

Implementing Credit Portfolio Derivatives in Practice

Xenomorph's Credit Trading Update Seminar
London, The Brewery, 14 April 2005



Agenda

- § Default correlation dependent products
- § Correlation modelling
- § Impact on implementation

Default Correlation Dependent Products

Basic correlation dependent products

§ All products have portfolio of credit references as underlying

- Defaultable debt (cash portfolio)
- Single name CDS (synthetic portfolio)

§ 1st-to-default swap

- Like CDS, but default occurs if first reference of underlying portfolio defaults
- Default probability decreases with increase of correlation

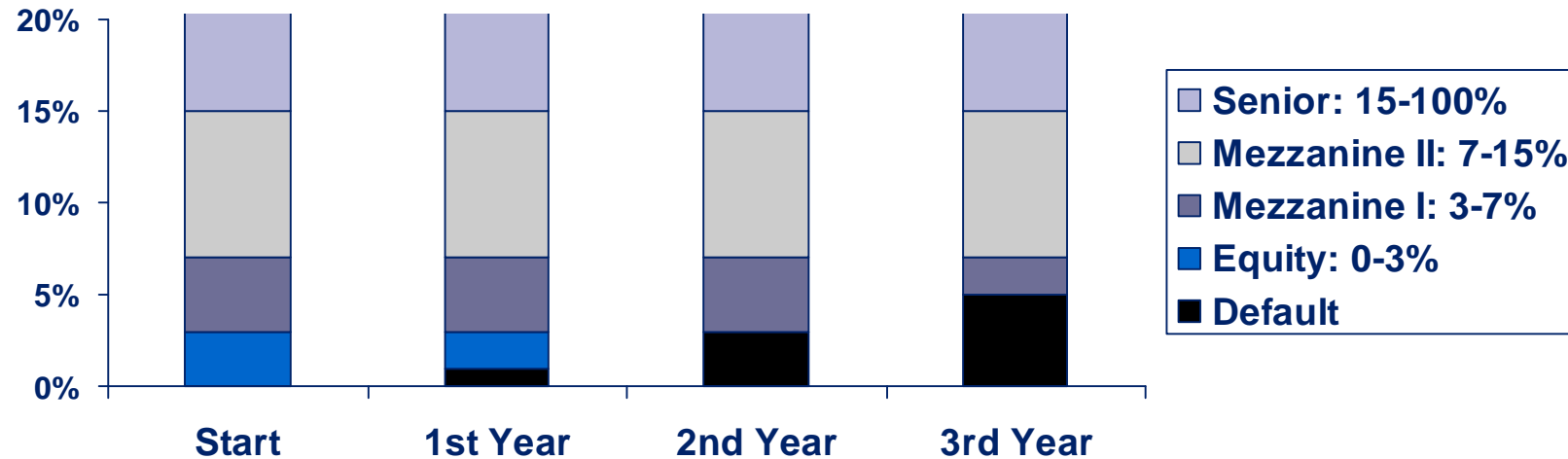
§ nth-to-default swap

- Like CDS, but default occurs if nth reference of underlying portfolio defaults

CDOs

- § Securitisation of collateralised loss layers of underlying credit portfolio
 - E.g. 3% to 7% of total nominal of portfolio
- § Underlying portfolio may contain other CDOs or ABS
 - CDO squared (CDO²)
- § Loss layers designed for different needs of risk/return profiles
 - Equity tranche, mezzanine tranches, senior tranche
 - Each tranche pays different coupon related to its default risk
- § Portfolio may be (more or less) actively managed
 - Exchange of references after downgrade
 - Regular mark-to-market by issuer
- § Rated by rating agency (S&P, Moody's, Fitch, ...)

CDO Performance Over Time



- § After 1st year, 1% of total nominal has defaulted, i.e. 33% of equity tranche
- § After 2nd year, 100% of equity tranche has defaulted
- § After 3rd year, 5% of total nominal has defaulted, i.e. 50% of mezzanine I tranche

Correlation Modelling

Features of Portfolio Credit Derivative Models

- § Marginal default distribution should be consistent with single name distributions
- § Realistic forecasts of timing and dependency of joint default
- § Number of parameters should not grow exponentially with number of obligors
 - 2^N possible joint default events
 - Still $N(N-1)/2$ independent correlation parameters for multivariate Gaussian distribution
- § Tractability (using numerical or analytical techniques)

