Counterparty Risk – Quantitative Analysis Tools

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Transactions with Credit Exposure

- If counterparty is an exchange like Nymex or ICE, it is treated as having zero risk
- Secured transactions
  – Counterparty is margined
    - When money owed is above threshold
    - Minimum transfer amount
    - Limited credit risk
- Unsecured transactions
  – Counterparty is not margined
  – Maximum risk

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Counterparty Credit Risk

- Risk that counterparty defaults on its obligations, now or in the future, resulting in financial loss
- All of the following factors affect the risk
  - PD - Probability that the counterparty defaults
  - EAD (Exposure at default) – Expected, Maximum Loss if and when counterparty defaults, assuming zero recovery of debts
  - LGD (Loss given default) – depends on how much can be recovered from counterparty in case of default
- Once risk is understood, how is it handled
  - Selecting future counterparties and transactions with given counterparties
  - Modifying contracts and agreements with counterparty
  - Holding capital to cover possible losses

Ways to Reduce Exposure -Netting Agreements

- Within a set (netting set) of transactions with a counterparty, values of all transactions, positive and negative, are summed together and only the net value after summing needs to be exchanged in case of default.
- Maximum exposure is sum of exposures of all transactions in the netting set
- The exposure could be zero after netting

Ways to Reduce Exposure - Margining

- Ask counterparty for collateral
  - Not everyday like an exchange
  - Threshold and Minimum transfer amount(MTA)
  - If

    [amount owed by counterparty if it defaulted today – (threshold + MTA)]>0
  - Then receive from counterparty

    [amount owed –threshold]
- Exposure is limited to
  - threshold +
  - MTA+
  - possible price movement before remaining part of contract is replaced

Exposure at Default (EAD)

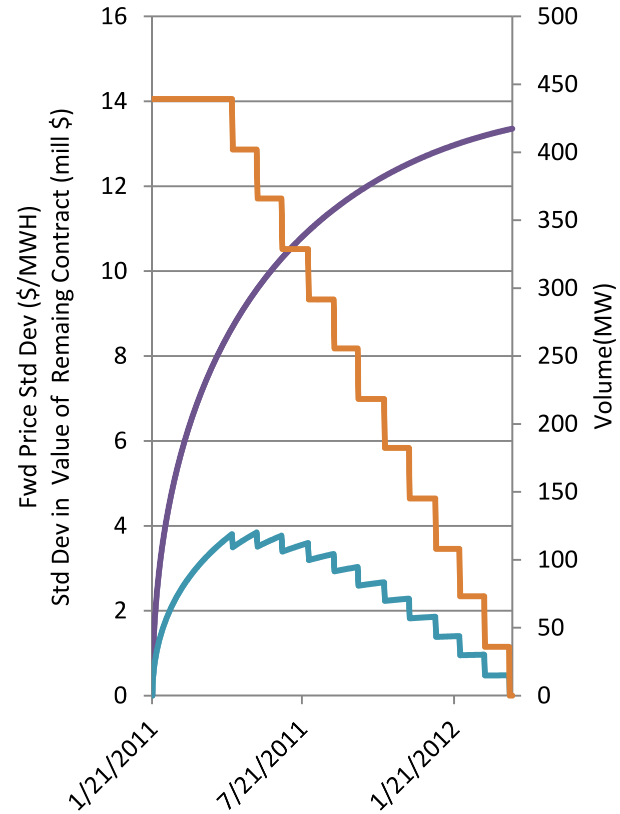
- Exposure to counterparty depends on
  - Contracts with counterparty
  - Netting arrangements
  - Individual contracts
    - Maturity
    - Collateral
      - Threshold
      - Minimum transfer amount

Future Exposure

- If a counterparty were to default today, the resulting loss would be the cost of replacing all the remaining transactions and parts of transactions with the counterparty. This cost is called the "current exposure"
- In case the counterparty defaults in the future, the amount owed will probably be different from current exposure. Depending on duration of various contracts, loss will depend on when the counterparty defaults.
- Future exposure is usually calculated using Monte Carlo simulations of forward prices , along with characteristics of contracts and the netting agreements with the counterparty.

