Fundamentals of Commodities Spot and Forward / Futures Markets

Hélyette Geman
Professor of Finance
Birkbeck University of London & ESCP- EAP

GSCI TR
DJ-AIGCITR
Commodities as a Desirable Investment as of early 2000

Growth of $100: 2000-2004
DJ-AIG Energy - January 2002 to July 2006

Is Mean Reversion Dead? Geman 2005, JAI
### Major Commodity Exchanges

<table>
<thead>
<tr>
<th>Exchange</th>
<th>Commodities</th>
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</thead>
<tbody>
<tr>
<td>NYMEX (New York, 1872)</td>
<td>Crude oil (WTI), natural gas, heating oil, propane, unleaded gasoline</td>
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<tr>
<td>IPE (1980)/ICE (2005)</td>
<td>Crude oil (Brent), natural gas</td>
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<td>Nordpool, EEX, APX, Powernext, GMX, OMEL ....</td>
<td>Electricity</td>
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<tr>
<td>London Metal Exchange (London, 1877), COMEX</td>
<td>Aluminum, copper, nickel, tin, lead and silver</td>
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<tr>
<td>London Bullion Exchange, CBOT</td>
<td>Gold and silver</td>
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<tr>
<td>CBOT (Chicago, 1850)</td>
<td>Corn, soybean, wheat, rice</td>
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<td>CME (Chicago, 1898)</td>
<td>Pork bellies, beef, lumber</td>
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<tr>
<td>Dubai Exchange</td>
<td>Middle East Crude oil, gold, wheat</td>
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<tr>
<td>IMEX (Qatar)</td>
<td>Liquid Natural Gas (LNG)</td>
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Commodity Prices: A shift of Paradigm

→ The price of a commodity
  − is not the present value of future cashflows
  − nor the expected value (under the right probability measure) of the final payoff
→ It is fundamentally driven by supply and demand
Another key quantity is the available inventory at the date of analysis, worldwide or in a given region. This inventory has in particular a major impact on price volatility (see Geman-Nguyen 2005).

In contrast to financial markets, volume risk is as important as price risk.

It takes several forms:

- Volumetric options (financially traded or embedded in supply contracts)
- Uncertainty on oil reserves may generate a downward jump on the stock of an oil company.
Comparative Moves of WTI and Brent Crude Prices
A very unusual situation related to US inventory

Crude oil prices for WTI, Brent and the difference (Aug 2008 - Feb 2009)
Commodities and Numéraire

→ Most commodities are denominated in US dollars

→ During the recent decline of the dollar, some OPEC members considered the possibility of using as a "numéraire" the arithmetic average of the dollar and the euro

→ Maybe the right way of thinking is to use the commodity (e.g., a barrel of oil) as the numéraire when managing an energy derivatives portfolio!

→ Gold has partly been playing this rule for decades
Shipping and Freight

→ Two types of freight
  • Dry bulk: Capesize, Panamax, Handymax
  • Tankers: Suez-Aframax

→ Major actors in the spot and forward markets: Cargill, Louis Dreyfus, Total, Shell, Deutsche Bank, Morgan Stanley

→ Trading activity
  • Baltic Exchange (London), used to offer Futures contracts, now only forwards
  • Imarex (Oslo), provides daily quotes on maritime shipping
  • LCH-Clearnet (London)
  • Nymex (New York), very active for dry bulk
Freight Derivatives Market

Basics of FFAs

→ An FFA (Forward Freight Agreement) is a contract to buy or sell the price of freight for a specific cargo route over a defined future period

→ It is based on a defined voyage or time charter

→ It is financially settled, the settlement being based on the spot market index (typically the average of the last 7 days in expiration month or the monthly average) as assessed by the Baltic Exchange or Platt's
Baltic Indices

The Baltic Handymax Index (BHMI), the Baltic Panamax Index (BPI) and the Baltic Capesize Index (BCI) are calculated from average rates on major routes, both voyage and timecharter, as assessed by a panel of brokers.