Copulas

Given a set of random variables X_1, X_2, \dots, X_N with marginal distribution functions F_1, F_2, \dots, F_N and joint distribution function F , there exists an N -dimensional Copula C with

$$F(\mathbf{x}) = C(F_1(x_1), F_2(x_2), \mathbf{K}, F_3(x_3))$$

and

$$C(1, \mathbf{K}, 1, F_i(x_i), 1, \mathbf{K}, 1) = F_i(x_i)$$

=> Copula defines dependency structure for given set of random variables and their marginal distributions

Gaussian Copula

§ Generates N -dimensional multivariate Gaussian distribution function

§ For $N > 2$, no analytical form of Copula exists, but use following algorithm

- Generate X_1, X_2, \dots, X_N jointly normal distributed variables with zero mean, standard deviation one and correlation matrix \mathbf{R}
- Calculate set of variables Y_1, Y_2, \dots, Y_N using

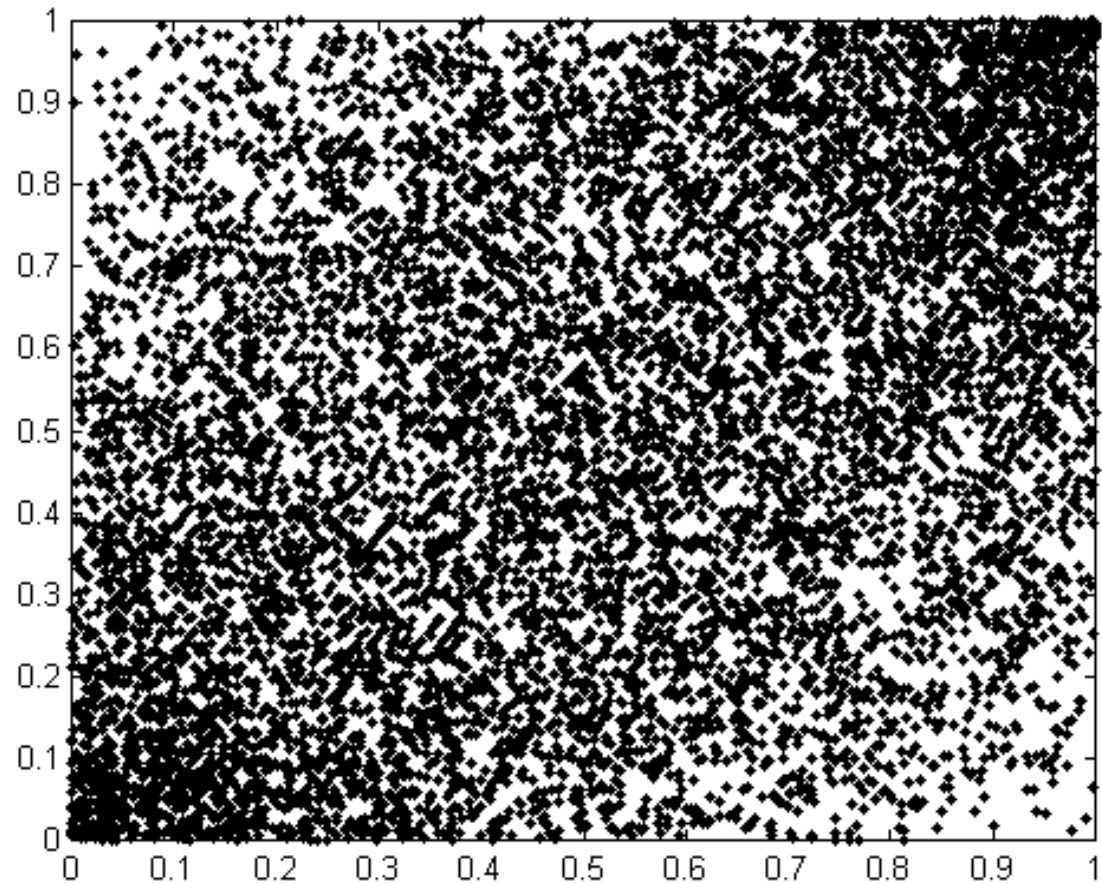
$$Y_i = F_i^{-1}(\Phi(X_i))$$

$\Phi(x)$ Cumulative standard normal distribution

Y_i will have marginal distributions F_i , but Gaussian dependency structure

Joint Probability Distribution – Example

- § Gaussian copula
- § Two dimensions
- § $\rho=50\%$
- § 10,000 sample pairs



CDO PV Calculation with Monte Carlo Methods

- § Using the joint default distribution, simulate the default time for each obligor
- § Order the obligors by time of default
- § Simulate recovery at each default
- § Calculate PV of each tranche
- § Repeat for some ten thousand paths and calculate average