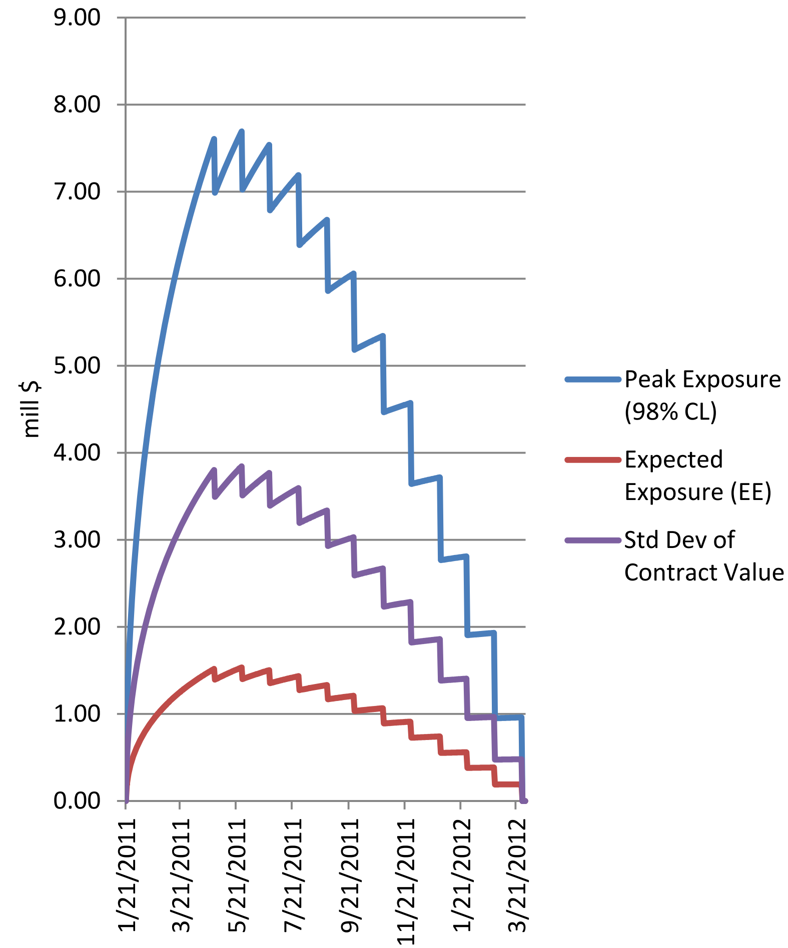
Future Exposure Example

- One transaction with Counterparty
  - Bought forward power from counterparty
    - Equal volumes in 12 consecutive months
    - Unsecured , Initial value=0
    - Delivery starts in 3 months
    - Total exposure period = 15 months
    - Range of defaults dates = 15 months
- If counterparty defaults at time t from now, look at the amount it might owe at the time of default
- Width of probability distributions for forward prices increases as √t, or slower because of mean reversion
- Volume Remaining decreases as $1/(t-t_o)$ after delivery starts at time t_o
- Uncertainty in value of remaining contract varies as a product of the two
- Expected value of remaining contract = 0
- Probability of exposure at time t= probability that value at that time > 0



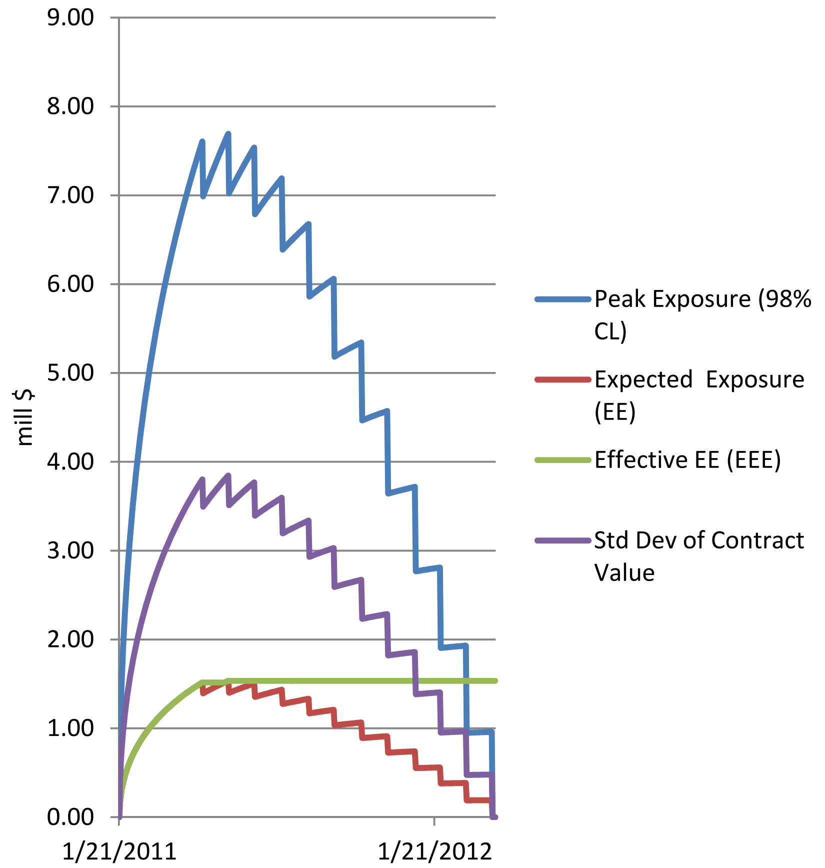
Measures of Future Exposure

- Exposures calculation –
  - Monte Carlo simulation of forward prices
  - calculate values of remaining parts of contracts with counterparty on selected future dates, t_i , spread over period of interest.
- Exposure at given future time t_i is positive if total value of contracts with counterparty is positive, i.e., counterparty owes money, *otherwise exposure is zero*.
- Expected Exposure, EE(t_i)
  - average exposure at time t_i over all trials
- Expected Positive Exposure, EPE
  - average value of expected exposure EE over the whole exposure period under consideration
- Peak Exposure at time t
  - Max exposure at time t at a high Confidence level (98%)



Measures of Future Exposure (Continued)

- Expected Exposure, $EE(t_i)$
  - average exposure at time t_i over all trials
  - Many short term transactions will probably be rolled over
  - If we ignore this probable rollover, the expected exposure in the future may be less than the current exposure
- Effective Expected Exposure, $EEE(t_i)$
  - $\max[EEE(t_{i-1}), EE(t_i)]$
  - Takes care of EE reduction when contracts are rolled over
- Effective Expected Positive Exposure, EEPE
  - average value of Effective Expected Exposure EEE over the whole exposure period under consideration
- Potential Exposure, PE
  - Max of Peak exposures over exposure period



Potential Exposure for Common Trades

- Short forward outright (power or gas)
  - Worst case : Price→0
  - PE limited to initial price of forward
- Long forward outright
  - PE = Max possible price increase (at 98%CL), could be high
- Long Option : (Max possible price increase (at 98%CL) – strike), could be high
- Short Option with premium paid in advance : PE = 0
- Long Physical power/gas – replacement could be high in case CP defaults
- Short Physical power/gas
  - Payment due on 25th / 20th of following month
  - PE = Price of one month and 25/20 days of power/gas
- Physical – receive gas, deliver power to same counterparty
  - 5 day mismatch in billing time causes some exposure

