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Valuation and Risk of Structured Credit Products and Bespoke CDOs: *A Scenario Framework*

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The Need for Second Generation Models for Structured Credit Products

- Industry still largely relies on *first generation* models – Single-Factor Gaussian Copula framework
  - Well documented practical and theoretical limitations: e.g. models are static in nature and not arbitrage-free
  - Treatment of bespoke portfolios is generally ad hoc
  - Valuation of cash CDOs
    - Simple bond-models and matrix pricing
    - Stochastic models with simplified waterfall and risk factor assumptions (e.g. deterministic amortization)
- This session introduces new developments of practical models for structured credit valuation and risk
  - Detailed bottom-up models to value bespoke portfolios and cash CDOs using Monte Carlo techniques
  - Application of dynamic models for pricing and hedging synthetic CDOs

Preface – in the News…

- Current estimate writedowns and credit losses now over $320B
  - Charges from collapse of the U.S. subprime mortgage market but also reflect credit losses or writedowns of non-subprime and leveraged-loans, etc.
  - Biggest source: AAA pieces of CDOs (which repackage subprime bonds)
- Investors blaming a *"1 in 10,000 years" event*…
- And then…

  "It all happened exactly like he said it would happen... in every single detail…"

  > *"The hedge fund creator's name was John Paulson… by making between $3 billion and $4 billion for himself in 2007, he appears to have set a Wall Street record… no one has ever made so much so fast."*

Structured Credit Modelling – Current State

1. Valuation of synthetic CDOs
   - Gaussian copula framework still prevalent
   - Pricing bespoke portfolios difficult – "mapping" models are generally ad-hoc
   - Application of dynamic models and detailed bespoke models still in infancy
2. Valuation of structured credit (cash CDOs, ABSs,…)
   - Difficult, non-standard, computationally intensive
   - IR, spreads, prepayment, credit (and correlation) risks
   - Structures are complex and opaque
   - Simple "bond models" and matrix pricing generally used (e.g. ratings-based)
   - Simplified collateral & waterfall CFs might be used with stochastic models
   - Advanced models are fairly new and standardized calibration is difficult
3. Generally Lack of integrated view of synthetic and cash products and single-name credit derivatives: pricing and risk management

Summary: Scenario Framework – Valuation & Risk

- ***Implied factor distributions*** and ***weighted MC*** techniques
  - Multi-factor credit models – characterize correlations for different baskets
  - Weighted Monte Carlo techniques (used in options pricing)
  - CDO analytics and computational techniques
  - Ability to incorporate a full bottom-up approach
- Basic idea: set of scenarios where instruments are consistently valued
  - Imply "risk-neutral" distribution (process) for *underlying systematic risk factors*
    - Observed (liquid) prices (e.g. CDSs, index tranches)
    - Prior distribution or "quality" preferences and subjective views
- Structured finance CDOs (ABS and CLO products)
  - Flexibly incorporate detailed cash-flow waterfalls, prepayment and LGDs

Cash CDO = bespoke portfolio + complex cashflow waterfall

- Methodology is general (dynamic) – this paper focuses on static models

Introduction: Pricing Synthetic CDOs

- Underlying pool of credit default swaps – divided into "tranches"

Tranche	Attachment	Detachment
Equity	0%	3%
1st Mezzanine	3%	7%
2nd Mezzanine	7%	10%
Senior	10%	15%
Super Senior	15%	30%

Size of the *n*-th tranche

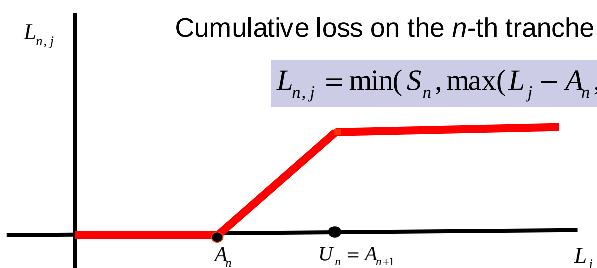
$$S_n = U_n N - A_n N = N \cdot (U_n - A_n)$$

Cumulative portfolio loss of up to t_j

$$L_j = \sum_k N_k \cdot LGD_k \cdot 1_{\tau_k \le t_j}$$

Cumulative loss on the *n*-th tranche up to time *tj*

$$L_{n,j} = \min(S_n, \max(L_j - A_n, 0))$$



Introduction – Pricing Synthetic CDOs

- Standard model for pricing synthetic CDOs: single-factor Gaussian copula (Li 2001)
  - Codependence through a one-factor Gaussian copula of *times to default*
  - Single parameter to estimate (correlation for all obligors in portfolio)
- Basic model does not simultaneously match market prices of all traded tranches
  - "Correlation skew" – set of correlations that match the prices of all tranches
- Base correlations – alternative to tranche correlations
  - Implied correlations of equity tranches with different attachment points (mezzanine/senior tranches as difference between two equity tranches)
- Interpolation (or extrapolation) model
  - Calibrated to observed tranche prices (e.g iTraxx or CDX)
  - Pricing of bespoke portfolios – mapping (risk of bespoke vs. index portfolio)

General Framework: Gaussian Copula Model

1. Scenarios: systematic factors

2. Conditional def. prob.

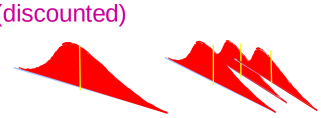
3. Conditional portfolio losses (discounted)

Conditional tranche losses

Conditional value of tranches

Z

$$p_k^Z(t) = \Phi\left(\frac{\Phi^{-1}(F_k(t)) - \sqrt{\rho_k}\, Z}{\sqrt{1-\rho_k}}\right)$$



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$$PV_{Buy} = \sum_{j=1}^{T} s_n (t_j - t_{j-1}) D_j E_Q[S_n - L_{n,j}] = \sum_{j=1}^{T} s_n (t_j - t_{j-1}) D_j \cdot (S_n - E_Q[L_{n,j}])$$

$$PV_{Sell} = \sum_{j=1}^{T} D_j (E_Q[L_{n,j}] - E_Q[L_{n,j-1}])$$

$$s_n = \frac{\sum_{j=1}^{T} D_j (E_Q[L_{n,j}] - E_Q[L_{n,j-1}])}{\sum_{j=1}^{T} (t_j - t_{j-1}) D_j \cdot (S_n - E_Q[L_{n,j}])}$$

