UNIVERSITY OF TEXAS
AT AUSTIN

McCombs School of Business
Department of Finance

2004 ENERGY FINANCE CONFERENCE

Hosted by:
Center for Energy Finance Education & Research (CEFER)
and
ConocoPhillips Inc.

"The Future of Natural Gas Demand, Supply, and Prices"

Ehud I. Ronn
Professor of Finance and
Director, Center for Energy Finance
Education and Research

February 20, 2004

IF YOU ARE WATCHING US ON THE WEB . . . ,

PLEASE LET US KNOW AT:

<Angela.Dorsey@mccombs.utexas.edu>

Background

In 6/10/03 testimony before the House Energy and Commerce Committee, Federal Reserve Chairman Alan Greenspan addressed the topic of "Natural gas supply and demand issues":

1. "In recent months, in response to very tight supplies, prices of natural gas have increased sharply.
2. "Our inability to increase imports [of liquefied natural gas (LNG)] to close a modest gap between North American demand and production is largely responsible for the marked rise in natural gas prices over the past year.
3. "Today's tight natural gas markets have been a long time in coming, and futures prices suggest that we are not apt to return to earlier periods of relative abundance and low prices anytime soon.
4. "Since 1985, natural gas has gradually increased its share of total energy use and is projected by the EIA to gain share over the next quarter century, owing to its status as a clean-burning fuel.
5. "That [NG] price has risen gradually from $2 per MMBtu in 1997 for delivery in 2000, ... to more than $4.50 for delivery in 2009, the crude oil heating equivalent of rising from less than $12 per barrel to $26 per barrel.
6. "As the technology of LNG liquefaction and shipping has improved, ... a major expansion of U.S. import capability appears to be under way. These movements bode well for widespread natural gas availability in North America in the years ahead.
7. "The perceived tightening of long-term demand-supply balances is beginning to price some industrial demand out of the market. It is not clear whether these losses are temporary, pending a fall in price, or permanent."

WELCOMING COMMENTS

- Laura T. Starks
  - Charles E. and Sarah M. Seay Regents Chair in Finance and
  - Chairman, Department of Finance
- David L. Boggs, President, Energy Finance Group

PANEL 1: The Uncertainties of Natural Gas Supply & Demand, and the Future Potential of LNG

- Moderator: Vince Kaminski, Adjunct Professor, Jesse H. Jones Graduate School of Management, Rice University

- Panelists:

  1. Steve Beasley, President, ANR Pipeline & Tennessee Gas Pipeline, El Paso Corporation
  2. Britt Dearman, Manager Special Projects – U. S. Operations, Apache Corporation
  3. Scot Brady, Business Development & Contracts Manager, Chevron-Texaco
  4. Vince Kaminski, Adjunct Professor, Rice University

PANEL 2: Forecasting Future Prices of Natural Gas

- Moderator: Ehud Ronn, Professor, Department of Finance, University of Texas at Austin

- Panelists:

  1. Ed Kelly, Head of N. A. Gas & Power Consulting, Wood Mackenzie Global Consultants
  2. Greg Rizzo, Executive Vice President – Pipelines, Duke Energy
  3. Andy Weissman, Founder & Chairman, Energy Ventures Group
  4. Ehud Ronn, Professor of Finance, University of Texas at Austin

UNIVERSITY OF TEXAS
AT AUSTIN

McCombs School of Business
Department of Finance

2004 ENERGY FINANCE CONFERENCE
"The Future of Natural Gas Demand, Supply, and Prices"

The Future of Natural Gas Prices: The Message from Markets

Ehud I. Ronn
Professor of Finance and
Director, Center for Energy Finance

and

G. Luther Lu
MBA Graduate Student
McCombs School of Business

February 20, 2004

OVERVIEW

- Calibration: Extracting Model Parameters from Market Prices
- Example: Implied Volatility — the volatility implied by applying the Black-Scholes model to option prices
- Modeling Natural Gas Prices — and the Message from Markets

An Example of Calibration: Black-Scholes "Implied Volatility"

- The Black-Scholes model provides the value of an option (C) given the inputs of: Stock price (S), strike price (K), riskfree rate (r), time to expiration (T) and volatility (σ)
- Of these, all are observable save volatility (σ)
- Implied vol changes the question: Instead of asking,

  "What is the value of the option?"

  the question posed is:

  "Given the option's observable market price, and assuming the market is using the Black-Scholes model to price options, what volatility number is the 'market' using?"
- For example, if $S = K = \$40$, $r = 1\%, T = 1$ yr. and $C = \$5$, then the Black-Scholes implied vol σ is 30.3%
- The term "Implied Vol" is due to its being *implied by* the option's market price

We can similarly inquire: "Assuming a model for natural gas prices, what is the market telling us about future prices?"