Calculation of Future Exposures and Losses

- Decide on a basic set of market factors which will be initially simulated in the Monte Carlo
  - Factors could be prices, bases, ratios of prices
- Express all future forward prices in terms of these basic factors
- Divide time between now and the expiration of last contract into “time buckets”
  - Finer time intervals for immediate future
- Determine equations that describe evolution of market factors in the future
  - Volatilities of market factors
  - Correlations between market factors
- Simulate market factors with a Monte Carlo simulation at future time buckets
- For each Monte Carlo trial
  - For each time bucket
    - determine exposure related quantities like
      - value of each contract
      - Value of each netting set
      - Sum of exposures from all netting sets for each counterparty
    - Throw random numbers to simulate default and LGD
    - Determine default related loss for the trial from exposure and default number

Example of Future Exposure Calculation

- Transactions
  - Sell 50 MW 5X16 Power 2012
  - Buy natural gas (50 X (Heat rate) X (5X16 Hours) in 2012
- Basic market factors
  - Natural gas forward prices G_i for 12 months of 2012 at various times through 2012
  - 5X16 forward Heat Rates H_i for 12 months of 2012 at various times through 2012
  - Total of 24 factors
- Divide the exposure period into time buckets (t_k, k=1,2,…N)
- Write Equations describing evolution of risk factors between time buckets

$$G_i(t_k) = G_i(t_{k-1}) \times \exp\left[-\frac{1}{2}\sigma_{gik}^2 \times (t_k - t_{k-1}) + \sigma_{gik} \times \sqrt{t_k - t_{k-1}} \times z_{ik} \right] \qquad \text{Brownian motion}$$

$$H_i(t_k) = H_i(t_{k-1}) + \mu_i \times \left[H_i(t_{k-1}) - H_{i0} \right] + \sigma_{hik} \times h_0 \times \sqrt{t_k - t_{k-1}} \times z_{(12+i)k} \qquad \text{Mean Reversion}$$

σ_{gik} is the gas volatility for the forward month i at time t_k

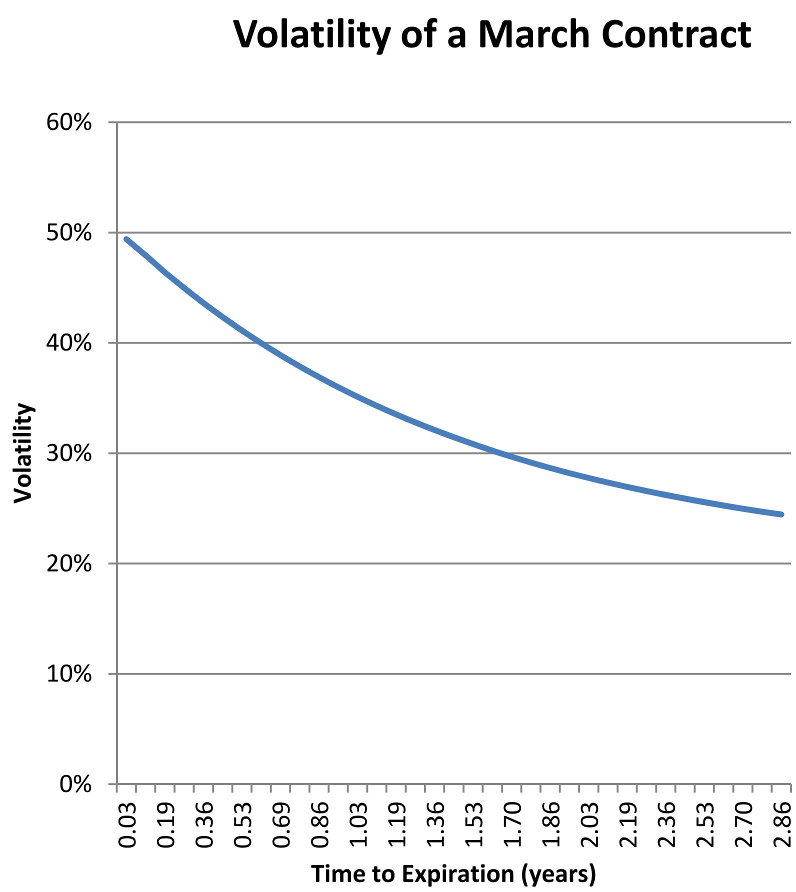
σ_{hik} is the heat rate volatility for the forward month i at time t_k

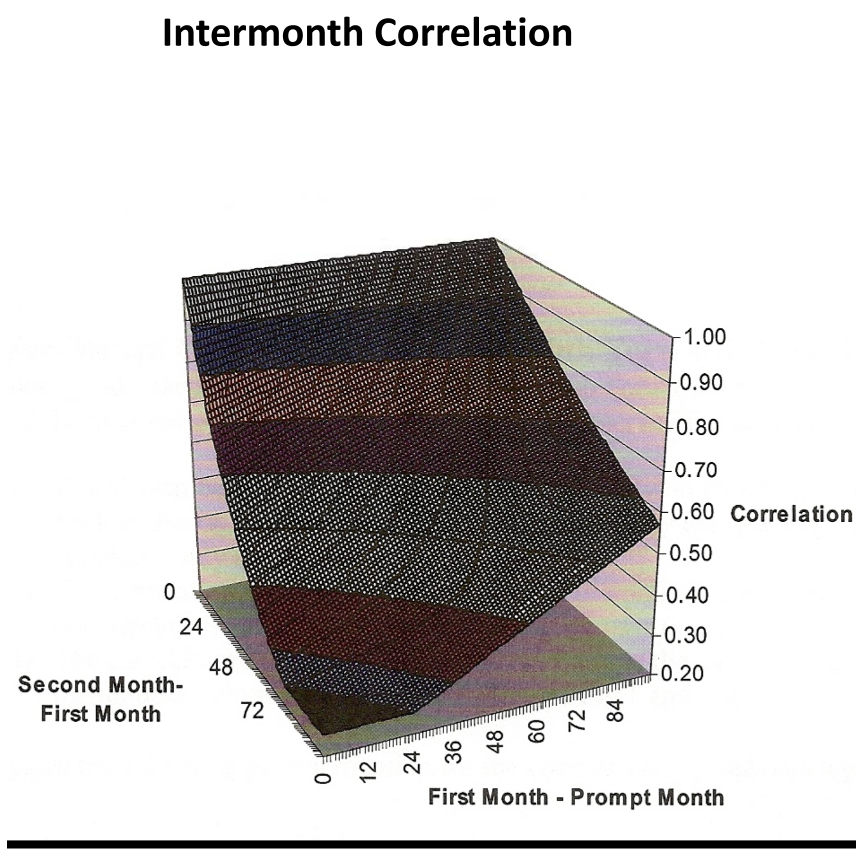
z_{ik} $(\mathrm{i} = 1,2,\ldots,24)$: normally distributed random numbers with specified correlations

