay of credit risk, market risk and other sorts of risk**

Example

Portfolio

- 10,000 loans, 159 billion EUR in total
- Normal distribution of loans over 18 rating grades (PD 0.03% - 20%, mean 0.6%)
- Loans randomly distributed over six sectors (sytemic risk) and thirteen countries
- Dependence of the loans on respective sstemic risk factors varies between 25% and 75% and is randomly distributed in each sector
- Sectorial variation calculated from the volatilies of the PDs

Model

- CreditRisk+™
- Stress calculation: modelling interrelation of the risk parameter PD on riks factors (via linear regression)

Source: V.M. Gundlach Development of Stress Tests for Credit Portfolios, in Engelmann / Rauhmeier (ed.), The Basel II Risk Parameters, Springer 2006
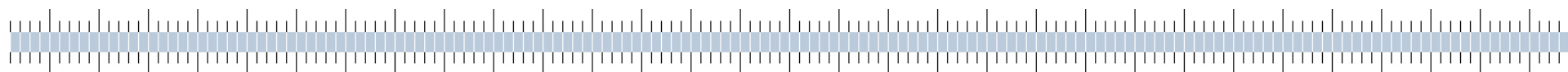
Example

| Stress test	Regulatory capital (million EUR)	Economic capital (million EUR)	Expected loss (million EUR)	Loss provision (million EUR)
Base case	3,041	1,650	235	0
PD * 150%	3,715	2,458	353	0
PD * 150% with provisions	3,631	2,255	320	332
PD * 200%	4,138	3,267	470	0
PD * 200% with provisions	4,151	2,996	427	332
Rating class + 1	3,451	1,911	273	376
LGD + 5%	3,676	1,985	283	0
LGD + 5%, PD * 150%	4,490	3,935	567	0
Systematic factor * 150%	3,041	3,041	235	0
Real estate bubble	3,106	1,686	240	0
Stock price decline	3,591	2,368	329	0
Rise of oil price	3,430	2,057	300	0
Sep 9 / 11	3,897	2,622	399	0
Recession USA	3,688	2,307	351	0
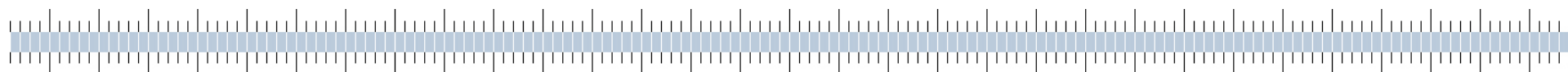
Example – Description of scenarios

- Flat increase of all PDs by a rate of 50% (without and with loan loss provisions)
- Flat increase of all PDs by a rate of 100% (without and with loan loss provisions)
- Uniform upgrade of all ratings by one
- Flat increase of all LGDs by 5%
- Flat increase of all PDs by rate of 50% and all LGDs by 5%
- Flat increase of all sectorial variances by a rate of 50%
- Flat increase of all LGDs by 10% for real estates in UK and USA (real estate bubble)
- Drop of stock market index by 25%
- Rise of oil price by 40$
- Drop of oil price by 25%, Stock market index by 5.5%, EURIBOR by 25%
- Drop of stock market index by 10%, GDP of USA by 5%, GDP of EU by 2%, increase of EUR/USD-exchange rate by 20%
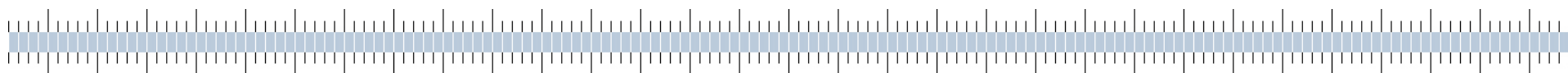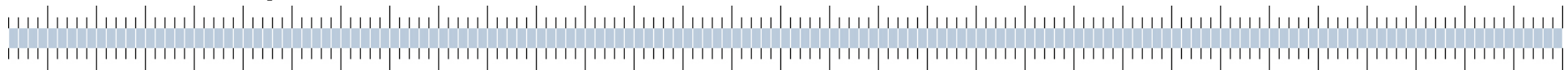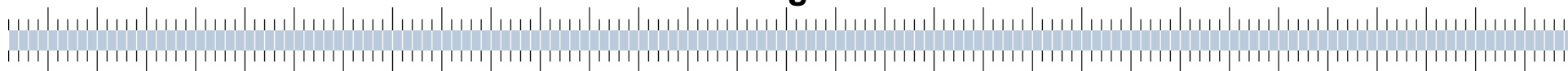
SUMMARY
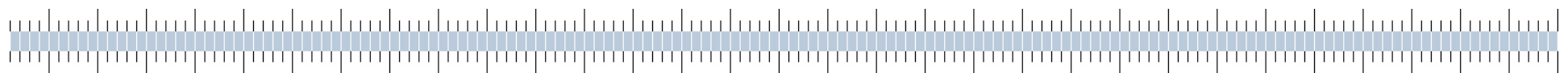
Summary

I Stress test is a management tool for estimating the impact on a portfolio of a specific event, an economic constellation or a drastic change in risk relevant input parameters, which are exceptional, even abnormal, but plausible and can cause large losses.

I It can be seen as an amendment aswell as a complement to VaR-based evaluations of risk.

I It allows the combinations of statistical analysis and expert opinions for generating relevant and useful predictions on the limits for unexpected losses.

I Stress testing is also a means towards analysing risk and risk relevant constellations.

I In particular, it should lead to a higher awareness and sensitivity towards risk.

I This requires a abetter knowledge of risk drivers, portfolio structure and the development of risk concentrations.

Summary

- The basis of stress tests is provided by rich data for defaults, rating transitions and losses.

- Starting point for the development of stress tests should be an analysis of the volatilities of these rates and estimations for bounds on deviations for them.

- Statistical analysis should be accompanied by investigations of the reasons for the deviations. It should be studied which fraction of the deviations arise from the methodology of the rating processes and which from changes in the economic, political etc. environment

- Expert opinion should be used to estimate bounds for the deviations arising from the methodology.

- Statistical analysis should lead to an identification and quantification of the exogenous risk factors having the main impact on the risk parameters needed to determine capital requirements.

- Combination of expert opinion and statistical analysis should lead to an establishment of uniform stress testing.

Q & A