4. Expected tranche losses & values

$$\sum_{\omega} p_{\omega} E[V \mid Z_{\omega}]$$

General Framework: Implied Factor Distributions

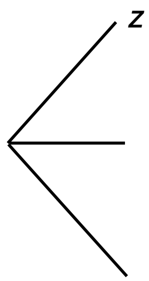
1. Scenarios: systematic factors

2. Conditional def. prob.

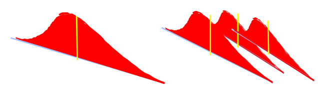
3. Conditional portfolio losses (discounted)

Conditional tranche losses

Conditional value of tranches



$$p_k^Z(t) = \Phi\left(\frac{\Phi^{-1}(F_k(t)) - \sqrt{\rho_j} Z}{\sqrt{1-\rho_j}}\right)$$



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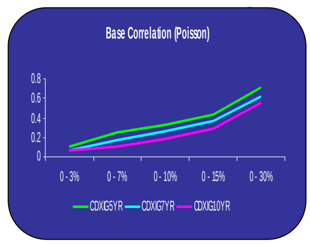


Calibration:

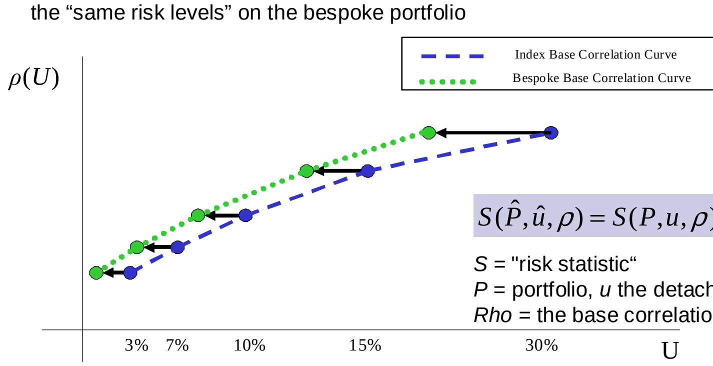
- Correlation of each tranche *j*
- *Base correlation*
  - *Equity tranches*

4. Expected tranche losses & values

$$\sum_{\omega} p_{\omega} E[V \mid Z_{\omega}]$$

Bespoke Portfolios and Mappings

- Main idea: base correlations → different levels of risk in reference portfolio
  - Transfer base correlation structure from standard portfolio to bespoke - by finding the "same risk levels" on the bespoke portfolio

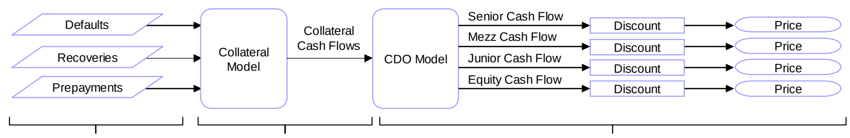


$$S(\hat{P}, \hat{u}, \rho) = S(P, u, \rho)$$

S = "risk statistic"
P = portfolio, *u* the detachment point)
Rho = the base correlation

Mapping: for each point (index portfolio), solve for the detachment point(s) in the bespoke portfolio which matches the equation
(the base correlation for the standard portfolio is used on both sides

Modelling Cash CDOs



- Step 1: Gather collateral cash flow assumption vectors
  - e.g. assumptions by collateral type (e.g. ABS, loan)
  - For ABS CDOs, can use loan performance analysis on the loans in each ABS
- Step 2: Generate cash flows for each piece of collateral
- Step 3: Use collateral CFs and CDO waterfall to generate CDO cash flows
- Step 4: NPV – discount cash flows (appropriate discount rate)
  - Discount rate (spread) – from market quotes where available
  - Application of discount rate to all other tranches with the same rating, deal type, vintage, etc.

- Complex cashflow from collateral and structure waterfall
- In addition to default and LGDs: prepayment (applies differently to tranches)
- Underlying: loans, bonds, retail loans (mortgages, credit cards, etc.), ABSs, CDOs (CDO^2)

Cash CDOs: "Bond" Models (Single-Scenario)

- ***Single-scenario*** modelling
  - Deterministic cash-flow approach (scheduled amortization)
- No direct modelling of correlations, optionality, non-linearities
- Detailed cash-flow modelling of collateral pool and of CDO waterfall
  - Pool level assumptions and loan-level assumptions and clustering
- Comparative pricing via matrix approach (generally relies on ratings)
  - Scenario assumptions, discount spreads (premiums)
- Useful stress-testing framework

$$PV = \sum_{j=1}^{T} CF_j(Y) \cdot e^{-(r_j + s_j(X)) \cdot t}$$

$$Y = (PP, Def, LGD, \ldots) \qquad X = (\text{rating}, \text{sector}, \text{vintage}, \ldots)$$

Scenario Framework: Implied Factor Distributions and Weighted Monte Carlo Methods

Implied Factor Models & Weighted MC

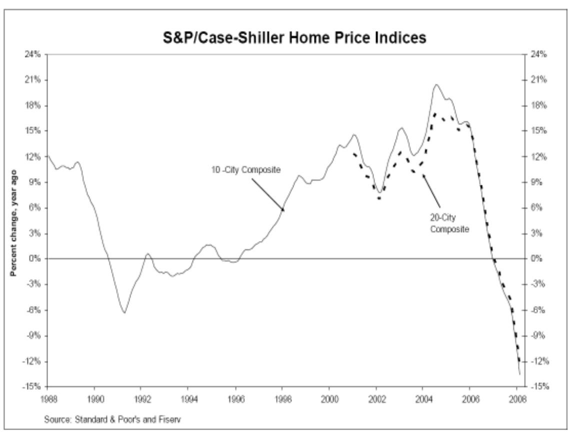
Background

- Weighted MC approach used to price complex options
  - e.g. Avellaneda et al. (2001), Elices and Giménez (2006)
- Similar idea to fitting the implied distribution (or process) in a (discrete) lattice
- Hul-White's "implied copula" model (2006) is essentially an application of this concept
  - Homogeneous portfolio – ad-hoc extensions to price bespoke portfolios
  - Similar ideas (also for homogeneous portfolios) in Brigo et al (2006), Torresetti et al (2006)

