Energy Finance / INREC 2010

Essen, October 2010

Gas storage valuation using a multi-factor price process

Alexander Boogert

www.kyos.com, +31 (0)23 5510221

What drives the value of gas storage?

Maximum volume

Max. injection/withdrawal rates

Operational limitations

} Physical aspect

Forward curve

Price volatility

Cost injection/withdrawal

Interest rate

} Economic aspect

Gas storage valuation: market perspective

Strategy	What do we trade?	Multi-factor price process
Rolling intrinsic	Complete forward curve	Easy to implement
Spot-based	(In principle) only spot action	**Possible! Current talk**

Starting point

Boogert & De Jong - Gas Storage Valuation Using a Monte Carlo Method (Journal of Derivatives, Spring 2008)

Adjust Least-Squares Monte Carlo to gas storage valuation

- Use 1-factor price process for simulation
- Include only spot prices into regression

Key results:

- Values converge well for few paths
- Results stable when using different basis functions (powers and b-splines)

KYOS

Multi-factor price process

Multi-factor needed to capture realistic price behavior

Multi-factor relevant for risk management

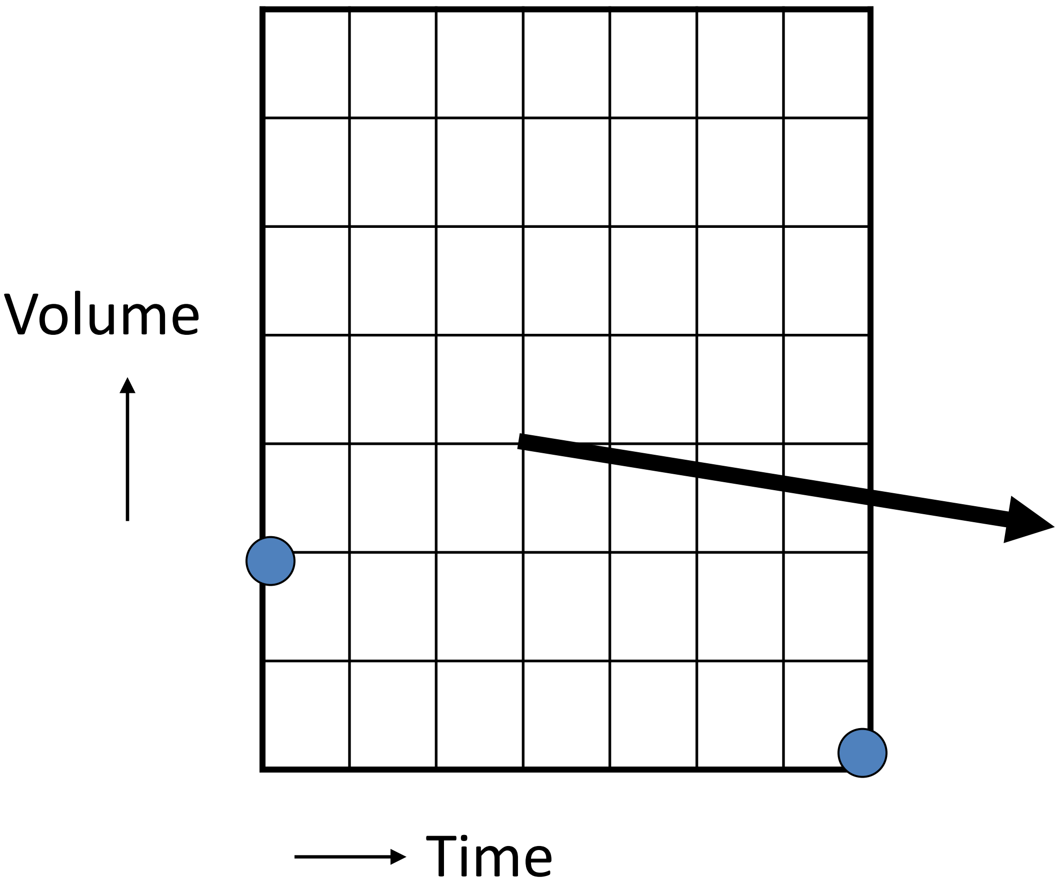
Different specifications available

Our price process contains three factors:

1. Spot factor (as 1-factor Schwartz model used in starting point)
2. Long-term factor
3. Winter-summer factor

Note: this model has not been published in the literature so far

Gas storage pricing problem



Possible decisions:

- Inject
- Do nothing
- Withdraw

In each time step:
find optimal decision
dependent on
price and volume.

