Modelling Incremental Risk Charge

Content

- Regulatory requirements and definitions
- Modelling approach
- Implementation
Modelling Incremental Risk Charge

Evolution of Regulatory Decrees for the Trading Book

- **2005**
  - Application of Basel II to Trading Activities and Treatment of Double Default Effects

- **2005**
  - Amendment to the Capital Accord to incorporate market risks (Update)

- **2006**
  - Basel II Framework - Comprehensive Version

- **2006**
  - EU: Capital Requirements Directive (CRD)

- **2006**
  - Proposed Principles for Modelling Incremental Default Risk in the Trading Book

- **2007**
  - Guidelines for Computing Capital for Incremental Default Risk in the Trading Book

- **July 2009**
  - Revisions to the Basel II market risk framework

- **July 2009**
  - Enhancements to the Basel II framework

- **October 2009**
  - EU: Proposed Amendments to Capital Requirements Directive

- **Changes in June 2010 (postponed to 2012)**
Modelling Incremental Risk Charge

Incremental and Comprehensive Risk Charge

Internal Market Risk Models

Value-at-Risk, 10 day risk horizon, fiscal year parameterization, 99% confidence level, factor 3+x+y

Stressed Value-at-Risk, as above, but parameterized by stress period (e.g. 2007/08), factor 3+z

General Market Risk

- EQ, EQ vol
- FX, FX vol
- IR*, IR vol

* IR = base curve + sector-by-rating spreads

Specific Market Risk

- Residual Risk
  - Issuer spreads, Equities

- Event Risk
  - Equities
  + ...

Incremental Risks

- 1 year risk horizon and ≤1 year liquidity horizon (*), 99.9% confidence level, factor 1
- Default and migration risk (at least specific IR)

(*) Assumption: constant level of risk

Comprehensive Risk

- All relevant price risks: „Correlation Trading Portfolio“
- Sufficient liquidity, factor 1
- Floor: 8% (standardised charge)

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

Price dynamics of a bond

Market price development of a long term corporate bond

- **Issuer downgrade A → BBB**
- **Specific interest rate risk** (issuer specific residual spread risk)
- **Corporate issuer specific curve**
- **General market risk** (sector rating spread risk)
- **General market risk** (base curve interest rate risk)

*Yield calculated from quoted bond price*
Modelling Incremental Risk Charge

Incremental Risk in some Detail

<table>
<thead>
<tr>
<th>Modelling Nature</th>
<th>Selected Regulatory Requirements:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Risk Driver</td>
<td>securitisations as defined in the “Basel II framework” can not be included</td>
</tr>
<tr>
<td>Dynamics</td>
<td>no N-th-to-Default credit derivatives</td>
</tr>
<tr>
<td>Parametrisation</td>
<td>equities may be modelled (e.g. for reasons of consistency)</td>
</tr>
<tr>
<td>Mapping Initial Data</td>
<td>constant level of risk assumption</td>
</tr>
<tr>
<td>Type of Simulation</td>
<td>liquidity horizons (floor: 3 months)</td>
</tr>
<tr>
<td>Risk Measure</td>
<td>(systematic) correlations, concentrations</td>
</tr>
<tr>
<td>Risk Indicators</td>
<td>reflect basis risks (product, seniority, rating, maturity, differences between offsetting positions)</td>
</tr>
<tr>
<td></td>
<td>validation (good quality of market data entering the model, stress tests, etc.)</td>
</tr>
</tbody>
</table>

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<th>Risk Measure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Risk Driver</td>
<td>Value-at-Risk (99,9% 1y)</td>
</tr>
<tr>
<td>Dynamics</td>
<td>Monte-Carlo, Portfolio Models</td>
</tr>
<tr>
<td>Parametrisation</td>
<td>Probability of Occurrence</td>
</tr>
<tr>
<td>Mapping Initial Data</td>
<td>Probabilities, Correlations</td>
</tr>
<tr>
<td>Type of Simulation</td>
<td>Discrete</td>
</tr>
<tr>
<td>Risk Measure</td>
<td>Default, Migration</td>
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<tr>
<td>Risk Indicators</td>
<td>Probability of Occurrence</td>
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</tbody>
</table>
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

**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)

**Fallback:** CTP-specific standardised charge (restricted hedging possibilities)
Modelling Incremental Risk Charge

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
Modelling Incremental Risk Charge

IRC Modelling Framework

Spread Curve Construction
Building sets of sector/rating credit spread curves (extra- and interpolation between tenors and rating classes)

Spread curves

Revaluation Model
Revaluation of positions after migration with FO pricing engines

PVs for different ratings

Structural Merton Model
Simulation of migration & default (multi step extension for constant level of risk)

Stochastic LGD Model
Parameterization Models (Correlation, R²)

Loss Distribution (Percentiles)
IRC contribution of positions
Modelling Incremental Risk Charge

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:
  \[
  r_i = R \cdot X_i + \sqrt{1 - R^2} \cdot \varepsilon_i = R \cdot (w_{i1} \cdot Y_1 + w_{i2} \cdot Y_2) + \sqrt{1 - R^2} \cdot \varepsilon_i \sim N(0,1)
  \]

