Risk Management of Energy Portfolios

Energy & commodity trading in Italia: realtà e prospettive

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Milano, February, 2008

Risk Management of Energy Portfolio

Need for FloVaR

- Several energy trading desks own positions involving long-dated **structured transactions** with counterparts of **limited credit quality**.
- Modelling FloVaR's of each transaction as well as composite portfolios allows one to properly **assess** the corresponding **risk-return trade-off** and possibly provide indications about operations of **credit protection** by third parties.
- **MIFID** specifies that portfolio risk assessment must be performed for all (netting) credit exposures on marked-to-market transactions exceeding a certain sizes and maturities
- FloVar is a quantile of the P&L distribution of a portfolio of energy commodities

Environment

- Energy producers, energy retailers, and commodity traders, all share a common issue: " How to
  - Identify,
  - Measure,
  - Monitor,
  - Mitigate

  portfolio exposure to commodity price fluctuations? "
- The difficulty stems from the fact that most energy contracts:
  - are **Long-term** deals, and
  - involve a **flow delivery** .

Idea

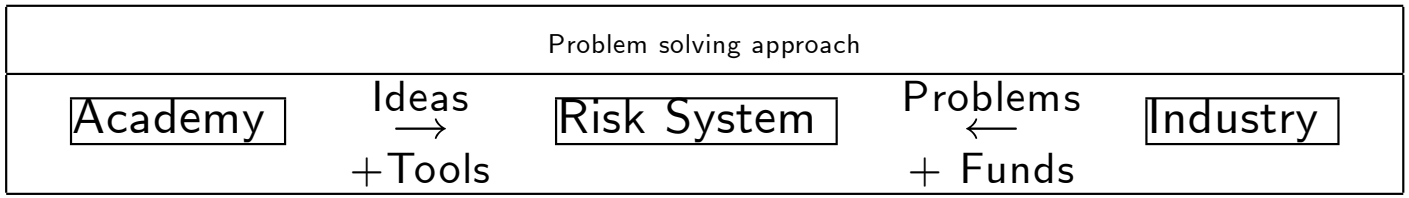
- **Situation**:
  - Higher and higher spending requirements for compliance with potential loss management;
  - Convenience to create globally consistent corporate risk-management practices.
- **Goal**
  - Creation and development of a simple and effective **framework** for energy risk measurement and management;
  - Address to the creation of a **standard setting** for the industry.

Ideal Steps

- **Starting opportunity**
  - Deliver an easy-to-use risk management service through a secured internet-based platform.
- **Continuation path**
  - Introduce, develop, and test improvements through modular extensions (*e.g.*, jump-diffusion models, parametric estimators of continuous-time diffusions)
  - Propose valuation tools for structured contracts (*e.g.*, collateralized commodity obligation issued by Barclay's Capital PLC)
  - Formalize a kernel for a standard setting

Structure and Concrete Actions

- **Key point**

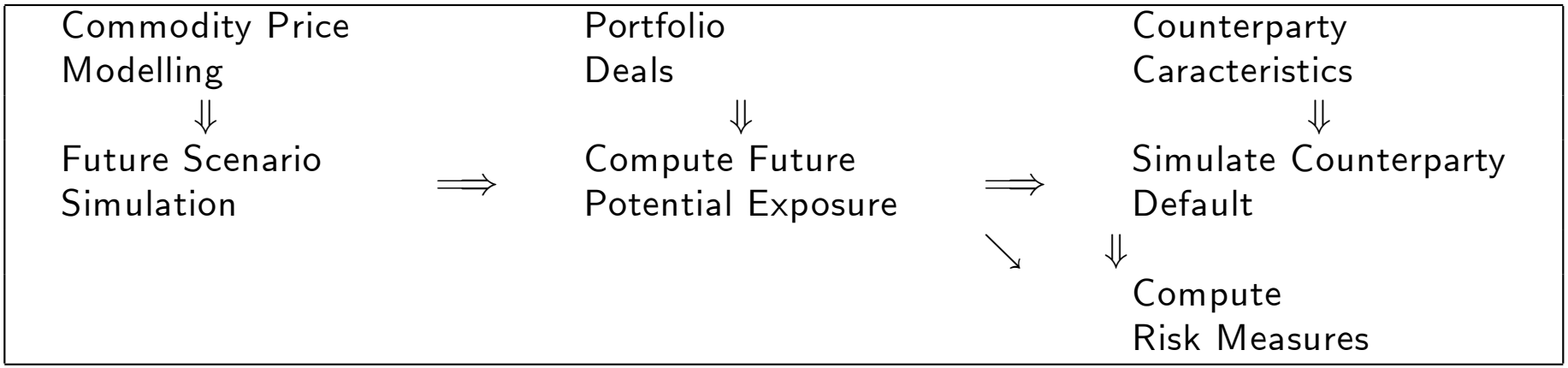


- **Actions and Support**:
  - Develop and market a web-based version of risk measurement system;
  - Determine and implement pilot projects with PhD's;
  - Produce publications in applied computational finance;
  - Advertise the spin-off (presentations, website, sponsor);
  - `Gather a supporting group of companies`