Unsolved Problems with Gaussian Copula

§ Too many parameters

- For 100 names, the correlation matrix has $(N-1)N/2=4950$ independent parameters

§ Timing of default events is not plausible

- For a given time period, the probability for joint defaults is highest at the beginning

§ Alternative more efficient methods

- Reduction of parameters
- Semi-analytic
- etc.

Dimension Reduction Techniques

=> Factor model

- Simulate low dimensional process with independent Gaussian V and V_i
- Only N parameters left

$$Y_i = b_i V + \sqrt{1 - b_i^2} V_i$$

$$\text{Corr}(Y_i, Y_j) = d_{ij} + (1 - d_{ij}) b_i b_j$$

=> Use flat correlation

- Standard method for quoting CDOs
- Each tranche has a different flat correlation

=> Base correlation

- View CDO as call/put spread on credit portfolio
- Correlation for 0-3%, 0-7%, 0-10%, ... tranche

Other Credit Portfolio Models

§ Use of another copula

- Students-t distributed t-copula
- Clayton copula

§ Binomial Expansion Technique (BET)

- Developed by Moody's
- Used for risk assessment / rating of credit portfolio
- Idea: Assume independence, but for a number $D < N$ of obligors
- Further ad-hoc adjustments
- Not practical for pricing

Calibration to Market Data

§ Default correlation data are sparse

- KMV database
- For many sectors too few defaults

§ Obligor specific default correlations are not available

- After default, the obligor does not exist any more

§ Correlation of share prices seems to be too high

- Ad-hoc adjustments?

§ Implied correlation calibration procedure is highly model dependent

=> Correlation calibration puzzle is not yet solved

Implementation Issues

Objective of Credit Derivative System

§ Deal capture

- Flexible data model for product data

§ Maintenance of product during lifetime

- Keep track of credit events, portfolio changes, ...

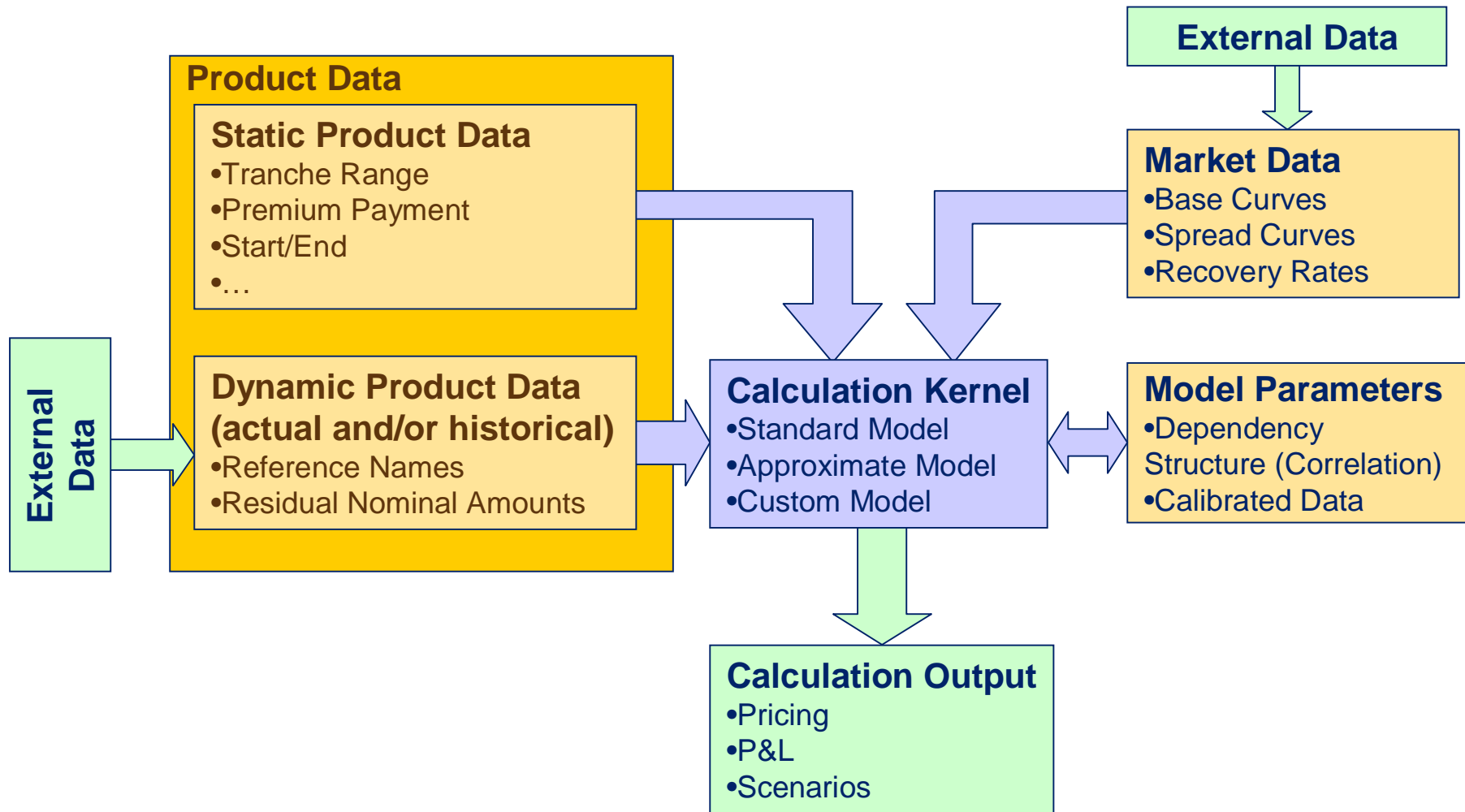
§ Maintenance of market data and model parameters