μ_i is the mean reversion strength for forward month i

- Volatilities and correlations are determined from historical data and other information

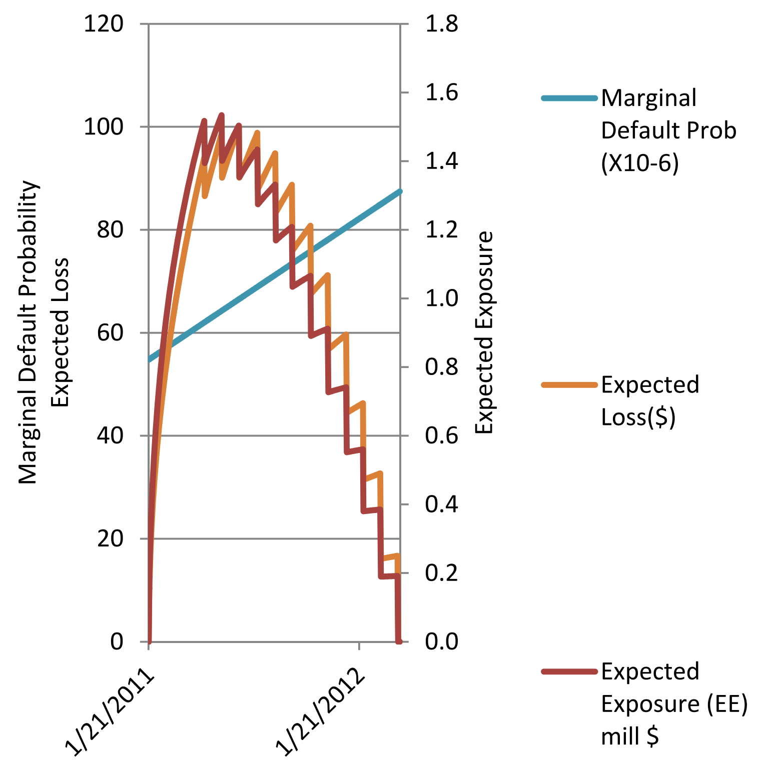
Modeling of Volatility and Correlations for Forward Natural Gas Contracts





Credit Reserves

- Credit Reserve is the expected loss resulting from the nonzero probability that the counterparty will default at a time when there is significant exposure to it.
- This amount should be deducted when calculating expected profit from a transaction.
- Expected loss in a bucket is calculated by multiplying the Expected Exposure by the probability that the default will occur in that bucket.
    - Default probability is estimated using a variety of sources, e.g.,
        - Financial statements
        - Industry Information
        - Credit Ratings
- Credit Reserve is the sum of expected losses in all buckets
- “Funding Benefit” is credit reserve that the counterparty will calculate from its exposure to you and your probability of default



Capital Needed for Surviving Potential Loss from Counterparty Default

- After taking actions to limit counterparty risk
  - Entering netting agreements
  - Selecting/rejecting transactions based on exposure
  - Introducing margining provisions
- There is some residual counterparty risk
- Liquid capital should be held to survive a big loss in case of counterparty default
- Holding capital is expensive
- How much capital is held depends on what is the maximum acceptable probability of an event where the loss exceeds the capital
- The probability distributions for future losses are calculated by extending the Monte Carlo simulations used for calculating future exposures
  - Random numbers simulating default characteristics are generated in addition to those simulating price uncertainty for each simulation path
  - The exposure and the default numbers can be multiplied to calculate loss for a path

Challenges in Determining Required Capital from Exposure

- The potential loss at any time in the future depends on
  - Exposure at Default (EAD)
  - Loss given default (LGD)
  - Probability of default (PD)
- The calculation would be relatively straightforward if the three were factors were independent of each other
- They are usually correlated
- The probability of default might be positively correlated with the exposure (wrong way risk)
  - Example – many retail power suppliers defaulted in 2005 when the power prices shot up in September because they had retail sales that were not hedged
  - If we had a forward contract to purchase power at a fixed price from one of these retail suppliers, our exposure would rise as the forward price increases
  - At the same time the retail company would have more and more margin calls that it will be unable satisfy and it would be more likely to default
- Default being a rare event, the appropriate probability of default is not very well determined
- Estimates of PD and the correlations have large uncertainties
- This makes precise determination of potential loss, and hence the required capital, more difficult

Regulatory Capital

- Basel II Accord – recommendations, including those for *required capital*, issued by Basel Committee on Banking Supervision that banking regulators can use when creating regulations
- Banks can calculate the required regulatory capital using a simplified procedure
  - EAD, PD and LGD are estimated separately
  - The required capital is calculated using these quantities making adjustments in a manner prescribed in the recommendations
  - The adjustments are based on some general observed relationships between the quantities involved in the calculation
  - The analysis of the observed behavior is probably more appropriate for assets that the banks usually deal with