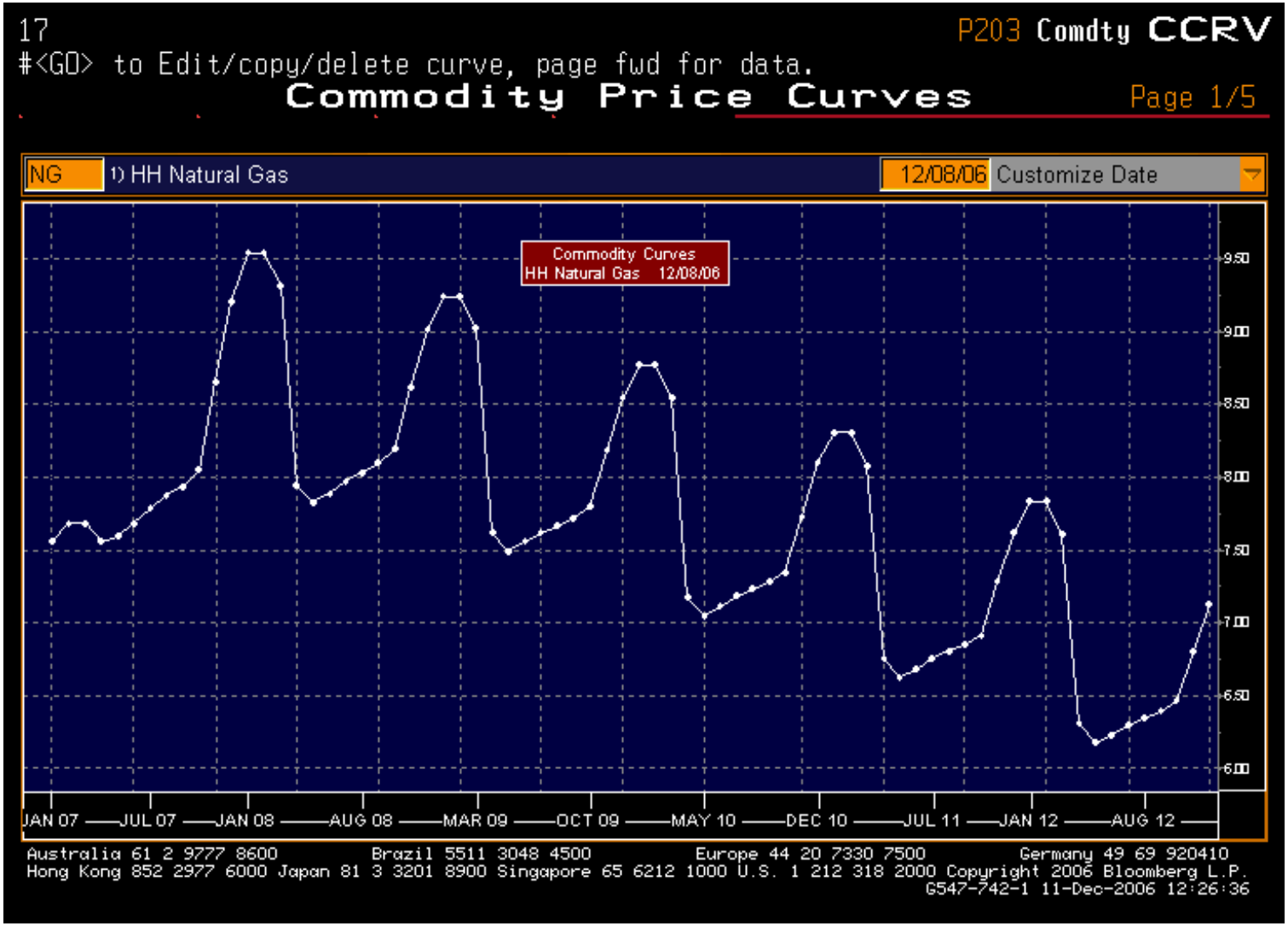
FloVaR Shortcut

- **Flow Value-at-Risk (FloVaR)** is an estimation of the marked-to-market value of a portfolio at a given point in time.
- **Input**
  - Portfolio composition,
  - Standing forward curves and risk factors,
  - Future dates $t_1, ..., t_n$.
- **Output**
  - P&L probability distributions at times $t_1, ..., t_n$ = Functions assigning a probabilities of occurrence to a range of possible future exposure figures.
  - Value at Risk figures
  - Hot Spot

