Commodities (oil, coal, gas)

Iuzbashev Artem

Charles University in Prague

3rd December 2020

Introduction

A **commodity** is a basic good used in commerce that is interchangeable with other goods of the same type. Commodities are most often used as inputs in the production of other goods or services. The quality of a given commodity may differ slightly, but it is essentially uniform across producers.

Example of commodities: Gold, Grain, Oil, Gas, Coal, etc.

Futures, Forwards and Options

Forward contracts allow people to buy or sell a specific type of asset at a specific time at a given price
Futures contract is a standardized legal agreement to buy or sell something at a predetermined price at a specified time in the future, between parties not known to each other.
Options contract offers the buyer the opportunity to buy or sell—depending on the type of contract they hold—the underlying asset. Unlike futures, the holder is not required to buy or sell the asset if they choose not to.

Market specification (1)

The importance of fuel to the modern world is unique. It is used inter alia for transportation, heating and production. As such, fuel availability and prices thus affect the global output capacity, rate of growth and level of in action and hence oil price fluctuations can have important macroeconomic repercussions.

First attempts to price especially oil was taken almost century ago in "Working, H. (1948). The theory of the price of storage"

Market specification (2)

- Fuel prices tend to exhibit strong seasonal patterns in response to cyclical fluctuations in supply and demand mostly due to weather and climate changes
- The prices of fuel can suddenly spike. This comes about when stored supplies are exhausted, or when storage is full, or when the production capacity is exhausted
- In equilibrium it is assumed that the future price converges to the spot price of the underlying asset as the delivery month of the futures contract is approached
- Oil prices are very volatile, have a high degree of mean reversion

Factor model

In such model target value depends on some random variables (factors):

$$y = a + \sum_{i=1}^{n} b_i x_i + \epsilon,$$

x_i - some random market parameters,

ϵ - error term

Gabillon Two-Factor Model

Jacques Gabillon in his paper "The Term Structures of Oil Futures Prices" (1991) presented two-factor model. There futures prices are assume to be depended:

- Spot price
- The long-term price of oil

Gabillon Model Equation

A Futures Pricing Model with a Long-Term Price of Oil:

$$F(S, L, t, T) = A(t, T) S^{B(t,T)} L^{1-B(t,T)}$$

$$A(t, T) = exp[\frac{\nu}{4\beta}(e^{-\beta(T-t)} - e^{-2\beta(T-t)}) - \frac{\theta}{\beta - \eta} e^{-\eta T}(1 - e^{-(\beta-\eta)(T-t)})]$$

$$B(t, T) = e^{-\beta(T-t)}$$

where S is a spot price, L is a long-term price, F is a futures price, t is a current time, T is a maturity time.

Cortazar and Schwartz Three-Factor Model

In 2003 Cortazar and Schwartz used a parsimonious three-factor model to explain the relationship between spot and futures prices to model term structures. In this model, the authors consider factors:

- Spot price
- Convenience yield
- The long-term spot price return

Black–Scholes Model Assumptions for European Option Pricing

The assumptions on the assets:

- The rate of return on the riskless asset is constant
- The stock price follows a geometric Brownian motion, and we will assume its drift and volatility are constant
- The stock does not pay a dividend

The assumptions on the market are:

- No arbitrage opportunity
- Ability to borrow and lend any amount, even fractional, of cash at the riskless rate
- ability to buy and sell any amount, even fractional, of the stock (this includes short selling).
- The above transactions do not incur any fees or costs

Black–Scholes Model Interpretation

$$C(F,\tau) = D[N(d_+)F - N(d_-)K]$$

$$d_\pm = \frac{1}{\sigma\sqrt{\tau}}[ln(\frac{F}{K}) \pm 0.5\sigma^2\tau]$$

- $C(F,t)$ is the price of a European call option
- K is the strike of the option
- σ the standard deviation of the stock's returns
- $N(x)$ is the cumulative distribution function of the standard normal distribution
- $\tau = T - t$ is the time to expiry
- $D = e^{-r\tau}$ is the discount factor
- $F = e^{r\tau}S = \frac{S}{D}$ is the forward price of the underlying asset

Other Models

- Markov-switching models (Hamilton, J.D. (1989). A New Approach to the Economic Analysis of Nonstationary Time Series and the Business Cycle.)
- S.L. Heston. (1993) A closed-form solution for options with stochastic volatility with applications to bond and currency options.
- Alan L. Lewis. (2000) Option Valuation Under Stochastic Volatility: With Mathematica Code
- V. Piterbarg. (2005) Time to smile.

Model calibration

One of the major problem is not only to construct the model but also calibrate it based on observed data. Some possible approaches are used:

- Kalman filtering
- Formulation and solution direct optimisation problem
- Finding numerical approximation for target function
- Using deep learning techniques to estimate target function

Dramatic Oil Price Movements

- The US invaded Iraq in 2003 leading to supply uncertainties. This was further compounded by massive demand growth by Asia and China. Consequently, prices jumped from $28.38 per barrel in July 2000 to $146.02 in July 2008
- Flooding of the market by US shale has led to a sharp drop in global oil prices, from $114.84 per barrel in June 2014 to $28.47 in January 2016
- A historic drop occurred on April 20, when the price of West Texas Intermediate crude dropped by almost 300%, trading at around negative $37 per barrel

The global financial crisis of 2008

JUNE 10, 2008. Thomas Reuters. "OPEC, source of two in every five barrels of oil, is pumping 32.2 million barrels per day (bpd), more than estimates of demand for its oil in 2008, Badri said. World consumption of 87 million bpd is smaller than the value of trading in oil-related financial instruments." Secretary General of OPEC Abdullah al-Badri

SEP. 11, 2008 The report by Masters Capital Management "Investors poured $60 billion into oil futures markets during the first five months of the year as oil prices soared from $95 a barrel in January to $145 by July. Since then, those investors have withdrawn $39 billion from those markets as prices have retreated dramatically, the report said." (Price was $102)