

Modelling Incremental Risk Charge

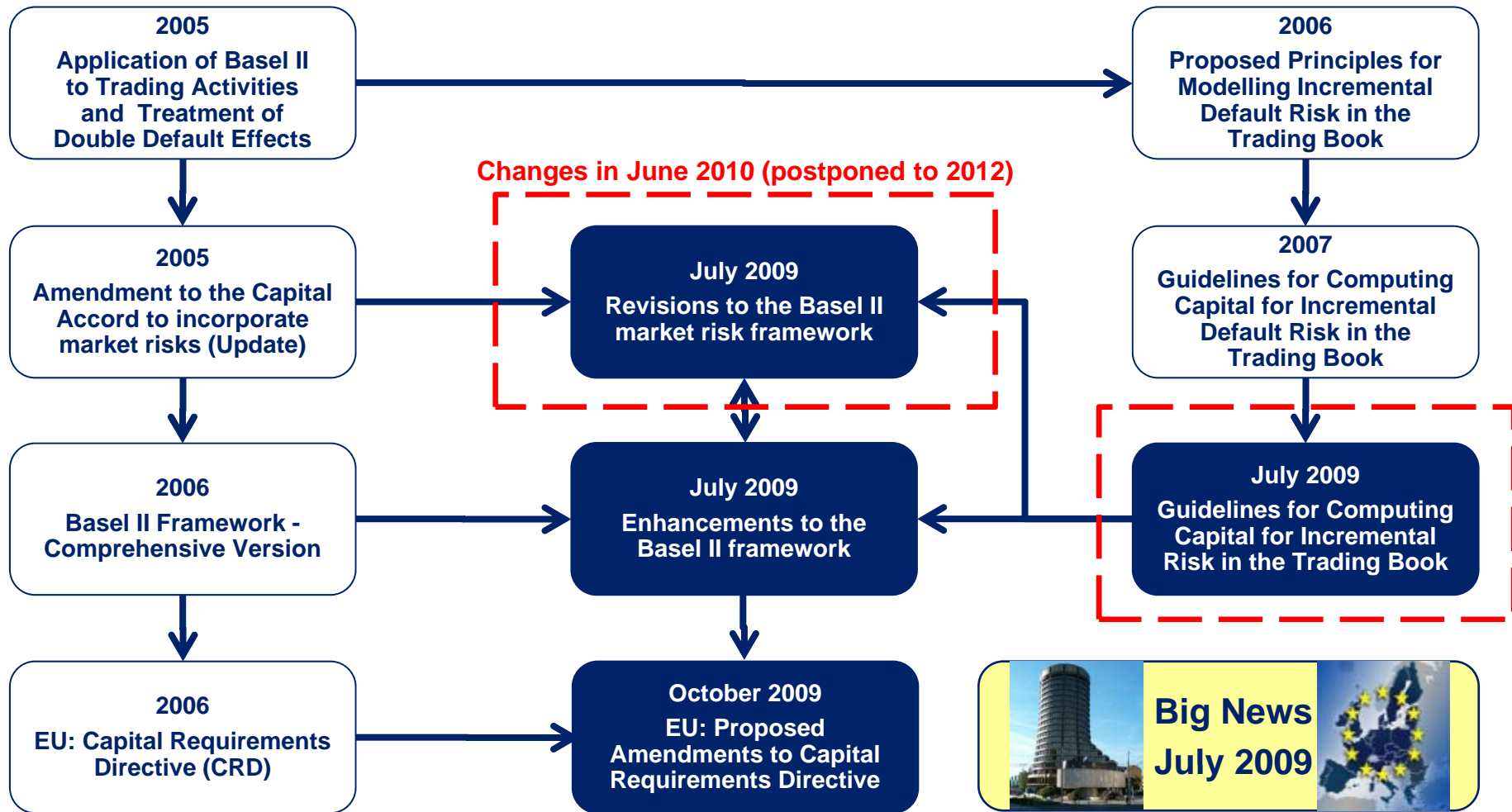
Capital Allocation and Management
London
13-Sep-2010