American option: compare continuation value and exercise value
Gas storage: compare different continuation values

Least-Squares Monte Carlo – one factor storage

Determine relevant state variables

Generate large number of scenarios

Work backwards, derive exercise boundaries by estimating continuation values as a function of current prices and other state variables

X = gas price now

Y = discounted value of subsequent cash flows

For each path determine continuation value via

$$E[Y \mid X] = c_1 f_1(X) + c_2 f_2(X) + \ldots$$

for basis functions f by least-squares regression

KYOS

Multi factor optimization

Original Longstaff-Schwartz article already considered derivatives based on multi factor price process

With two exceptions [KYOS (2006), Li (2007)], this appears not to have been picked up in gas market

LS example: value cancelable index amortizing swaps

- Swap term structure driven by two independent processes: X Y
- Use 9 basis functions
  - Constant
  - First three powers of value underlying non-cancelable swap
  - X X^2 Y Y^2 XY

KYOS

Multi-factor optimization for gas storage

State variables

- Three-factor price process delivers three factors (spot X, long-term Y, winter-summer Z)
- Use price state variables X Y Z in regression
- Do not use volume state variable in regression

Basis functions

- Use more spot than long-term & winter-summer in basis
- Use limited number of basis functions
- Alternative: use greedy approach: take as many basis functions as possible while keeping basis regular

Questions

1. Impact of using 1 factor instead of 3 factor price process?
2. Impact of using 1 factor instead of 3 factors in optimization?
3. Impact of basis functions (different families?) and different number of simulations?

Example

Consider simple storage: inject 1, withdraw 1, max volume 100 units

Consider three situations :

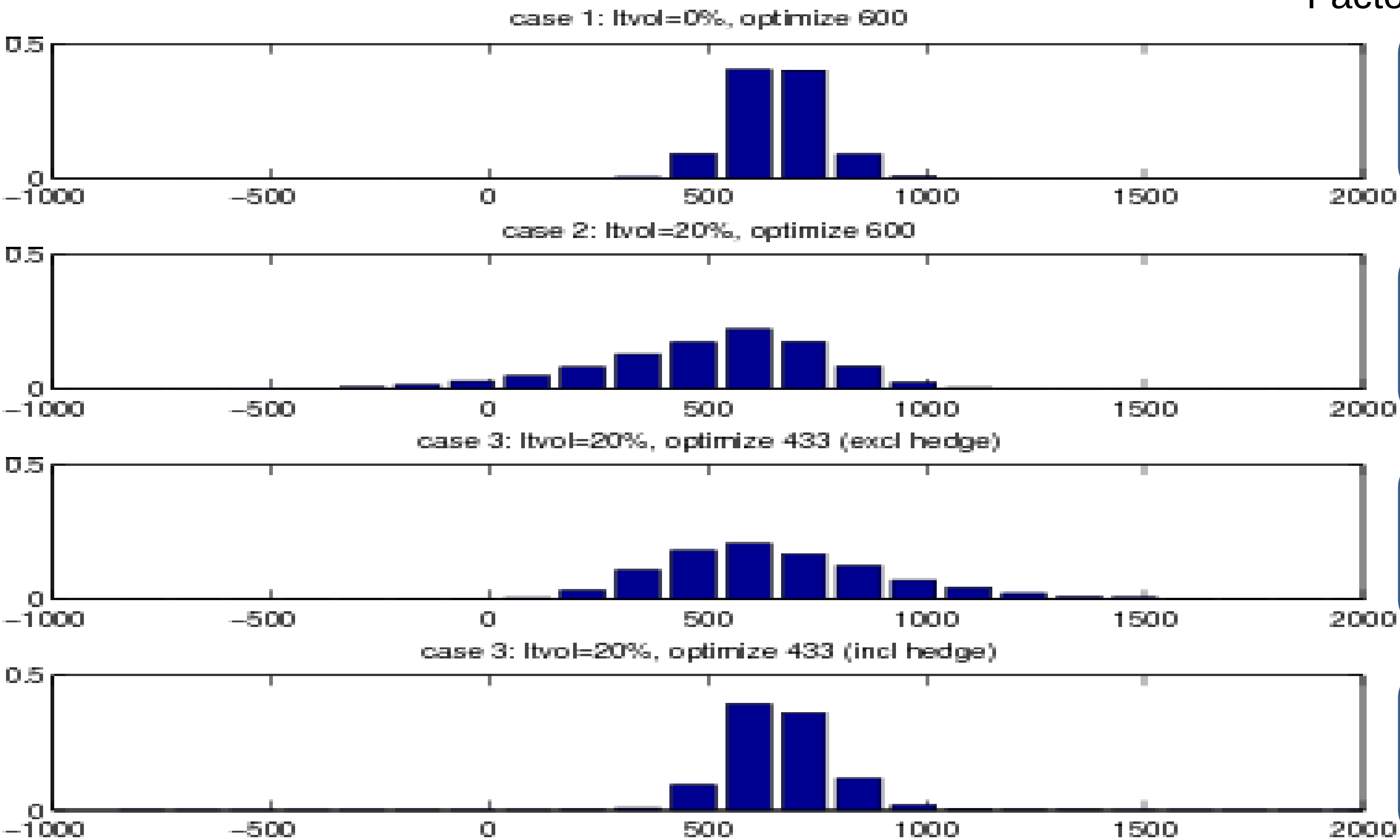
- Use 1 factor price process and 1 factor optimization
- Use 3 factor price process and 1 factor optimization
- Use 3 factor price process and 3 factor optimization