Credit Risk and Factor Models

- Factor models are currently used extensively to asses portfolio credit risk and measure credit economic capital
  - Capital allocation – capture sector/geographical concentrations
- Over a decade of industry experience: KMV, CreditMetrics, CreditRisk+, CreidtPortfolioView
  - Conditional independence framework – mathematical equivalence
- Extensive empirical studies on estimation of credit correlation parameters (Basel committee, rating agencies, vendors, financial institutions and academics)
- The origins of the Gaussian copula method to price CDOs trace back to the KMV and CreditMetrics model

Systematic Risk Factors…



- Strong conditional systematic factor → falling home prices
  - Default rates of subprime mortgages
  - Correlation of default of ABS tranches
- Home prices in the US could not continue to increase indefinitely - regime switch
- Default rates and ABS tranche's correlations based on benign period (1996-2006 – prices continually rising) not applicable in a falling price environment

Weighted MC – *GLLM* Framework

- Portfolio model can be a Gaussian copula or, more generally, we can use other "link functions"
  - Logit, NIG, double-t, Gaussian mixtures, etc…
- ***Generalized linear mixed models*** (*GLMM*)

$$p_j^Z(t) = h\left(a(t) - \sum_k b_k Z_k\right)$$

  - Example of general multi-factor copula $p_j^Z(t) = G_j\left(\frac{H^{-1}(F_j(t)) - \sum_k \beta_k Z_k}{\sqrt{1 - \sum_k \beta_k^2}}\right)$
  - For each name, the "unconditional" default probability term structure

$$p_j(t) = \int p_j^Z(t)\, df(z)$$

Weighted MC – *GLLM* Framework

- General formulation:

$$PD_{it}(Z^t) = h\left(a_{it} + \sum_{k=1}^{K} b_{ik}^t Z_k^t\right)$$

- Gaussian copula:

$$a_{it} = \frac{\Phi^{-1}(PD_{it})}{\sqrt{1 - \sum_{k=1}^{K} \beta_k^2}}, \quad b_{ik} = \frac{\beta_k}{\sqrt{1 - \sum_{k=1}^{K} \beta_k^2}}$$

- Poisson mixture (e.g. CreditRisk+)

$$\lambda_i(Z) = E[U_i \mid Z] = c_i \sum_{k=1}^{K} \beta_{ik} Z_k$$

- Logit model:

$$h(x) = \frac{1}{(1 + \exp(-x))}$$

Implied Factor Models & Weighted MC

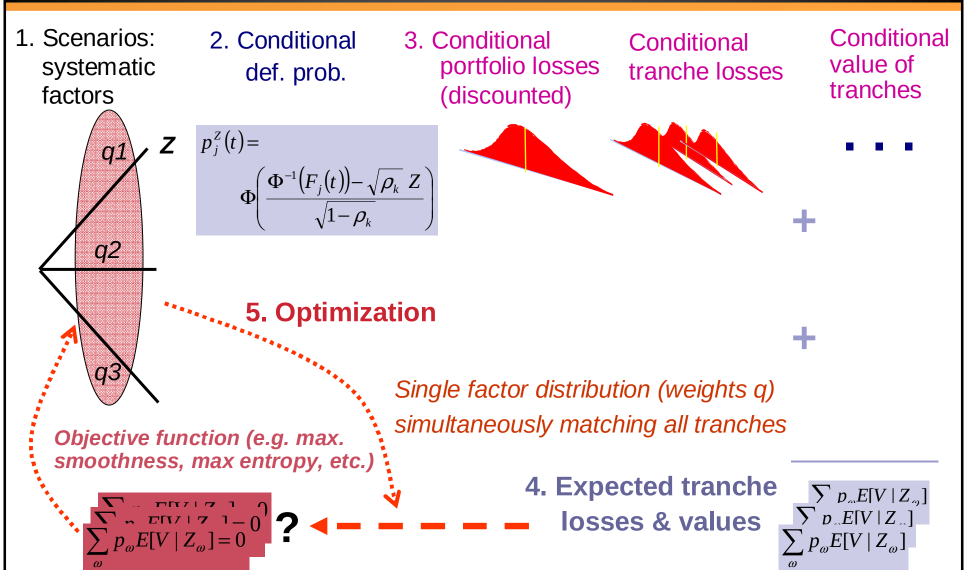
Assumptions

- Factor model → joint default behaviour under real world measure *P*
  - Correlations of names in portfolio through systematic factors
  - Coefficients of factor model for portfolio are known and fixed
- Difference between real measure *P* and RN-measure *Q* : joint distribution of the systematic factors
  - (Marginal) distribution of default times for each name under the risk-neutral measure based on CDS spreads
  - Conditional distribution of default times, as a function of the factor levels under the RN measure still given by the same formula

Solution

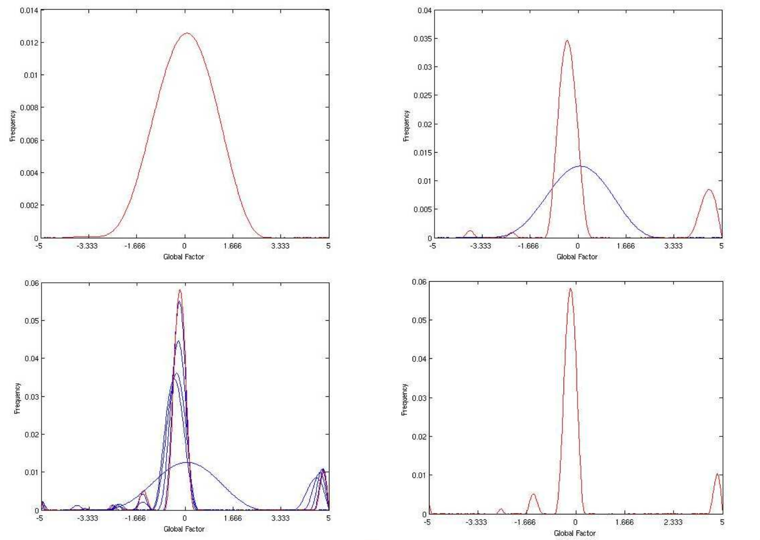
- Sample discrete "paths" (in this case, single values) for the systematic factors and adjust probabilities of paths to match prices

General Framework: Weighted MC



Global Factor Implied Distribution

Evolution of distribution – from prior to tight fit of prices



Implied Factor Distributions – Intuition

Key objective: tractable distribution of joint default times – match marginal distributions and prices of CDSs and quoted CDO tranches

- In a Gaussian copula – conditioning on the systemic factor

$$p_j^Z(t) = \Phi\left(\frac{\Phi^{-1}(F_j(t)) - \sqrt{\rho}Z}{\sqrt{1-\rho}}\right)$$

