Credit Risk Modelling in the Energy Industry

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Outline

- Introduction
- Energy Credit Risk
- Credit Portfolio Loss Modelling
  - Part I: Market Risk
  - Part II: Credit Risk
- Developing a **Risk Simulation Engine** for
  - Part I: Market Risk
  - Part II: Credit Risk
- Analysing Concentration Risk

Credit Risk

- The risk that a counterparty may be unable or unwilling to fulfill obligations.
- It is in the form of either
  - Actual Default, or
  - Deterioration of counterparty's credit quality.
- The question is how much money an entity could lose if counterparty(s) default?
- Exposure=Max(MtM, 0)

Potential Future Exposure (PFE)

- What is the worse exposure we would have at a certain time in future?
- PFE will address this question with reference to a certain confidence level.

$$PFE_\alpha = \mu + \sigma\, \Phi^{-1}(\alpha)$$

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PFE vs. VaR

VaR

- Short term fluctuations

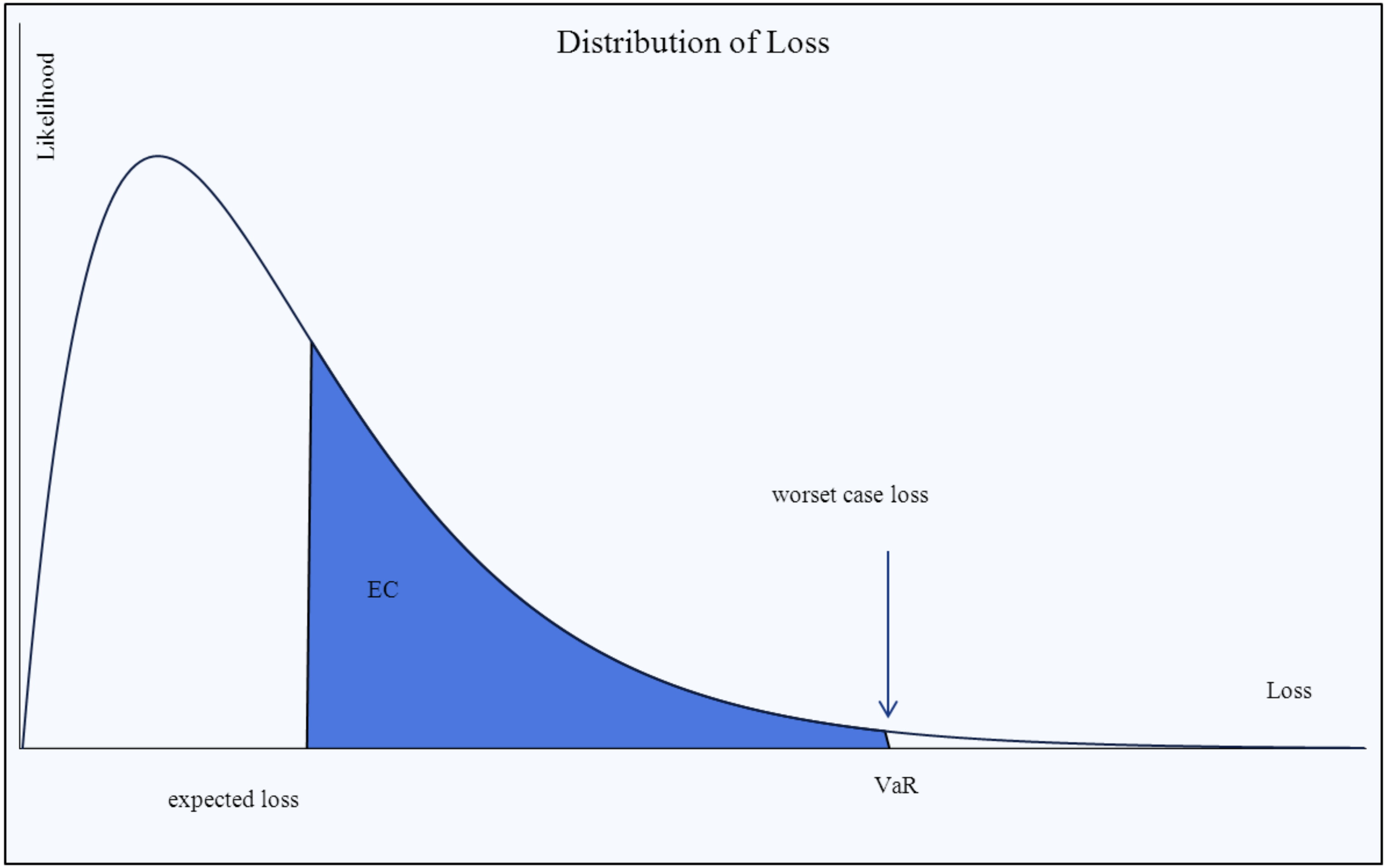
- Worst-case loss

PFE

- Long holding period

- Worst-case gain(exposure)

Distribution of Loss



Credit Value at Risk

The maximum we could lose in a worst case event -- say 1 in 20 -- if & when counterparties default.

Credit Risk Metrics

How much capital Should one hold -- for rainy days?

