

Commodity markets (overview)

INTRODUCTION

Commodity markets cover physical assets such as precious metals, base metals, energy (oil, electricity), food (wheat, cotton, pork bellies), and weather. Most of the trading is done using futures (total trading volume around 200 billion dollars for the year 2002). However, over the last few years, an OTC market has also been growing (total size estimated to several tens of billion dollars for the year 2002), as an increasing number of market participants are trading in exotic options.

DESCRIPTION OF THE VARIOUS MARKETS

Commodity markets cover the following assets:

- Energy:
 - mainly oil and gas like crude oil, jet fuel, gasoline, fuel oil, heating oil, natural gas and propane.
 - electricity as well as renewable forms of energies like solar and wind energy
 - weather: weather is obviously not a tradable asset but we include them here because, over the last years, many derivative products whose underlying is weather (temperature, wind, precipitation) have been forth and traded.
- Agricultural:
 - Livestock: live hogs, cattle and pork bellies.

- Grain: corn, wheat, soybeans, soyoil, sunflower seed and oil.
- Forest products group: lumber and plywood.
- Textiles: cotton.
- Foodstuffs: cocoa, coffee, orange juice, rice, cheddar, and sugar.
- Metals
 - Base metals: aluminium, copper, zinc, nickel, and lead, tin, iron.
 - Precious metals: gold, silver, platinum, rare metals (palladium, titanium).

SPOT MARKETS

Spot markets are organized exchanges where commodity products can daily be traded (by large amounts, even). Typical examples are the CME (Chicago Mercantile Exchange), the MCE (Mid America Commodity Exchange).

FUTURES MARKETS

At their very early stage, commodity markets futures trading exchanges, served the purpose of hedging against price fluctuations in agricultural commodities. Sellers (farmers) and buyers would commit themselves to future exchanges of grain for a certain amount of cash. Nowadays, the rationale for trading futures is threefold:

- Hedging against price fluctuations. Both producers, refiners (in the case of oil) and consumers would look to it. For example, a producer, that is a participant who wants to sell the physical commodity, will hedge by selling futures. On the other hand, a consumer will try to be long futures, once she decided to buy the commodity in question.

- Speculation: trading futures, as compared to spot assets, presents many advantages, as futures:
 - are more leveraged than the spot instruments because of the low margin requirement,
 - are cheaper in term of transaction costs
 - and finally do not require storage during the lifetime of the contract.
- Arbitrage between spot and futures markets: for commodities, the cash and carry arbitrage is more difficult to realize because of storage and delivery costs.

Below are given some examples of futures commodity contracts.

<i>Contract</i>	<i>Exchange</i>	<i>Contract size</i>
Corn	CBOT/MCE	5000/1000bu
Wheat	CBOT/MCE	5000/1000 bu
Cocoa	CSCE	10metric tons
Orange Juice	NYCE	15,000 lbs
Gold	CME/CBOT	33.2/33.15 troy oz
Hogs	CME	50,000 tons
Pork Bellies	CME	40,000 lbs

Table 1: Some Commodity Futures

Name	Stands for	Country
CBOT	Chicago Board of Trade	US
CME	Chicago Mercantile Exchange	US
NYCE	New York Cotton Exchange	US
MCE	Mid America Commodity Exchange	US

Table 2: Some Commodity Futures exchanges

Because of the growing interest in commodity products, various institutions have developed commodity indices, exactly like the stock market index like the Dow Jones 30 index, the Nasdaq 100 or the S&P 500 index. One of the most popular ones has been the *GSCI*, Goldman Sachs Commodity Index, measuring the performance of a basket of commodity products weighted by their world production quantities (as one cannot talk of *market capitalization* in the commodities' universe). Because futures markets are the dominating markets for trading commodity, the index is using futures (which are highly liquid in energy, e.g.), and more specifically the so-called *nearby contracts* (*nearby*: the contract with the closest settlement date), rolling them forward (that is exchanging them with other futures corresponding to the next maturity date) between the 5th and 9th business day of each month, at the official close. Half of the index is comprised of energy commodities as this represents half of the commodity market. The basis of the GSCI index is 100 on 1-Jan-1970.