- Base correlations → the correlation *rho* is a function of the detachment point
- Implied copula → model directly conditional PDs through discrete scenarios (on a common hazard rate) for homogeneous portfolio
- Implied multi-factor distribution → model directly the ***distribution of the systematic risk factor*** through discrete scenarios → conditional default probabilities through the "link function"
  - Extensible to multiple factors and models, and applied to other portfolios

Weighted MC – Basic Optimization Problem

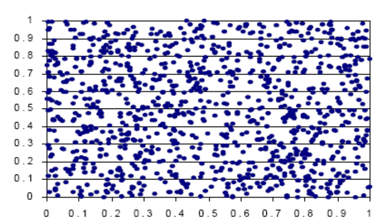
- Objective function → factor distribution “quality”:
  - min. distance from prior, max. entropy, max. smoothness
- Match tranche and index prices (can be more than one index at a time)
- Match CDS prices (cumulative default probabilities for all names)

$$\max G(q) \qquad \text{subject to :}$$
$$\sum_{m=1}^{M} q_m PV_{Buy}^{n}\left(Z^m\right) = \sum_{m=1}^{M} q_m PV_{Sell}^{n}\left(Z^m\right) \quad \text{for all } n$$
$$\sum_{m=1}^{M} q_m PD_{i,j}(Z^m) = F_{i,j} \qquad \text{for all } i, j$$
$$\sum_{m=1}^{M} q_m = 1 \;, \quad q_m \geq 0 \quad \text{for all } m$$

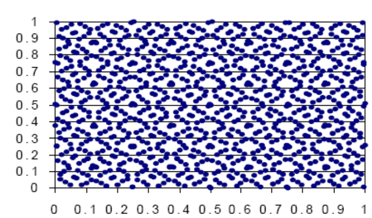
- In practice, we trade-off a well-behaved “smooth” solution and matching of prices (with some bounds)
  - Instead of perfect “perfect match” → minimize price differences
  - Weights might also be restricted to a given distribution: eg. NIG, t, Normal-mixture

Weighted MC – Scenario Generation

- Number of paths
  - Low dimensions – numerical integration
  - More generally – Quasi-MC methods
- Quasi Monte Carlo– basic idea
  - Deterministic points generated from *low discrepancy sequences (LDS)*
  - LDSs attempt to cover the space of risk factors “evenly”– avoiding the clustering of pseudo-random sampling
  - Number of scenarios for a desired level of accuracy in pricing or risk calculations is reduced



(a) Two-dimensional pseudo-random points



(b) Two-dimensional Sobol sequences

Source: Dembo et al. (1999), Mark-to-Future

Examples

Examples

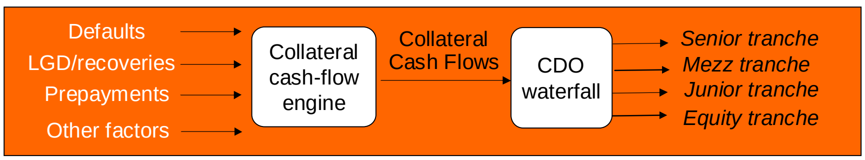
1. ABX and cash CDO
2. CLO and HY Index
3. Bespoke synthetic CDO in Multi-factor model (sector concentrations)
4. Bespoke synthetic CDO with portfolio in Europe and North America (two indices)

Example 1 – ABX

- ABX –referencing 20 Asset Backed CDS (ABCDS)
  - Home Equity / Sub-prime Bonds (thousands of small loans)
  - Five indices: AAA / AA / A / BBB / BBB-
  - Trading Began January 2006
- Standard prices and quotes
- Modelling issues
  - Default risk and prepayment risk
  - Cash-flow generation

    (underlying loans, bond (and CDS) waterfall

ABX	MktPrice
ABX-XHAAA72_INDEX	91.81
ABX-XHAA72_INDEX	71.06
ABX-XHA72_INDEX	44.31
ABX-XHBBB72_INDEX	26
ABX-XHBBBM72_INDEX	23



Example – ABX Valuation Model

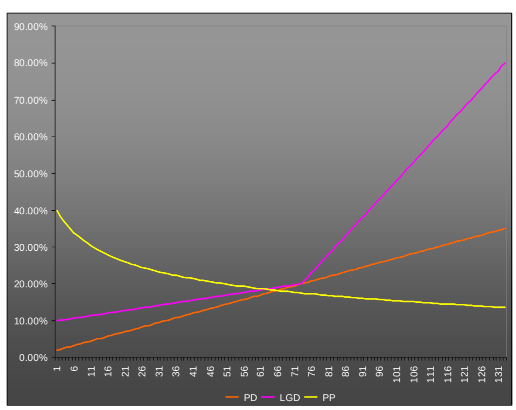
Simple valuation model (illustration purposes)

- Single systematic factor – drives
  - Default rates
  - Prepayment rates
  - Recovery rates

  (underlying loans in the pools)

$$p_j^Z(t) = h\left(a(t) - \sum_k b_k Z_k\right)$$

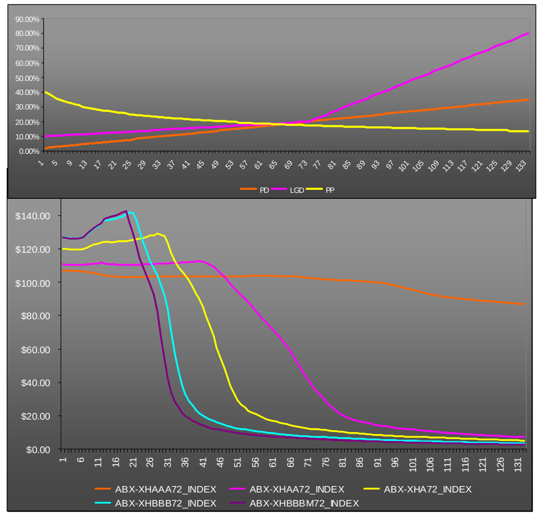
- Large homogeneous portfolio assumption
- Discretization
  - 135 systematic factor scenarios



Example – ABX Valuation under Scenarios

- ABX bonds discounted Cashflows (values) under scenarios

ABX	MktPrice
ABX-XHAAA72_INDEX	91.81
ABX-XHAA72_INDEX	71.06
ABX-XHA72_INDEX	44.31
ABX-XHBBB72_INDEX	26
ABX-XHBBBM72_INDEX	23