- Economic Loss (EL) = Mean(Loss Distribution)
- Unexpected Loss = StdDev (Expected Loss)
- Economic (Buffer) Capital (EC) = CVaR - EL

Credit Risk: Energy vs. “others”

- Different nature of exposure from that of bank-- Delivery of goods, derivative deals by exchanges.
- Shorter-term and lower value credit risks.
- Should be tracked and monitored each day.
- Non-normality of return distributions.
- Seasonality.
- Specific product characteristics (non-storability for electricity)

Credit Portfolio Loss Modelling

Market Risk Modeling

Step1: MtM Engine

Step2: Correlation

Step3: PFE Simulation

Credit Risk Modeling

Step1: Transition Matrix Scaling and Regularization

Step2: Survival Function

Step3: Obligors Correlation Matrix

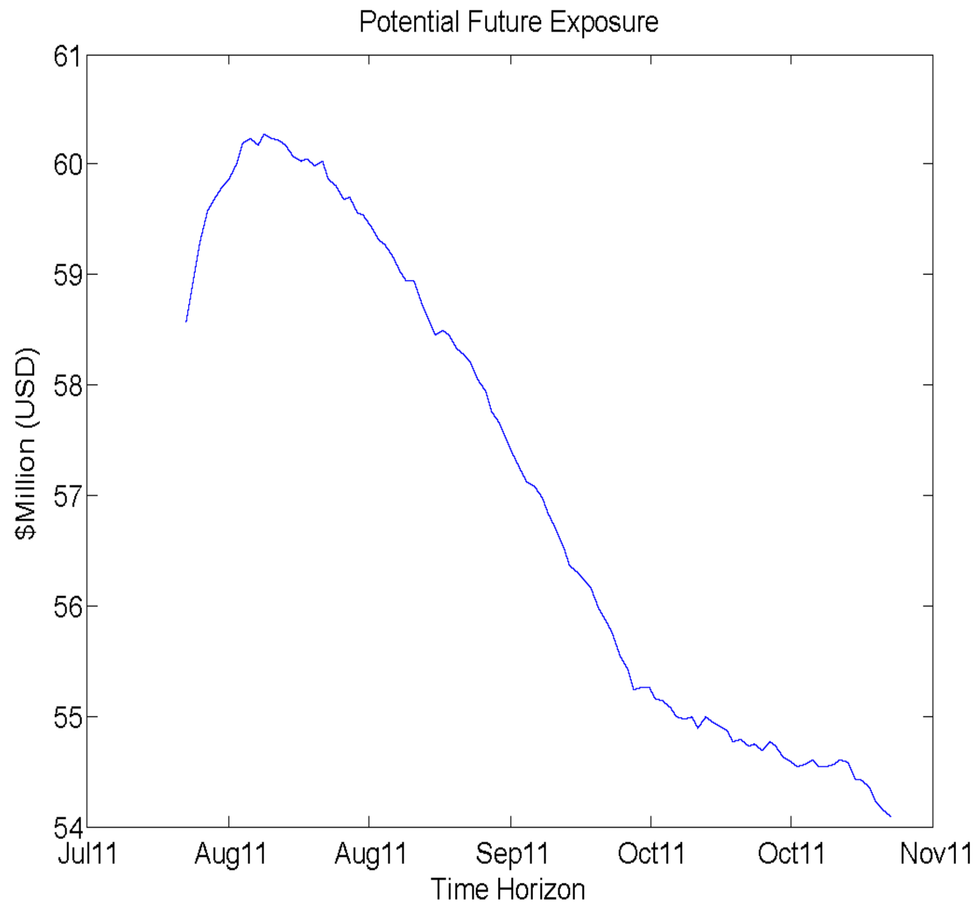
Step4: Copula and Default Time Simulation

Step5: Portfolio Loss Evaluation

Risk Decomposition

- Risk Beta
- Component CVaR

Part I: Market Risk: Potential Future Exposure



Part II: Credit Risk, Step1: Transition Matrix Scaling and Regularization

- The Transition Matrix can be scaled in time by using the following rules:

$$M_{T_1+T_2} = M_{T_1} + M_{T_2}$$
$$M_k{}^T = M_T{}^K$$
$$M_{\frac{T}{k}} = \sqrt[k]{M_T}$$

- We scale the one year transition matrix to one month by using $M_{\frac{1}{12}} = M_1{}^{\frac{1}{12}}$ (piece of cake in MATLAB).

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Part II: Credit Risk, Step1: Transition Matrix Scaling and Regularization

- Transition Matrix might not be regular Markov matrix, which in that case it has to be regularized.

- The QOM(Quasi-Optimization of the root Matrix) algorithm was used to regularize the transition matrix based on [1].

Part II: Credit Risk, Step2: Survival Function

- Survival Function indicates the probability that an obligor will not have default at time *t* (the *d* sub index means the default column in transition matrix).

- Algorithm to produce Survival Function Table [3]