Regulatory Capital and the Energy Companies

- Energy companies are not bound by the same regulation as the banks, but they could use part of the recommendation that is appropriate for them
- Banking industry has vast experience with estimating default related characteristics, and the recommended values of the adjustment parameters involving correlations are probably useful
- However, natural gas and electricity markets have several characteristics that make then different from the usual markets that banks deal with
  - Extreme segmentation in geographical regions
  - Limited or no storage for the commodity
  - FERC regulation
  - Many prices that are set by regulatory agencies (installed capacity)

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Regulatory Capital Calculation

- The components used to calculate required capital
  - EAD – exposure at default - calculated for a netting set
    - Internal Models Method – use your own model to calculate EAD
      - $EAD = \alpha \times$ Effective EPE
      - α accounts for factors like
        - » correlations between counterparties
        - » model risk
        - » risk that the economy may be in a bad state
      - $\alpha = 1.4$, value as low as 1.2 can be used if approval is obtained to calculate ones own
- PD – probability that a counterparty defaults in a given year
- LGD – Loss given default, calculated for an economic downturn situation
- $Adj_{Maturity}$ = Maturity adjustment for remaining maturity > 1 year
  - Takes care of possibility of future downgrades of the counterparty credit rating
  - Larger adjustment for smaller probability of default
  - Internal Models Method – use your own model to estimate

Regulatory Capital Calculation
Advanced Internal Ratings Based Approach

$$C_{\mathrm{Reg}} = EAD \times K \times Adj_{Maturity}$$ Regulatory Capital

$$K = LGD \times N\left(\frac{N^{-1}(PD) + \sqrt{\rho}\,N^{-1}(0.999)}{\sqrt{1-\rho}}\right) - LGD \times PD$$ Designed to protect at 99.9% CL

$$\rho = 0.12 \times \frac{1-\exp(-50 \times PD)}{1-\exp(-50)} + 0.24 \times \left[1 - \frac{1-\exp(-50 \times PD)}{1-\exp(-50)}\right]$$ Asset Correlation

$$Adj_{Maturity} = \frac{1+(M-2.5)\times b}{1-1.5\times b} \qquad b = \{0.11852 - 0.05478 \times \ln(PD)\}^2$$

$$Adj_{Maturity} = 1 \text{ if remaining maturity} \le 1 \text{ year}$$

$$M = 1 + \frac{\sum_{t_k > 1 year} EE_k \times \Delta t_k d_k}{\sum_{t_k \le 1 year} Effective\ EE_k \times \Delta t_k d_k}, \qquad \text{M} \le 5 \text{ years}$$ Effective maturity

$t_k = time$ from now to time bucket k in the future

$\Delta t_k = width$ of time bucket k $\qquad d_k = discount$ factor for time bucket k

Credit Default Swaps (CDS)

- The risk due to counterparty default can be mitigated using a credit default swap
- The purchaser of the swap
  - makes regular payments
  - receives big payment in case the counterparty default
- Seller is exposed to default of seller if sale is not cleared on exchange
  - ICE has plans to start clearing trades involving CDS
- Cost of buying protection through CDS is close to expected credit loss, and hence depends on the exposure
- Example
  - Purchase forward power for Jan 2012 from counterparty A
  - Buy CDS to protect against default of counterparty A
  - If forward price increases, exposure increase, more CDS's have to be bought
  - One can buy forward power to pay for the increased cost of CDS's as the forward price goes up
- Contingent Credit Default Swaps
  - The payment in case of default can be linked to forward price at time of default

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Example of Calculation of Short Term Liquidity Needs

- Cleared Trades (counterparty is exchange)
  - Daily margining
  - Estimate maximum collateral (95% CL) needed during the next few days
  - Procedure similar to VAR calculation
- Look at recent daily changes of the portfolio
- Estimate standard deviation of daily change of portfolio value from historical data.
  - From volatilities and correlations of individual market factors

    Or
  - Tracking value of current portfolio over recent past and measuring standard deviation of daily changes
- Simulate changes in portfolio value using standard deviation
  - Estimate max change in portfolio value at 95% CL over the next few days

Challenges in Estimating 5-day Collateral Need or VAR

- Which time window to use for determining standard deviations and correlations for estimating range of future changes
  - Standard deviations vary considerably over short periods
    - Surges in volatility for short periods
    - Estimate of required capital or collateral needs to be responsive to these surges
    - Otherwise one might hold too much capital most of the time and yet underestimate the required capital when the volatility surges
- With statistical analysis, the higher the confidence level demanded, the more unreliable the result
  - To obtain results at higher CL we extrapolate into ranges of values of variables, where there is limited historical data.
  - Usually higher CL results depend on a strong assumption that the whole distribution, including the part that has not been seen before, is described by one normal distribution
  - The parameters of the normal distribution are obtained from a central part, which might be consistent with one normal distribution
  - These parameters are used to estimate the population in the tails