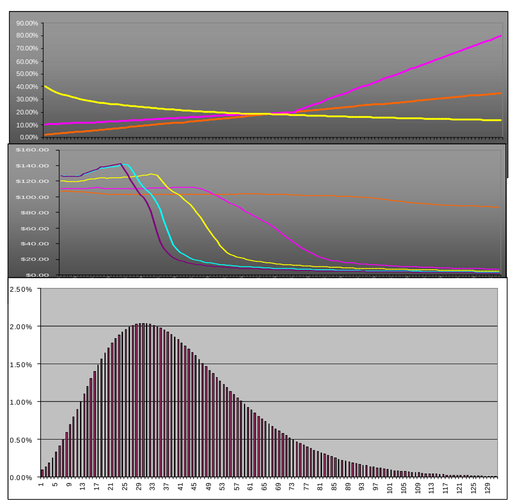


Example – ABX Valuation and Calibration

- Weighted MC → implied factor distribution (implied scenario weights)

Example:

- Vasicek PD distribution (Gaussian copula GLLM)
  - Implied avg. PD = 12%
  - Implied correlation = 7%



	Market Price	Estimated Prices
ABX-XHAAA72	91.81	103.06
ABX-XHAA72	71.06	94.40
ABX-XHA72	44.31	78.89
ABX-XHBBB72	26	57.19
ABX-XHBBBM72	23	48.47

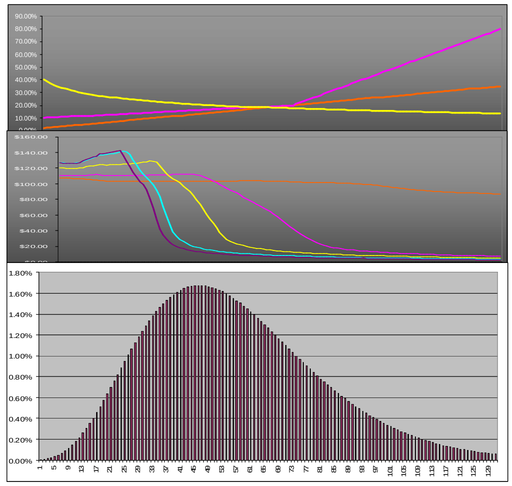
Example – ABX Valuation and Calibration

- Weighted MC → implied factor distribution (implied scenario weights)

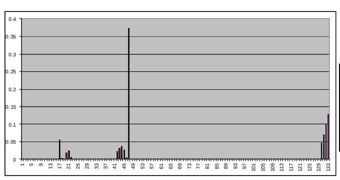
Example:

- Vasicek PD distribution (Gaussian copula GLLM)
  - Implied avg. PD = 16%
  - Implied correlation 6.5%

	Market Price	Estimated Prices
ABX-XHAAA72	91.81	102.11
ABX-XHAA72	71.06	74.52
ABX-XHA72	44.31	48.36
ABX-XHBBB72	26	27.81
ABX-XHBBBM72	23	21.78

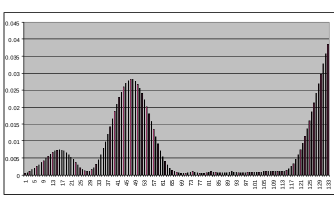


Example – ABX Valuation and Calibration



	Market Price	Model Prices	
ABX-XHAAA72_INDEX	91.81	97.66	5.99%
ABX-XHAA72_INDEX	71.06	69.91	-1.65%
ABX-XHA72_INDEX	44.31	44.69	0.86%
ABX-XHBBB72_INDEX	26	25.84	-0.63%
ABX-XHBBBM72_INDEX	23	23.02	0.08%

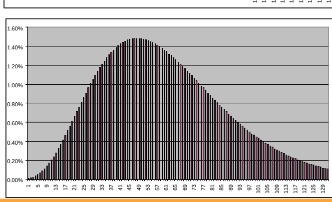
Best fitted prices



	Market Price	Model Price	
ABX-XHAAA72_INDEX	91.81	98.46	7.2%
ABX-XHAA72_INDEX	71.06	69.59	-2.1%
ABX-XHA72_INDEX	44.31	44.94	1.4%
ABX-XHBBB72_INDEX	26	26.04	0.2%
ABX-XHBBBM72_INDEX	23	22.70	-1.3%

7.8%

Smoothed distribution (non-parametric)



	Market Price	Model Price	
ABX-XHAAA72	91.81	101.46	10.5%
ABX-XHAA72	71.06	69.07	-2.8%
ABX-XHA72	44.31	45.35	2.3%
ABX-XHBBB72	26	27.21	4.7%
ABX-XHBBBM72	23	21.70	-5.7%

13.3%

Optimal parametric Distribution PD=16.5 R=7%

Modelling ABS CDO Structured Credit Products

- Important to understand contents and model collateral details (inhomogeneous portfolios)
  - Scenario vectors with specific loan assumptions
- Key to model concentration risk
  - Within a product – impact on valuation and risk
  - Across products – portfolio credit risk
- Risk metrics
  - Sensitivities
  - Scenarios and stress testing
  - Statistical measures (VaR) and risk contributions

Detailed Asset Modelling and Discrimination

Important to understand underlying pools and model collateral details (bottom-up)
- sub-prime vs. prime, vintage, region, etc…

Metropolitan Area	November 2007 Level	November/October Change (%)	October/September Change (%)	1-Year Change (%)
Atlanta	131.46	-1.8%	-1.2%	-2.0%
Boston	167.40	-1.1%	-0.8%	-3.0%
Charlotte	132.68	-1.0%	-0.9%	2.9%
Chicago	161.61	-0.9%	-0.8%	-3.9%
Cleveland	113.29	-2.3%	-1.2%	-5.8%
Dallas	122.38	-1.6%	-0.8%	-1.2%
Denver	133.36	-2.0%	-1.7%	-3.1%
Detroit	105.24	-2.7%	-2.4%	-13.0%
Las Vegas	201.95	-3.2%	-2.2%	-13.2%
Los Angeles	240.43	-3.6%	-2.1%	-11.9%
Miami	237.99	-2.6%	-2.1%	-15.1%
Minneapolis	158.57	-1.7%	-1.4%	-6.6%
New York	203.88	-0.8%	-0.5%	-4.8%
Phoenix	194.45	-3.1%	-2.2%	-12.9%
Portland	183.65	-0.8%	-0.3%	1.3%
San Diego	209.60	-3.4%	-2.6%	-13.4%
San Francisco	195.49	-3.2%	-2.1%	-8.6%
Seattle	187.14	-1.4%	-0.9%	1.8%
Tampa	203.45	-1.4%	-1.8%	-12.6%
Washington	223.45	-1.7%	-0.8%	-7.8%
Composite-10	205.09	-2.2%	-1.4%	-8.4%
Composite-20	188.82	-2.1%	-1.4%	-7.7%