$$S(.,1M) = \vec{1} - (T_{1/12})_{.d}$$

$$S(.,2M) = \vec{1} - (T^{2}{}_{1/12})_{.d}$$

$$S(.,3M) = \vec{1} - (T^{3}{}_{1/12})_{.d}$$

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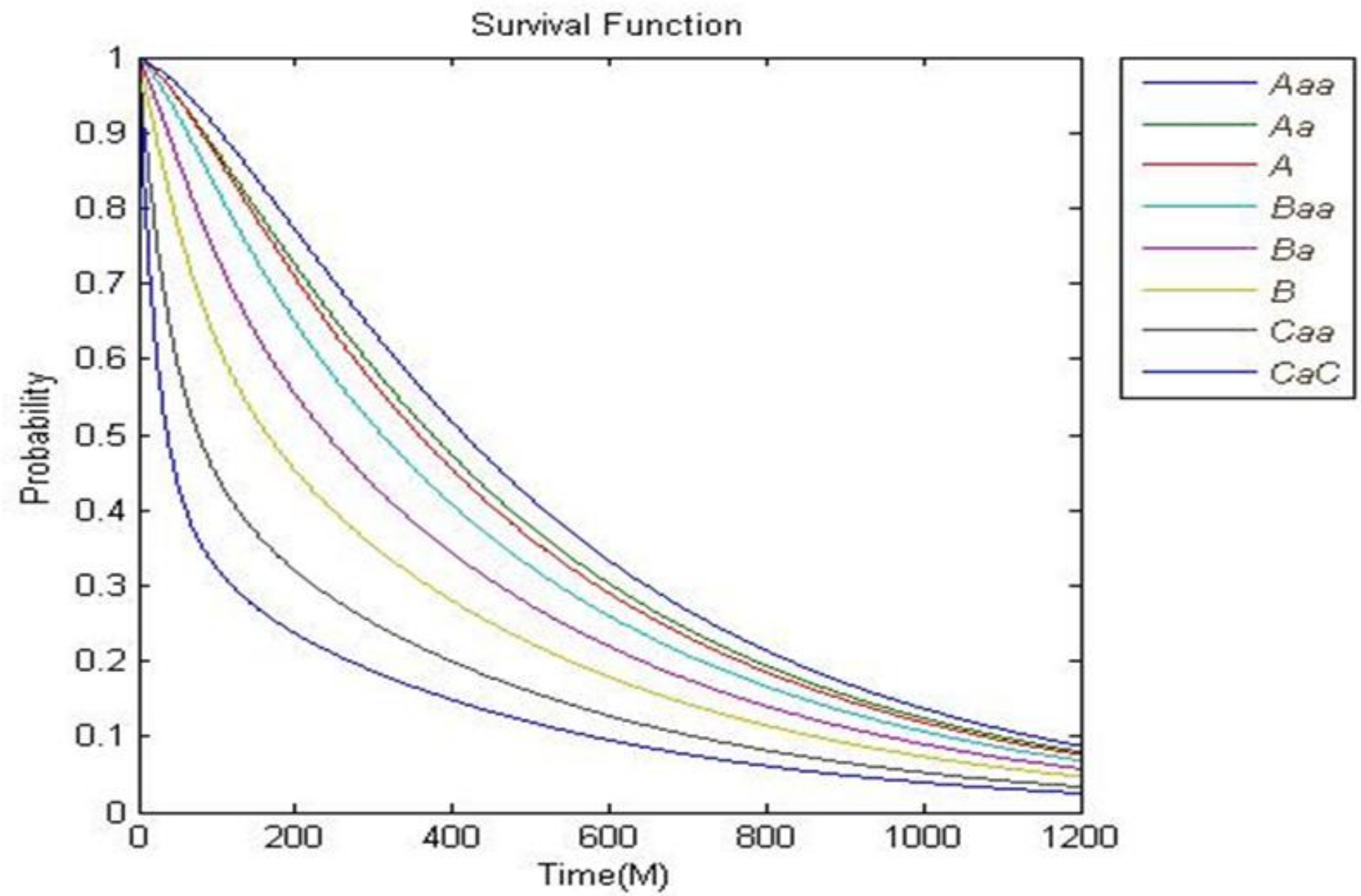
Part II: Credit Risk, Step2: Survival Function



Part II: Credit Risk, Step3: Obligors Correlation Matrix

$$\rho^{D,D}{}_{i,j} = \frac{P^{D,D}{}_{i,j} - P^{D}{}_{i} P^{D}{}_{j}}{\sqrt{P^{D}{}_{i}(1 - P^{D}{}_{i})}\sqrt{P^{D}{}_{j}(1 - P^{D}{}_{j})}}$$

$P^{D}{}_{i}$: Sector *i* Probability of Default

$P^{D,D}{}_{i,j}$: Sector *i* and *j* Joint Probability of Default

Part II: Credit Risk, Step3: Obligors Correlation Matrix

$$P^{D,D}{}_{i,i} = \sum_{i=1}^{n} w \frac{T^{t}{}_{i,D}(T^{t}{}_{i,D} - 1)}{N^{t}{}_{i}(N^{t}{}_{i} - 1)}$$

Where

w is the weight ,here $\frac{1}{n}$ (others weights in [2])

n: Number of years.

$N^{t}{}_{i}$: Number of obligors in sector i at the beginning of year t.

$T^{t}{}_{i,D}$: Number of obligors in sector i that default in year t.

Part II: Credit Risk, Step3: Obligors Correlation Matrix

$$P^{D,D}{}_{i,j} = \sum_{i=1}^{n} w \frac{T^{t}{}_{i,D} . T^{t}{}_{j,D}}{N^{t}{}_{i} . N^{t}{}_{j}}$$

The probability that individual obligor in sector *i* defaults follows by

$$P^{D}{}_{i} = \sum_{i=1}^{n} w \frac{T^{t}{}_{i,D}}{N^{t}{}_{i}}$$

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Part II: Credit Risk, Step4: Copula and Default Time Simulation

Copula Simulation

Both Gaussian and T-Student copula was generated in MATLAB based on the obligors covariance matrix