Consider 60 different seeds and five different basis functions

- Powers
- Chebyshev of the first kind A
- Laguerre
- Legendre
- Hermite A

Spot approach: impact multi-factor and hedge

Price Factor – Factor optimization



1 – 1

3 – 1

3 – 3

3 – 3 + hedge

10000 simulations, power basis function, 1 seed

KYOS

Impact of basis function + convergence

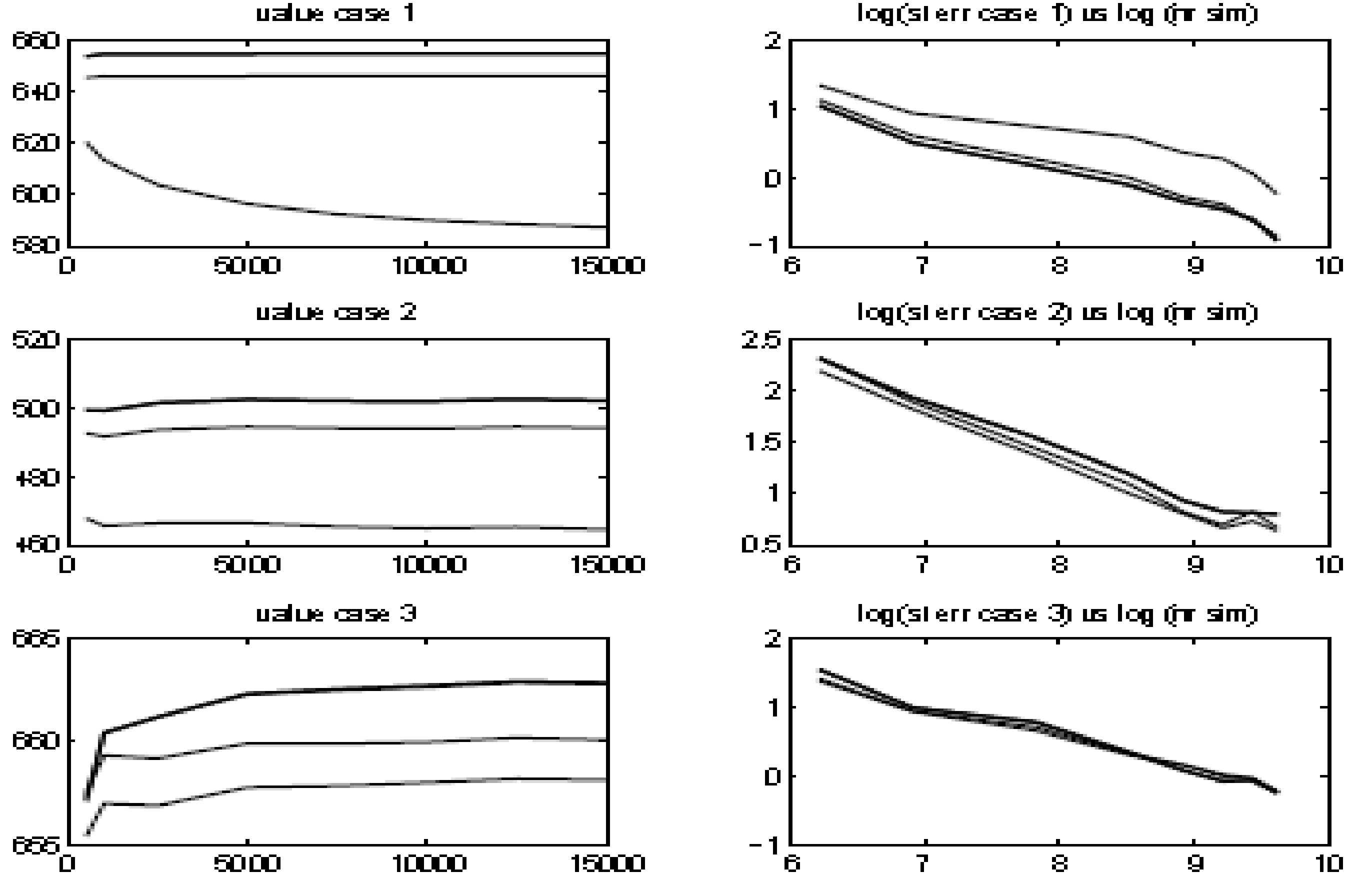
Chebyshev and Hermite polynomials under perform