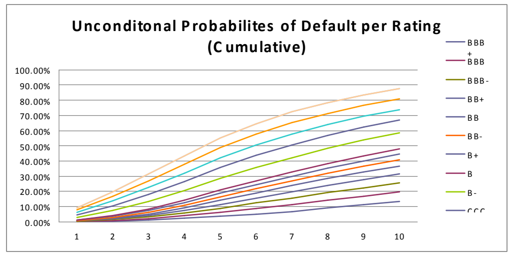
Source: Standard & Poor's
Data through November 2007

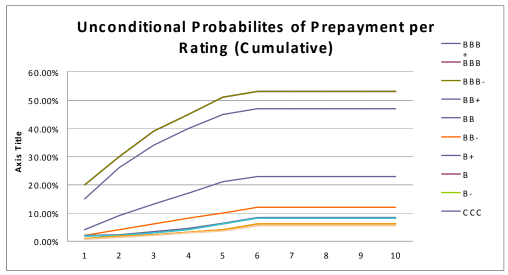
Example 2 – CLO

- CLO consisting of 270 loans
  - Five tranches
  - Loan ratings: BBB+ to BBB-

Calibration

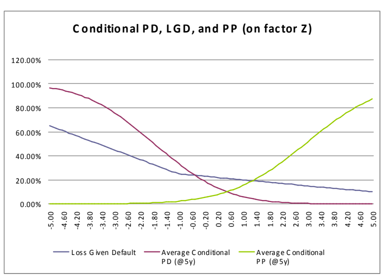
- Individual name *PD* tem structures: CDXHY index
- Prepayment: “upward migration to investment grade” adjusted for historical rates, where available

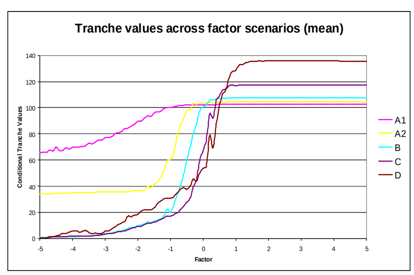


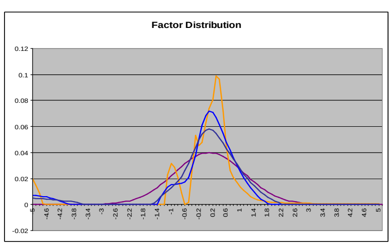


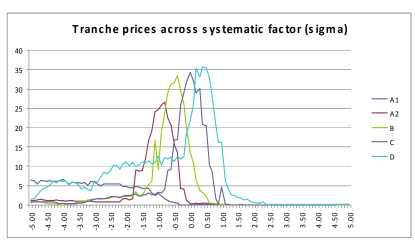
Example – CLO Valuation

Tranche	Price
A1	$ 100.40
A2	$ 96.61
B	$ 87.99
C	$ 75.46
D	$ 72.40





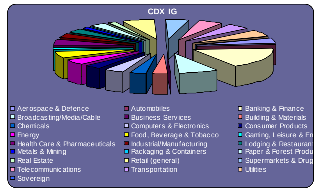


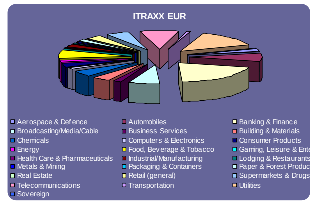


Example 3: Multi-Factor Model & Bespoke Synthetic

Industry concentration by Notional

	CDX HY	CDX IG	ITRAXX EUR	ITRAXX CJ	ITRAXX ASIA
Exposure Per Name	10MM	8MM	8MM	20MM	1B
Number of Names	100	125	125	50	50
Industry (Fitch)					
Aerospace & Defence	3.00%	4.00%	2.40%		
Automobiles	9.00%		7.20%	4.00%	4.00%
Banking & Finance	3.00%	17.60%	20.00%	20.00%	24.00%
Broadcasting/Media/Cable	7.00%	8.00%	7.20%		
Business Services	4.00%		1.60%	10.00%	
Building & Materials	4.00%	3.20%	4.00%	6.00%	
Chemicals	6.00%	3.20%	4.80%	2.00%	2.00%
Computers & Electronics	10.00%	4.00%	1.60%	8.00%	6.00%
Consumer Products	5.00%	3.20%	3.20%	4.00%	
Energy	10.00%	4.80%	1.60%		10.00%
Food, Beverage & Tobacco	4.00%	5.60%	7.20%	4.00%	
Gaming, Leisure & Entertainment	3.00%	1.60%	0.00%		2.00%
Health Care & Pharmaceuticals	3.00%	5.60%	0.80%	0.00%	
Industrial/Manufacturing	2.00%	3.20%	2.40%	8.00%	6.00%
Lodging & Restaurants	3.00%	3.20%	0.80%		
Metals & Mining	2.00%	1.60%	0.80%	12.00%	4.00%
Packaging & Containers	2.00%				
Paper & Forest Products	5.00%	3.20%	1.60%		
Real Estate		1.60%	0.00%	4.00%	
Retail (general)	3.00%	6.40%	4.00%	4.00%	8.00%
Supermarkets & Drugstores	1.00%	4.80%	4.80%		
Telecommunications	4.00%	4.80%	8.80%	2.00%	12.00%
Transportation	3.00%	4.80%	0.80%	8.00%	4.00%
Utilities	4.00%	5.60%	14.40%	4.00%	4.00%
Sovereign					14.00%
Herfindahl	5.7%	7.0%	9.5%	9.8%	12.2%
Effective number of sectors	17.5	14.2	10.5	10.2	8.2