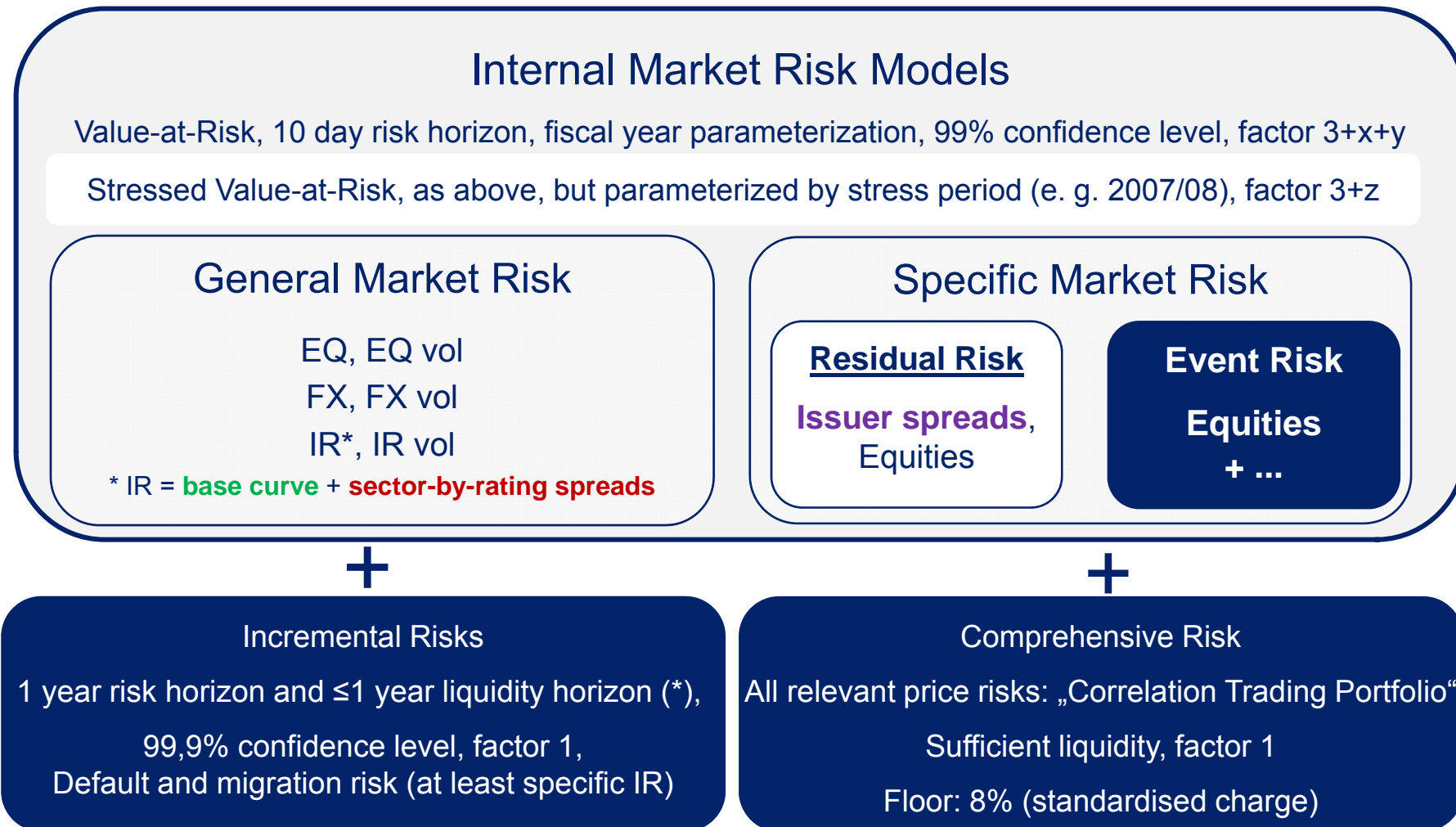
Content

- Regulatory requirements and definitions
- Modelling approach
- Implementation

Evolution of Regulatory Decrees for the Trading Book



Incremental and Comprehensive Risk Charge

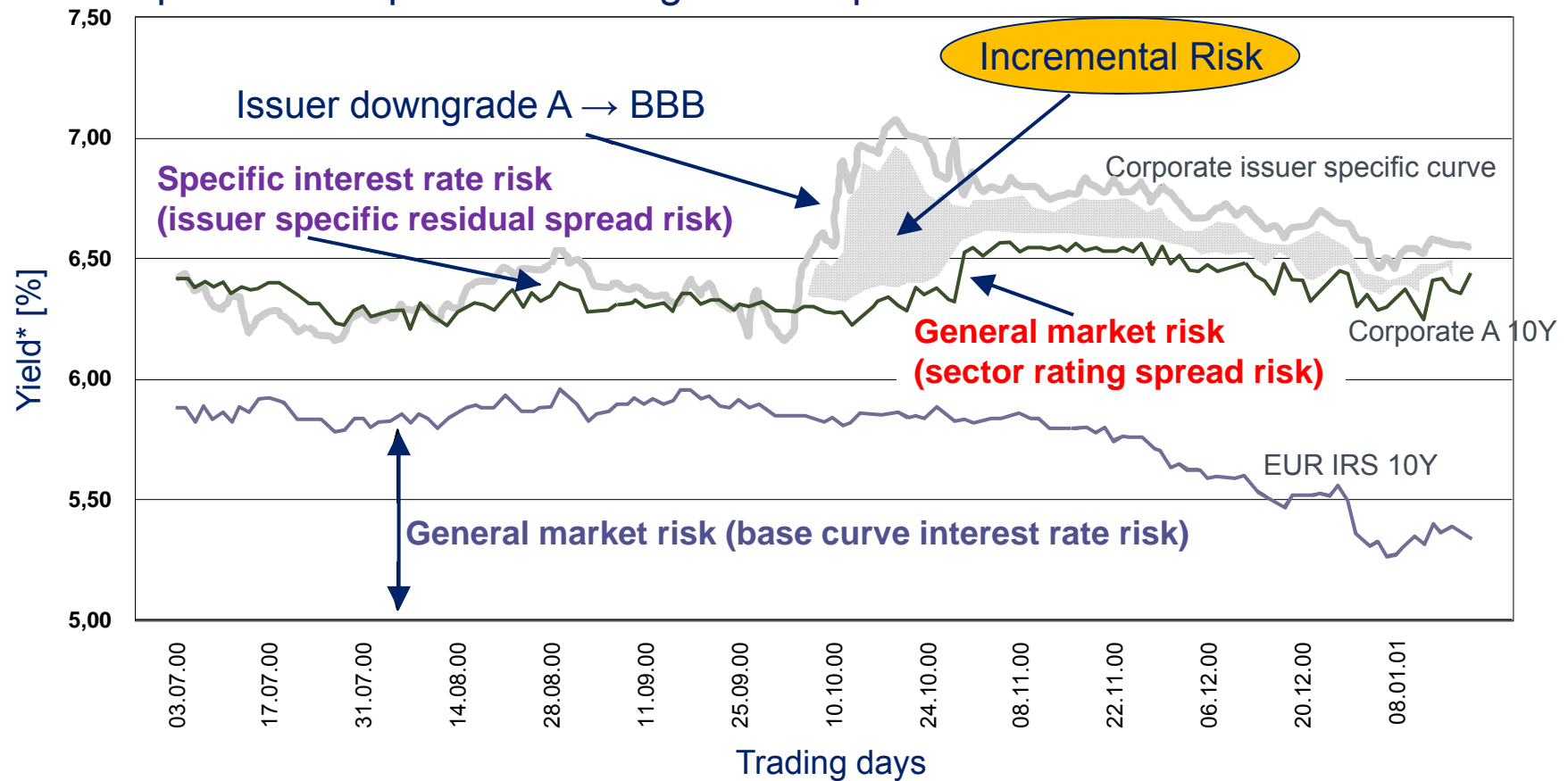


(*) Assumption: constant level of risk

x (0,1) supervisory additional charge dependent on quality of market risk model
y additional capital charge from back-testing results

Price dynamics of a bond

Market price development of a long term corporate bond



*Yield calculated from quoted bond price

Incremental Risk in some Detail

Modelling Nature

Risk Driver	Default, Migration
Dynamics	Discrete
Parametrisation	Probability of Occurrence
Mapping Initial Data	Probabilities, Correlations
Type of Simulation	Monte-Carlo, Portfolio Models
Risk Measure	Value-at-Risk (99,9% 1y)
Risk Indicators	Risk Contributions

Selected Regulatory Requirements:

- securitisations as defined in the “Basel II framework” can not be included
- no N-th-to-Default credit derivatives
- equities may be modelled (e.g. for reasons of consistency)
- constant level of risk assumption
- liquidity horizons (floor: 3 months)
- (systematic) correlations, concentrations
- reflect basis risks (product, seniority, rating, maturity, differences between offsetting positions)
- validation (good quality of market data entering the model, stress tests, etc.)

Comprehensive Risks (Market & Credit Risk)

Correlation Trading Portfolio

actively traded single-name reference entities
(liquid underlyings)

no re-securitisations, R/CMBS, Retail-Securities

credit derivatives, (other) securitisations, hedges

Hedge relations fully covered

**Fallback: CTP-specific standardised
charge (restricted hedging possibilities)**

Selected Regulatory Requirements

- multiple (ordered) defaults in tranches
- credit spread risk
- volatility of implied correlations
- volatility of recovery rate (stochastic recovery rates)
- hedge-slippage, rebalancing costs
- CRC stress tests
- Back-testing (historical explanation)
- all requirements for incremental risks
- minimum capital 8% of standard charge (current EU Capital Requirements Directive)

Incremental Risk Charge – Validation

Model Validation

- No back-testing as required for 1 day market risk, however, all results should be validated quantitatively (as for Basel II)
- **What?**
 - Model assumptions, e.g. liquidity horizon
 - Parameter estimation e.g. migration matrix, correlation matrix, spread shifts
 - Numerical stability
 - Resulting uncertainty of risk measures
- **How?**
 - Stress Tests and scenario analyses
 - Sensitivity analysis
 - Statistical Bootstrapping

“Use Test“

- Application as steering instrument within the bank
- Use within economic capital calculation

Content

The IRC regulatory framework

Modelling Approach

Implementation

Incremental Risk Charge – Implementation Choices

System architecture

- Market risk model
- credit portfolio model
- stand-alone system

Rating Migrations

- Jump Diffusion
- Merton Model

Valuation

- Migration
- default (deterministic or stochastic Recovery)