MARKETS RATIONAL

Although the primary reason of being of commodity markets was to have efficient markets for agricultural and energy goods, where producers and

consumers can transact deals, commodity markets have been growing to offer commodity-linked trading and speculative instruments. Compared to other assets like equity stock or bonds, commodities exhibit strong seasonality as well as high level of volatility (cf. the spike in oil prices in 1973, 1979 or the Gulf war), making hedging strategies a true challenge for the various market participants. The arrival of news (especially ones relating to local wars or political crises) can have a very high impact on commodity prices, especially oil. In addition, commodities present negative correlation with stocks and bonds (around -15% to -30% over the last ten years, if one looks at the correlation between the GSCI and the SP 500 for instance), making them valuable diversification investment instruments to other assets like equity stocks and bonds. With the growing volume of futures contracts, commodity futures contracts have become a very liquid instrument besides being an easy one to trade.

Standard arbitrage theory provides that the price of futures contracts is equal to:

$$[\text{Spot Price}] + [\text{Cost of Carry}] = [\text{Futures Price}] \quad (1.1)$$

Where the cost of carry is equal to:

$$\begin{aligned}
 [\text{Cost of Carry}] = & [\text{Interest Rate Cost}] \\
 & - [\text{Reinvestment Costs}] \text{ like coupon or dividends} \\
 & + [\text{Storage cost}]. \quad (1.2)
 \end{aligned}$$

Where under [Reinvestment costs] one should understand [coupons] and/or [dividends].

However, for commodity products, the cash and carry arbitrage is very difficult to put in place and the theoretical price is often an upper bound of the traded price. In practice, commodity futures trade often at a substantial discount to their fair value. This premium is referred to as the *convenience yield*. From an economic point of view, this stems from the fact that the global demand is in excess of the supplies and that the cash-and-carry arbitrage is not easily put forward, especially in view of storage problems associated with certain commodities. Put another way, market participants are ready to pay a premium for readily available commodities, reflected by the convenience yield. When the spot trades above futures prices, one then says that *the market is in backwardation* while when spot trade below futures prices, *the market is in contango*. The degree of contango is limited by the fair value of the futures prices whilst there is no limit to the degree of backwardation. Backwardation is the most frequent state of the market, although, both states can occur. For instance, over the last 10 years (data from 1990 to 2000), the WTI nearby contracts have been 58% in backwardation.

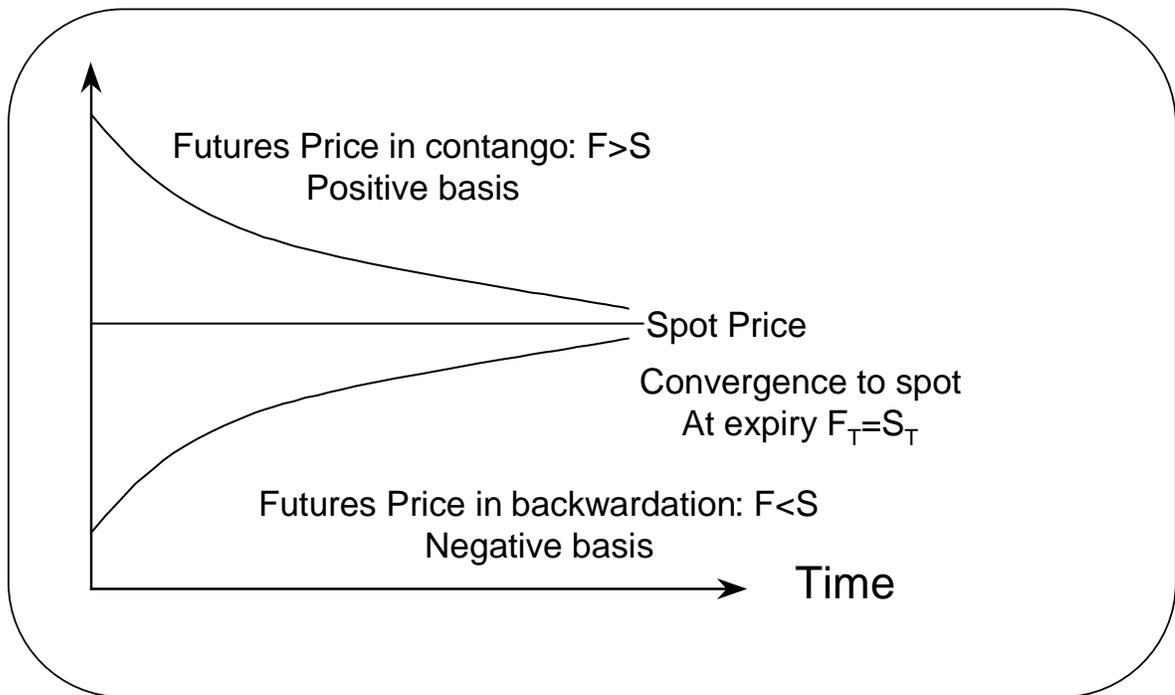


Figure 1: Backwardation and contango

Big players in the commodity markets comprise not only raw material producers, who try to hedge their risk, but also