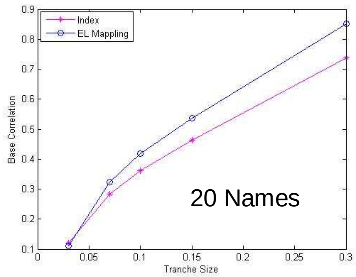


Bespoke Portfolios and Concentration

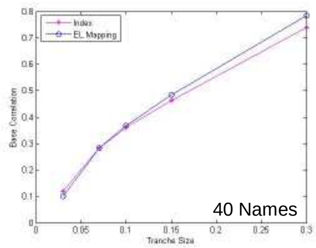
	CDX Index		Bespoke Portfolio (40)		Bespoke Portfolio (20)	
Sector (aggregate)	**Weight (Notional)**	**Weight (EL)**	**Weight (Notional)**	**Weight (EL)**	**Weight (Notional)**	**Weight (EL)**
TECH	20.8%	21.4%	20%	14.5%	**50%**	**72.3%**
SERVICE	9.6%	10.9%	15%	16.7%		
PHARMA	5.6%	3.6%	5%	3.9%		
RETAIL	20.0%	29.0%	17.5%	27.2%		
FINANCE	19.2%	11.8%	10%	6.6%	**50%**	**27.7%**
INDUSTRY	9.6%	9.9%	15%	14.2%		
ENERGY	15.2%	13.5%	17.5%	16.9%		
HI	0.16	0.19	*0.16*	*0.18*	***0.50***	***0.60***
No. Eff. sectors	6.07	5.40	*6.30*	*5.63*	***2.00***	***1.67***

Avg 5yr PD Index = 3.65% 40 Name = 3.92% 20 Name = 3.36%

EL Mapping 20 Names



CDX Point	EL Mapped Point (40)	**EL Mapped Point (20)**
3%	3.45%	**3.17%**
7%	7.01%	**5.89%**
10%	9.75%	**7.98%**
15%	14.01%	**11.55%**
30%	27.77%	**24.65%**

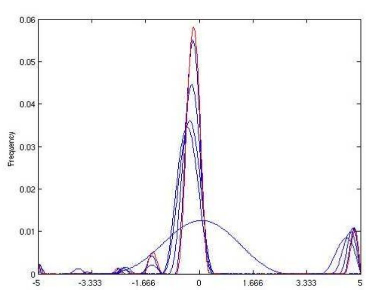


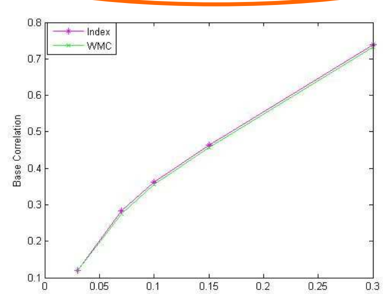
PRICES

Tranche	Index	Bespoke (40)	Bespoke (20)
0 - 3%	31.81%	34.04%	28.26%
3 - 7%	99	139	113
7-10%	21	43	29
10-15%	9.9	18	11
15-30%	5.5	0	0

Example – Weighted MC and CDO Index Prices

Penalties	Global factor statistics				Tranche Prices				
	MEAN	STD	SKEW	EX.KURT	0-3%	3-7%	7-10%	10-15%	15-30%
None	0.00	0.99	-0.11	-0.27	28.47%	229.06	45.97	9.81	1.12
level 1	0.37	1.90	1.49	1.02	32.31%	118.39	32.85	23.27	9.47
level 2	0.30	1.81	1.68	2.05	32.22%	111.58	34.8	18.67	10.37
level 3	0.22	1.69	1.90	3.33	32.04%	106.54	30.78	16.12	10.77
level 4	0.14	1.54	2.23	5.01	31.89%	101.58	24.46	12.47	7.5
Final	**0.12**	**1.47**	**2.42**	**5.98**	**31.82%**	**99.35**	**21.47**	**10.77**	**5.77**
MARKET					**31.81%**	**99**	**21**	**10.5**	**5.5**





Example – Bespoke (40 Names)

	0-3%	3-7%	7-10%	10-15%	15-30%
MARKET	***31.81***	***99***	***21***	***10.5***	***5.5***
WMC INDEX	***31.81***	***99.53***	***19.96***	***10.86***	***5.48***
BESPOKE (WMC MF)	***33.13***	***214.54***	***24.66***	***11.18***	***5.53***
BESPOKE (WMC SF)	32.57	203.51	33.07	13.37	6.09
BESPOKE EL Mapping	34.04	139	43	18	0

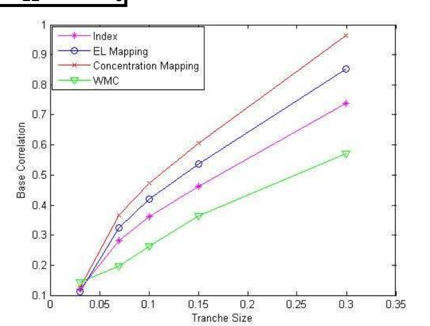
SWMC pricing of bespoke portfolio (40 names) – multi-factor model

Moments of implied multi-factor distributions

Factor	MEAN	STD	SKEW	KURT
Global	0.66	1.26	1.35	2.89
TECH	0.15	2.91	-0.14	-1.13
SERVICE	0.13	2.86	-0.07	-1.09
PHARMA	0.31	2.59	-0.09	-1.14
RETAIL	-0.36	2.73	0.13	-1.01
FINANCE	0.13	2.41	0.06	-0.72
INDUSTRY	0.39	2.78	-0.21	-1.13
ENERGY	0.37	2.83	-0.16	-1.10

Example – Bespoke (20 Names)

	0-3%	3-7%	7-10%	10-15%	15-30%
MARKET	***31.81***	***99***	***21***	***10.5***	***5.5***
WMC INDEX	*31.81*	*99.53*	*19.96*	*10.86*	*5.48*
BESPOKE (40 name) WMC	*32.57*	*203.51*	*33.07*	*13.37*	*6.09*
BESPOKE *(20 Name) WMC*	**20.98**	**266**	**81**	**30**	**8**
BESPOKE EL Mapping	28.26	113	29	11	0



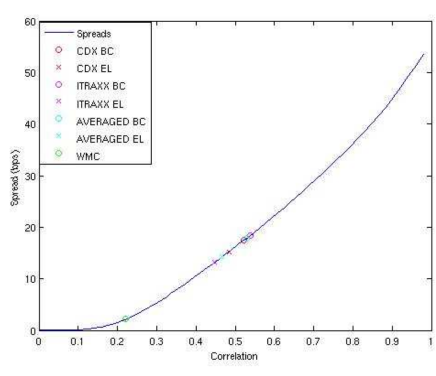
Example 4: Super Senior Bespoke (CDX & iTraxx)

