CME Group

Trading Calendar Spread Options on Energy Futures

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Calendar Spread Options (CSOs) are options on the spread between two different futures expirations. The Energy futures term structure represents the time value of Energy market variables such as storage costs, seasonality, and supply/demand conditions. Calendar Spread Options provide a leveraged means of hedging against, or speculating on, a change in the shape of the futures term structure.

CME Group has a diverse product offering that includes Crude Oil, Natural Gas, and Refined Products CSOs. This article illustrates the main characteristics of CSOs and some of their applications in the Energy markets.

Calendar Spread Options (CSOs)

A Calendar Spread Option is an option to enter into two separate futures positions: one long and one short. A call option can be exercised into a long futures position that is closest to expiration and a short futures position in a more distant month. The put option can be exercised into a short futures position that is closest to expiration and a long futures position in a more distant month. The strike price is the price differential between the long and short futures positions.

A call option with a $0.50 strike price, for example, represents a long futures position priced $0.50 higher than a short futures position of a more distant maturity. A put option with a $0.50 strike price, by contrast, represents a short futures position priced $0.50 higher than a long futures position of a more distant maturity.

The payoff for a long CSO call or put position at maturity T is:

$$C(T)=Max(o,Đ(FĐ\text{-}T_1\ (T)\text{-}F\text{-}T_2\ (T))\text{-}K)$$

$$P(T)=Max(o,ĐK\text{-}(FĐ\text{-}T_1\ (T)\text{-}F\text{-}T_2\ (T)))$$

Where
T: Option expiration
FT1(T)-FT2(T): Calendar spread
K: Strike price

If the futures spread settles higher than $0.50 on the day of the CSO expiration, the owner of the $0.50 call profits on the difference.

Natural Gas CSOs

The Natural Gas term structure is defined by seasonality. The withdrawal season ("Winter") — ranges from November to March and is noted for its volatility. The injection season ("Summer") — ranges from April to October and is generally less volatile.

Chart 1: Natural Gas (Henry Hub) Futures Term Structure

Source: CME Group

During the Winter season, gas consumption peaks as a result of increased heating demand from residential, commercial, and industrial end-users. During the Summer season, gas demand decreases while production continues, resulting in excess Natural Gas that can be stored. As a result of unpredictable Winter demand, the Winter Natural Gas futures trade at a premium to the Summer futures (see Chart 1). The Winter term structure is in backwardation – defined by the scenario when near-month futures are priced higher than back-month futures — versus the Summer term structure in contango, characterized by near-month futures trading at a discount to back-month futures.

Commercial firms typically produce or purchase Natural Gas at a lower price during the Summer season and inject that Natural Gas into storage. Those firms then sell the stored Natural Gas in the Winter season at a higher price to profit from the demand premium. The ability to purchase, store, and sell Natural Gas across the Winter and Summer seasons creates implicit optionality.

Natural Gas CSO Example 1:

As an example, a storage operator has accumulated Natural Gas inventories late in the Summer and intends to sell his inventories early in the Winter. This replicates a long Summer and short Winter futures position, and for the sake of this example, a long October and short November position. This gives the storage operator the optionality to sell inventories in November should the futures price exceed the October price at which the Natural Gas was stored, after factoring in financing and storage costs. The storage operator's position is the equivalent of owning a call on the October/November calendar spread.

For simplicity's sake, there are two possible outcomes as time moves from October to November: the October/November futures spread either widens or contracts between the time of injection and withdrawal.

The storage operator buys physical Natural Gas in October at an average price of $2.50 per MMBtu while the price of November Natural Gas is $3.00 per MMBtu (displayed as an Oct/Nov spread price of $-0.50). He wants to ensure he can profit at least $0.50 when he sells the physical gas in November. To do this, he would buy an Oct/Nov $-0.50 call option. Thirty days ahead of the October futures expiration, the Oct/Nov $-0.50 call can be purchased for $0.25.