↓

Default Times Simulation

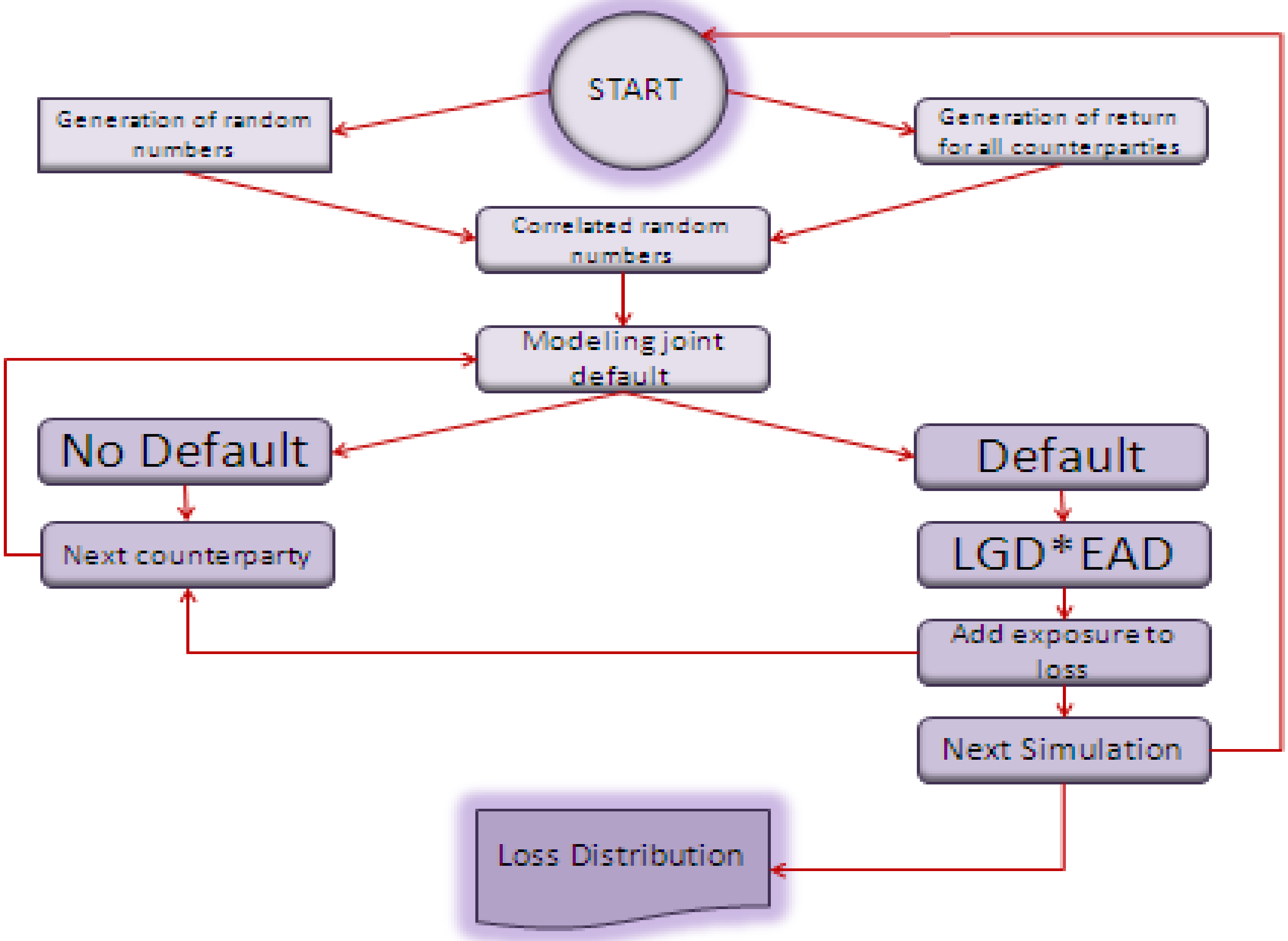
Survival Function Table	Search for the month in the table by copula value for each rating in each simulation

↓

EAD & Recovery Rate

Add up all Exposure at Default (EAD)	Multiple by Recovery Rate at that point for that Obligor

Developing a Risk Simulation Engine



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Risk Simulation Engine

A 3 Layer Software with

1. A Relational Database storing
   - Forward and Spot data on commodity prices
   - FX data
   - Coupled with Counterparty Info
   - Credit Information

2. Risk Pricing\Simulation Engine
   - Flexible enough to easily add a new contract without Hardcoding.

3. Reporting Engine
   - Reporting risk metrics by granularities of
     - Counterparty, Contracts, Month.

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Difficulties and the Challenges

- Each contract across the curve has a unique feature (e.g. Oct requires different Volatility model than Apr).
- Difficulties gathering data and counterparty information.
- Any PFE and Credit Analysis Requires re-calculation of MtM at different market states.

Difficulties and the Challenges

- Unique Nature of the commodities compared to other assets, rules out using most academic models.
- Correlation between contracts in PFE simulation.
- Correlation between sectors in default simulation.
- **AUTOMATION**

