Commodity Forward Curves: The Old and the New

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Commodities and Shipping

→ They have existed as long as humankind, and will continue to be there for a long time...

→ In the last 100 years, there have been a number of cycles of boom. The end of the 1970s boom can be identified with the crash in 1980 of precious commodities – and the failure of the famous Hunt brothers’ squeeze of the silver market. Then followed nearly 20 years of stagnation in commodity prices.

The 2000s decade started with gigantic rises in all commodity prices (at different points in time across the years 2001 to 2005), witnessed the effect of the financial crisis on commodities and a rebound afterwards.

As far as theory is concerned, commodities have been up to the late 1980s essentially part of economic theory, with no major results coming from finance, and contributions by economists called Keynes (1936), Kaldor (1939), Working (1949)
The Outlook of Commodity Markets in 2010

→ Increasing wealth invested in commodity indexes (DJ –UBS, GSCI, DB, RICI…)

→ Financial investors were usually positioned on the first nearby as the best to the spot and avoid the hurdles of physical delivery and warehousing. Given the « noise » on the first nearby and the frequent contango shape of the forward curve, they now go to more and more distant maturities – which used to be the domain of action of the specific industry. Hence, correlations and co-movements of the forward curve need to be taken into account.

→ Banks and private equity are buying physical assets, such as power plants, aluminium smelters, which give them direct exposure to the spot price – in particular for hedging activities.

→ At the same time, we witness a flurry of M&As, sometimes hostile, in the mining industry worldwide, with some major actors being partly or fully state-owned (Chinalco, Petrobras..)
Growth of $100 invested in two major indexes during the period 1991-1999:

*Mean – Reversion in prices*
Commodities as a Valuable Asset Class as of 2000
Is Mean-Reversion Dead? (Geman - Sept 2005, J of Alternative Investments)
CRB Commodity Index – 1990 to 2011
The price of a commodity is firstly 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 an impact on prices – hence, is carefully watched by many CTAs (Commodity Trading Advisers) and on price volatility (see G - Nguyen, Management Science, 2005).

→ For exhaustible commodities like crude oil, copper, gold.. reserves are the fourth key quantity ultimately important.

→ In contrast to financial markets, volume risk in commodity markets is as important as price risk. Commodity markets (electricity, natural gas) have been used to handling volume risk (Operational research, dynamic programming); financial markets are used to price risk. The mathematical challenge today is to address both simultaneously; the financial economics one is the market incompleteness, of various degrees of profundity.
Playing the WTI/Brent spread while being “crude oil price neutral”
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“.

Moreover, forward curves used to be viewed as being mostly in backwardation, the so-called “normal backwardation”, due both to the convenience yield and an assumption of mean-reversion in prices.
Spot-Forward Relationship for a Storable Commodity

Under no arbitrage

\[ f^T(t) = S(t) \left[ 1 + \frac{r(T-t)}{\text{cost of financing}} + \frac{c(T-t)}{\text{cost of storage}} - \frac{y_1(T-t)}{\text{implicit dividend}} \right] \]

If we define a convenience yield net of cost of storage

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

Or in continuous time, at a fixed date \( t \) for a given maturity \( T \)

\[ f^T(t) = S(t)e^{(r-y)(T-t)} \]
Correlation Spot- Prompt month (Nordpool):
The standard convenience yield does not apply to electricity
(Eydeland- G, RISK, 1998)
The Forward Curve

→ The set \( \{F^T(t), T > t\} \) 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 not always liquid.

→ It allows to identify possible « carry arbitrage »: buy \( S \), sell a future maturity \( T \) and pay the cost of storage and financing as long as the net cashflow is strictly positive.

→ The shape of the forward curve is at any date \( t \) in a one-to-one mapping with the convenience yield \( y \).

→ It will reflect the seasonality in the case of seasonal commodities such as natural gas or Agriculturals.
A typically backwardated commodity forward Curve - 27 May 2008
Gold as a Numéraire Commodity

→ Historically, gold has been held as an international currency, independent of individual countries.

→ At various times in history, domestic currencies have been backed by gold: the “gold standard”

→ The unit of account of the International Monetary Fund (IMF) used to be denominated in gold; now, a currency basket is used for indexation

→ Over the period following the financial crisis and up to now, gold is viewed in all nations as a currency of intrinsic value and even as an “asset class”

→ Gold is traded in fine Troy ounces, ounces of actual gold in the ingot (there are 32.15 Troy ounces in a kilo)
Gold Forward Curve - 27 May 2008
Gold Forward Curve, October 26, 2009
Gold Forward Curve – Feb 2010

Gold (12 Feb 2010)
Number of Ounces of Gold that can buy the Average US House: the Role of the Numéraire in the study of Commodities
Copper (15/Oct/2010)
Forward Curves and Inventories

→ The importance of inventory in explaining spot price volatility has been widely documented in the economic literature.

→ Brennan (1958) and Telser (1958) analyze in the context of several agricultural commodities the spread between a long-term future and the prompt month divided by the prompt month.

→ They exhibit a negative correlation between this "relative spread" and the variance of the commodity.
Fama & French (1987) take as a given the property of the spread being an adequate proxy for inventory. This allows them to analyze 21 commodities, including metals, for which good inventory data were missing in their period of analysis.

Ng & Pirrong (1994) examine four industrial and one precious metals over the period 1986-1992 and use the same proxy for inventory to conclude that fundamentals drive metal price dynamics.

G. & Nguyen (2005) reconstruct a world database of soybean inventory (with Brazil and Argentina having become more important than the US in the last few years) and establish a quasi perfect affine relationship between scarcity defined as inverse inventory and spot price volatility.
Inventory and Forward Curve Adjusted Spread in Oil and Natural Gas Markets

→ As said before, crude oil is not a seasonal commodity, natural gas is a very seasonal commodity

→ G- Ohana (Energy Economics, 2009) choose the maturity of the “distant” Future on criteria of liquidity and ability to filter out the seasonality

\[
\text{adjusted spread} = \frac{\text{Futures 13M} - \text{Futures 1M} \cdot (1 + \text{rate 1Y})}{\text{Futures 1M}}
\]
We used a price database consisting of daily NYMEX Futures prices
- for the oil from January 1990 to August 2006
- for natural gas from January 1993 to August 2006
We use for inventory data the EIA website
- for crude oil, we collect the volume of all stored petroleum products in OECD countries at the end of each month from the end of December 1989 to the end of July 2006. This volume is expressed in billion barrels for oil
- for natural gas, the website provides the volume of stored natural gas in the United States at the end of each month during the period end of December 1992 - end of July 2006

This inventory is expressed in Trillion cubic feet
Using *detrended inventory*, it becomes

\[ \text{Rel-spread} = 0.046 - 0.691 \text{ Inv} \]

with

- Residual standard error = 0.092
- \( R^2 = 26\% \)
Crude Oil Adjusted Spread vs Detrended Inventory
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 (without including tar sands)

→ 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, and the recent rig accident
Crude Oil Price Spread 29th Versus 1st

Spread of the Oil Forward Curve - Dec 1995 / Dec 2005
Oil Forward Curve - March 2006 (Bid and Ask)
Back to Backwardation in September 2007
Crude Oil Forward Curve – Feb 2010

Oil (12 Feb 2010)
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