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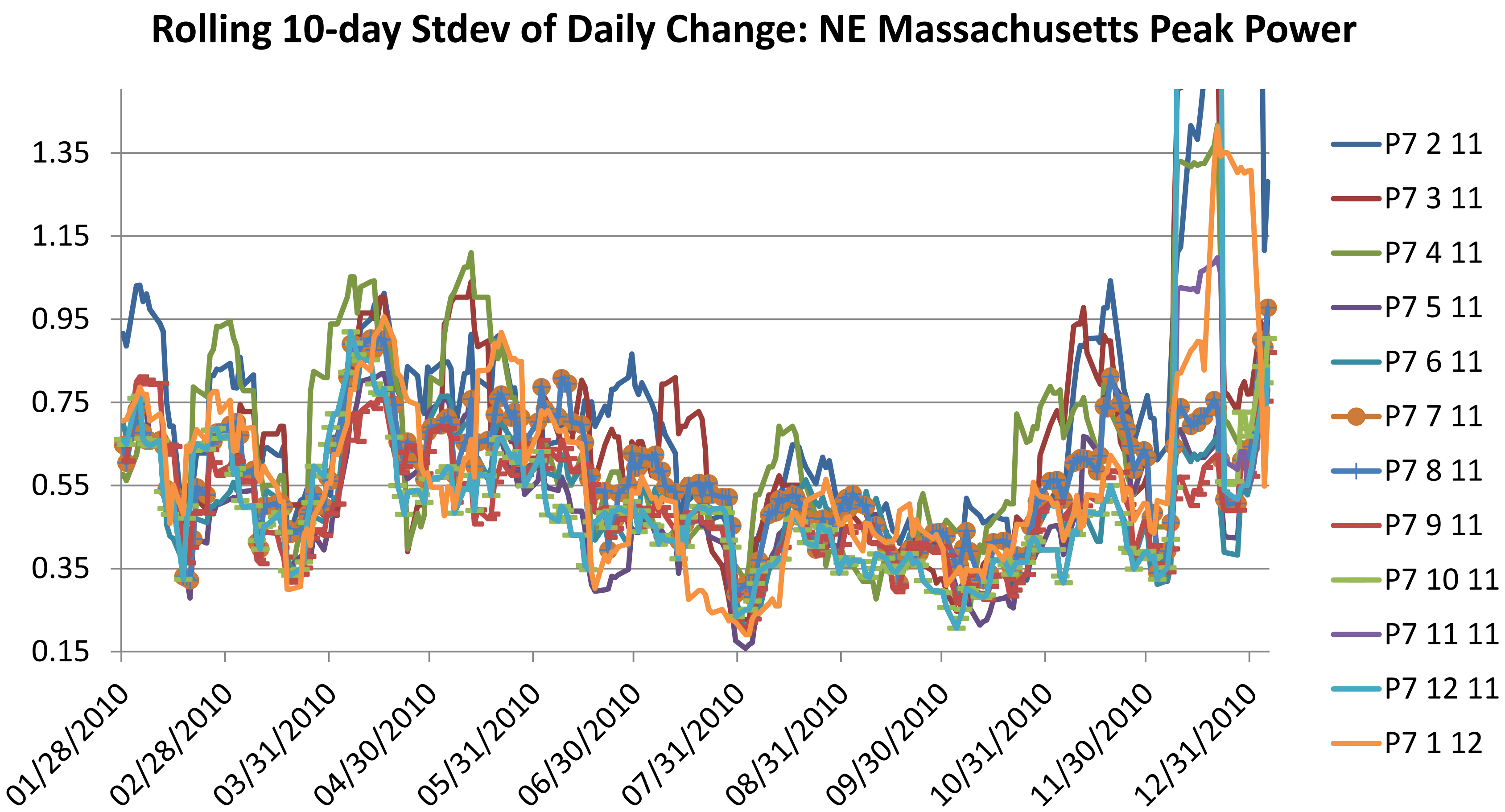
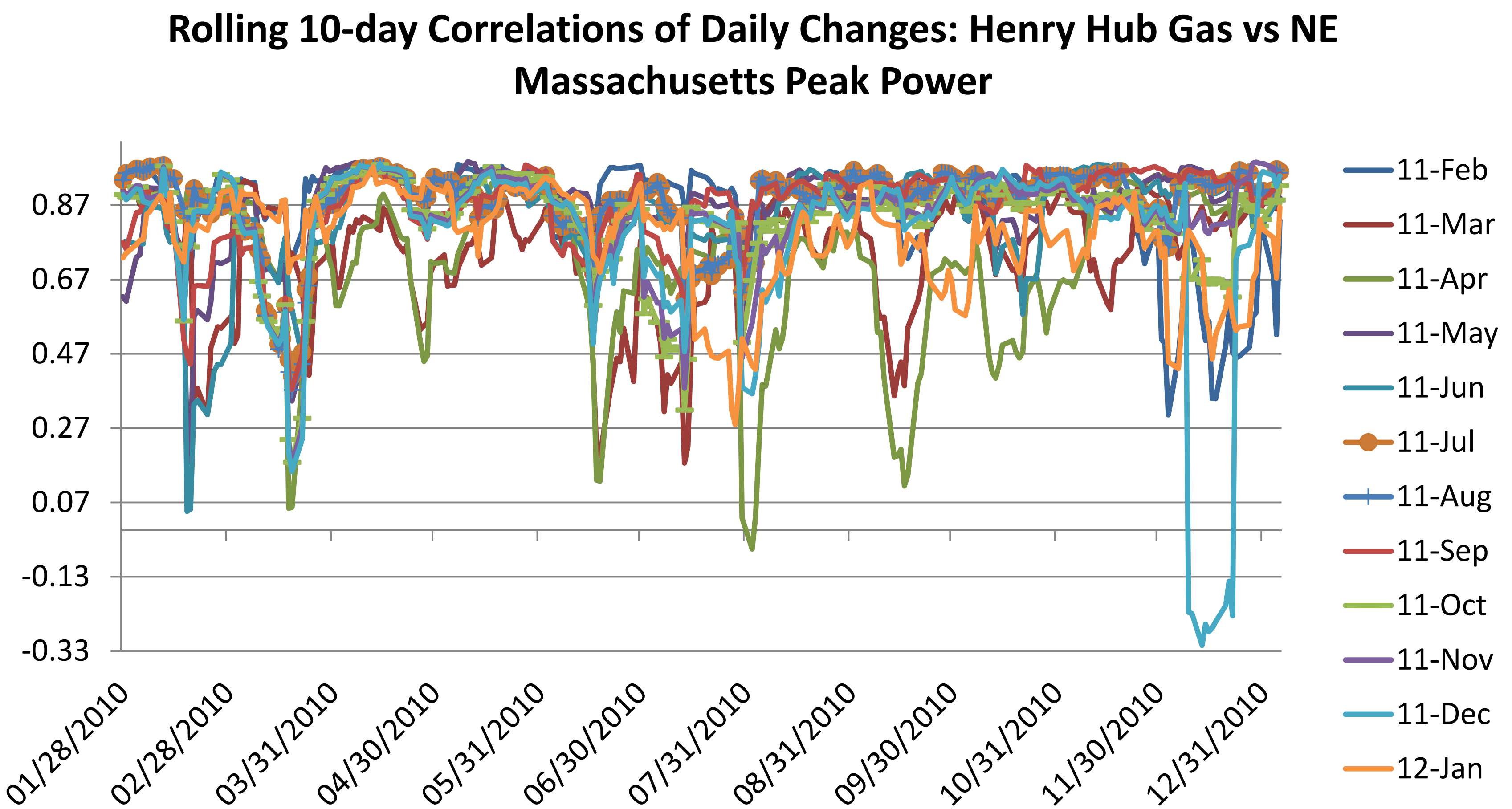
Choosing the Time Window to Calculate Historical Standard Deviations of Forward Prices