Automation

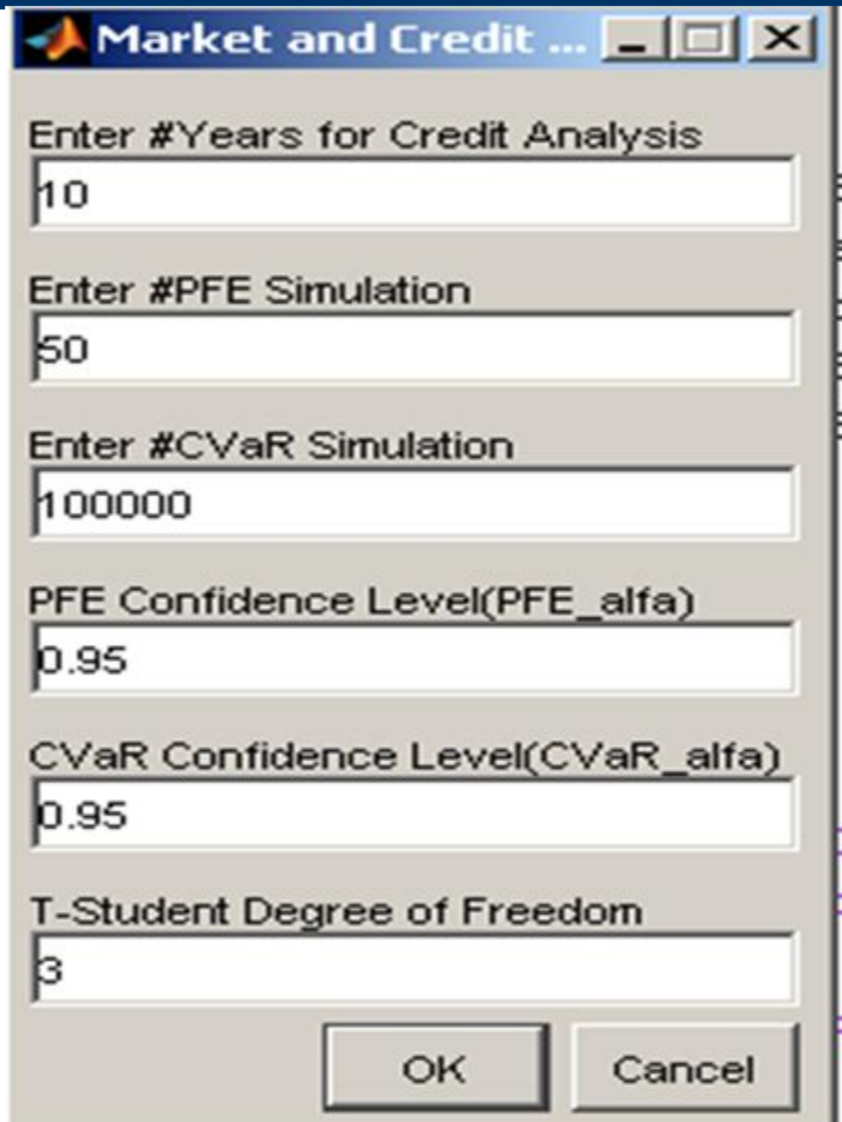
We have automated analytics so that

We just update Position Tables and Risk factors so if

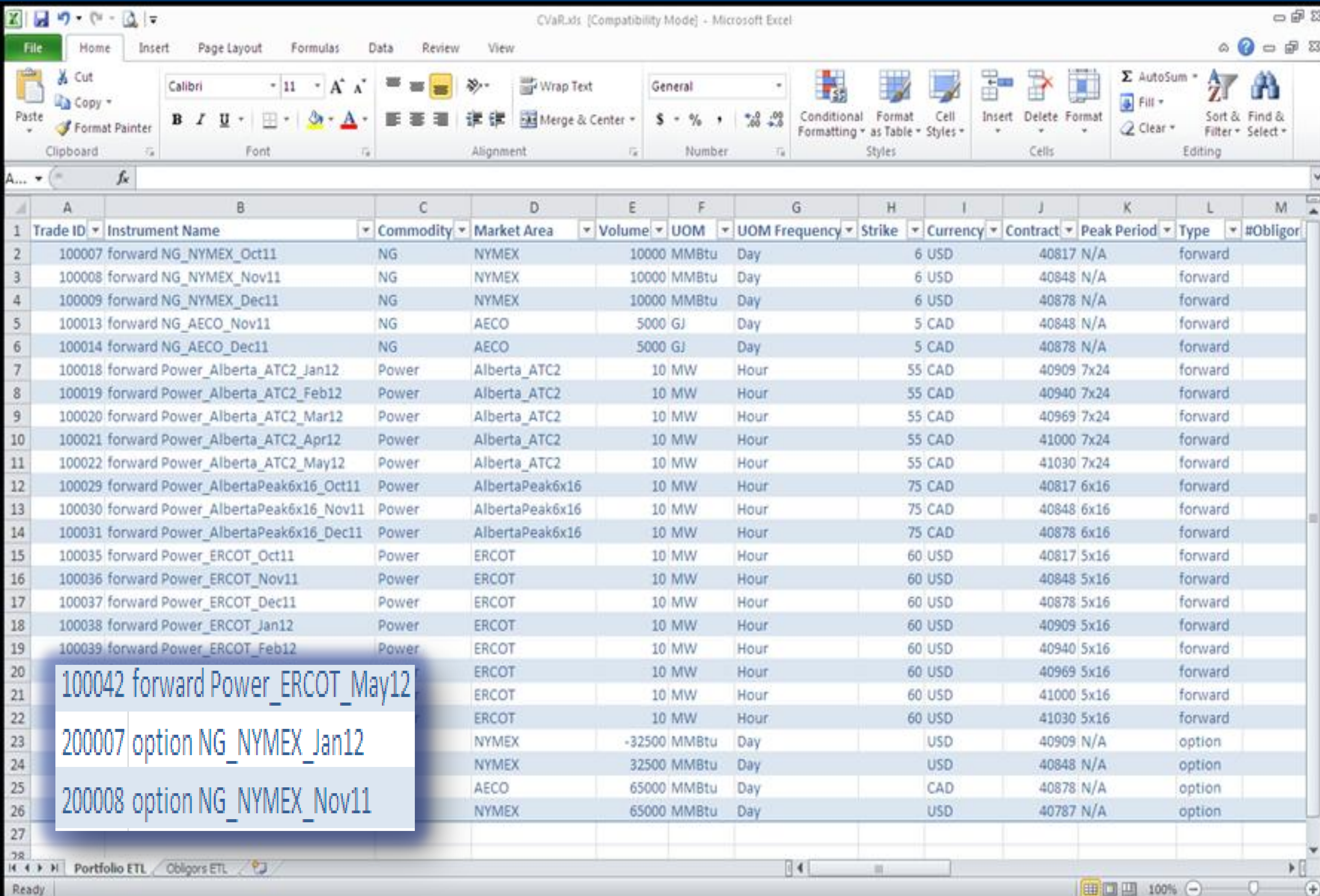
- Trader? How my risk metrics changes if I take this position?
- Management Team? How our exposure moves in the next 6-12 month if this deal is done?

Well we got the answer immediately.