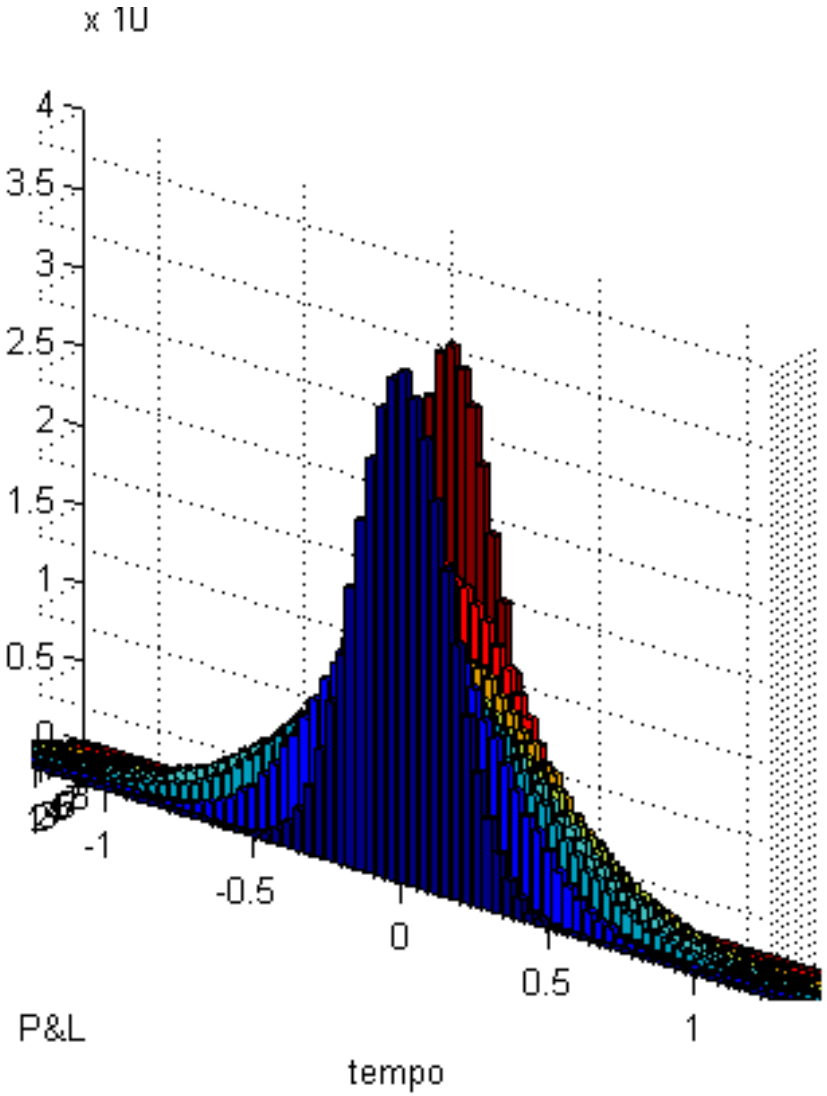
Modular Process



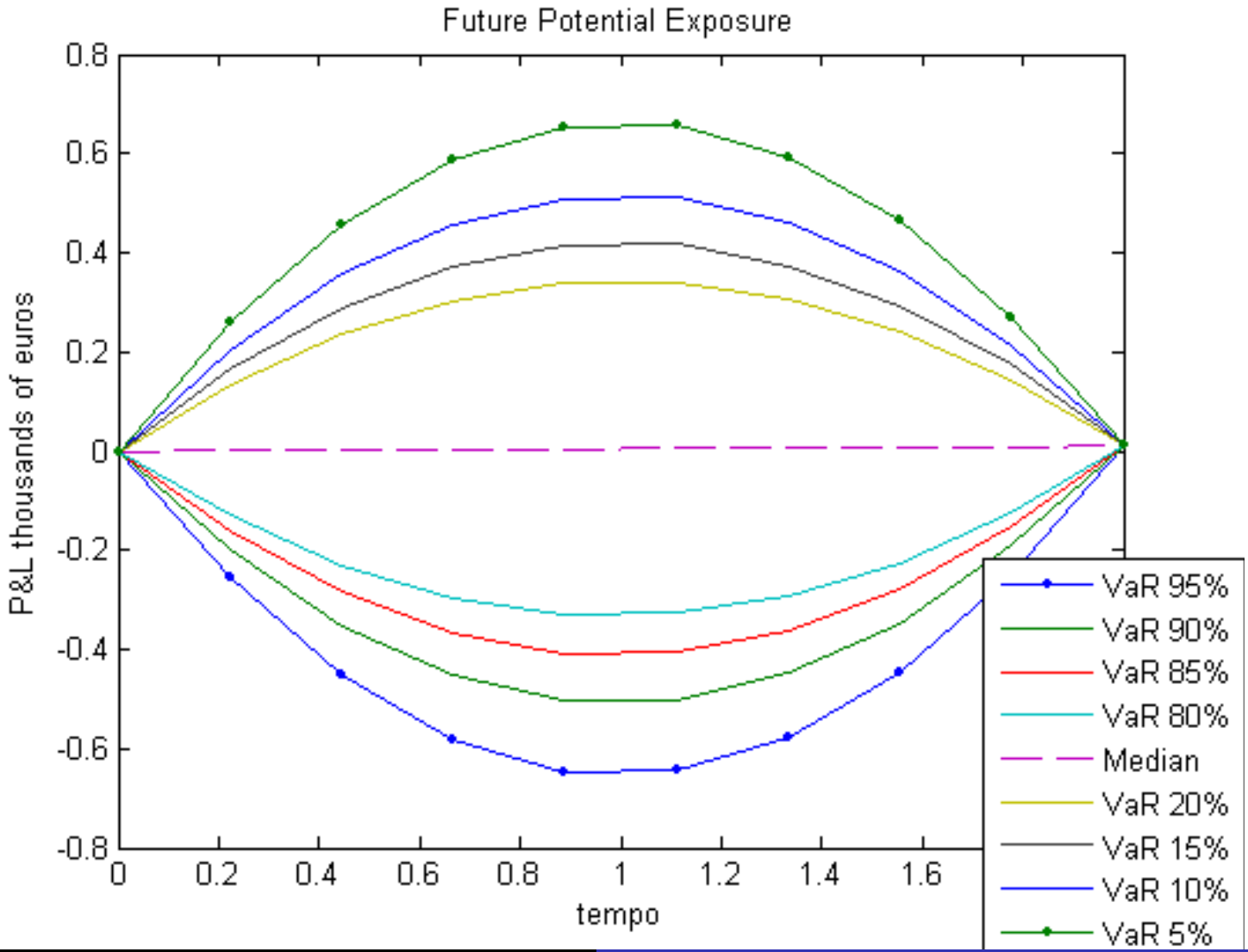
Starting point



Simulated P&L at different times



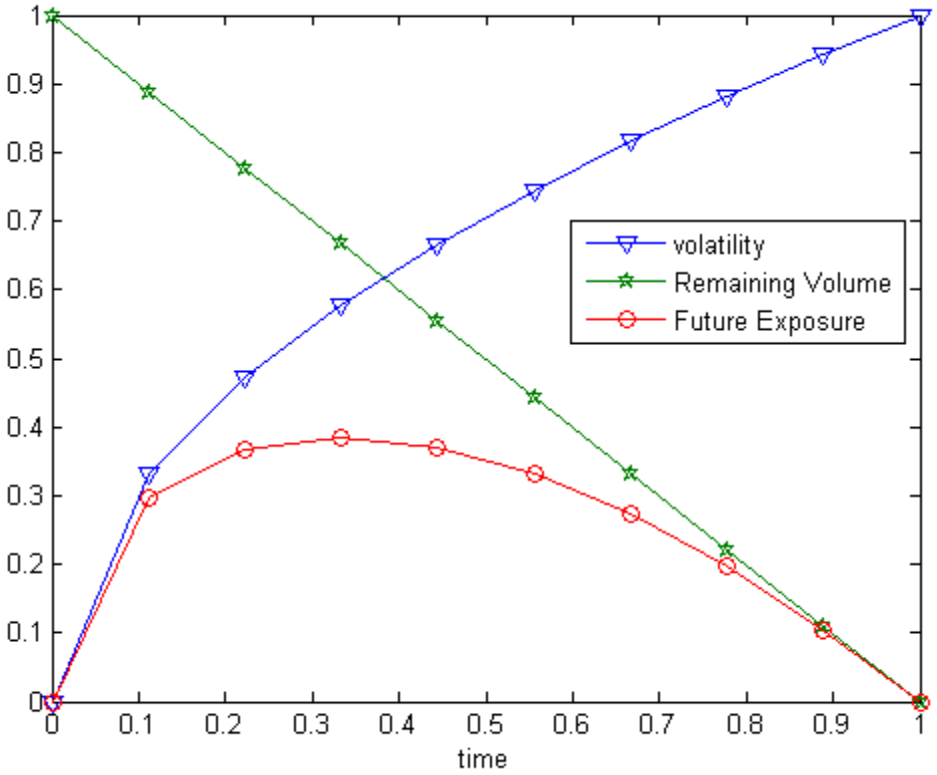
Future Potential Exposure (FPE)



Conflicting Forces

- **Graph's shape** of swaps FloVaR resulting from 2 opposite effects:
  1. Future prices uncertainty increases over time,
  2. Swap's outstanding volume decreases as expiry approaches.

Forces



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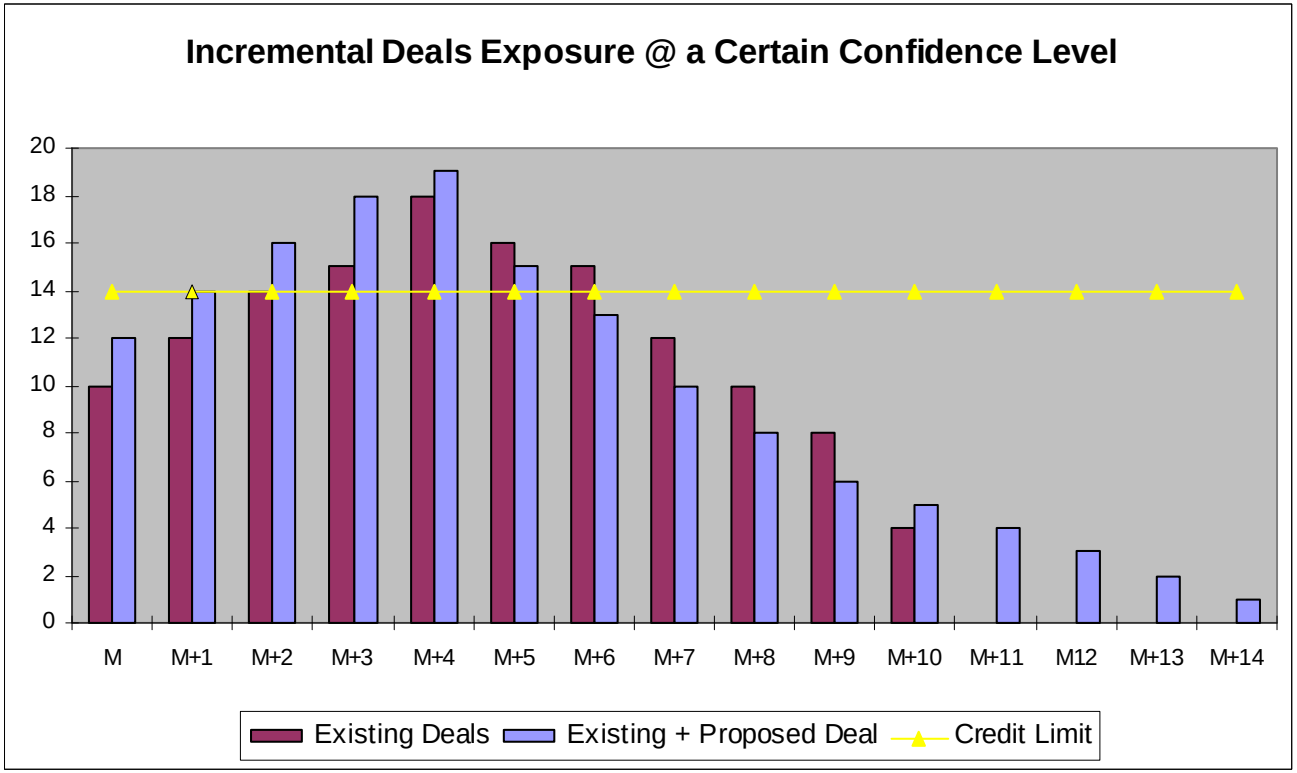
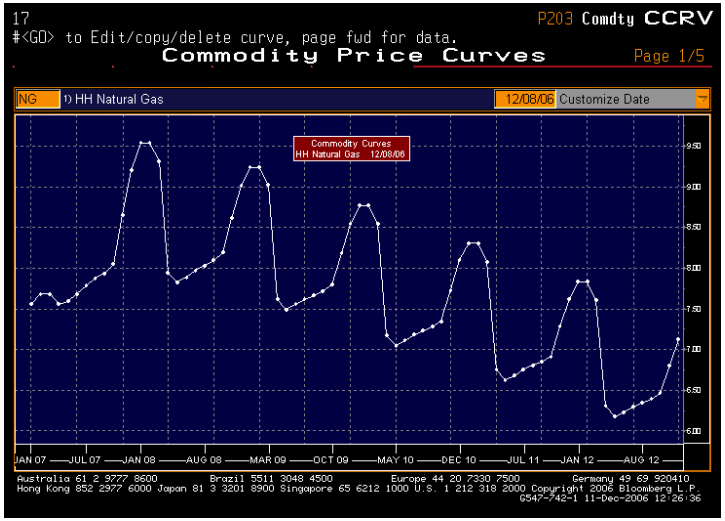
Hot Spots