  - Normalised asset value
  - Systematic risk (e.g. country & industry)
  - Idiosyncratic risk

- Correlation of migration and default events induced by correlated systematic risk factors \( Y_j \) (e.g. MSCI country or industry indices):
  \[
  \vec{Y} = (Y_1, Y_2) \sim N(0, \Sigma) \quad \text{where } \Sigma \text{ is the covariance matrix of systematic factors}
  \]

- 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:
  \[
  d_{\text{def}_i} = N^{-1}(PD_i)
  \]
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; \(\rightarrow\) thresholds)
- Double default
- Optional: Stochastic LGD (recovery)
  - e.g. Beta distribution, generalised logit function
  - Dependent or independent of PD
Modelling Incremental Risk Charge

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

Multi-period Credit Risk Model
Modelling Incremental Risk Charge

Structural Merton Model: Constant Level of Risk

Multi-step extension for replacement of positions within risk horizon

1. Simulate first 6-months section of asset value process (AVP):
2. Assess 6-months rating & lock in $\Delta PV(D)$
3. Constant-level-of-risk $\Leftrightarrow$ reset AVP to zero
4. Simulate second 6-months section of AVP
5. Asses 12-months rating & lock in $\Delta PV(CCC)$ for Bond 1 & for Bond 2
   - $\Delta PV(BB)$
6. Scenario loss Bond 1:
   - $\Delta PV(D) + \Delta PV(CCC)$
   - (over entire risk horizon)
Revaluation Model: Bond Valuation – Standard Model

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

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

- PV is the sum of cash flows discounted with the spot curve \( r_{\text{bond}} \):
- 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
Modelling Incremental Risk Charge

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
  
  \[
  P_{V_{bond}}(t) = \sum_{i=1}^{n} \frac{c(t_i)}{(1 + r_{bond}(t, t_i; R_{scenario}))^{t_i-t}}
  \]

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

Components of an instrument specific curve for a bond

- Original spot curve $r_{base}$
- New spot curve $r_{bond}(R_{scenario})$
- $s_{residual}$
- $s_{general}$

Time to maturity $T$
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=99.9%-percentile

Impact of Liquidity Horizon at 99.9% IRC Percentile

Net long

Net short

IRC’s sensitivity to parameters is not intuitive
Content

The IRC regulatory framework

Modelling Approach

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

Spread curve generation → Spread curves

Market risk reporting infrastructure → Test portfolio → FO-pricing engines

IRC-engine

Migration matrices → Correlation model → R² → parameterization suite

ΔPV vectors
IRC Infrastructure: Flexible Modularised Architecture

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

- **Data Supply**
  - Transaction Data
  - Issuer Data
  - Market Data
  - S&P Data

- **Data Pre Processing**
  - IRC Portfolio Setup Component
    - IRC Sector/Rating Spread Curve Generator

- **Parameterization & Portfolio Setup**
  - Pricing Engines
  - IRC Parameterization Suite

- **IRC Calculations & Reporting**
  - IRC Engine Calculation Kernel
  - Validation/Stress Testing Component
  - IRC GUI
  - IRC Reporting Component
  - IRC Results

**Steps**:
- Load transaction-, issuer- & market data
- Setup IRC portfolio & QA of input data
- Calibration of model and pre-processing
- IRC calculation kernel, GUI, reporting & validation
Modelling Incremental Risk Charge

IRC Calculation Kernel: Data Process

Merton engine kernel

Facility table generator:
- Data validation
- Missing data imputation
- Reasonability checks
- Portfolio reports

EC calculation module

EC input DB

EC output DB

EC temp. DB

Merton engine incl. pre-/post-processing

Process Control

EC engine: internal data setup

Data interface

Archive

Clients Source Systems

control

e.g.: Country/Product to RiskgroupID mapping,
CovarianceMatrix, FactorWeights, $R^2$

e.g.: FacilityCEC, FacilityESF, PortfolioEC, PortfolioESF

portfolio data, capital allocation

report
Modelling Incremental Risk Charge

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
Modelling Incremental Risk Charge

Implementation Phases and Elements

**Phase 1**
- Current situation
  - Gap analysis
  - Model selection
- gap analysis
- Model selection

**Phase 2**
- Setup of portfolio and parameterization
- Missing data replacement
- Setup of portfolio
- Selection of factors appropriate for counterparty risk profile
- Estimation of correlation matrix
- Mapping of parties to systematic factors
- Estimation of $R^2$

**Phase 3**
- Calculation and reporting design
- Test calculation phase of IRC
- Benchmarking results
- IRC calculation at different levels of portfolio aggregation
- Conception and draft design of reports (internal and regulatory)

**Phase 4**
- Documentation phase
- Documentation of methodology and business specifications
- Documentation of pre-requisites, data capture and database requirements, test results, reports, IT environment, resources, maintenance and further standards etc.

**Elements**
- Investigation of current situation and developments
- Availability of transaction data (PD, LGD, Exposure)
- Methods to calculate short term PD, EAD and LGD
- Gap analysis
- Suitable framework and further proceeding

**Results**
- Documentation of gap analysis and workshop presentation
- Parameterised portfolio, correlation model and other parameters
- Test results of IRC calculations and prototype reports
- Business concept, methodological concept, report guidelines
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