- airlines companies that face the risk of unfavourable jet fuel price fluctuations.
- utility companies, facing important risk due to the deregulation of the energy market.
- various hedge funds interested in risk diversification.

Moreover, the deregulation of the energy markets, after year 2000, first in the US and now in Europe, has made risk management of commodities a must for utilities, distributors and suppliers.

Regulation, accounting and tax issues

One of the major fundamental changes over the past years has been

- in the US, the "**FAS 133**" standard of FASB (**F**inancial **A**ccounting **S**tandards **B**oard). FAS 133 requires that all derivatives must be carried on the balance sheet at market value and changes in the latter value should be included in the income statement. If a derivative qualifies as a *hedge*, the company may choose to use "hedge accounting" to reduce the latter statement's volatility that would result upon changes in the derivative's market value. This forces companies to disclose gains or losses on their derivatives. But since in many cases forward sales are *physically* delivered (this is the rule with electricity markets), mark-to-market can lead to misleading volatility in reported earnings. Companies have been forced to implement complex internal reporting systems to comply with the accounting standards. They have also been tempted to use more dynamic hedging strategies instead of more traditional option strategies.
- Internationally, the counterpart of SFA133 is the **IAS 39** standard that sets requirements and rules for recognition and measurement of all assets and liabilities. Again, all derivative instruments have to be accounted at fair value, and gains and losses arising from changes in the fair value of the derivatives will have to, unless some stringent hedge effectiveness criteria are satisfied, appear on the income statement. Conforming to the standard, then, leads to the facing the challenge of building internal systems that can accurately calculate fair values for derivatives as well as rigorously test for effectiveness of hedging strategies.

In terms of market participants, the market of commodity derivatives has seen consolidation among the dealers, especially with Enron buying out many of its competitors. After the collapse of Enron, the two American bank mammoths remain the dominant player with various other energy specific dealers and brokers.

PRODUCTS

One of the important derivatives on the commodity market has been the *commodity swap*, especially in oil, natural gas, and metals markets. For agricultural underlying, the volume of commodity swap is relatively low because of the importance of the futures market. Commodity swaps allow hedging the commodity risk but also geographical or quality basis risk as well as mismatch of maturity compared to futures. Liquidity of commodity swap varies greatly from the very liquid jet fuel commodity swap to the relatively illiquid agricultural commodity swap on some unusual and not easily (or even not at all) hedgeable risk.

Going long a commodity *payer (receiver)* swap, means paying (respectively receiving) a stream of fixed cashflows against receiving (respectively paying) the return of a given commodity index or commodity asset plus a spread for management fee. The floating return can be either the total return on the index, or the excess return (return over the US Treasury's one). Other types of swap includes *basis swap*, where one swaps the return of a given commodity index or asset versus the one of another index. A popular basis swap is the

one between the return on gold and the GSCI. Yet another commodity swap is the *Commodity-for-interest* swap whereby the total return on the commodity at hand is exchanged for some money market rate (the latter supplemented by a spread). Commodity swaps can have as underlyings:

- West Texas Intermediate, Brent, or Dubai crude oil
- Jet fuel, Gasoline, Fuel Oil, Gas oil, Cracks, Natural Gas
- Electricity
- Metals: Gold, silver, copper and aluminium

For metals, there exists also a substantial market of forward and averages to five years. Various commodities options are also listed on the exchange, like for instance the options on the GSCI index (CME), with expiry months available for each month, and a contract size of 250 times the index (hence a tick size by 0.1 index points of \$25).