- Scenario A:

  At October futures expiration, the Oct/Nov spread settles at $-1.50: October at $2.50 and November at $4.00. The storage operator gains $1.00 on his physical position, but at the same time, he loses $0.25 from the $-0.50 strike call premium which settled out-the-money.

  The storage operator protected himself from the Oct/Nov spread narrowing with the purchase of a CSO call.

- Scenario B:

  At October futures expiration, the Oct/Nov spread settles at $0.80: October at $3.00 and November at $2.20. The storage operator profited $1.30 on his CSO position, less the $0.25 insurance premium of the call, for a total CSO profit of $1.05.

  In this case, the call finished in-the-money and offset some of the losses resulting from the futures spread trending against the storage operator's physical position.

In Example 1, the storage operator benefitted from owning a CSO call. For a relatively small insurance premium of $0.25 to buy the call, he was protected from an adverse move in the futures spread, but still realized a profit when the spread moved in his favor.

Besides hedging physical storage, CSOs can also be used to capitalize on volatile moves in futures spreads. The most volatile of all Natural Gas futures spreads is the March/April spread, when the transition from withdrawal to injection begins [see price spikes in Chart 2].

Chart 2: Natural Gas 1-Month Calendar Spread During 2013/2014 Winter Season

Source: CME Group

Natural Gas CSO Example 2:

A Natural Gas trader is expecting a colder than normal Winter and is bullish on the March/April spread (expecting March futures prices to trend much higher relative to April futures prices).

On December 1st, the March/April spread is trading at a differential of $0.20 with March at $3.10 and April at $2.90. The trader believes the March/April spread will settle higher than $1.00 when it expires at the end of February.

The trader purchases a CSO call on the March/April spread at a strike price of $0.65 at a cost of $0.13. In order to break even, the March/April spread must reach at least $0.78 upon expiration ($0.65 strike + $0.13 premium).

Purchasing a call limits the trader's downside risk versus going long the futures spread. The maximum loss on the CSO is the premium paid ($0.13), where the maximum loss on a futures position can be much greater.

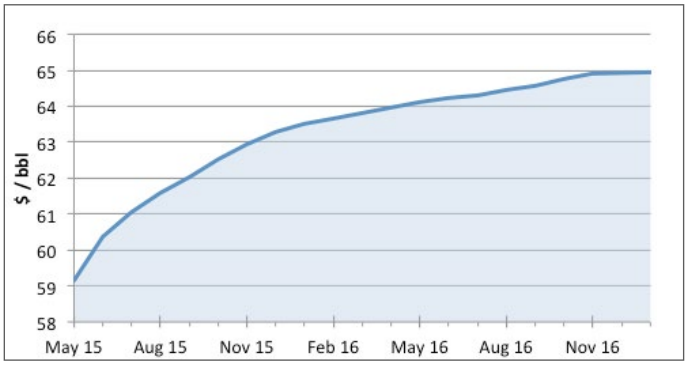
At March futures expiration, the March/April spread settles at $1.10: March at $4.20 and April at $3.10. The trader's bullish sentiment was correct – and his CSO call settled in-the-money by $0.45, netting a profit of $0.32 ($0.45 profit – $0.13 option premium).

The seasonality and resulting volatility in Natural Gas markets provide all participants – from physical storage operators to professional traders – opportunities to utilize CSOs to hedge against or benefit from moves in Natural Gas futures spreads.

Crude Oil CSOs

The Crude Oil futures and options markets are global and are the most liquid and actively traded commodities contracts in the world. The forward term structure in Crude Oil is largely influenced by supply/demand, storage costs, and production estimates. This results in the market's expectation of a more continuous price evolution. This is in contrast to the Natural Gas market, where seasonality dictates the shape of the forward futures curve.