The Baltic Dry Index (BDI) is the average of the BHMI, BPI and BCI. It provides a good general indicator of movement in the dry bulk market and continues the time series of the Baltic Freight Index (BFI) which was introduced in 1985.
Freight Dry - Bulk Market

→ The Baltic Capesize Index (BCI) reached an absolute maximum (level 9000) in January 2005, then experienced a huge drop later that year:
   - 5125 Oct 15
   - 4637 Nov 15
   - 3385 Dec 15
   - 3018 Jan 15, 06

→ The annual volatility is of the order of 110%

→ Both spikes and volatility make this market similar to the electricity market
Baltic Capesize Index

Chart created with NeoTicker EOD © 1998-2007 TickQuest Inc.
Baltic Panamax Index
Three fundamentals results:

→ The convenience yield accounts for the benefit that accrues to the holder of the physical commodity but not to the holder of the futures contract. It is represented as an implicit dividend

→ The volatility of the commodity spot price is high when inventory is low

→ The volatility of Futures contracts decreases with the maturity: "Samuelson effect"
The Convenience Yield (continued)

→ It is the "comfort" provided by holding the spot commodity

→ Owning the commodity allows
  · to reduce costs and delays in delivery (Kaldor)
  · to satisfy an unexpected rise in demand (Brennan)
  · to secure the continuity of production (Kaldor)

→ The convenience yield is all the higher as inventory is low

→ It is positively correlated to the spot price of the commodity

→ It accrues to the holder of the physical commodity but not to the holder of a derivative contract
Spot-Forward Relationship for a Storable Commodity

Under no arbitrage

\[ f^T(t) = S(t) \left[ 1 + r(T-t) + c(T-t) - y_f(T-t) \right] \]

If we define a convenience yield net of cost of storage

\[ f^T(t) = S(t)[1 + (r - y)(T-t)] \]

Or in continuous time

\[ f^T(t) = S(t)e^{(r-y)(T-t)} \]

as long as \( r \) and \( y \) are constant over the period \((t, T)\)
Correlation Spot-Futures (Nordpool)

Correlation spot price - first nearby
Crude Oil

Matthew Simmons, *Twilight in the Desert*

→ "Sooner or later, the worldwide use of oil must peak because oil, like the other two fossils - coal and natural gas - is non renewable"

→ Over the past 30 years, daily oil consumption has risen by approximately 33 million barrels, Asia accounting for more than half of this growth in demand

→ Current consumption levels suggest that the world's oil supply should last until around 2045

→ The world's largest producers are Saudi Arabia (13% of world production), Russia (12%), the United States (7%), Iran (6%) and China (5%)

→ The Gulf of Mexico region provides about 29% of the US oil production, hence the disruption created by the long shutdown of many oil rigs after hurricanes Katrina and Rita in summer 2005
Brent Crude Oil – April 2007 to March 2009
The Forward Curve

→ The set $\{F_T^T(t), T > t\}$ is the forward curve prevailing at date $t$ for a given commodity in a given location.

→ It is the fundamental tool when trading commodities, as spot prices may be unobservable and options illiquid.

→ The shape of the forward curve is at any date $t$ in a one-to-one mapping with the convenience yield $y$. 
The oil market as a World Market

→ Seasonality is not significant since tankers are rerouted to satisfy a surge of demand in a given region

→ The representation of the spot price as a geometric Brownian motion is less questionable since it has indeed been increasing in average

→ It is in the context of this crucial commodity that Brennan and Schwartz (1985), Gibson and Schwartz (1990) remarkably introduced in the valuation of derivative contracts the economic concept of *convenience yield*

→ Gabillon (1991) shows the role of the convenience yield in explaining the role of oil forward curves
WTI Oil Prices Jan 2002 - Oct 2007
Spread of the Oil Forward Curve - Dec 1995 / Dec 2005

Crude Oil Price Spread 29th Versus 1st

- Price Spread 29th Versus 1st
Oil Forward Curve - March 2006 (Bid and Ask)
Back to Backwardation in September 2007
Crude Oil Future curve (17/11/2008)
NYMEX First Nearby – Jan 2001 to Jan 2009

NYMEX Oil Near Month Contract Prices (Jan 2001-Jan 2009)
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hgeman@hotmail.com