Choosing the Time Window to Calculate Historical Correlations Between Forward Prices



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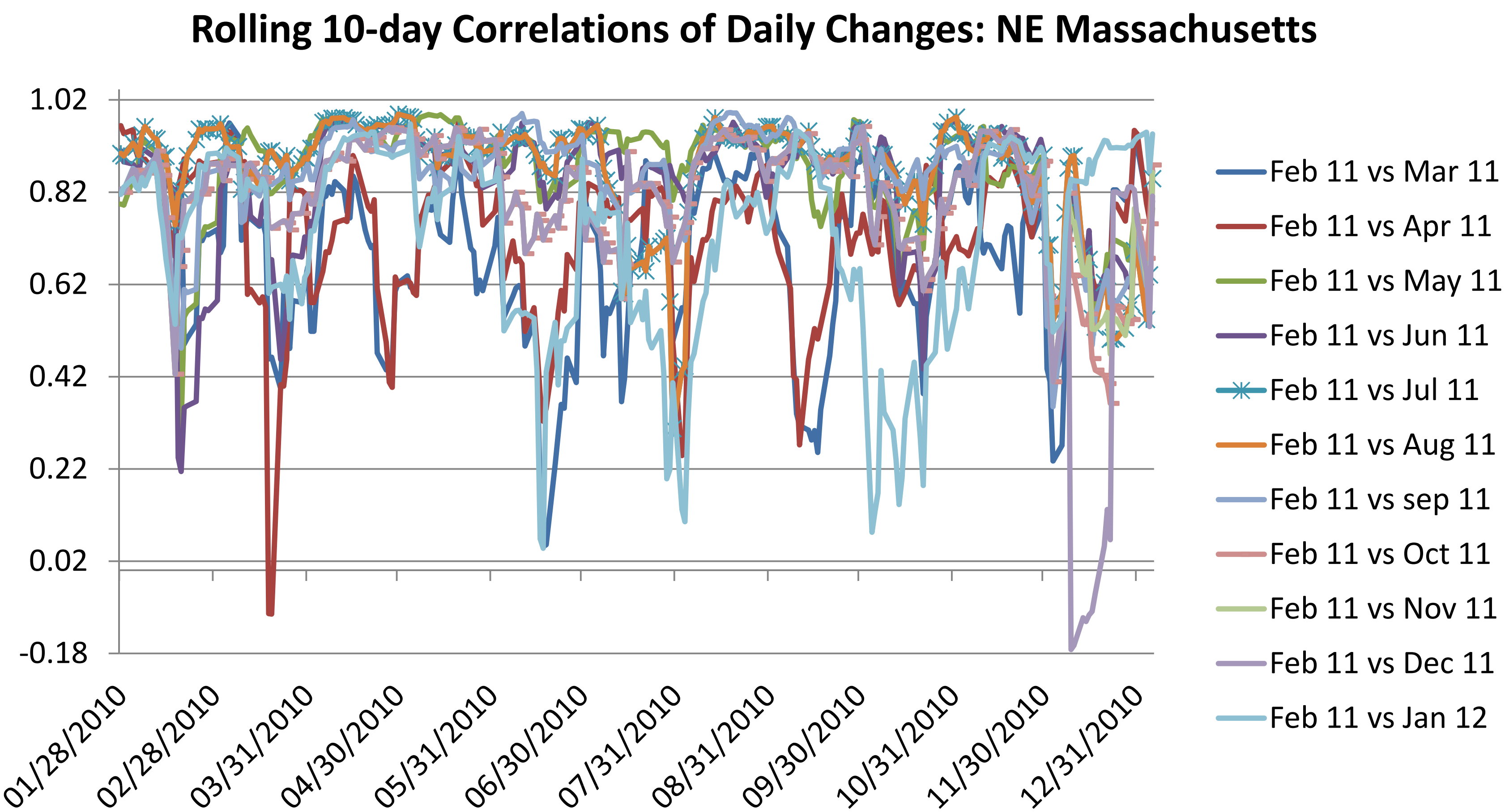

Issues in Estimating 5-day Collateral Need or VAR Suggestions

- Time window to use for determining standard deviations and correlations for estimating range of future changes
  - Use of a wide time window to calculate standard deviations results in holding too much capital most of the time and yet underestimating the required capital when the volatility surges
  - The width of the window used should be of the appropriate width decided by looking at recent historical data
  - The appropriate width depends on the exposure period for the collateral or the VAR
- For results at high CL, that is, for covering extreme scenarios
  - Risk should be estimating using other means in addition to statistical analysis
  - Consider plausible scenarios that could cause extreme changes
  - It might be difficult to say exactly how unlikely a rare an extreme scenario would be
  - It might be possible to place a reasonably low limit on the probability for the scenario
  - However it would take an extremely good understanding of all the rare events that could possibly occur to be able to say whether a certain collateral covers needs at a 99.2% CL or 99.8% CL.