Ratings

- external vs. internal Ratings
- grading

Liquidity horizon

- Definition of criteria
- Calculation of Short-term PDs

Constant Level of Risk

- One Period Model
- Multi-Period Model

Determination of Risk factors

- Systematic
- Idiosyncratic

Point-in-time vs. Through-the-cycle

- Correlation model

Inclusion of CRC

- other product types
- additional requirements

Model: Market risk like + jump processes

Problems

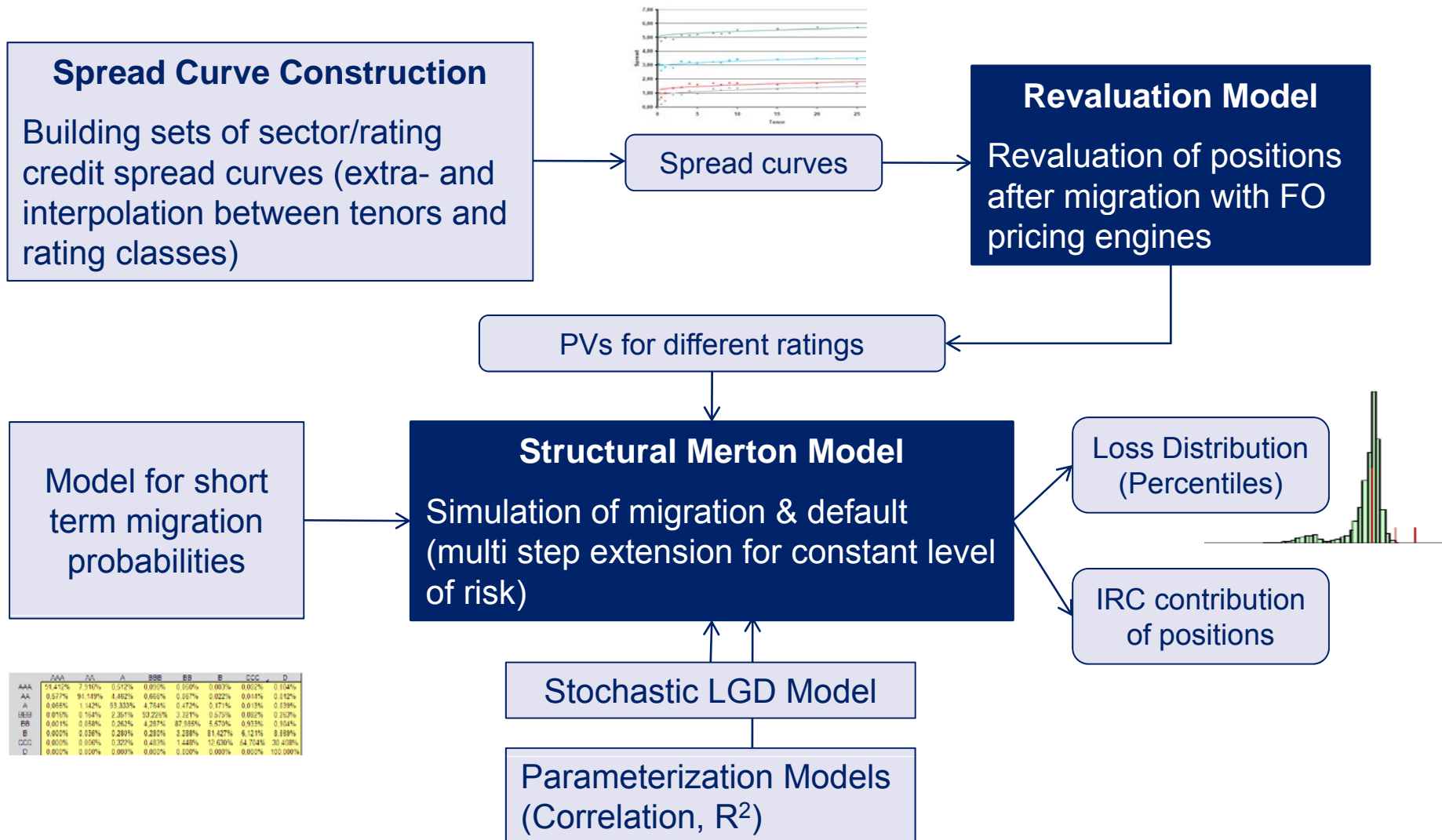
- Modelling of different liquidity horizons
(possibly via multi-period simulations, but difficult to calibrate)
- Calibration of jumps to actual migration or default probabilities
- Correlation between jumps
- Spread changes do not cover migration and default risk only.
- Calculated risk might be fluctuating with changing spread volatility.

Integrated Market and Credit Risk Model

Problems

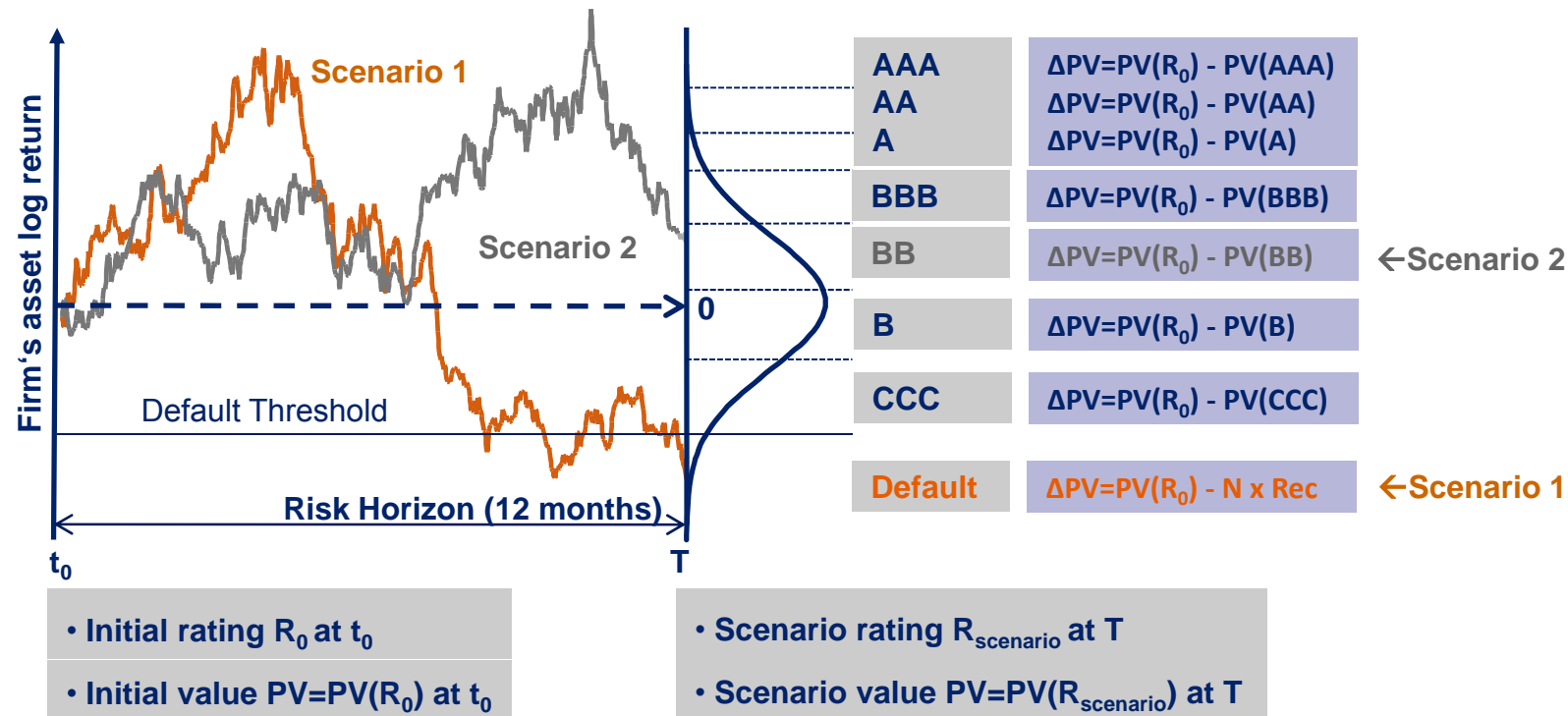
- Need of scenario generator simulating relevant risk factors
- Choice of risk factors
- Correlations between credit risk and market risk factors
- Inclusion of stochastic volatility, recovery and base correlation, jump events
- Model validation
- IT infrastructure

IRC Modelling Framework



Structural Merton Model: Simulating migration P&L

Model firm's normalized asset log return process at risk horizon



Key modelling issues:

1. Specification of firm's (normalized) asset log return process in factor model
2. Rating class dependent revaluation of position at risk horizon

Structural Merton Model: Specification & Assumptions

Asset value log return process driven by multivariate factor model

- Asset return of obligor i at risk horizon assumed to be normally distributed:

$$r_i = R \cdot X_i + \sqrt{1-R^2} \cdot \varepsilon_i = R \cdot \left(\underbrace{w_{1i} \cdot Y_1 + w_{2i} \cdot Y_2}_{\text{Systematic risk}} \right) + \sqrt{1-R^2} \cdot \underbrace{\varepsilon_i}_{\text{Idiosyncratic risk}} \sim N(0,1)$$