Calibrating a Seasonally-Adjusted Mean-Reverting Process to Prices of Futures and Option Contracts

Model Assumptions [Extending Jaillet, Ronn and Tompaidis (2004)]:

- The spot price S_t incorporates a seasonal factor, such that

$$S_t = f_t \, D_t$$

where

S_t = Spot price in month t

D_t = Deseasonalized spot price in month t

f_t = Deterministic seasonality factor satisfying:

1. $f_{T+12} = f_T$ — Cross-year seasonality factor is constant
2. $f_1 \times f_2 \times f_3 \times \ldots f_{12} = 1$ — Product of twelve seasonality factors f_t equals 1

- Logarithm of deseasonalized spot follows a one-factor mean-reverting process with drift μ :

$$d \ln D = [\kappa \, (\xi - \ln D) + \mu] \, dt + \sigma \, dz$$

Valuation of Futures Contracts and Option Prices under Seasonally-Adjusted Mean-Reverting Model

- Valuation of Futures Contract: Futures price for delivery at time T

$$\ln F_T = \ln f_T + e^{-\kappa T} \ln D_0 + \xi \left(1 - e^{-\kappa T}\right) + \frac{\sigma^2}{4\kappa} \left(1 - e^{-2\kappa T}\right) + \mu T \qquad (1)$$

- Valuation of Call Option on Futures: Value today of a European call expiring at time T on a futures contract maturing at time T is given by:

$$C = e^{-rT} \left[F_T N(d) - K N(d - \sigma_1)\right] \qquad (2)$$

where

$$d = \frac{\ln\left(F_T / K\right)}{\sigma_1} + \tfrac{1}{2}\sigma_1$$

$$\sigma_1^2 = \frac{\sigma^2}{2\kappa}\left(1 - e^{-2\kappa T}\right)$$

Calibrating Model Parameters to Observable Futures Contracts and Option Prices

- Data:
  - End-of-month Natural gas futures prices for 1/98 - 12/03 (36 months per day): For maturity T, $\widehat{F}_T$
  - (One) Near-term option per day, $\widehat{C}_0$
- Parameters:

Parameter	Symbol	Parameter	Symbol
Mean reversion rate	κ	Volatility	σ
Long term average value	ξ	Initial value	$\ln D_0$
Drift (expected price change)	μ	Seasonality factors	$f_1, f_2, \ldots, f_{12}$

- Objective Function: At each date, use $\ln F$ from (1) and C from (2),

$$\min_{\{\mathbf{x}\}} \sum_{T=1/12}^{36/12} \left| F_T - \widehat{F}_T \right|, \qquad \text{subject to}$$

$$\prod_{m=1}^{12} f_m = 1, \quad C_0 = \widehat{C}_0, \quad \mathbf{x} = \{\kappa, \sigma, \xi, \ln D_0, \mu, f_1, \ldots, f_{12}\}$$

Projecting a Deseasonalized Three-Year Futures Price

- Estimating a standardized three-year futures price on each date entails:
  1. Calibrating the futures curve on each date, by extracting an estimate of the parameters $\mathbf{x} = \{\kappa,\ \sigma,\ \xi,\ \ln D_0,\ \mu,\ f_1,\ \ldots,\ f_{12}\}$
  2. Ignoring the seasonality factor (i.e., $\ln f_T = 0$), set $T = 3$ yrs. in the futures-price equation (1):

$$\ln F_3 = e^{-3\kappa} \ln D_0 + \xi \left(1 - e^{-3\kappa}\right) + \frac{\sigma^2}{4\kappa} \left(1 - e^{-6\kappa}\right) + 3\mu$$

- Intra-year seasonality appears quite stable, showing winter-peaking, but no indications of a *summer-peaking* season
- Model, while imperfect, nevertheless provides interesting information on market "expectations"
- Extrapolation feasible, but subject to the additional criticism that such extrapolation takes the model beyond the maturities to which it was calibrated