Valuing the LNG Arbitrage Option

Mark Hayes

Ph.D. Candidate

Program on Energy and Sustainable Development

Stanford University

http://pesd.stanford.edu/

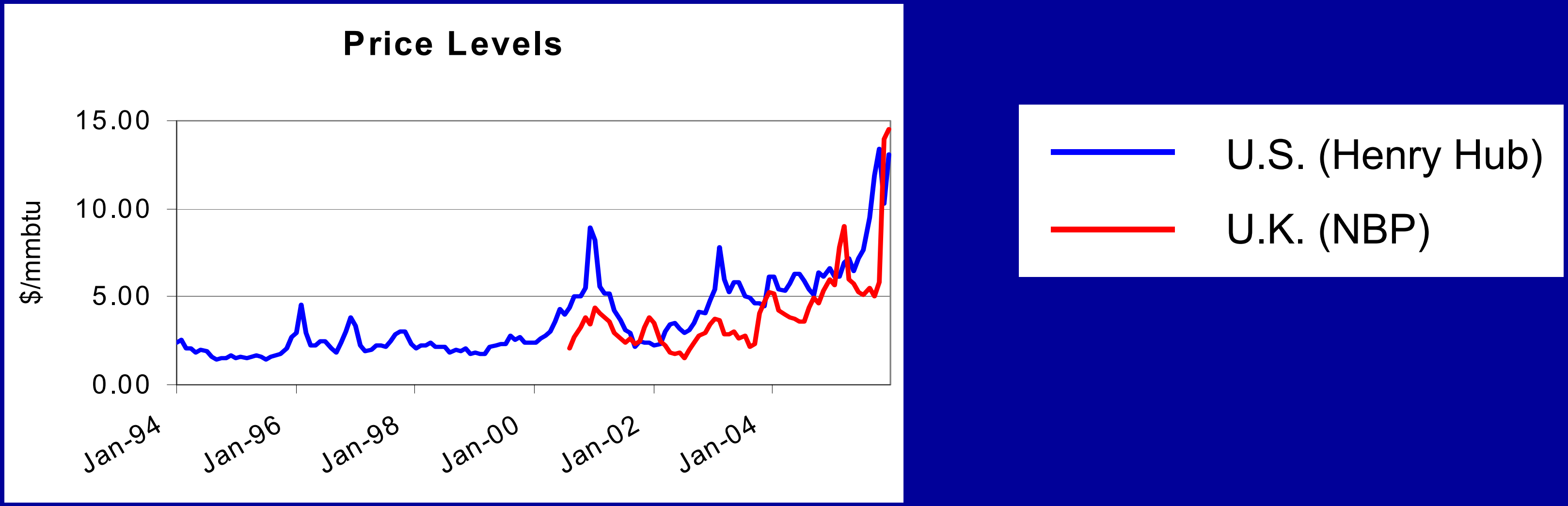
Overview

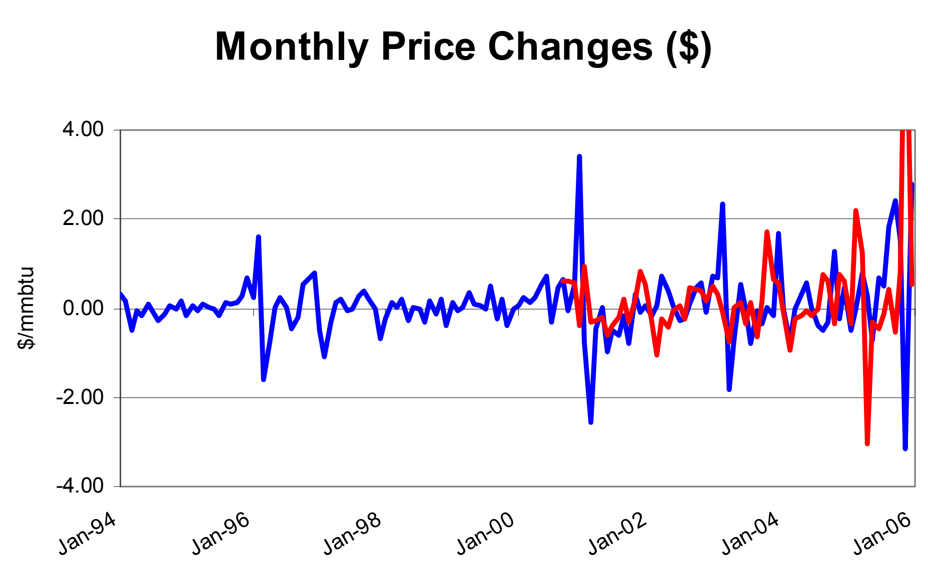
- Non-correlated demand and price deviations in regional markets <u>create arbitrage opportunities</u>
- But… exercising the option requires tanker capacity and access to regasification capacity in the arbitrage market
- How does the value of the arbitrage option compare to the cost?
  - Construct model to simulate future price developments and physical cargo diversion
  - Focus here on Atlantic Basin circa 2015