Position
'Sector'
Issuer

Normalised **asset value**
Systematic risk
Idiosyncratic risk

log return at risk horizon
(e.g. country & industry)

- Correlation** of migration and default events induced by correlated systematic risk factors Y_j (e.g. MSCI country or industry indices):

$$\vec{Y} = (Y_1, Y_2) \sim N(0, \Sigma) \quad \text{where } \Sigma \text{ is the } \mathbf{covariance matrix} \text{ of systematic factors}$$

- Assume **conditional independence** of obligors' asset returns upon systematic risk:

$$\varepsilon_i \sim N(0,1) \quad ; \quad \text{cov}(\varepsilon_i, \varepsilon_j) = 0 \quad \& \quad \text{cov}(\varepsilon_i, Y_j) = 0$$

- Impact of systematic and idiosyncratic risk term steered by parameter R^2

- Default and migration **thresholds** are obtained from migration probabilities:

$$d_i^{\text{def}} = N^{-1}(\text{PD}_i)$$

Structural Merton Model: Special Features for IRC

Extension of Merton model to satisfy regulatory requirements

- Treatment of hedges (short and long CDS positions)
- Issuer concentration (same idiosyncratic risk for different bonds of same issuer)
- Constant level of risk assumption:
 - After a so called **liquidity horizon** a positions can be replaced by another position having its original „risk profile“.
 - Reflects that „buy-and-hold“ is not appropriate for trading book.
 - Implementation by a multi-step version of the Merton-Model in which the position's asset return process is reset at its liquidity horizon.
- Multi-step model requires modelling of short term migration matrices (generator matrix approach; → thresholds)
- Double default
- Optional: Stochastic LGD (recovery)
 - e.g. Beta distribution, generalised logit function
 - Dependent or independent of PD

Specific topic: Constant Level of Risk

Rollover and replacement of positions

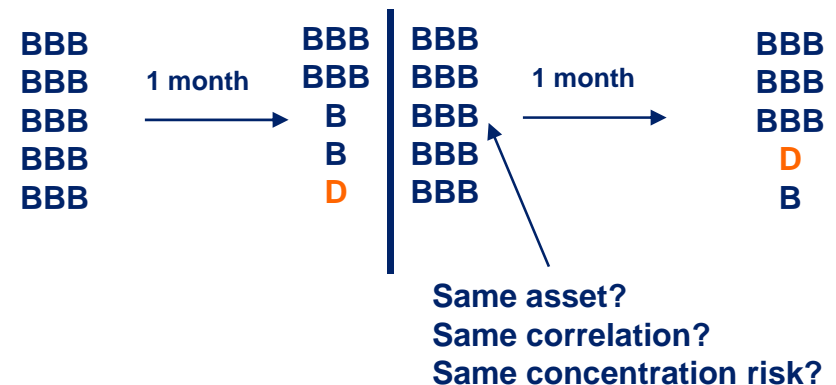
- ❑ Replace assets with changed credit quality with similar asset at liquidity horizon
 - Same name?
 - Same industry/country?
 - Distribute the exposure to other similar names?
 - What if no other or only few other names of same characteristic exist?

- ❑ Constant Level of Risk:= Same loss distribution
 - Consider sub-portfolio assigned to one month liquidity horizon
 - Calculate one month loss distribution using one month default probabilities
 - For second month assume same loss distribution again
 - One year constant level of risk loss distribution is convolution of 12 copies of one month loss distribution
 - In Monte Carlo context, sum 12 independent draws from one month loss distribution, repeat many times to derive one year loss distribution

Buy and Hold



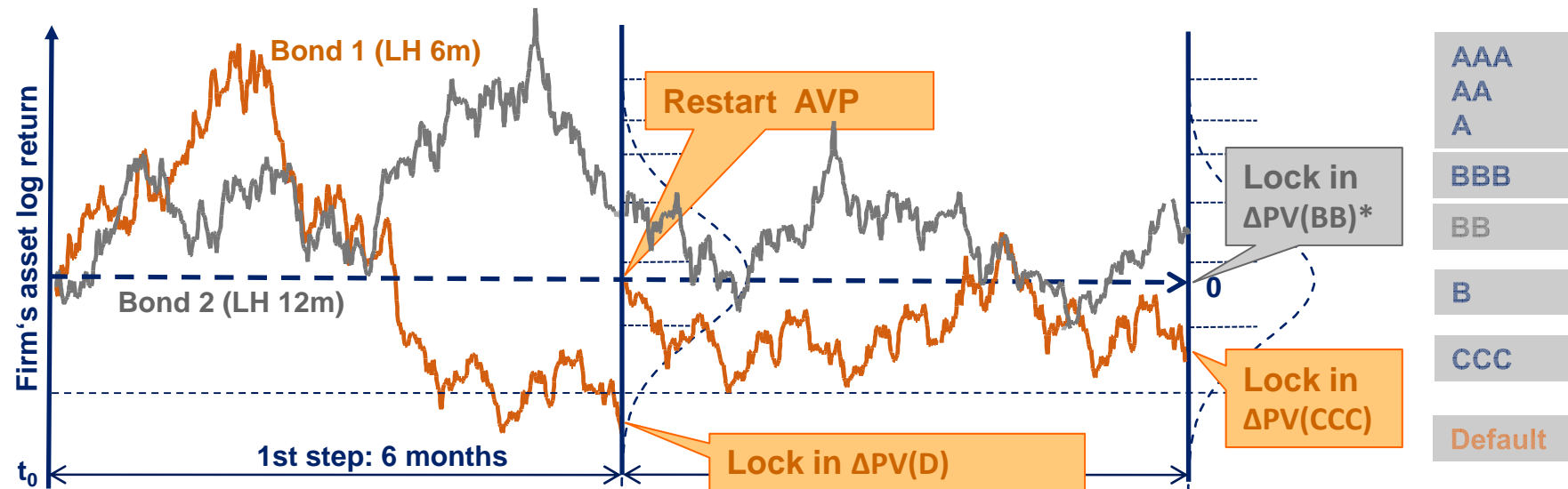
Constant Level of Risk



➔ Multi-period Credit Risk Model

Structural Merton Model: Constant Level of Risk

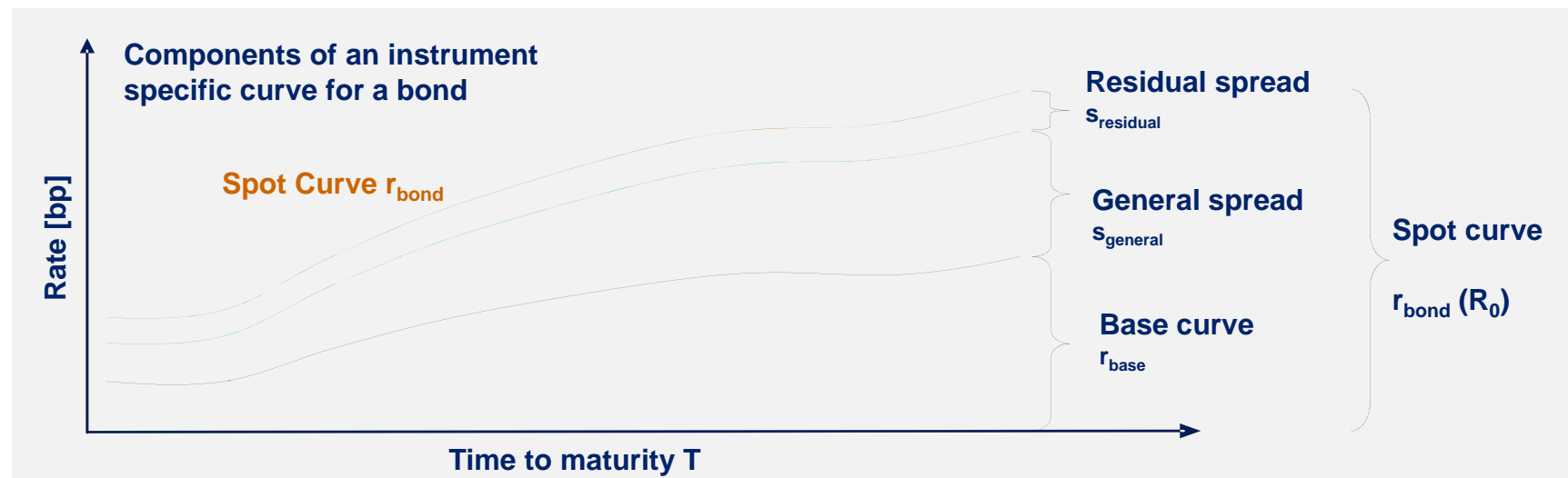
Multi-step extension for replacement of positions within risk horizon