Commodity derivatives dealers also offer various exotic variations on the vanilla commodity swap such as:

- *basket* swap, where the relevant return is based on a specific basket of commodities, (hedged easily as the basket of the individual swap if the weights are constants, otherwise, involves to model the correlation between the various assets),
- *forward* swap starting in the future,
- *deferred* swap, where payments are deferred in time,
- *digital* swap, which pays a given amount only if the underlying return has reached a certain level,

- *cliquet* type swap, where the fixed coupon locks in according to the previous return of the underlying commodity,
- *double up (double down)* and more generally cancellable (also referred to as extinguishable) swaps, where the writer of the swap has the right to double (resp. halve) the notional of the swap, and more generally to cancel or extend the swap according to various conditions. The right to cancel the swap may be conditioned on a third commodity's price movement. Furthermore, a swing swap allows the option buyer to specify the notional of the transaction

As the commodity swap market has been growing, commodity derivatives houses have started offering options like swaptions, but also various exotic (Asian, lookback, cliquet, binary, basket, chooser and barrier type) options on liquid commodity indexes. These exotic options are often quantoed for investors whose main currency is different from the nominal currency of the option's underlying. Typical examples are for instance Asian cliquet quanto calls on jet fuel prices sold to airlines companies to hedge their risk, whereby the contract size can be quite big (around a billion dollar notional for the big ones). Spread options (standard, Asian form or even barrier type) paying the difference between two commodities indexes are quite popular as well, especially in the oil market. Various types of commodity specific options like the one of the commodity markets are also the weather derivatives contracts. Precipitation swap, (where one pays or receives according to the degree of rainfall or snowfall above a certain level), and sunshine options (where one has an option on the number of hours of sunshine) are the two most common weather derivatives contracts, in addition to weather-linked bonds.

A growing market is the one of hybrids where the option involves cross assets. A typical example is to include credit and commodity assets or commodity and interest rates, like a cancellable credit default swap triggered by the level of oil or an interest rate-amortizing swap, triggered by the level of crude oil.

MODELLING ISSUES OF COMMODITY MARKETS

The largest portion of existing literature on commodity price modelling would only focus, up to a few years ago, on storable commodities. However the relatively recent deregulation of electricity markets, has transformed electricity to the first non-storable traded commodity. This, in turn, triggered the appearance of new theoretical models that deal with this asset. Yet another unique feature of about electricity is that its supply and demand has to be balanced continuously if a collapse of the network is to be avoided. Moreover, if one looks at historical time-series of electricity prices, one observes spikes of significant magnitude (sometimes even gigantic ones, as was the case in summer 1998, where wholesale prices fluctuated between \$0/MWh and \$7,000/MWh in US Midwest).

Among the most important commodity price models of the "ante-electricity" era, one can mention the models put forward by Schwartz (1997). These models cover copper, gold and crude oil. We will only dwell on "model 2" by

Schwartz which consists in taking the convenience yield to be stochastic and its dynamics being coupled to the stochastic dynamics of the spot price. The two equations read:

$$\frac{dS_t}{S_t} = (\mu - \delta)dt + \sigma_1 dz_1 \quad (1.3)$$

$$d\delta = \kappa(\alpha - \delta)dt + \sigma_2 dz_2 \quad (1.4)$$

$$dz_1 dz_2 = \rho dt \quad (1.5)$$

Going over to the equivalent martingale measure, one then gets:

$$\frac{dS_t}{S_t} = (r - \delta)dt + \sigma_1 dz_1 \quad (1.6)$$

$$d\delta = (\kappa(\alpha - \delta) - \lambda)dt + \sigma_2 dz_2 \quad (1.7)$$

$$dz_1 dz_2 = \rho dt \quad (1.8)$$

where λ stands for the market price of risk for the convenience yield. Then, a closed formula for the futures price is given by:

$$F(S_0, \delta, T) = S_0 \exp \left[-\delta \frac{1 - e^{-\kappa T}}{\kappa} + A(T) \right] \quad (1.9)$$

$$A(T) = f(r, \kappa, \lambda, \sigma_1, \sigma_2, \rho, T) \quad (1.10)$$

where $f()$ is a function whose exact form is not of real interest in our discussion. The above system is then cast in a "state-space" form, in view of the fact that the factors, or state variables of the model are, in many cases, non-observable quantities: e.g., for some commodities, the spot price is not easy to obtain, so one uses the 1st nearby as a proxy.