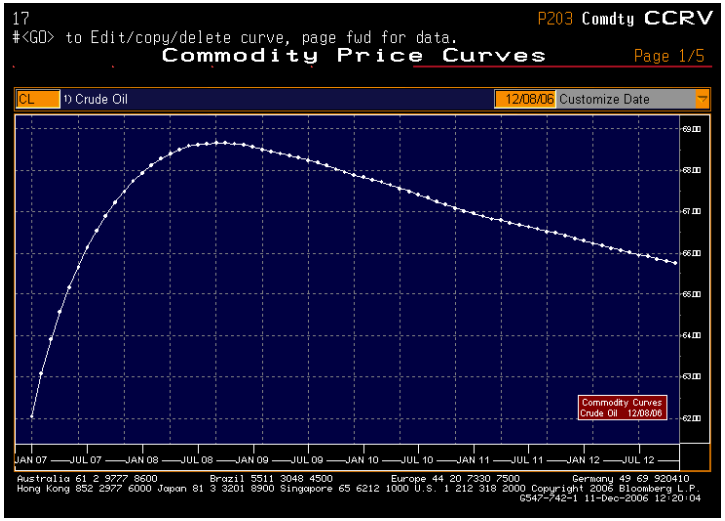
- What is the contribution of an existing deal to the FloVaR?
- What is the contribution of a new hypothetical deal to the FloVaR?