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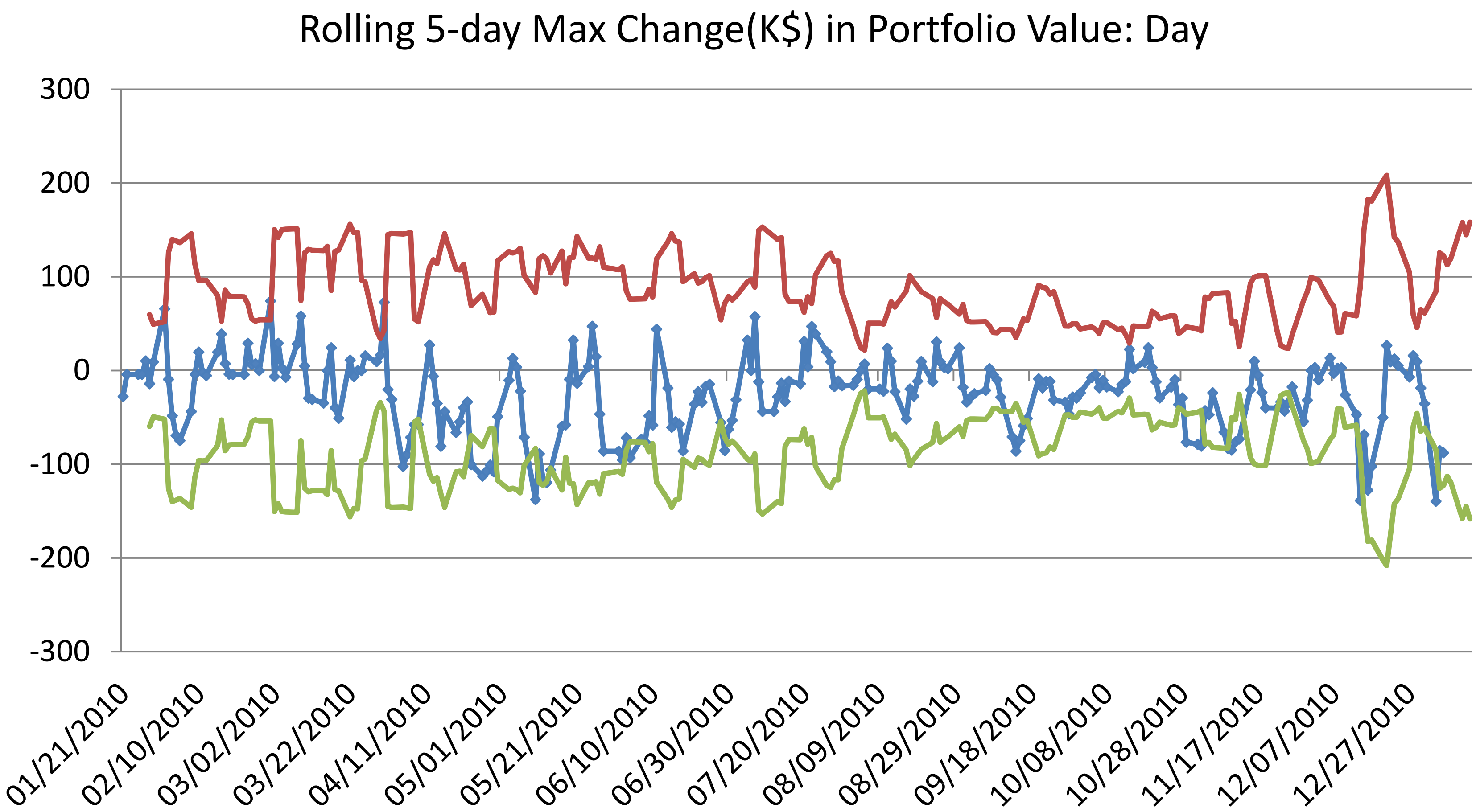
Estimating 5-day collateral Needs



Pitfall in Treatment of Correlated Variables

- Reliable and reasonably precise determination of value of a trade is one of the first steps risk calculation
  - Reliable value - one can make the opposite trade at a value that lies within the estimated range
  - "Reasonably precise" - if the range of values is narrow enough for the valuation to be useful
- A common pitfall when valuing a trade that involves two correlated variables
  - Example : Forward Spark spread Option
  - The value is usually expressed in terms of
    - Forward power and natural gas prices
    - Forward power and natural gas price volatilities
    - Correlation between natural gas and power prices
- If the trade is being marked to market, all of the 5 inputs value should be current – it is a package deal
- Pitfall
  - Get the forward prices from the market
  - Use historical correlations, because correlation value is not available in the market
- Volatilities and correlations can vary wildly from week to week or day to day
- When volatilities are high, power and gas price might move together, that is with higher correlation, so the value of option, or related quantities like value of generation capacity, are fairly stable
- If the volatilities during a cold wave, when the price are volatile, are used along with some historical average correlation, the value of the option can be grossly overestimated

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Conclusions

- Counterparty credit risk, like other risks, can and should be managed.
- It can be reduced substantially by evaluating and limiting potential exposures
- Netting and margining can be used to reduce the exposure
- Credit Default Swaps can be used to mitigate counterparty credit risk
- Understanding and limiting counterparty credit risk requires reliable modeling of evolution of the portfolio during the exposure period
- The residual risk after all the actions taken to reduce the risk, is managed by holding capital to handle unexpected losses
- Basel II guidelines are useful in determining the magnitude of the capital
- Exposure calculations for counterparties in power and gas have to address several features that are unique to these markets