- | | | |
|---|--|--|
| <ol style="list-style-type: none"> 1. Simulate first 6-months section of asset value process (AVP): 2. Assess 6-months rating & lock in $\Delta PV(D)$ | <ol style="list-style-type: none"> 4. Simulate second 6-months section of AVP 5. Assess 12-months rating & lock in $\Delta PV(CCC)$ for Bond 1 & for Bond 2 | <ol style="list-style-type: none"> 6. Scenario loss Bond 1:
 $\Delta PV(D) + \Delta PV(CCC)$
 (over entire risk horizon) |
| <ol style="list-style-type: none"> 3. Constant-level-of-risk \Leftrightarrow reset AVP to zero | $\Delta PV(BB)$ | |

Revaluation Model: Bond Valuation – Standard Model

Present value (PV) of bond computed with instrument specific spot curve



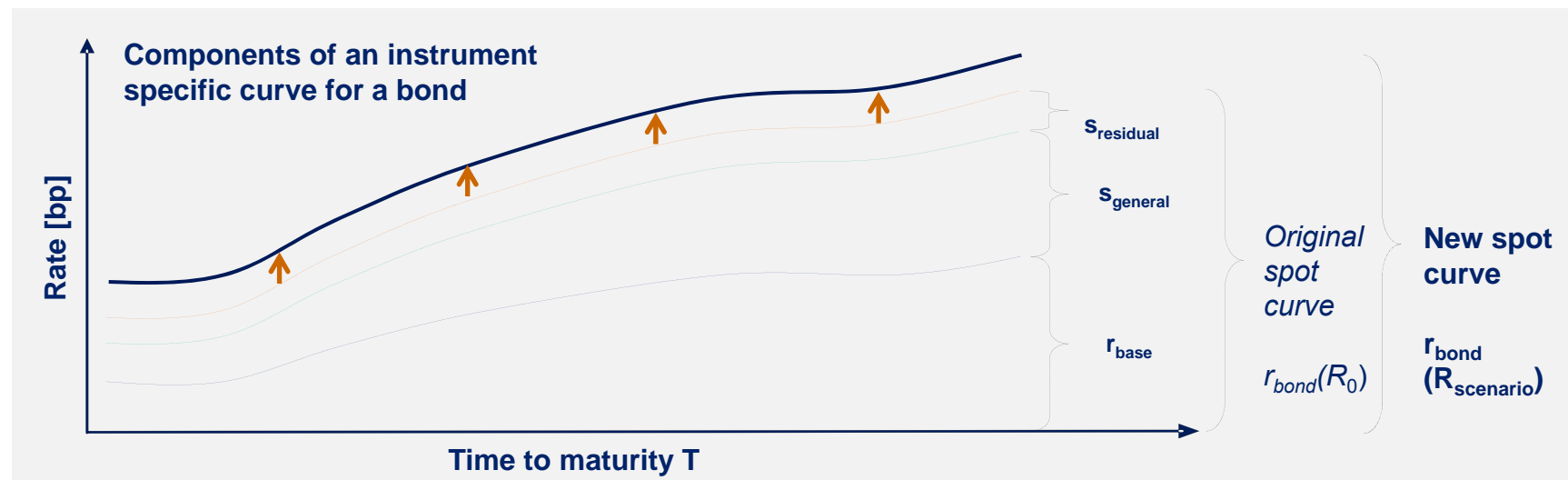
- PV is the sum of cash flows discounted with the spot curve r_{bond} :

$$PV_{bond}(t) = \sum_{i=1}^n \frac{c(t_i)}{(1 + r_{bond}(t, t_i; R_0))^{t_i - t}}$$

- Base curve: e.g. swap curve
- General spread represented by sector/rating/currency spread curve
- Residual spread obtained according to market price of the bond

Revaluation: Bond Valuation After Rating Migration

PV after simulated rating migration computed with adjusted spot curve



- New PV is the sum of cash flows discounted with the new spot curve

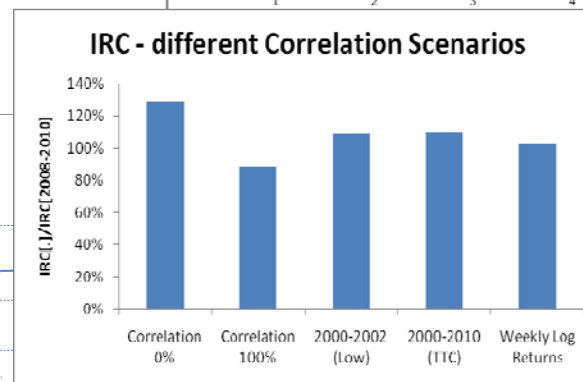
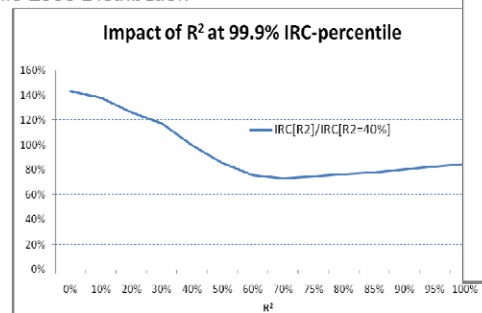
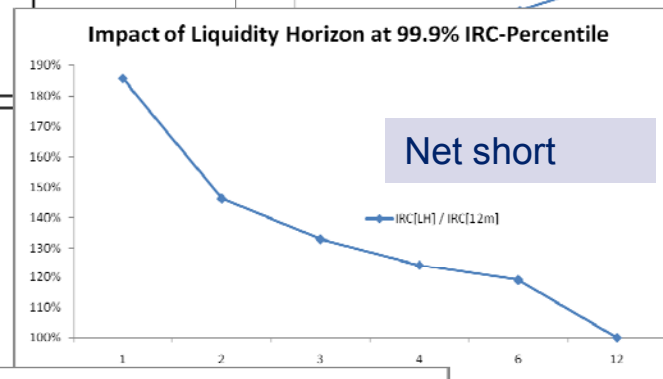
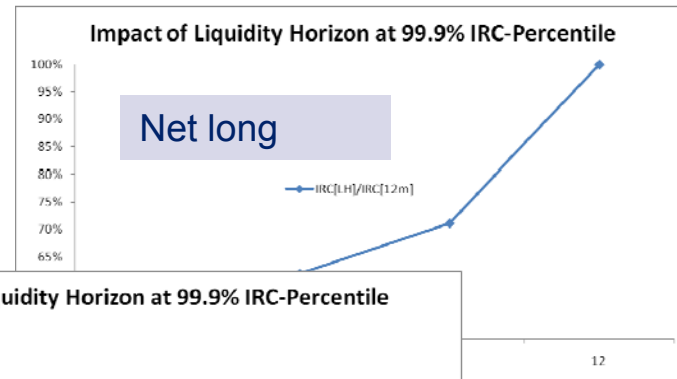
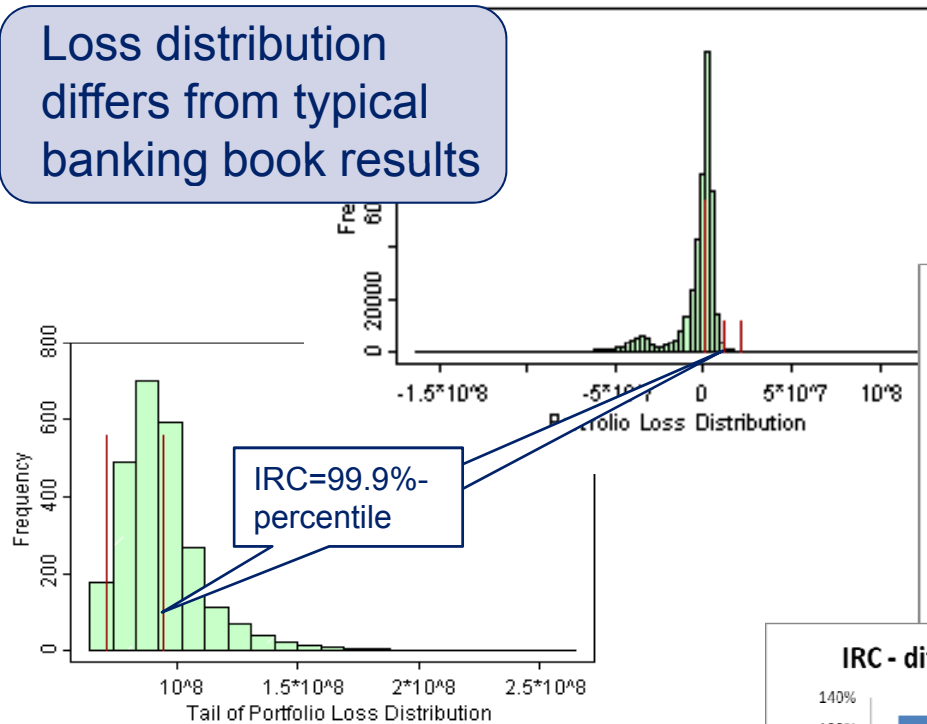
$$r_{bond}(R_{scenario}):$$