Automation, Input Dialog Box Screenshot



Developing a Risk Simulation Engine, Populated ETL Table in Excel Output



Trade ID	Instrument Name	Commodity	Market Area	Volume	UOM	UOM Frequency	Strike	Currency	Contract	Peak Period	Type	#Obligor
100007	forward NG_NYMEX_Oct11	NG	NYMEX	10000	MMBtu	Day	6	USD	40817	N/A	forward	
100008	forward NG_NYMEX_Nov11	NG	NYMEX	10000	MMBtu	Day	6	USD	40848	N/A	forward	
100009	forward NG_NYMEX_Dec11	NG	NYMEX	10000	MMBtu	Day	6	USD	40878	N/A	forward	
100013	forward NG_AECO_Nov11	NG	AECO	5000	GJ	Day	5	CAD	40848	N/A	forward	
100014	forward NG_AECO_Dec11	NG	AECO	5000	GJ	Day	5	CAD	40878	N/A	forward	
100018	forward Power_Alberta_ATC2_Jan12	Power	Alberta_ATC2	10	MW	Hour	55	CAD	40909	7x24	forward	
100019	forward Power_Alberta_ATC2_Feb12	Power	Alberta_ATC2	10	MW	Hour	55	CAD	40940	7x24	forward	
100020	forward Power_Alberta_ATC2_Mar12	Power	Alberta_ATC2	10	MW	Hour	55	CAD	40969	7x24	forward	
100021	forward Power_Alberta_ATC2_Apr12	Power	Alberta_ATC2	10	MW	Hour	55	CAD	41000	7x24	forward	
100022	forward Power_Alberta_ATC2_May12	Power	Alberta_ATC2	10	MW	Hour	55	CAD	41030	7x24	forward	
100029	forward Power_AlbertaPeak6x16_Oct11	Power	AlbertaPeak6x16	10	MW	Hour	75	CAD	40817	6x16	forward	
100030	forward Power_AlbertaPeak6x16_Nov11	Power	AlbertaPeak6x16	10	MW	Hour	75	CAD	40848	6x16	forward	
100031	forward Power_AlbertaPeak6x16_Dec11	Power	AlbertaPeak6x16	10	MW	Hour	75	CAD	40878	6x16	forward	
100035	forward Power_ERCOT_Oct11	Power	ERCOT	10	MW	Hour	60	USD	40817	5x16	forward	
100036	forward Power_ERCOT_Nov11	Power	ERCOT	10	MW	Hour	60	USD	40848	5x16	forward	
100037	forward Power_ERCOT_Dec11	Power	ERCOT	10	MW	Hour	60	USD	40878	5x16	forward	
100038	forward Power_ERCOT_Jan12	Power	ERCOT	10	MW	Hour	60	USD	40909	5x16	forward	
100039	forward Power_ERCOT_Feb12	Power	ERCOT	10	MW	Hour	60	USD	40940	5x16	forward	
			ERCOT	10	MW	Hour	60	USD	40969	5x16	forward	
			ERCOT	10	MW	Hour	60	USD	41000	5x16	forward	
			ERCOT	10	MW	Hour	60	USD	41030	5x16	forward	
			NYMEX	-32500	MMBtu	Day		USD	40909	N/A	option	
			NYMEX	32500	MMBtu	Day		USD	40848	N/A	option	
			AECO	65000	MMBtu	Day		CAD	40878	N/A	option	
			NYMEX	65000	MMBtu	Day		USD	40787	N/A	option	

100042 forward Power_ERCOT_May12

200007 option NG_NYMEX_Jan12

200008 option NG_NYMEX_Nov11

Analysis

- ✓ Sensitivity Analysis
- ✓ Scenario Analysis
- ✓ On the fly analysis
- ✓ Incremental Analysis
- ✓ Concentration Risk Analysis

Analysing Concentration Risk

It is essential to understand and visualize portfolio risk structure

- to compare portfolio components as to their contribution of risk for a proactive risk management ---> NO CONCENTRATION
- to illustrate diversification opportunities for creating the optimal portfolio ---> FULL DIVERSIFICATION