With the further assumption that these state variables are generated by a Markov process, a Kalman filter is, then, applied to the state-space system:

the filter consists of a system of two equations, the "measurement equation" connecting the observable quantities (e.g., historical futures prices) to the state variables (say, spot price and convenience yield) and the "transition equation" governing the evolution of the state variables. The Kalman filter, strives at computing the optimal estimator of the state vector at time t , conditional on the information available at time t , whilst enabling, the inclusion of new information. A likelihood function is built up, and by maximizing it, one obtains the values of the unknown parameters of the model.

Another model by Hilliard and Reis looks further at stochastic interest rates, and jumps in the spot price on the pricing of commodity futures, forwards, and futures options. It is deduced that jumps in the spot price do not affect forward or futures prices.

The drawback of the above formalism is that the model is fitted to the forward price curve instead of taking it as a starting point. The latter is the approach of the so-called "forward curve models": thus one models the dynamics of $F(t,T)$, that is the forward price at time t for maturity date T . If the dynamics is taken to be driven by M factors (independent sources of uncertainty), then one can write:

$$\frac{dF(t,T)}{F(t,T)} = \sigma_s(T) \sum_{i=1}^M \sigma_i(t,T) dz_i \quad (1.11)$$

where volatility functions have been split into two components, the one (multiplying the sum) accounting for the *seasonality* feature exhibited by many commodity forward curves.

A general energy price model should incorporate should address the issue of "explaining" (unless it's taken as input) the observed forward curve, *mean-*

reversion (when prices are high, supply increases which in turns puts a pressure downwards to prices; when prices are low, supply reduces which leads to a upward pressure on prices), *seasonality*, and *jumps* (and/or *spikes*, in the case of electricity). For electricity, more specifically one can look at a mean-reverting jump-diffusion process with stochastic volatility. Again, in the latter case, one can augment the model by including a commodity, such as the generating fuel prices, that is highly correlated to electricity (Shijie Deng, 2000).

The Gabillon Markovian two factor Gaussian model is one of the advocated easy and quite popular commodity models. In this setting the dynamics of the forward F_t^T (standing for $F(t,T)$) is given by a fast mean reverting highly volatility short term first factor $e^{-\lambda(T-t)}\sigma_s(t)dW_t^S$ and a less volatility mean reverting long term second factor $(1-e^{-\lambda(T-t)})\sigma_L dW_t^L$ correlated to the first factor

$$\frac{dF_t^T}{F_t^T} = e^{-\lambda(T-t)}\sigma_s(t)dW_t^S + (1-e^{-\lambda(T-t)})\sigma_L(t)dW_t^L \quad (1.12)$$

where dW_t^S and dW_t^L are two Brownian motions (Wiener processes), with term structure of correlation $\rho_{sL}(t)$, $e^{-\lambda(T-t)}$ is the mean reversion factor with exponential time decay of λ , $\sigma_s(t)$ the short term structure of volatility, $\sigma_L(t)$ the long term structure of volatility.

In practice, this model is used in its rotated form (diagonalised version of the previous model)

$$\frac{dF_t}{F_t} = e^{-\lambda(T-t)}\sigma_R(t)dW_t^R + \sigma_L(t)dW_t^L \quad (1.13)$$

where $\sigma_R(t)dW_t^R = \sigma_S dW_t^S - \sigma_L(t)dW_t^L$, implying in particular

$$\sigma_R(t) = \sqrt{\sigma_S^2(t) + \sigma_S^2(t) - 2\rho_{SL}(t)\sigma_S(t)\sigma_L(t)} \quad (1.14)$$

$$\text{and } \rho_{RL}(t) = \rho_{SL}(t) - \frac{\sigma_L(t)}{\sigma_S(t)} \quad (1.15)$$

The simplest version of this model is to have flat term structure of parameters, hence four parameters, short-term rotated volatility σ_R , long term volatility σ_L and correlation between the two ρ_{RL} and mean reversion speed λ . More sophisticated version of this model includes model with term structure of volatility, correlation and mean reversion, model with the two factors having different mean reversion term structure of speed ($\lambda_S(t)$ and $\lambda_L(t)$ ¹), version with smile (either using a shifter log diffusion or a CEV process). The CEV version of the model has become quite popular and is described by the following dynamics

$$dF_t^T = e^{-\lambda(T-t)}\sigma_S(t)(F_t^T)^{\beta_S} dW_{t^b}^S + (1 - e^{-\lambda(T-t)})\sigma_L(t)(F_t^T)^{\beta_L} dW_t^L \quad (1.16)$$

where the β_S describes the short term sked while β_L the long term one. Moreover, some practitioners have also advocated the use of a jump for the decorrelation and extra volatility of the spot, leading to a jump diffusion model of the type:

$$dF_t^T = e^{-\lambda(T-t)}\sigma_S(t)(F_t^T)^{\beta_S} dW_{t^b}^S + (1 - e^{-\lambda(T-t)})\sigma_L(t)(F_t^T)^{\beta_L} dW_t^L + J_t dN_t \quad (1.17)$$

sophisticated version of the previous model have been required when dealing with electricity market has the jump components is quite substantial in this market.