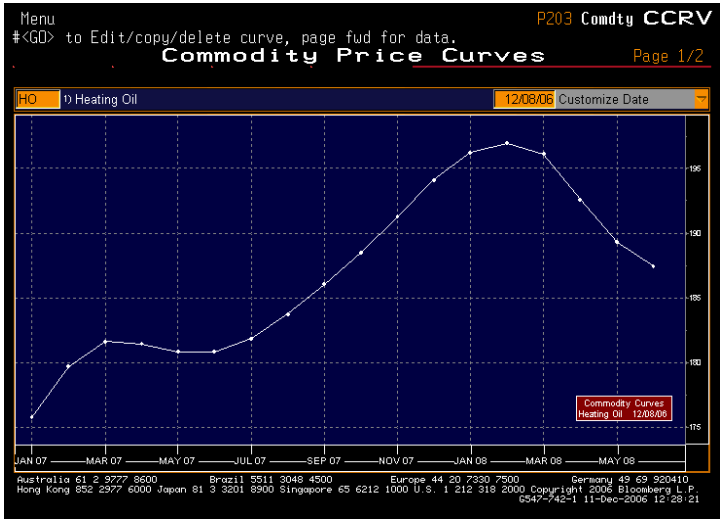


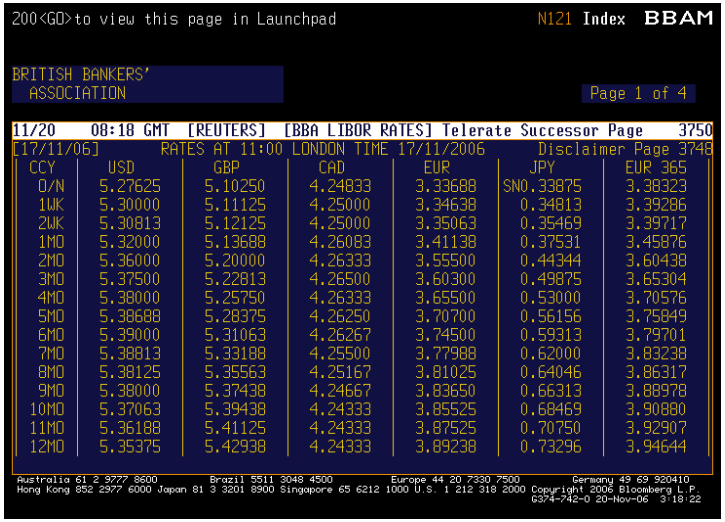
Technical Details

Underlying Prices

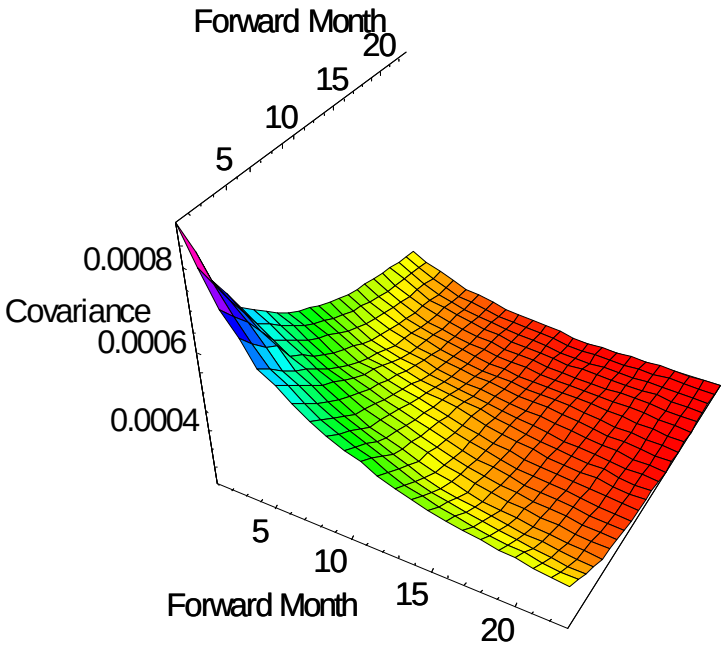


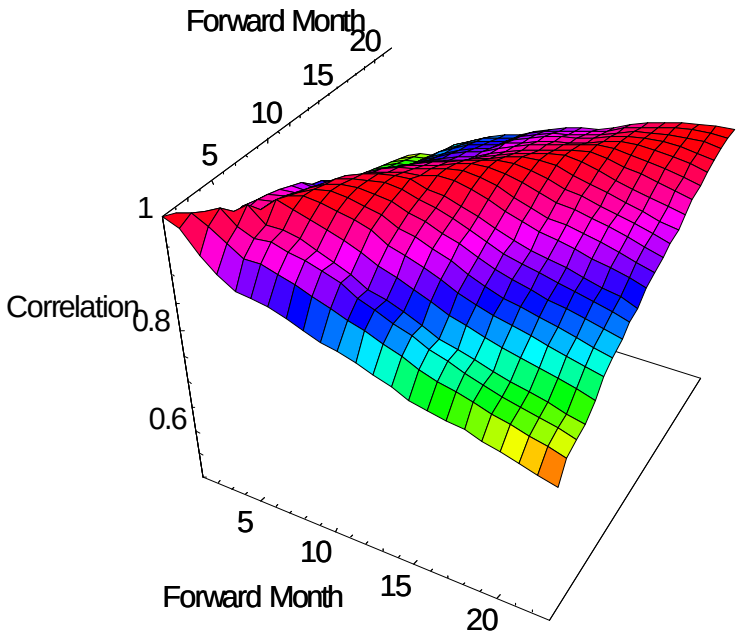






High but not perfect correlation





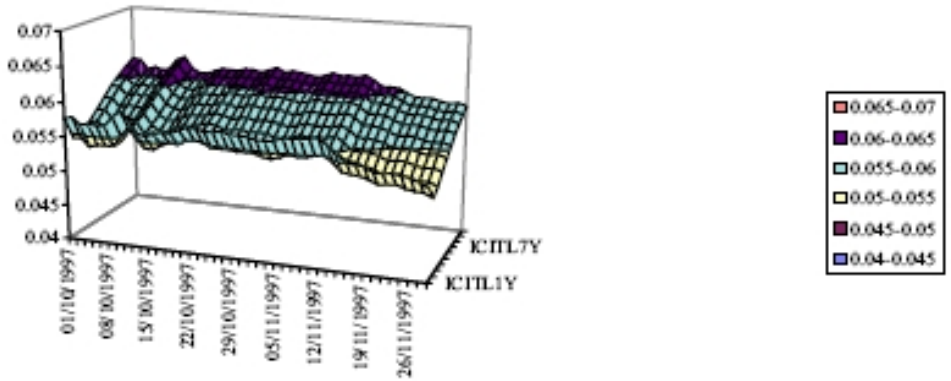
Module 1: Commodity Price Characteristics (PCA)

- **Input**: A time series of forward curves (1 curve = n fwd prices).
- **Method**: Diagonalize the empirical covariance of log-price variations.
- **Output:** Principal Components Decomposition:
  - Eigenvectors $\mathbf{u}^1, ...\mathbf{u}^n \longrightarrow$ uncorrelated shock components,
  - Eigenvalues $\lambda_1, ..., \lambda_n \longrightarrow$ volatility of each component.
- **Reduction**: fix min $m < n$:

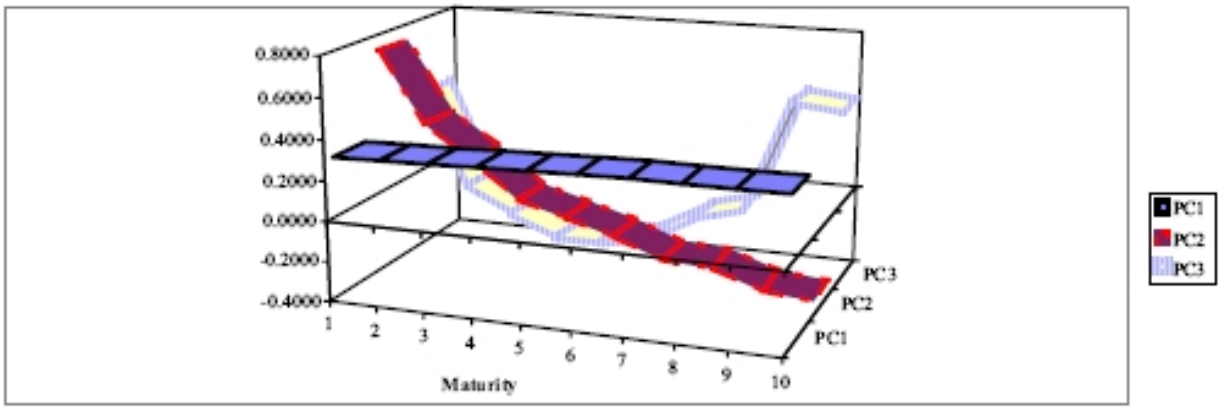
$$\begin{array}{ccc} \text{vol.}(m \text{ components}) & \geq & X\% \text{ of total vol.} \\ \sum_{i \leq m} \lambda_i & & 100X \times \sum_i \lambda_i \end{array}$$