$$PV_{bond}(t) = \sum_{i=1}^n \frac{c(t_i)}{(1 + r_{bond}(t, t_i; R_{scenario}))^{t_i - t}}$$

- Shift according to differences in sector/rating curves of R_0 and $R_{scenario}$ (tenor-wise)
- Construction of sector/rating curves a major ingredient

Net Short Position in Sample Portfolio Causes Unfamiliar Results from a Credit Risk Point of View

Loss distribution differs from typical banking book results



IRC's sensitivity to parameters is not intuitive

Content

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Implementation

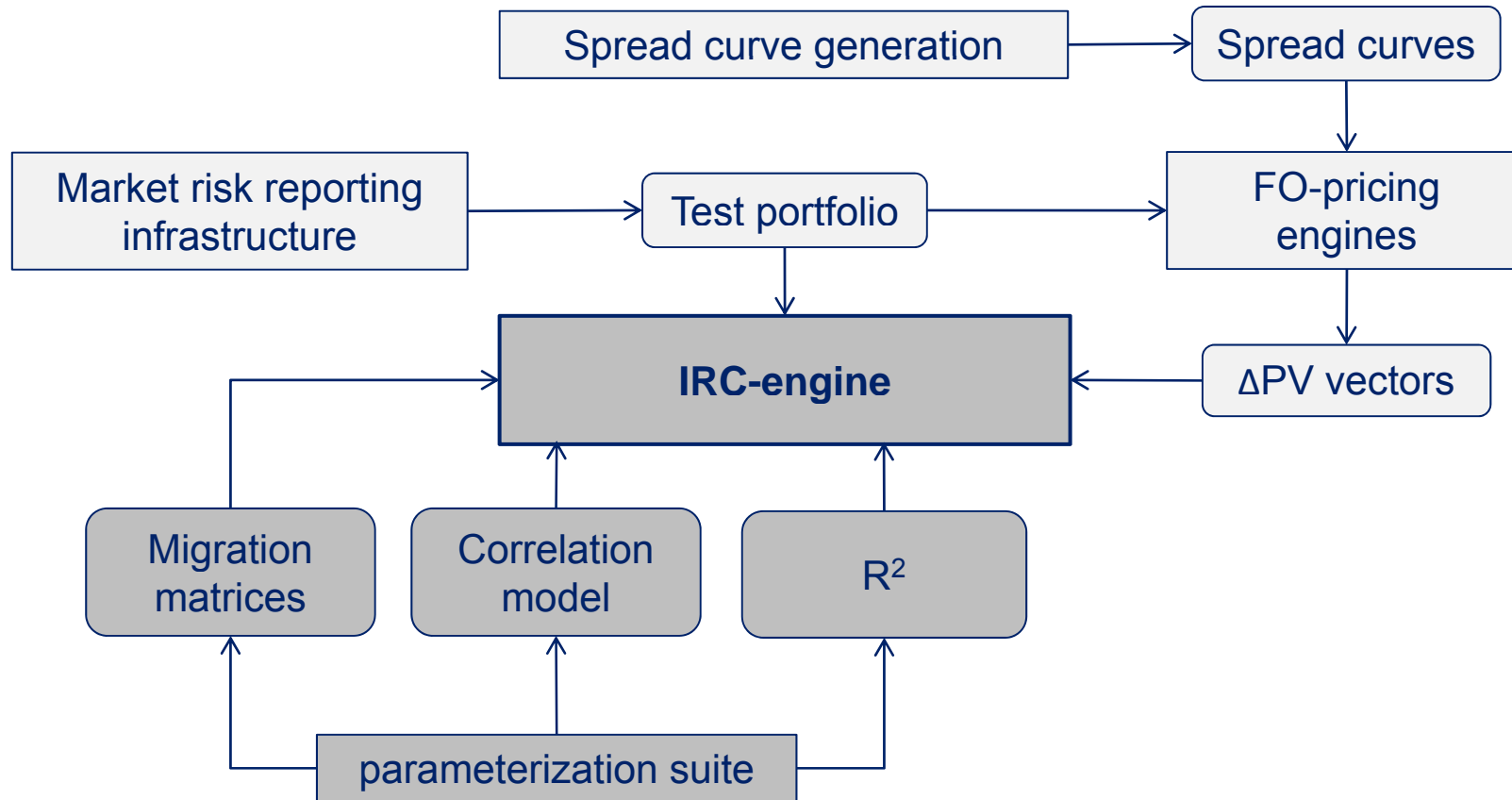
d-fine's IRC engine

IRC engine is a modified version of d-fine's EC-engine with the following features:

- Multi-Factor Merton Model
- Full Migration mode
- Interface to PV-vectors for each instrument at each different rating grade
- Constant level of risk
- Multi step model
- Stochastic recovery
- Treatment of different liquidity horizons of different instruments of the same issuer