Model Structure

- Use hypothetical Egypt to U.K. LNG project
  - 5 mtpa liquefaction facility with ships and full regasification capacity reserved in U.K.
  - Divert cargoes to U.S. when netback price favorable
- Key assumptions
  - Diverted volumes are price takers in both markets
  - Ships are available for charter (138,000 m^3 @ $52K per day)
  - Simulate correlated prices in both markets according to mean-reverting model
- Value the option of reserving “excess” regasification capacity in the U.S.

Benchmarking the Model: *Historical Prices and Volatility*





<u>1994 to 1999</u>

HH monthly volatility (σ) = $0.4

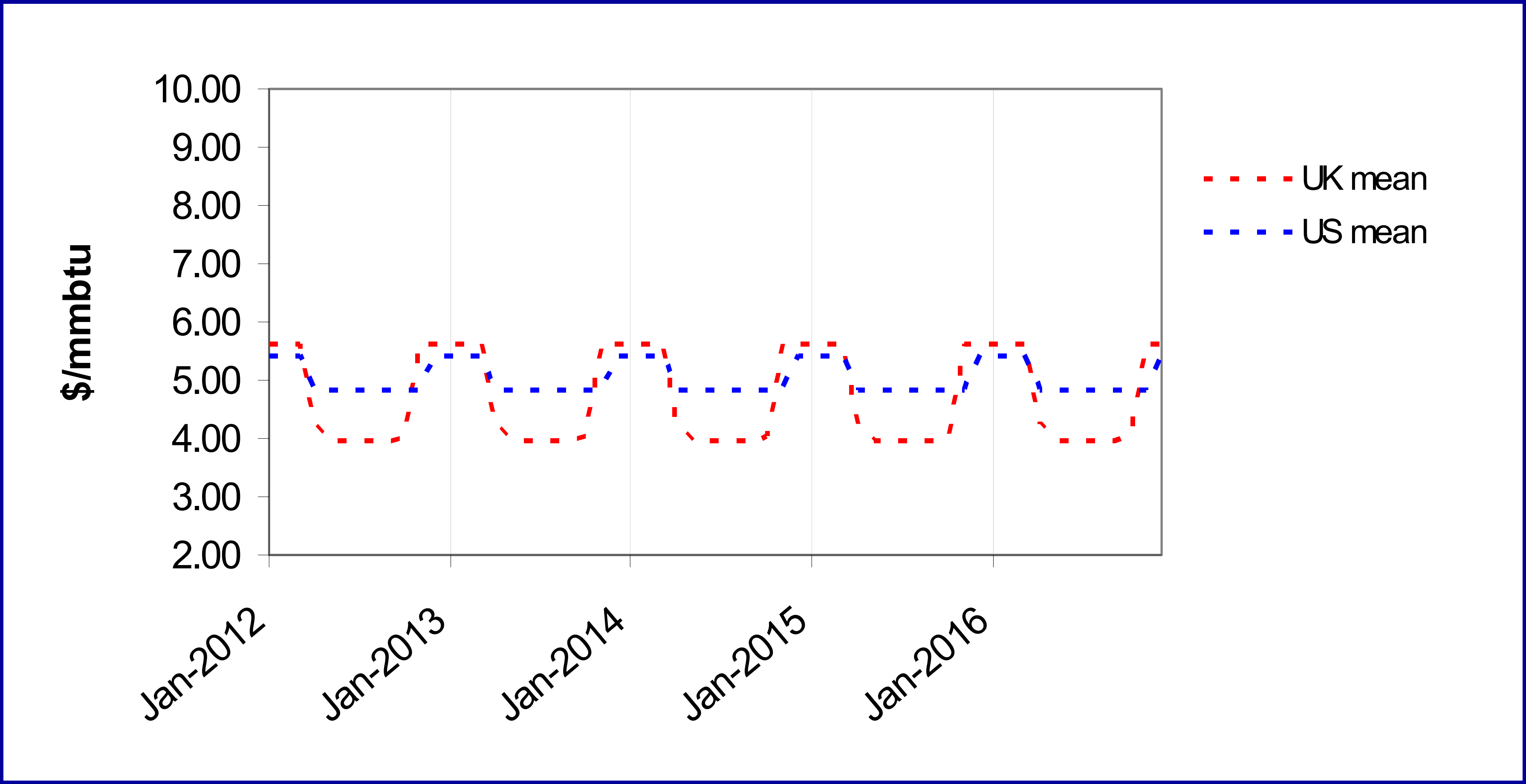
<u>2000-2005</u>

HH monthly volatility (σ) = $0.8

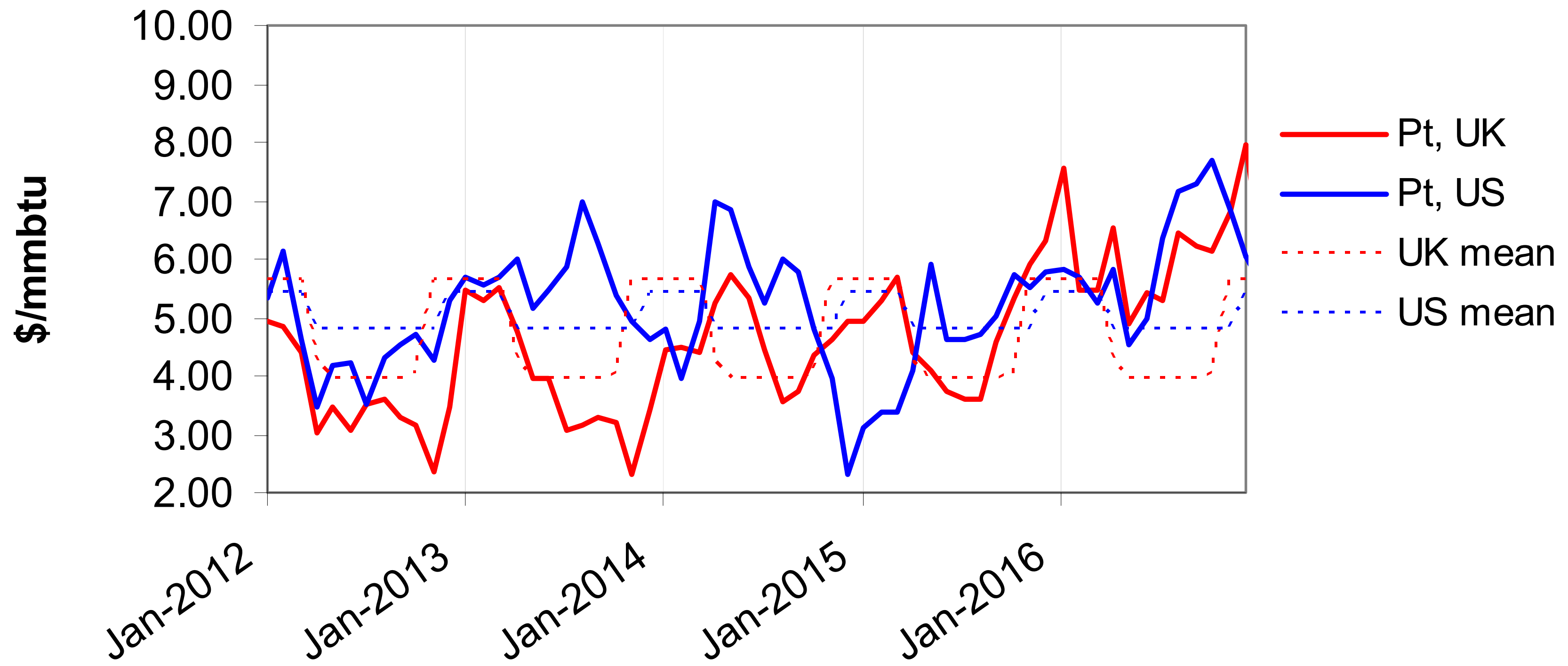
NBP monthly volatility (σ) = $0.7

…BUT, ONLY 12% CORRELATED

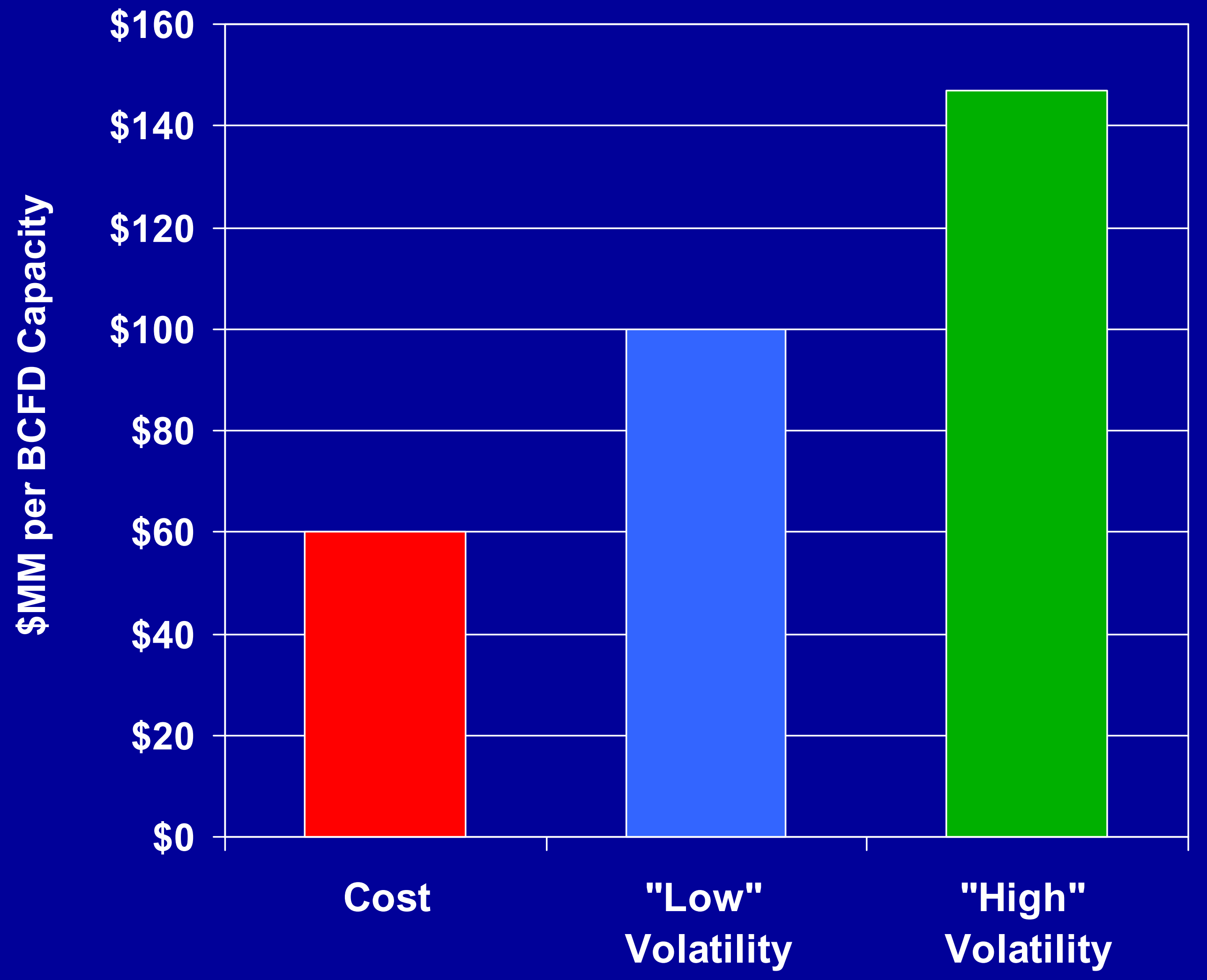
U.S. & U.K. Expected Price Levels



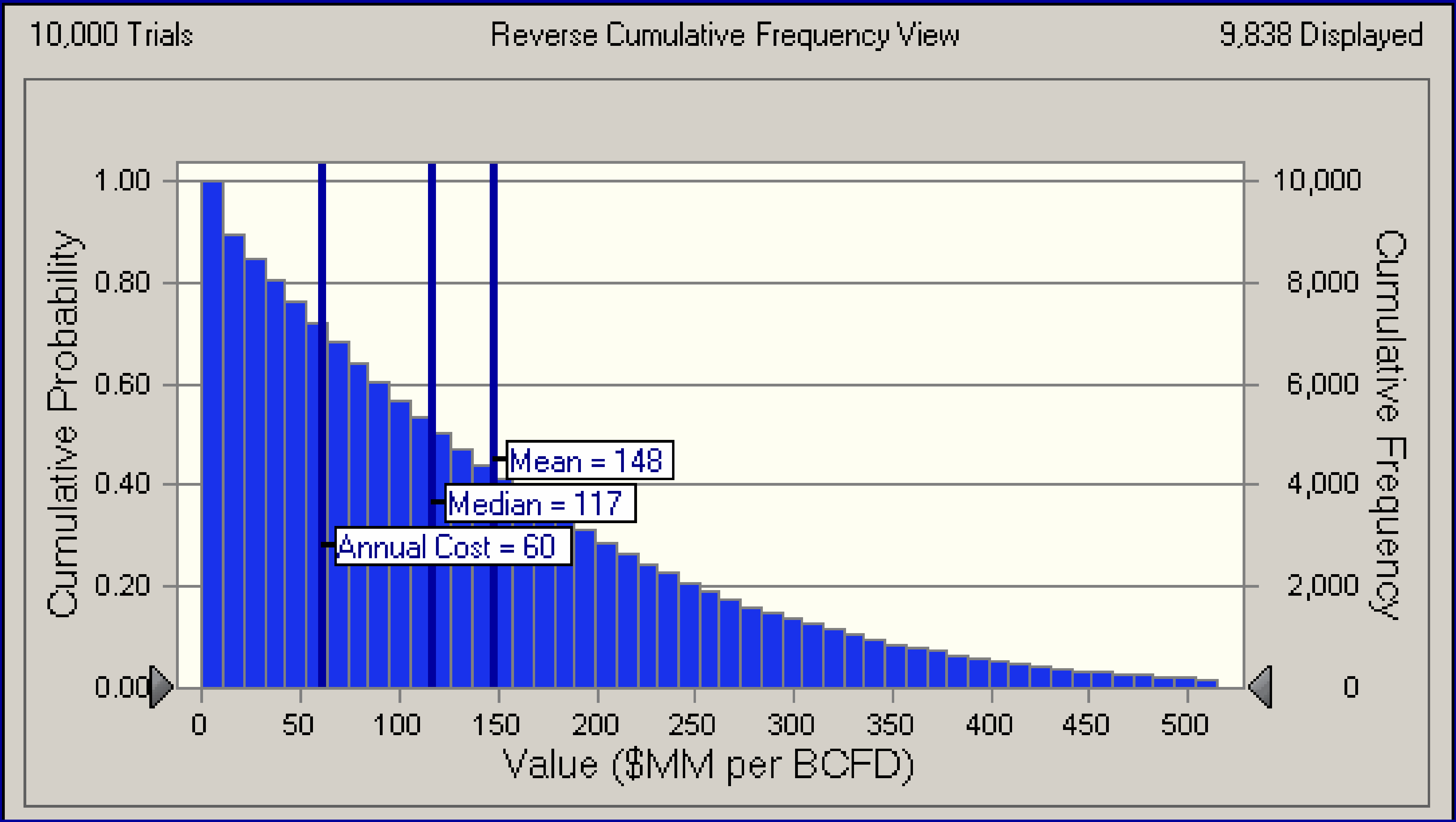
U.S. & U.K. Price Simulations
"High" Volatility Case



Expected Annual Value of Holding U.S. Regasification Capacity



Distribution of Returns - "High" Volatility Case



Conclusions

- Non-correlated price movements create incentive for investment in “excess” capacity in tankers and regasification