Analysing Concentration Risk

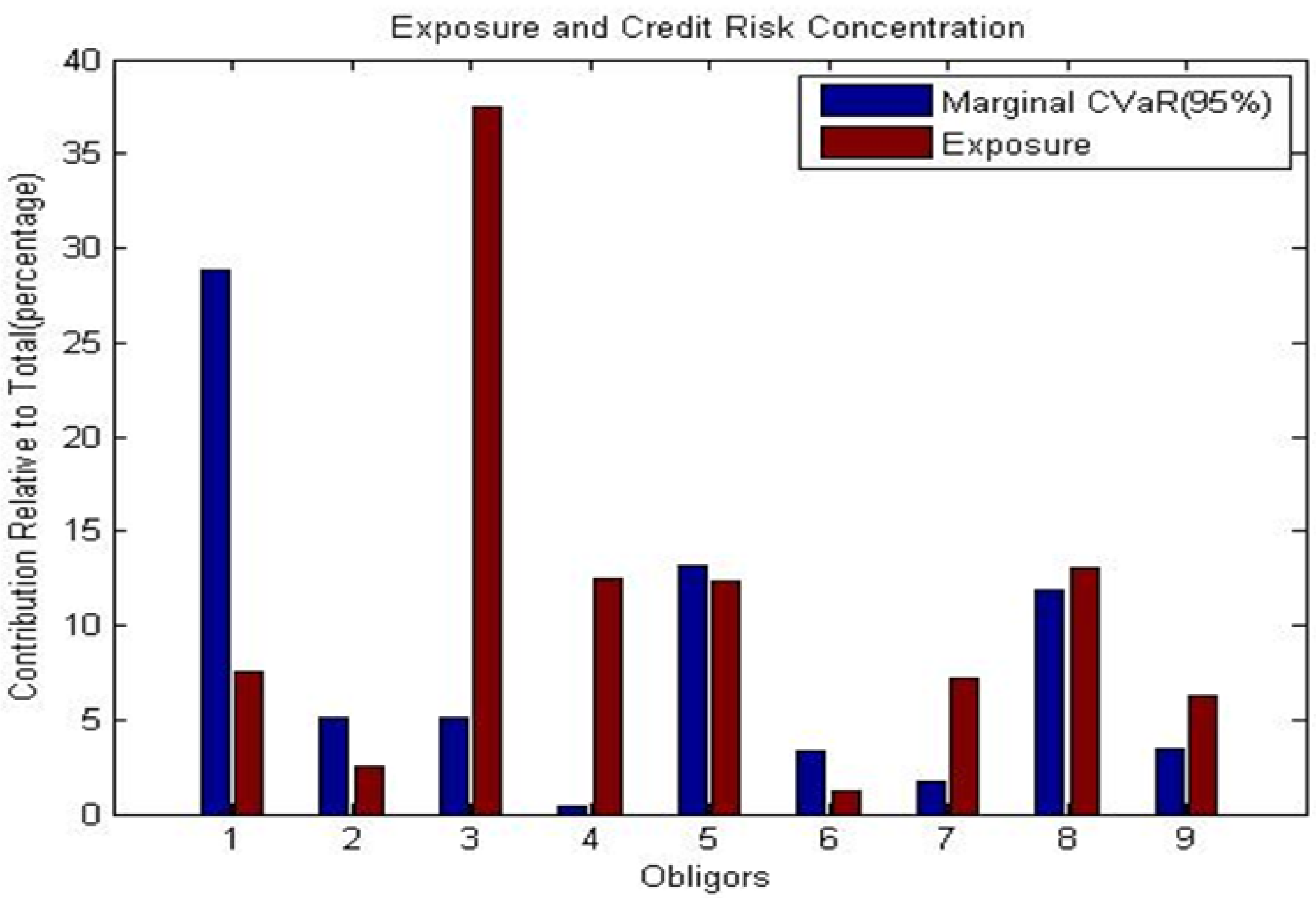
Risk Decomposition

- Marginal Risk Beta (beta)
- Risk Contribution (w*beta)
- Component CVaR
- Marginal CVaR

Concentration Ratios

- CvaR/Stand alone CVaR
- Marginal CVaR/Exposure Weight
- CVaR/Obligor Expsoure
- Marginal StdDev(%)

