Cashflow-at-Risk

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April 23rd, 2003

What is Cashflow-at-Risk (CfaR)

- Definition:

  "The maximum shortfall of net cash generated, relative to a specified target, that could be experienced due to the impact of market risk on a specified set of exposures, for a specified reporting period and confidence level" *(1)*

- Within the context of electric utility procurement, CfaR can be used to gauge expense level at the worst-case scenario given the portfolio's net short position

- Variable cashflow components include spot purchases for electricity and fuel, hedging expenses, etc.

(1) Source: RiskMetrics Group (spin-off from J.P. Morgan). This presentation is based on their CorporateMetrics framework to measure market risk for non-financial corporations.

General Approach

Cashflow Mapping

Identify all the input variables (or cashflow components) subjected to market risk that go into the cashflow equation.

Market Rate Forecast

Specify a set of future dates and obtain the forecast distributions of the cashflow components for each of these dates

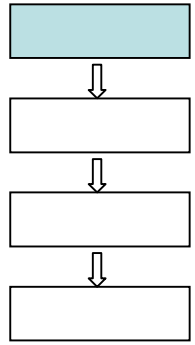
Scenario Simulation

Use Monte Carlo simulation to generate scenarios based on the joint distributions of the cashflow components

Risk Estimation

Calculate the risk measure under each scenario; based on the simulation results, determine the value of cashflow-at-risk

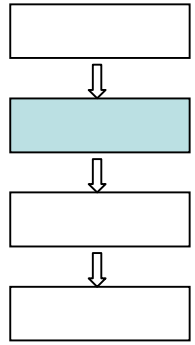
Cashflow Mapping



- Market variables that affect procurement expenses:
  spot price (energy/gas), forward price (energy/gas), interest rate…

- An example of a cashflow map:
  Energy Procurement Expenditure in May'03
  (unhedged position)
  = *spot electricity price to cover net short energy*
  + *spot gas price to cover fuel cost of tolling contracts*

Market Rate Forecast



- Problem: forecast the mean and variance of the probability distribution of one or more market variables

- Two approaches to estimating market rate distributions:

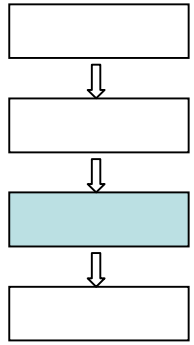
  (1) Extrapolate from current market information
  - the "Efficient market hypothesis" implies that market expectations are embedded in current market prices
  - Example: estimate mean values of future spot price from forward prices; estimate variance based on market rate volatility

  (2) Econometric modeling
  - Construct econometric forecasting model based on historical information
  - Single variable or multivariate autoregressive model
    e.g. $x_{(t)} = a + b*x_{(t-1)} + c*y_{(t-1)}$
  - Limitations: difficult to define the functional form of the model; may not work too well for non-storable goods with high degree of seasonality

Market Rate Forecast (cont'd)

- Estimating market volatility
  - Implied volatility based on current option price
    - Derived from the Black-Scholes option pricing model
    - useful for comparing options
  - Forecast volatility based on forward price curve
    - may not be accurate if the market is thinly-traded
  - Historic volatility based on historic prices
    - volatility is derived from a rich set of historic prices
    - Will depend on the time period chosen for the calculation

Scenario Generation

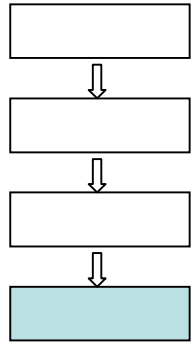


- Based on the forecast results of the market rate distributions, build covariance matrix to take into account the joint fluctuations of prices at different time horizons (2)
  - Price correlation across multiple periods
    - Example: construct a 3 x 3 covariance matrix for the price of gas at 3 forecast periods (expressed in terms of the variance forecasts)
  - Cross correlation between market variables
    - Example: construct a 3x3 cross covariance matrix for the price of gas and electricity over 3 forecast periods (need to estimate correlation coefficient between the two market variables)