Legendre, Laguerre and power perform similar

1 – 1

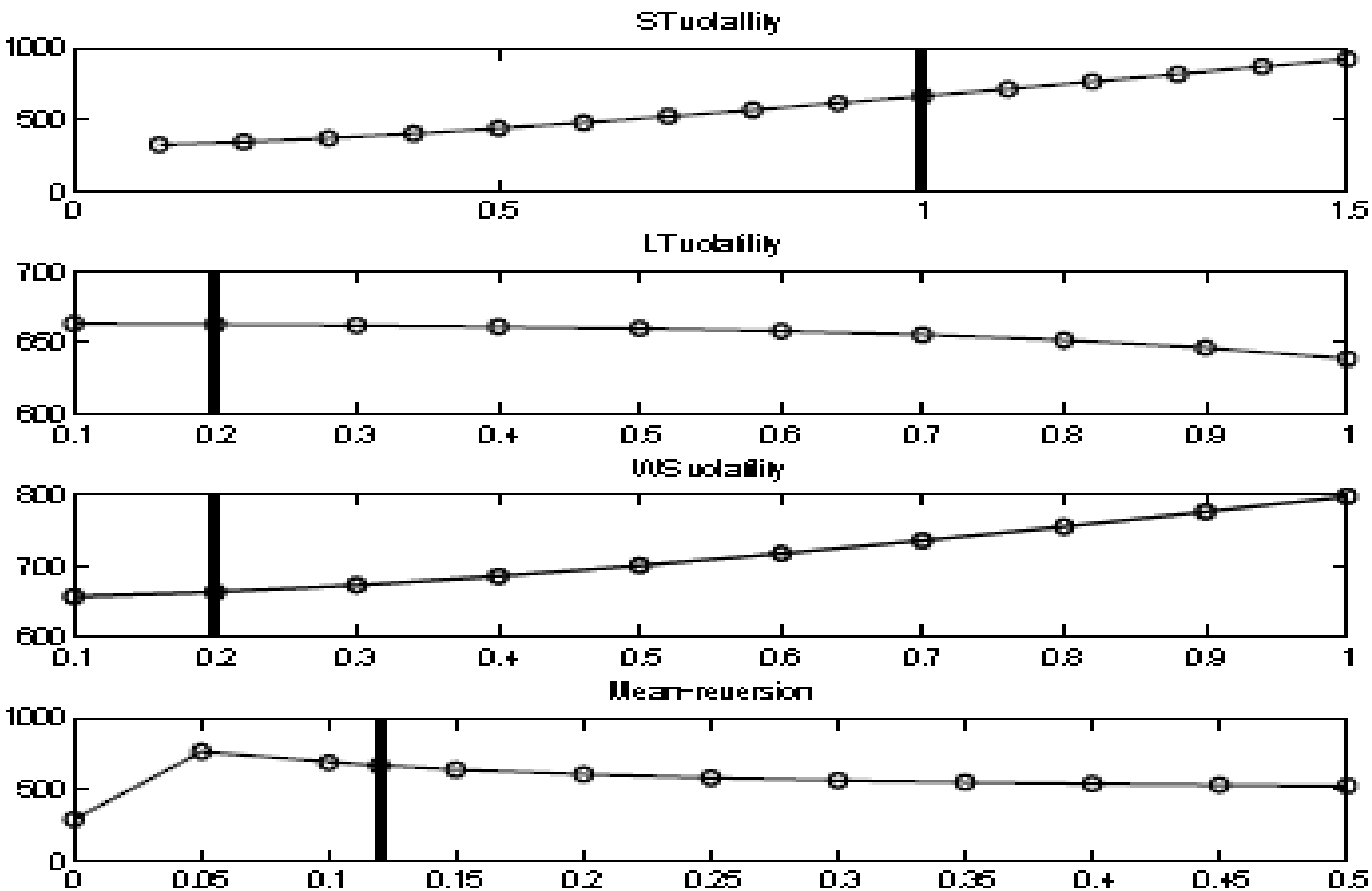
3 – 1

3 – 3



KYOS

Impact of changing market parameters



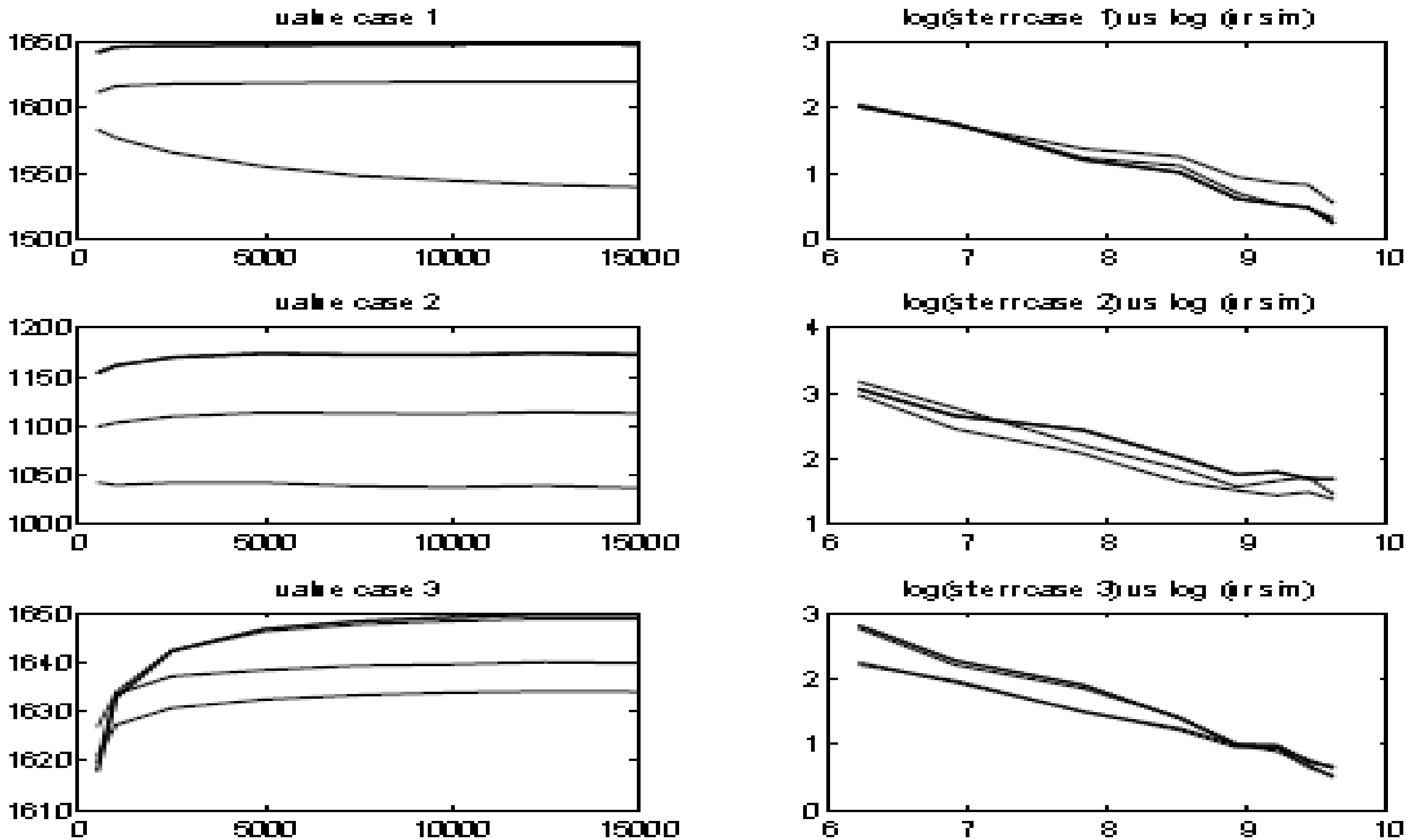
ST vol

LT vol

WS vol

Mean-reversion

Impact of operational parameters



Fast storage: inj = 2 / wd = 5 / vol = 100 (earlier inj = wd = 1 / vol = 100)

Conclusion

- When using multi factor price process:
  - Not sufficient to use one factor within optimization
  - Simple power basis performs well (Hermite/Chebyshev not)

- Practical results:
  - Adding factors increases expected standard deviation, but does not really change expected value
  - Static hedge improves no-hedge approach
  - Not all volatility is good for storage operator