Characteristics	Values
Attachment Point	15%
Detachment Point	60%
Underlying Portfolio	100 names, 51 NA (28 CDX, 23 bespoke), 49 Euro (= non NA, 28 iTraxx, 21 bespoke).
Bespoke Average Hazard Rate	0.0115
Bespoke Average 1 Yr. Implied Default Probability	0.0114

Sector	Bespoke	CDX	iTraxx
Comm. and Tech.	17%	14.4%	16%
Financial	14%	18.4%	20%
Materials	19%	8.8%	10.4%
Consumer Stable	11%	12.8%	14.4%
Utilities	2%	6.4%	12%
Energy	1%	4.8%	2.4%
Industrial	3%	11.2%	5.6%
Consumer Cyclical	32%	21.6%	17.6%
Government	1%	1.6%	1.6%
Eff. Num. Sectors	4.985	6.92	6.83

Bespoke CDO Pricing

Method	Bespoke Spread	CDX comp Spread	iTraxx comp Spread
Weighted Monte-Carlo	**2.19 (ρ=0.22)**	**3.78 (ρ=0.41)**	**2.05 (ρ=0.43)**
CDX Base Correlation	17.4 (ρ=0.52)	8.46 (ρ=0.52)	4.56 (ρ=0.52)
CDX EL Mapping	15.25 (ρ=0.49)	6.76 (ρ=0.49)	3.38 (ρ=0.49)
iTraxx Base Correlation	18.38 (ρ=0.54)	9.24 (ρ=0.54)	5.16 (ρ=0.54)
iTraxx EL Mapping	13.16 (ρ=0.45)	5.19 (ρ=0.45)	2.46 (ρ=0.45)
Avg. Base Correlation	17.88 (ρ=0.53)	8.84 (ρ=0.53)	4.85 (ρ=0.53)
Averaged EL Mapping	14.21 (ρ=0.47)	5.96 (ρ=0.47)	2.89 (ρ=0.47)



Summary – Weighted MC & Implied Factor Models

- Systematic approach – robust and practical CDO valuation framework
  - CDO analytics and computational techniques
  - Multi-factor credit models
  - Weighted Monte Carlo techniques (used in options pricing)
- Value consistently bespoke tranches, CDOs of bespoke portfolios, products on multiple indices, structured finance CDOs, CDO^2
  - Arbitrage-free prices
  - Flexible calibration – fits prices and makes effective use of market, historical and portfolio information
  - Characterize and model explicitly the effect concentration/diversification
  - Transparent, easy to understand and relate to market practices
  - Integration of other risks (prepayment) and complex structures (ABS, cashCDO)
- Practical advantages of working through factor models

Presenter's Bio

Dr. Dan Rosen is the co-founder and President of *R² Financial Technologies* and acts as an advisor to institutions in Europe, North America, and Latin America on derivatives valuation, risk management, economic and regulatory capital. He is a research fellow at the *Fields Institute* for Research in Mathematical Sciences and an adjunct professor at the *University of Toronto's* Masters program in Mathematical Finance.

Up to July 2005, Dr. Rosen had a successful ten-year career at *Algorithmics* Inc., where he held senior management roles in strategy and business development, research and financial engineering, and product marketing. In these roles, he was responsible for setting the strategic direction of Algorithmics' solutions, new initiatives and strategic alliances as well as heading up the design, positioning of credit risk and capital management solutions, market risk management tools, operational risk, and advanced simulation and optimization techniques, as well as their application to several industrial settings.

Dr. Rosen lectures extensively around the world on financial engineering, enterprise risk and capital management, credit risk and market risk. He has authored numerous papers on quantitative methods in risk management, applied mathematics, operations research, and has coauthored two books and various chapters in risk management books (including two chapters of PRMIAs Professional Risk Manger Handbook). In addition, he is a member of the Industrial Advisory Boards of the Fields Institute, and the Center for Advanced Studies in Finance (CASF) at the University of Waterloo, the Academic Advisory Board of Fitch, the Advisory Board and Credit Risk Steering Committee of the IAFE (International Association of Financial Engineers) and the regional director in Toronto of PRMIA (Professional Risk Management International Association). He is also one of the founders of RiskLab, an international network of research centres in Financial Engineering and Risk Management.

He holds several degrees, including an M.A.Sc. and a Ph.D. in Chemical Engineering from the University of Toronto.

Selected Recent Publications

- Rosen D. and Saunders D., 2007, *Valuing CDOs of Bespoke Portfolios with Implied Multi-Factor Models*, Working Paper, Fields Institute and University of Waterloo
- Rosen D. and Saunders D., 2008, *Valuing Cash CDOs and Structured Credit Instruments and with Implied Factor Models*, Working Paper, Fields Institute and University of Waterloo
- Rosen D. and Saunders D., 2008, *Analytical Methods for Hedging Systematic Credit Risk with Linear Factor Portfolios*, Forthcoming Journal of Economic Dynamics and Control
- Rosen D. and Saunders D., 2008, *Measuring Capital Contributions of Systemic Factors in Credit Portfolios*, Working Paper Fields Institute and University of Waterloo
- Garcia Cespedes J. C., Keinin A., de Juan Herrero J. A. and Rosen D., 2006, *A Simple Multi-Factor "Factor Adjustment" for Credit Capital Diversification*, Special issue on Risk Concentrations in Credit Portofolios (M. gordy, editor) Journal of Credit Risk, Fall 2006
- Garcia Cespedes J. C., de Juan Herrero J. A., Rosen D., Saunders D., 2007, *Effective modelling of Alpha for Regulatory Counterparty Credit Capital*, Working Paper, Fields Institute and University of Waterloo
- Mausser H. and Rosen D., 2007, *Economic Credit Capital Allocation and Risk Contributions*, forthcoming in Handbook of Financial Engineering (J. Birge and V. Linetsky Editors)
- De Prisco B., Rosen D., 2005, *Modelling Stochastic Counterparty Credit Exposures for Derivatives Portfolios*, Counterparty Credit Risk (M. Pykhtin, Editor), Risk Books, London
- Aziz A., Rosen D., 2004, *Capital Allocation and RAPM*, in Professional Risk Manager (PRM) Handbook, Chapter III.0, PRMIA Publications
- Rosen D., 2004, *Credit Risk Capital Calculation*, in Professional Risk Manager (PRM) Handbook, Chapter III.B5, PRMIA Publications

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