§ Product valuation

- P&L
- Quoting

§ Risk calculation

Production Environment for Portfolio Credit Derivatives



Product Data

§ Static product data

- Pay off specification
- Tranche range, (periodic) premium payments, etc.

§ Dynamic product data

- Current structure of underlying portfolio
 - List reference names or bonds
- Residual nominal amounts

§ Maintenance of dynamic product data

- External data provider (e.g. Intex, rating agency, internal rating model)
- Quality check procedure

Market Data

§ Default free base curves for each currency

- Swap curves
- Repo curves

§ Spread curves for each underlying in the credit portfolio

- External data provider
- Calculated from CDS quotes or from benchmark bonds
- Separate curve for each section by rating, industry, country, currency, etc.

§ Recovery values

- Recovery estimations from market data?
- Recovery model
- Approach for quoting purposes (40%)

Calculation Kernel

§ Standard valuation approaches

- Essential for quoting and calibration
- Gaussian copula with flat correlation / base correlation
- Fast implementation required
 - FFT
 - Semi-analytical approximations

§ Approximate pricing

- Fast intraday revaluation with actual market data (esp. for CDO²)

§ More advanced methods

- Multi factor model

Model Parameters

- § Pair wise correlations are often not applicable
 - Too many parameters (4,950 independent correlations for portfolio of 100 names)

- § Each portfolio derivative requires its own correlation structure
 - Different dependency structure for each product
 - Periodic recalibration of correlation parameters

=> Correlation parameters are model **and** product dependent

CDO² are more complex

- § Names may be included multiple times in list of credit references
- § Different pair wise correlations between identical references in underlying CDOs possible
- § Consistency does not allow to model underlying CDO as black boxes

=> Even with simple approach for correlation modeling, dependency structure for CDO² could be complex



defining d-fine

Professional Consulting
for the Financial Services Industry





d-fine in a Nut Shell

§ With well over 120 professionals, d-fine is a leading European consulting firm dedicated exclusively to the **financial industry**.

§ d-fine is built around

- **Risk Management**
- **Quantitative Finance**
- **IT Integration**

§ We help our clients with

- all **trading, back office, risk** and **asset/liability** projects,
- from analysis and design to full fledged **IT implementations**,
- from **mathematical models** to real time **interfaces**,
- from plain vanilla **loans** to exotic **derivatives**,
- from credit **rating systems** to risk adjusted **portfolio optimisation**.