Module 1: Commodity Price Characteristics (PCA)

From a set of Term Structure deformations

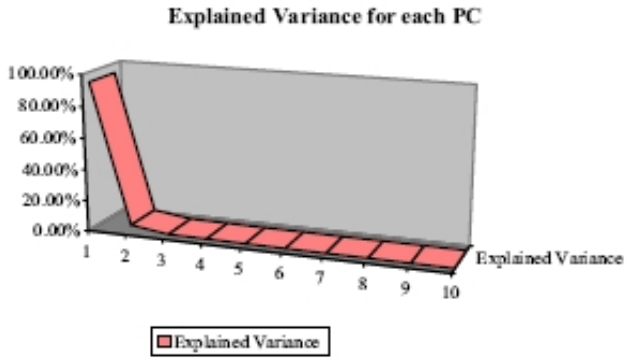


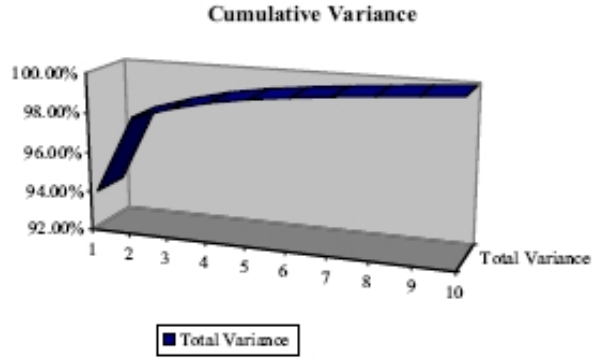
...to the principal ones



Contribution to the Overall Explained Variance of the Different Principal Components

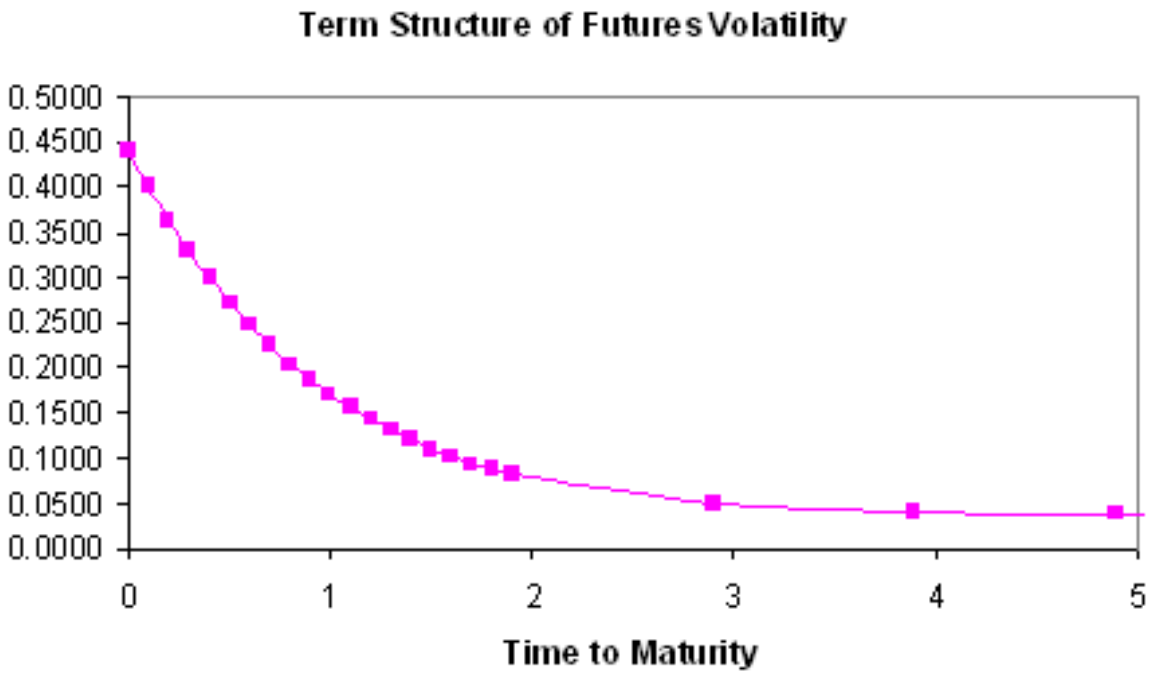
Principal Component	Eigenvalues	Explained Variance	Total Variance
1	2.05E-06	93.82%	93.82%
2	8.63E-08	3.95%	97.77%
3	1.30E-08	0.59%	98.36%
4	9.98E-09	0.46%	98.82%
5	6.90E-09	0.32%	99.14%
6	4.72E-09	0.22%	99.35%
7	4.40E-09	0.20%	99.55%
8	3.51E-09	0.16%	99.71%
9	3.29E-09	0.15%	99.86%
10	2.95E-09	0.14%	100.00%
Sum	2.18E-06		





Other Stylized Facts

- Declining volatility as expiry lengthen (mean-reversion in prices)
- Strong seasonality in spot data and in futures curves



Module 1: Extensions to several curves

- From PCA to Common PCA
- We need to model not only the single curve, but different curves at the same time
- The joint structure with a model that can potentially be used for scenario analysis and for estimating the risk of commodity portfolios.
- The procedure that we identify as preferable is a two-step PCA, with local curves decomposed in the first step and combined local PCs decomposed into a joint structure (PCA of PCs) in the second step.
- This procedure has a key advantage in that it makes any scenario analysis more meaningful by keeping local PCA factors, which have important economic interpretations as shift, twist and butterfly moves of the yield curve.