- Given the expected values of the market variables and the covariance matrix, run Monte Carlo simulations to generate prices at the forecast dates

(2) See calculation details in the "LongRun Technical Document" from the RiskMetrics Group

Risk Estimation



- Apply the simulation results to the cashflow map to obtain a distribution of the possible cashflow outcomes

- Plot the results in a histogram

- The following risk measures can be interpreted from the resulting plot (based on our example of procurement expenditure):
  - Average procurement expenditure
  - Standard Deviation
  - Maximum procurement expense, based on, say, a 95% confidence level *(cashflow-at-risk is the difference between the expense level at the 95% confidence and the target expenditure level)*

- Results are used in developing a procurement strategy

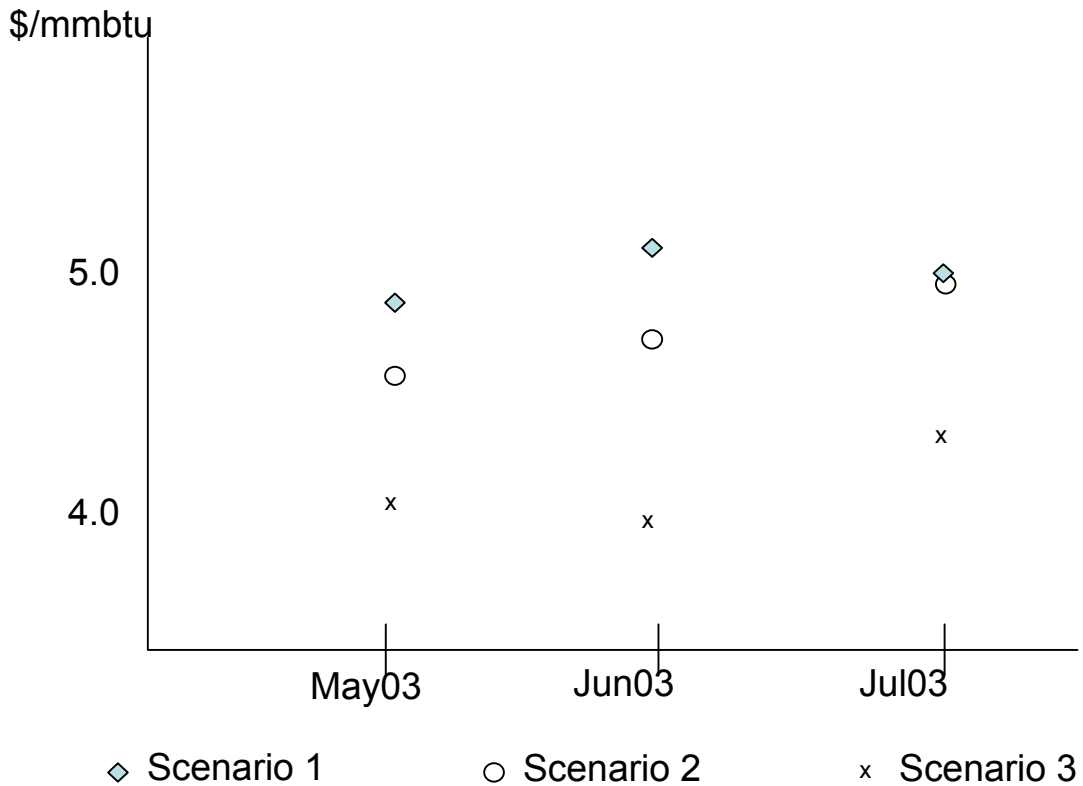
Example

- Calculate the CfaR on total fuel expenditure for a tolling contract with fuel delivery in May03, Jun03, and Jul03
  - Cashflow Map:
    10,000 therms * $P_{gas}(t_1)$ + 15,000 therms * $P_{gas}(t_2)$ + 19,000 therms * $P_{gas}(t_3)$