Our History

§ Successful in business since 1996

- Founded as a speciality consulting service of **Arthur Andersen** Germany
- Continuous and **constant growth** to 120 consultants end 2004
- Hundreds of **successful projects** on all scales
- **Long standing cooperation** with leading universities und software providers

§ Now a separate legal entity

- Since July 2002 – **d-fine GmbH**, Frankfurt
- Since Nov 2004 – **d-fine Ltd**, London



Our People

§ Profound mathematical and technological skills

- University degrees in **business**, **IT** and **sciences** (physics, mathematics)
- Quantitative background
- Majority (ca. 80%) has PhD level degrees

§ Well balanced profiles

- **Analytical** and Problem Solving Abilities
- **Information technology** expertise
- **Social** and **project management** skills

§ Continuous and intensive training

- Cooperation with the **University of Oxford** – Postgraduate M.Sc. programme in Mathematical Finance
- Cooperation with **Warwick Business School**



Our Services

- § Independent valuation of **Financial Products**
 - Validation of client's pricing models
 - Benchmarking vs. d-fine's bespoke 'MoCo' library
 - Selection of pricing models, hedging calculations, portfolio viewpoint
 - From simple instruments to complex **OTC Derivatives** and **Structured Products**
 - Development of risk management methodologies
 - Containing Interest Rate risk, Equity risk, FX risk, all other market risks, and Credit risk

- § **IAS** implementation
 - IAS 39
 - Hedge Accounting Tools

- § **CAD 2, Basel II, CRD (CAD 3)** implementation
 - Internal Ratings Based Models (IRBA)
 - Internal Capital Adequacy Assessment Process (ICAAP)
 - FSA Prudential Sourcebook (PRU)



Our Services (cont'd)

§ Development of **Rating Systems**

- Basel II compliant
- PD, LGD and EAD calculation
- for Corporate, Retail and Special Lending

§ **System** specification, validation, selection, customisation and **implementation**

- for trading front and back office
- for risk management and risk controlling
- for treasury and ALM

§ Development of **optimisation techniques** for

- asset and capital allocation
- risk adjusted portfolio optimisation
- asset liability management (ALM)

§ **In house Training** on any level from top management to technical experts

- on quantitative finance or risk management techniques
- on specific systems
- on Basel II, CRD, CAD 3, IAS 39, ICAAP, PRU



Our IT Expertise – Systems (abridged)

§ Trading systems

- Front Arena, Kondor+, Murex
- Summit, Sophis Risque, ...

§ ALM and Treasury systems

- RiskPro, Trema, Dimension (TMS2000)
- Almonde, Algorithmics ALM
- Fermat, ...

§ Market and Reference Data systems

- Xenomorph, Asset Control, Fame, ...
- Data Vendors
 - Reuters, Bloomberg, ISMA, Thomson Financial (Datastream), Mark-it Partners

§ Risk Management systems

- Algorithmics Suite / RiskWatch
- Misys RiskVision / Carma
- Sungard Panorama, Credent, ...
- SAS Risk Dimensions, ...



Our IT Expertise – Tools (abridged)

§ C / C++

- Various System APIs
 - e.g. Risk++ (Algorithmics)
 - e.g. Formula Engine/C-API (Asset Control)
- Pricing libraries, e.g. d-fine's own "MoCo Library"

§ Java

- Platform independent software clients
- Various GUIs for Asset Control

§ Data Base / Scripting / Macro Languages

- Various SQL dialects
- Python (Front Arena AEL)
- PERL (data pre-processing for e.g. Algo, AC)
- Visual Basic (e.g. Excel GUIs)
- UNIX shell scripts (process scheduling)

§ Middleware / EAI

- XML data modelling
- IBM MQSeries
- Vitria BusinessWare
- Reuters Tibco
- webMethods



Our Clients (abridged)

- § Banking
- § Insurance
- § Asset Management & Hedge Funds
- § Corporate Treasury

Clients include:

ABN Amro	Eurohypo
Bayerische Landesbank	Fiat Bank
Commerzbank	HBOS plc
CQSM	Gothaer Asset Management
DekaBank	Hypo-Vereinsbank
Deutsche Apotheker- und Ärztebank	KfW
Deutsche Postbank Deutsche Bank	SachsenLB
Deutsche Bundesbank	Toyota Financial Services
Dresdner Bank	Union Investment
DZ Bank	WestLB
E.ON	...

- § **Long term relationships** with our clients
- § **Sustained satisfaction** with our services
- § **Successful track record** on >>100+ projects

Our Credentials (abridged)

§ The following pages list a selection of our credentials.