- Valuation is sensitive to beliefs about future market price behavior
- “Spikey” nature of arbitrage returns creates potential communication challenges with both shareholders *and* regulators

Supplemental Slides

Fit Price Simulation to Historical Data

Parameter Estimates from Historical Price Series

Price Series (time period)	η (mean reversion rate %)	σ (volatility absolute $ price)
Henry Hub (Jan 1994 – Dec 1999)	0.27***	$0.39
Henry Hub (Jan 2000 – July 2005)	0.12*	$0.80
National Balancing Point (Jan 2000 – July 2005)	0.12	$0.70

*, **, *** indicate 90, 95, and 99% confidence intervals, respectively.

Model for Future Price Simulations

$$S_{t,US} = S_{t-1,US} + \eta_{US} * (\mu_{t,US} - S_{t-1,US}) + \sigma_{US} * \varepsilon_{1,t} \qquad (0.1)$$

$$S_{t,UK} = S_{t-1,UK} + \eta_{UK} * (\mu_{t,UK} - S_{t-1,UK}) + \sigma_{UK} * \varepsilon_{3,t} \qquad (0.2)$$

where:

$$\varepsilon_{3,t} = \rho * \varepsilon_{1,t} + \sqrt{1-\rho^2} * \varepsilon_{2,t} \qquad (0.3)$$

and $\varepsilon_1, \varepsilon_2 \sim N(0,1)$ (0.4)

$$S_{t,\max} = \max[S_{us}, S_e]$$

Divert cargoes when $S_{t,US} > S_{t,UK} - C_x$

Where C_x is the incremental cost of transport to deliver cargoes to the U.S. market.

Option Value of "Excess" U.S. Regasification