    where 10000, 15000 and 12000 are demand forecast for t_1, t_2 and t_3
  - Obtain future price quotes at t_1,, t_2, t_3
  - Calculate the 1month, 2 month and 3 month volatility values for gas prices based on historic gas prices
  - Construct the covariance matrix for gas prices in a 3-month period
  - Generate scenarios using Monte Carlo simulation
  - Calculate the fuel expenditure under each scenario and plot out the results
  - Calculate the CfaR at 95% confidence level based on the simulation results

Scenario Generation

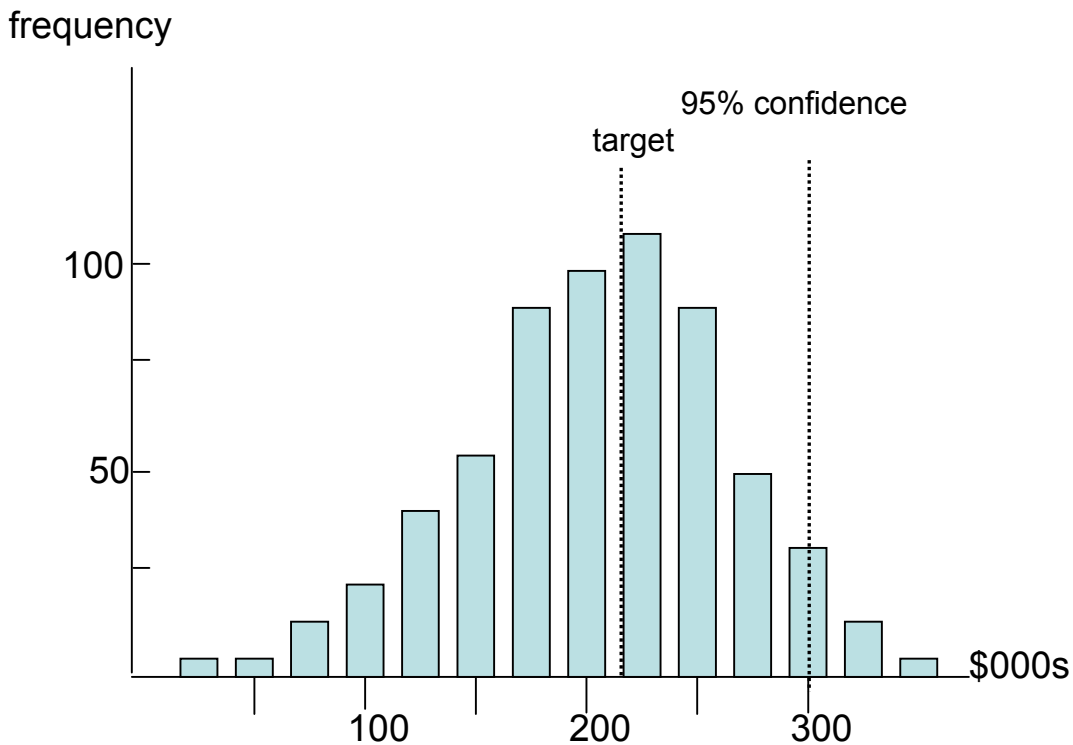
Below are the results of 3 simulation runs for gas prices in May, June and July (hypothetical)

Cashflow Map: 10,000 therms * $P_{gas}(t_1)$ + 15,000 therms * $P_{gas}(t_2)$ + 19,000 therms * $P_{gas}(t_3)$



Example

Distribution of 3-month fuel expenditure

Using the results of 1000 simulated runs, calculate the 3-month fuel expenditure for each run, and plot out the fuel expenditure distribution.

Result: < 5% chance that fuel expenditure for the 3 months will exceed $300K if target expense level is $210K, cashflow-at-risk = $90K