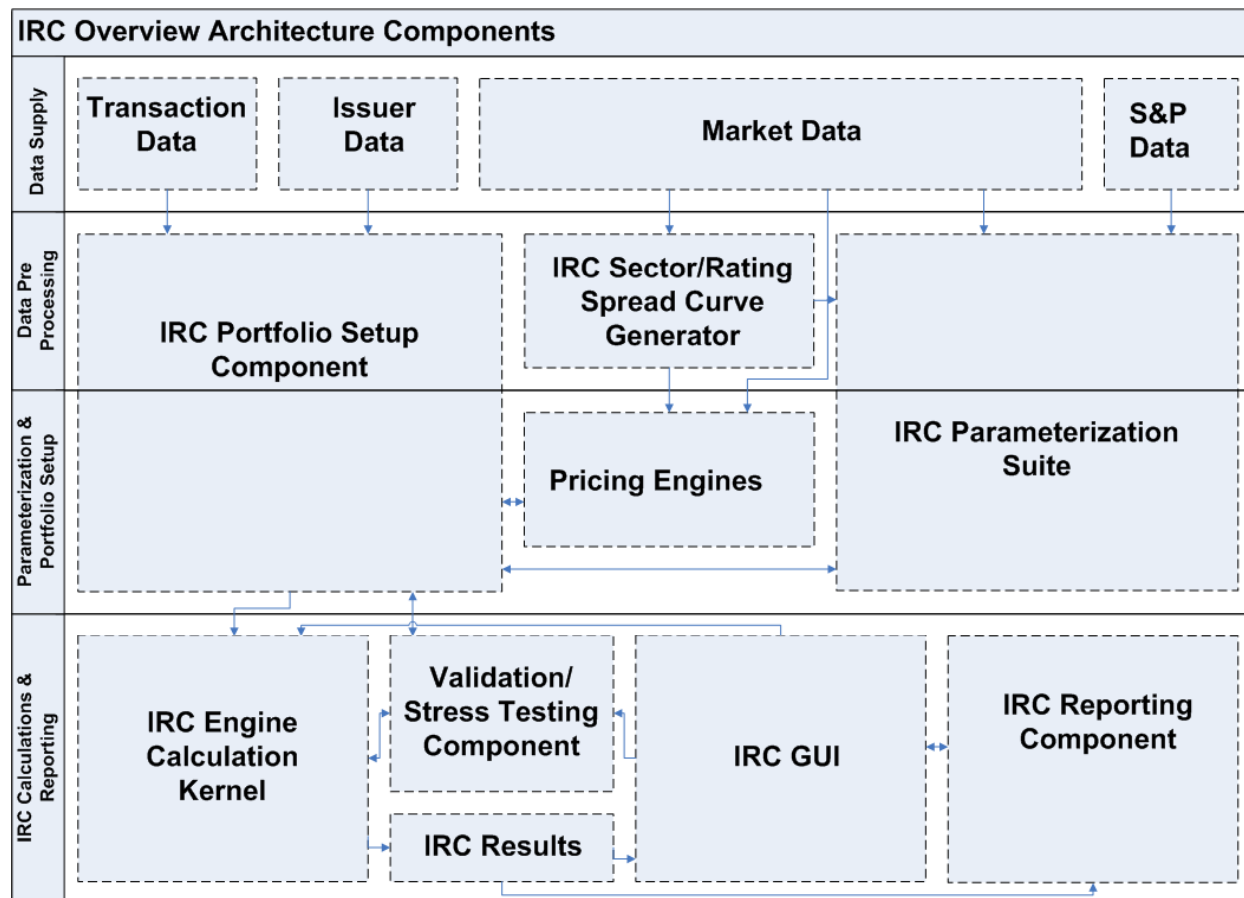
IRC Calculation Process

d-fine's IRC engine & calibration suite



IRC Infrastructure: Flexible Modularised Architecture

IRC calculations require interaction of various models, systems and data entities



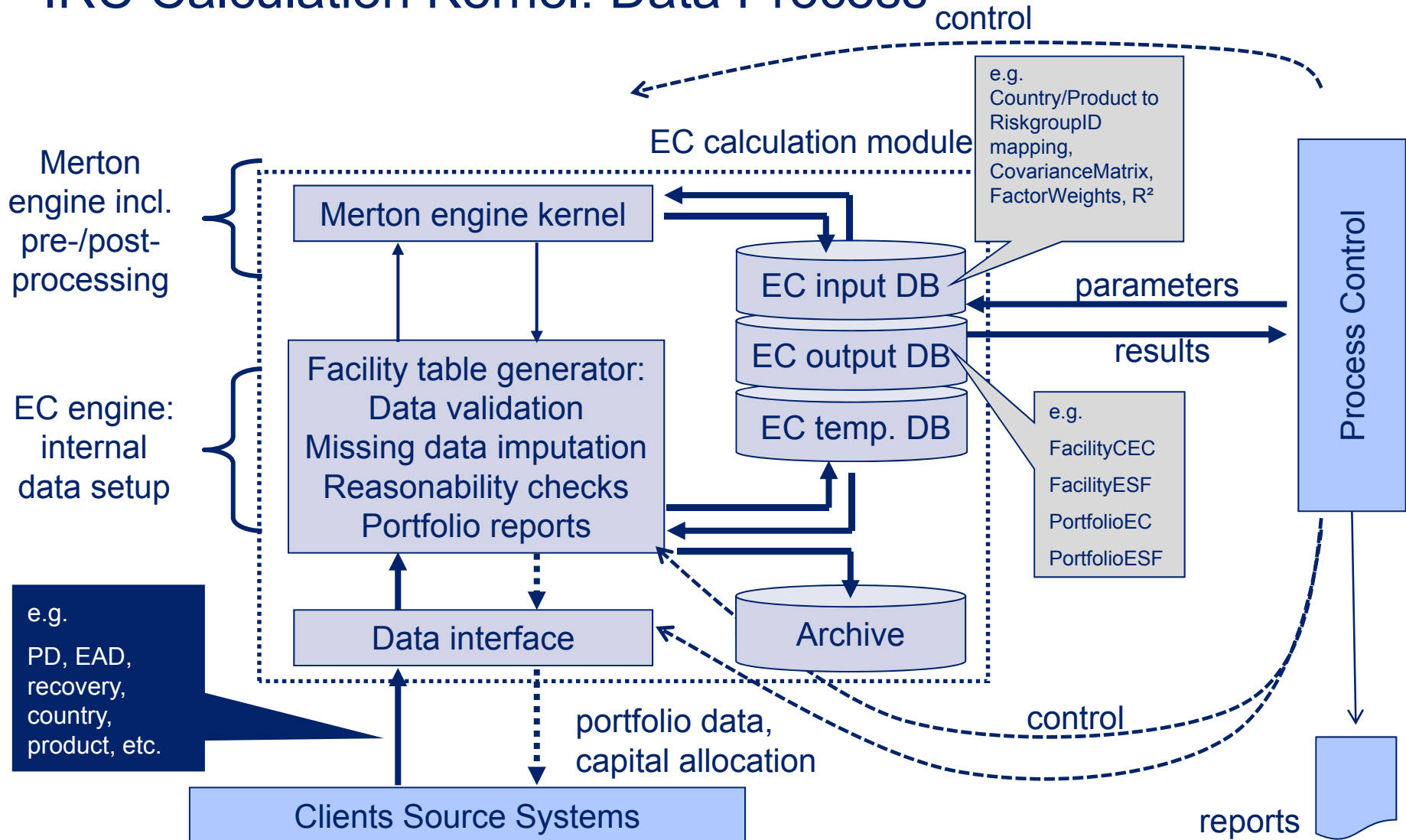
Load transaction-, issuer- & market data