Exposure and Credit Risk Concentration



Exposure and Credit Risk Concentration

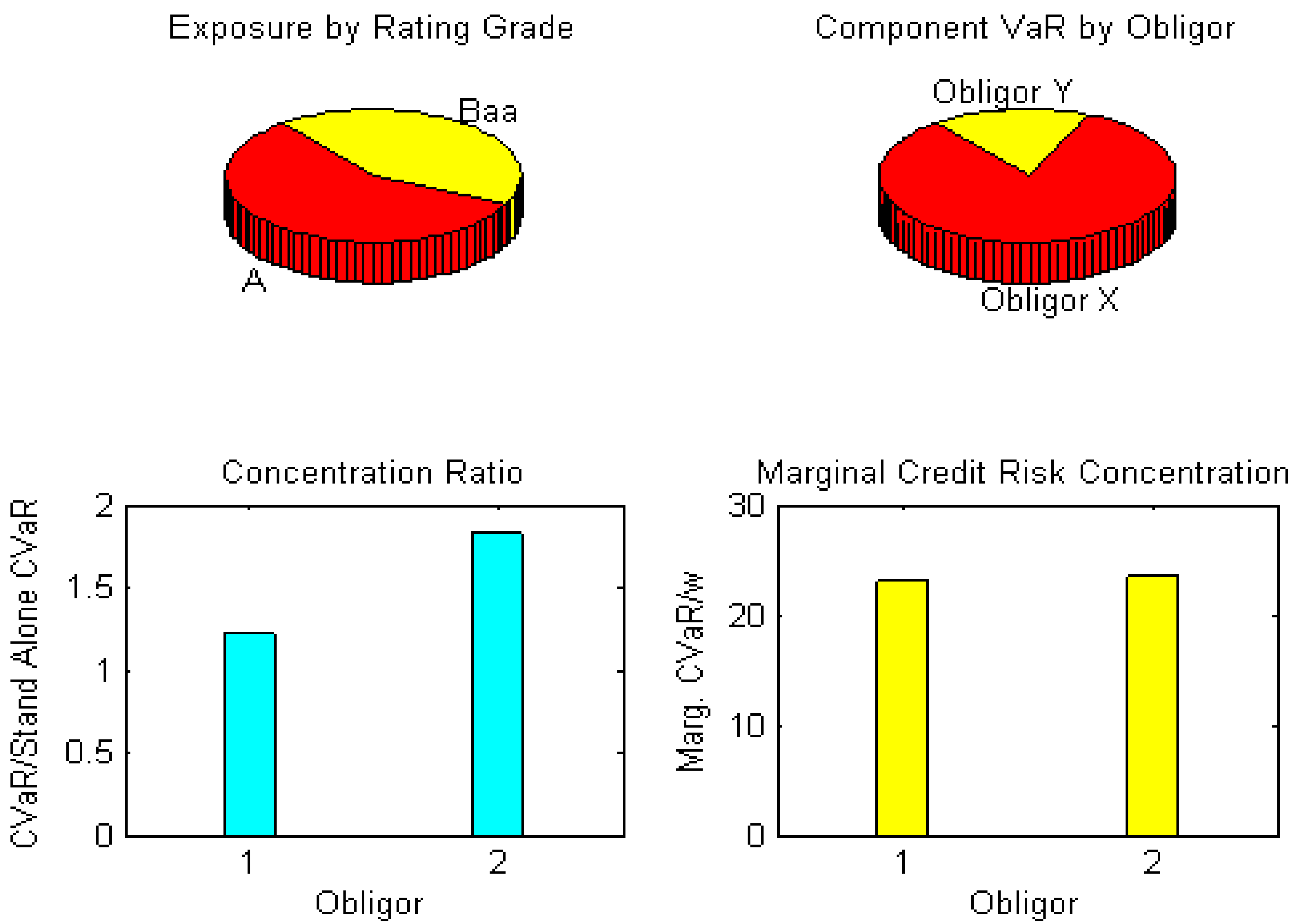
Obligor1

- Low Creditworthiness (Caa)
- Low Exposure Concentration
- High Risk Exposure

Obligor3

- High Creditworthiness (Aaa)
- High Exposure Concentration
- Low Risk Exposure

Analysing Concentration Risk



Analysing Concentration Risk

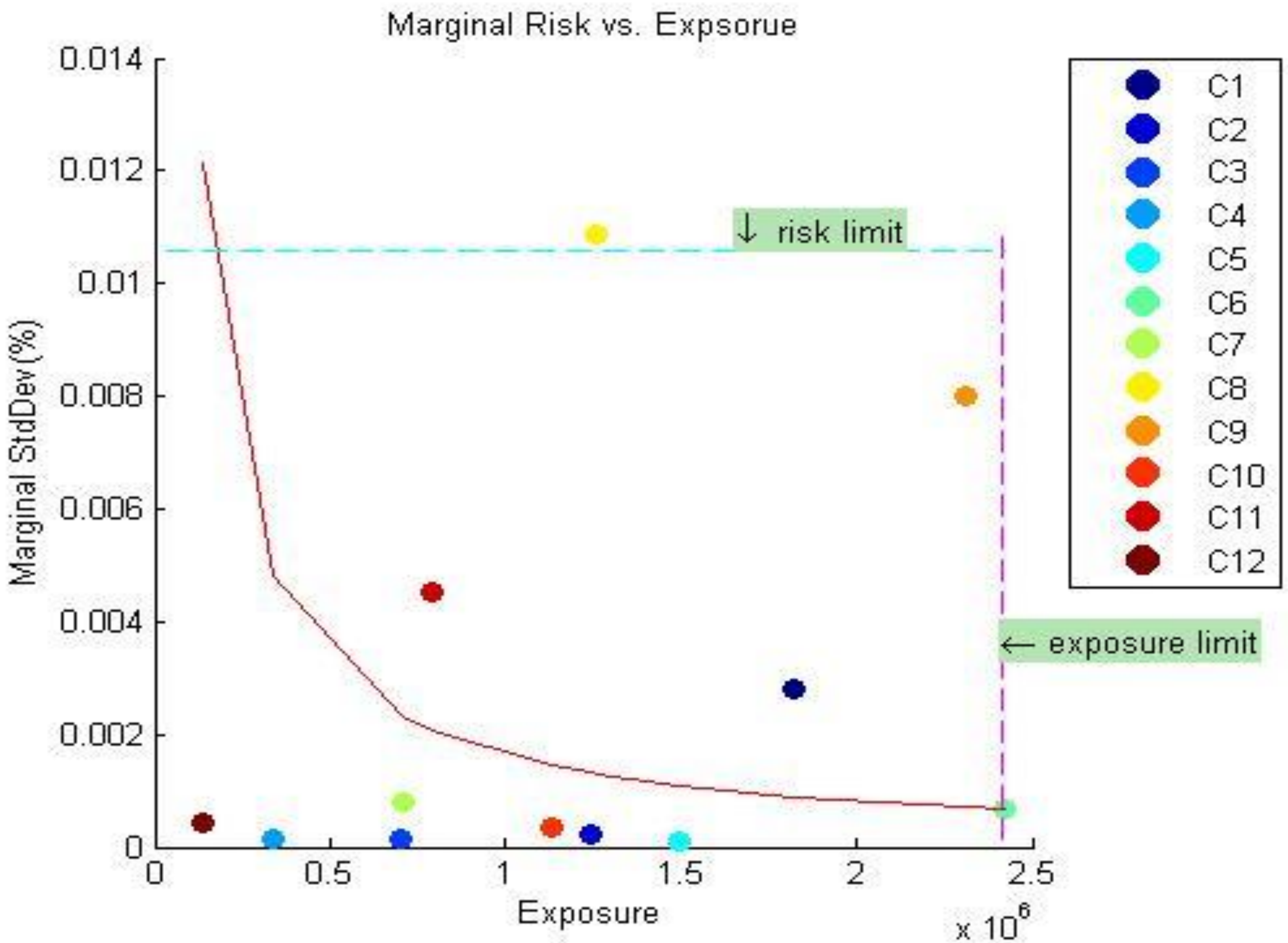
- **Exposure Limit**

"I don't want to lose more than X $ if one counterparty defaults."

- **Risk Limit**

"I don't want to concentrate more than X % of the total portfolio risk in one segment."

Analysing Concentration Risk



Reference

[1] Kreinin A. Sidelnikova M., *Regularization Algorithm for Transition Matrices*. *ARQ,* Vol.4, Nos. 1/2, (2001).

[2] Renault O. Servigny A., *Measuring and Managing Credit Risk,* Mc Graw Hill (2004).

[3] Torrent G., Ccruncher ,*Technical Document*, V.1.8-R727(2011).