¹ In this case, the rotated version is less simple.

The calibration of the model is done:

- For the long term parameters as well as mean reversion term structure and correlation, by using a set of liquid swaptions instruments.
- For the short term factor, by using short dated exchange traded vanilla options.
- Like in any other derivatives market, the numerical methods used are Monte Carlo as well as trees.

If one looks at a two-factor models, then when dealing with an option on N commodities (like for instance basket option), one needs to specify a number of $C_{2N}^2 = N(2N-1)$ correlations. Like any correlation products, the exact determination of the correlation levels is not easy as there is not hedgeable instruments for correlation. Backtesting, historical simulation as well as scenario analysis can help to take views on correlation. Other type of tools like copulas or dynamic copulas (specification of a term structure of copulas to capture desired smile dynamics and therefore appropriate delta) can also come at rescue. Last but not least, because of the interdependence between various commodities, like various sorts of oil products, it is often appropriate to model them as a spread asset over the most liquid one of the category. The intuition is to decompose commodities across various sectors and model the most liquid asset of a given sector accurately, using market implied calibration and have the other assets modelled as the representative asset plus a spread that can itself again be represented by a stochastic model, in order to assess the basis risk taken. The concept of regrouping the various commodities

across sector enables to split the tradign and hedging of the exotic commodity book into different buckets.

In terms or risk, it is often appropriate to provide risk reports in terms of individual components, as well as sector risk, and geographical risk reports as some market information may have serious impact only on a specific region of the globe. Trading institutions have also adopted various risk analysis, monitoring and reporting tools to identify potential risks. Typical examples include value-at-risk systems, stress testing, extreme VAR and other shortfall measure,s but also assessment of counterparty risk and system risk.

FAMOUS COMMODITY TRADING STORY

When speaking about commodity, one of the most famous stories is the debacle of ENRON.

ENRON

ENRON is the story of a spectacular loss of once a mighty energy giant trading company that ended bankrupt, and filed for Chapter 11. The total market capitalization of ENRON went from over \$60 billion to zero, making it the biggest ever bankruptcy in the business history. Enron was once an interstate pipeline company formed by the merger of Houston Natural Gas and InterNorth. From 1985 to 2000, the company expanded considerably its trading activity of natural gas, commodities and electricity, whilst building at the same time a trading platform entitled EnronOnline. The growth was

spectacular, as Enron became in 2000 the 7th largest Us company in terms of revenue. Its 401(k) pension fund held in fact a considerable amount of Enron share as 60 percent of its portfolio was constituted by Enron shares.

But in 2001, Enron reported \$618 millions loss and a reduction of shareholder equity of over \$1 billion. In November, it announced it had overstated its earning back to 1997 by about \$600 million. Share plunged to under \$4 from a high of \$90. Further investigation revealed that Enron had camouflaged a mountain of debt under a complicated matrix of partnerships, with lots of them being offshore. The investigation of Enron also revealed that its auditor, Arthur Andersen has been complaisant in auditing the company and hide consciously some of the debt of Enron.

Surprisingly, then Enron's debacle had a substantial impact more on the accounting practice and the credit derivatives market than on the commodity market. The financial commodity market suffered substantially, with spike of volatility but eventually managed to get back to normal, while the credit derivatives market experienced a liquidity crisis, especially on CDO. But the most important consequence has been the discredit thrown on accounting practices worsened by further bankruptcies (WorldCom), shaking up the accounting institution for quite a while.

Entry category: markets.

Scope: markets and instruments; structures; trading processes, emphasis on risk management, financial engineering issues.

Related articles: Commodity futures.

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The views and opinions expressed herein are the ones of the author's and do not necessarily reflect those of Goldman Sachs, Deutsche Bank or Elf Trading SA.