Setup IRC portfolio & QA of input data

Calibration of model and pre-processing

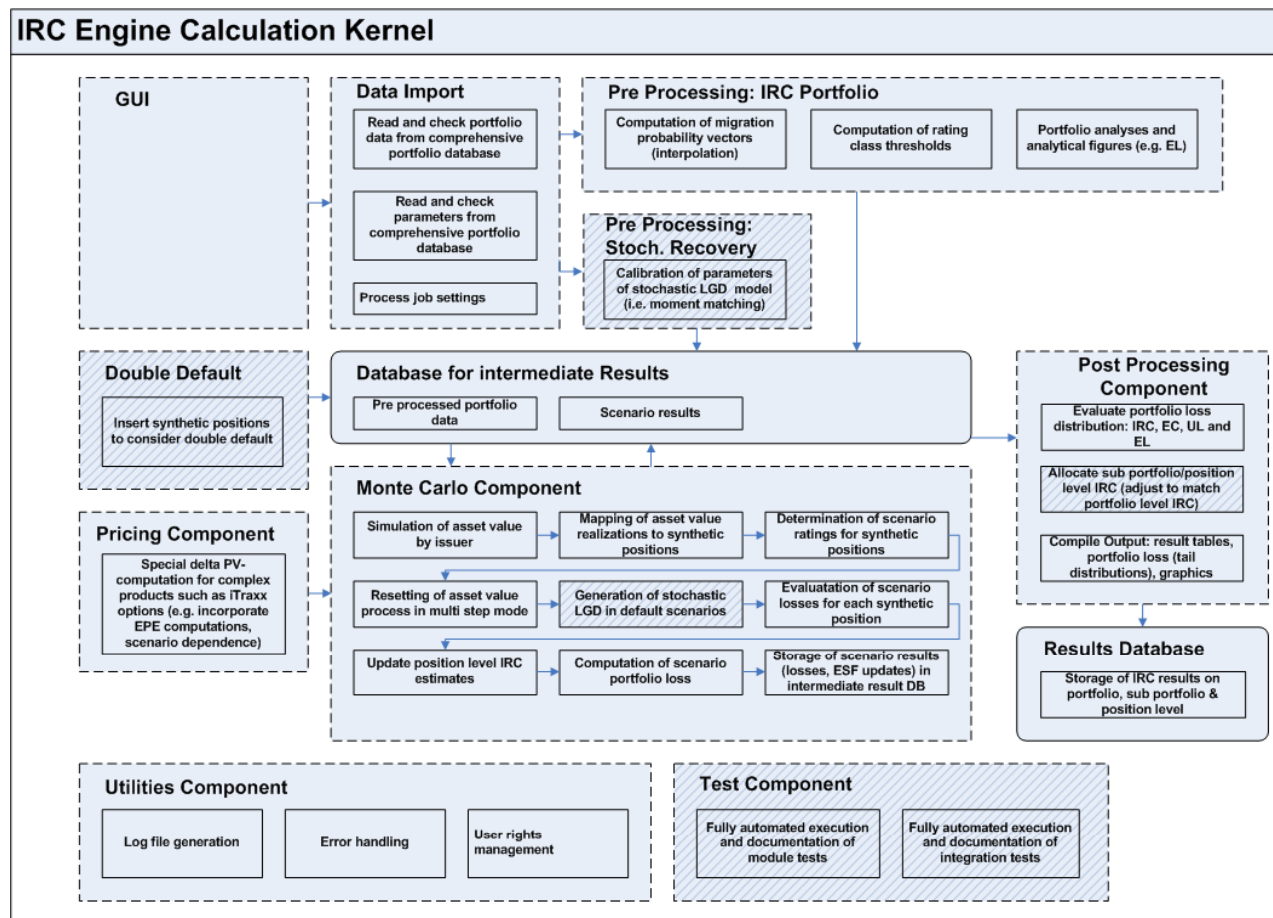
IRC calculation kernel, GUI, reporting & validation

IRC Calculation Kernel: Data Process



IRC Infrastructure: IRC Engine Calculation Kernel

Each component consists of various sub components and modules

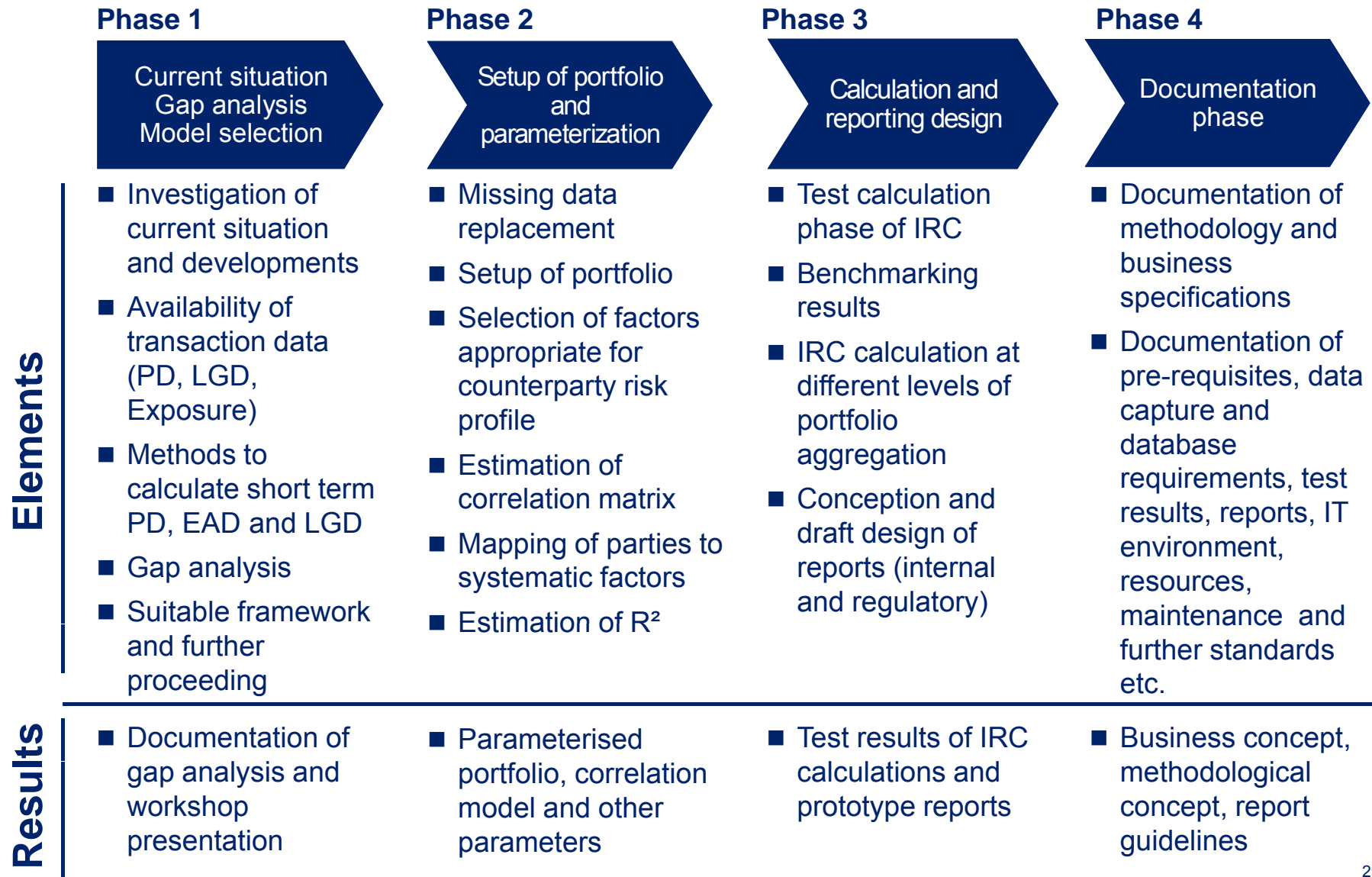


This is the „heart“ of the IRC system where the MC simulation is performed and related calculations are done.

d-fine's Approach to IRC

- ❑ Definition of liquidity horizon for trading book positions
- ❑ Determination of PV vectors in different migration states and exposure at default (EAD), jump to default values, recovery rates of trading book positions at liquidity horizon (depending on horizon, possible inclusion of EPE/PFE for derivatives e.g. hedge abort of CDS, Mtm + Add-on etc.)
- ❑ Incorporation of netting effects and hedge positions (short vs. long positions, offsetting positions with same party, hedges)
- ❑ Incorporating double default risk of issuer and hedge position
- ❑ Determination of recovery value (LGD) of trading book positions (recovery at different seniority classes for bonds)
- ❑ Stochastic recovery
- ❑ Calibration of short term PDs by usage of migration generator matrices
- ❑ Usage of multi-step portfolio model
- ❑ Parameterization of IRC engine (mapping of parties to industry and country factors, calibration of correlation model, calibration of idiosyncratic risk weights, PD term structures, rating migration matrices etc.)
- ❑ Calculation of incremental capital charge and design of reporting

Implementation Phases and Elements



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