These are an abridged list, restricted to the topics:

- Credit Risk
- Derivative Pricing
- Credit Trading (Systems)

§ More detailed references, in particular for other topics such as ... –

- | | |
|---|----------------------------------|
| – Asset Liability Management | – Market Risk & Internal Models |
| – Treasury | – Market Data and Reference Data |
| – Internal Ratings (Basel II – IRB) | – Operational Risk Pricing |
| – Capital Allocation (Basel II – ICAAP) | – RAROC and Economic P&L |
| – Front and Back Office Systems | – Controlling & MIS |
| – IAS / FAS / US GAAP | – Regulatory Reporting |

§ ... can be found online on www.d-fine.co.uk

Client	Project
Middle-sized German bank	Selection and implementation of a credit risk portfolio model
Deutsche Bank PKG	Conceptual design and implementation of an MBS servicing tool
Large European bank	Specification and implementation of an integrated trading system for spread and credit derivatives
Large European bank	Implementation of a trading and risk management system for securities and credit derivatives
Large European bank	Specification of a valuation-reference library and subsequent implementation of pricing models for all traded instruments for a large European bank
Middle-sized German bank	Business case to introduce securitisation transactions
Large European bank	Analysis of an MBS tool in respect of the technical mapping of contracts' individual components
Large European bank	Construction of a bond database; conceptual design and implementation of term structure and spread curve algorithms, volatility surfaces; support in the implementation of credit spread VaR
Large public bank	Analysis, categorisation and risk evaluation of a complex asset swap book. Creation of logging rules and adaptation of the trading system for risk adequate position management

Client	Project
Large investment bank	Comparison of the derivatives portfolios held by the Trading and Accounting departments
Large European bank	Comparison of the booking of exotic interest rate derivatives in Summit with those of accounting
Large European bank	Benchmark re-evaluation of the interest rate derivatives portfolio
Special Purpose Bank (non profit)	Selection of a banking system for a German bank providing universal and specialised services: compilation of data requirements in credit and private customer services (a system for capturing the bank's products and deals in the area of assets and liabilities, in compliance with MAK and Basel II), payment transactions, accounting and controlling; specification of a functional and data-requirement catalogue, compilation of a market overview; organisation of software vendor presentations; quantitative analysis of the proposed system solutions based on the degree of requirement coverage, the vendor's presentations and the evaluation of the bank's departments.
Large Global Bank	Feasibility study on potential future exposure (PFE) calculations: development of four successive scenarios for a stepwise evolution of refined and risk sensitive methods to measure the counterparty risk of OTC derivatives in the trading book. Development of a detailed feasibility study taking into account the functional and technical requirements and conditions, and resulting in reliable time and cost estimates.
Special Purpose Bank (retail & small corporates)	Selection of an internal credit risk portfolio model customised to a specific portfolio. Development, programming, testing and documenting of a CreditMetrics approach. Implementation of graphical reports.

Client	Project
Large Global Bank	Design and implementation of a market database for credit risk: Integration into the MDB, calculation and validation of credit spread curves for all relevant industry sectors and countries; implementation of an appropriate QA process.
German Landesbank	Construction of Credit Spread Curves
German Landesbank	Calculation of the implied credit spread curves of the P&L for ABS and MBS transactions.
Special Purpose Bank (retail & small corporates)	Feasibility study for the introduction of credit derivatives and securitisation transactions as new business areas for the bank
Special Purpose Bank (retail & small corporates)	Introduction of credit derivatives as a new business area for the bank
German Landesbank	Implementation of a central market- and credit risk system for the trading book. Development of a bank wide reporting on economical P&L and market risk. Implementation of a real time data connection of all trading activities. Implementation of a request driven market data feed.
Large Global Bank	System selection of a management and controlling system for market and credit risk at a large German bank
Large Global Bank	Model validation and independent derivatives valuation; in particular: independent price verification for FX derivatives, correlation baskets; model verification of an equity trading system and in-house library; support for model approval for new products; development of pricing models for complex products; development of term structure models (BDT,BGM)

Your contact to d-fine

Dr Mark Beinker

Senior Manager

Frankfurt Office

Mobile (+49) (0) 151 1481 9305

mark.beinker@d-fine.de

Dr Richard Rossmanith

Director

London Office

Mobile (+44) (0) 79 7909 3614

richard.rossmanith@d-fine.biz

d-fine Ltd

28 King Street

London EC2V 8EH

www.d-fine.co.uk