Module 2: Simulator of Future Prices

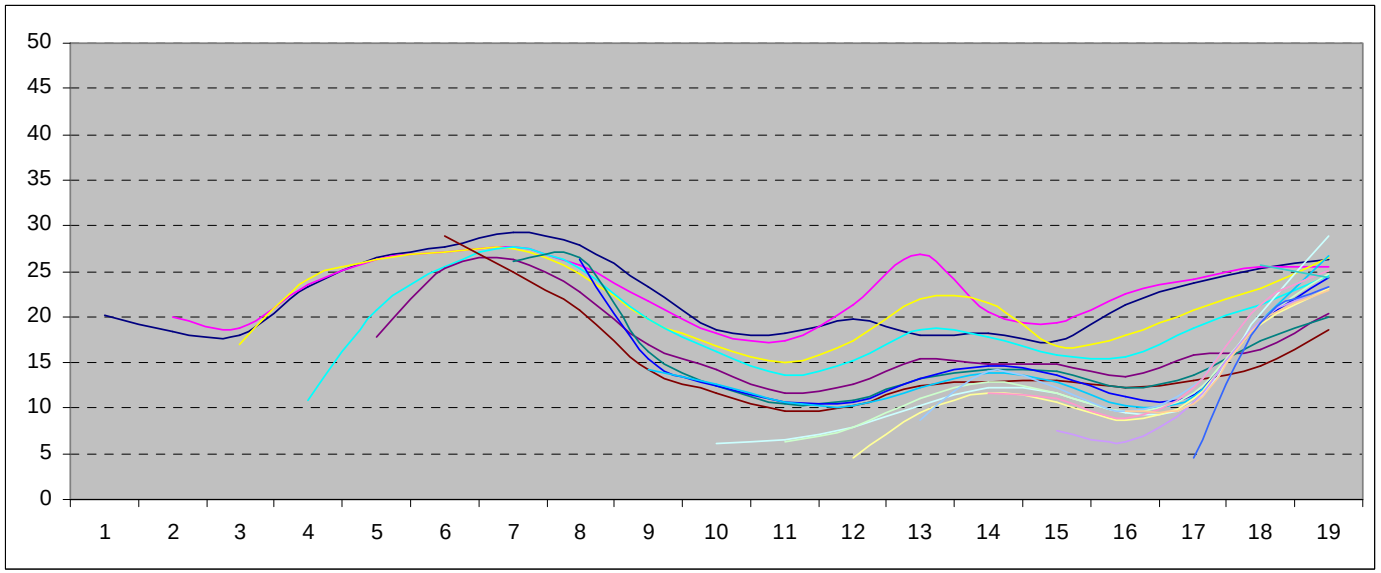
- **Simulated dynamics** across observed times to maturity:

$$\begin{aligned} df_{x_k}(t) &= f_{x_k}(t) \sum_{i=1}^{n} u_k^{(i)} \lambda_i \sqrt{dt} \mathcal{N}_i(0,1) \\ f_x(t_0) &= g(x) \end{aligned}$$

  with $dt = 1$ month.
- **Curve dynamics** $\longrightarrow$ interpolation over assessed points $f_{x_k}(t), k = 1, ..., M$.
- Price scenarios are generated for each **commodity**.
- Each **scenario** actually consists of a set of hypothetical forward curves derived from the current curve.

Module 2: Simulator of Future Prices

Maturity	M1	M2	M3	M4	M5
Time	32.5	32.2	31	30.3	30.1
1		33.2	33.4	33.2	32.8
2			34.1	34.3	34.5
3				34.4	34.6



Module 3: Calculation of FloVaR

- **FloVaR** is calculated in three steps:
  1. For any future date, each position is evaluated over the sample path,
  2. The portfolio is evaluated as a sum of all positions' values,
  3. A sample distribution of the overall portfolio value is derived for each time.

Modules 4 and 5: Simulate Default Event and Expected Loss Assessment

- FloVaR include module **Simulate Default Event** using a historical probability of default approach.
- Each MC iteration delivers a profile of losses which contributes to the overall FloVaR results.
- By excluding points with negative loss and multiplying pointwise by the relative probability of default at the standing time, FloVaR get a **weighed loss profile**.
- Profiles are actualized and averaged to deliver an **expected loss**.

Conclusions

- Portfolio risk assessment must be performed for all (netting) credit exposures on marked-to-market transactions exceeding a certain sizes and maturities.
- FloVar, a web-based version of risk measurement system, is a modular tool allowing for the computation of the potential future exposure at different maturities
- It allows simultaneous modelling of different commodities, taking into account their inter and cross-correlations, mean-reversion and seasonality effects.
- It is also easily extendible to include default risk and it is able to include market view trough a bayesian approach.
- `Gather a supporting group of companies.`