Chart 3: WTI Futures Term Structure



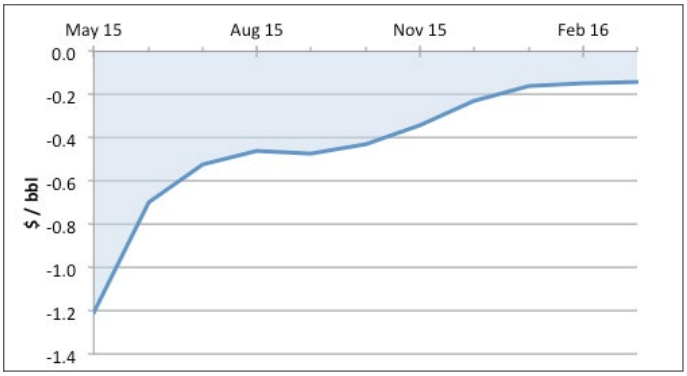
Source: CME Group

In Crude Oil, a backwardated market generally reflects potential supply constraints or shortages – distant futures prices are cheaper than near term because demand for oil adds a premium to the nearest delivery contract. Conversely, a higher price on the more distant futures contracts generally reflects plentiful supply or inventory levels. This is often referred to as a contango market. [See Chart 3: the WTI term structure on May 1, 2015, is in steep contango.]

The shape of the forward curve has important implications for inventory management. For example, if the market is backwardated, the current value of inventory is greater than the deferred future price. Holding inventory in this situation could result in selling at a lower price. Conversely, in a contango market, holding inventory and selling at a deferred date is expected to yield extra revenue net of storage costs.

This *convenience yield* can be viewed as the embedded optionality attached to holding a physical commodity. It is defined as the difference between the positive gain of holding a commodity minus the cost of storage. Therefore, the convenience yield can be positive or negative depending on the time period and the level of oil inventory.

Chart 4: WTI Spread of 1st vs 2nd Nearby Futures



Source: CME Group

Chart 4 displays the 1-month calendar spread curve of Crude Oil futures. If a market participant were holding a long position and needed to roll to the next contract month ahead of expiration, he would have to pay a premium to buy the next month's future.

Crude Oil CSO Example 1:

A Crude Oil producer extracts oil during the month of June and intends to store it until a buyer is procured. The producer has an incentive to store the oil because the forward price of oil is currently trading at a premium. The producer secures a 1-month storage contract requiring him to sell his physical Crude Oil when the June contract expires. The June Crude Oil future is trading at $57.50, while the July future is trading at a price of $58.80, making the June/July calendar spread -$1.30.

The producer is effectively long the June/July calendar spread and is exposed to a narrowing of that spread differential. The producer wants to hedge against a flattening of the term structure, which would reduce his expected profit on the oil sale. He purchases a -$1.20 strike call CSO for a premium of $0.16.

- Scenario A:

  At June futures expiration, the June/July spread has steepened and settles at $-2.00. The producer realizes a greater than expected profit on the physical position over his target $1.30 as the final June/July spread widened an additional $0.70. The producer protected his original profit target for a $0.16 premium, resulting in a total profit of $1.84 ($2.00 spread difference - $0.16 option premium).

- Scenario B:

  At June futures expiration, the June/July spread contracted to -$0.50. If the producer were to sell, he would now be faced with a profit $0.80 less than the original expectation of $1.30 on his physical position. However, the CSO call option he purchased is now in-the-money, worth $0.70 ($1.20 strike price - $0.50 spread price), which nets him $1.04 on the sale ($0.50 + $0.70, less the $0.16 premium paid for the call).

  In this case, the call finished in-the-money, protecting the storage operator from an adverse shift in the futures spread.

In Example 1, the storage operator benefitted from owning a CSO call. For a relatively small insurance premium of $0.16 to buy the call, he was protected from an undesirable move in the futures spread, but still realized a profit when the spread moved in his favor.

Crude Oil CSO Example 2:

A professional trader has a bullish view on oil futures and needs to roll his current long futures position when it expires in 30 days to the next calendar month. Depending on the shape of the crude term structure, rolling futures to maintain a long position can be costly. If the market is in contango, he will have to pay a premium each month to roll his long position forward.

In a possible scenario, the oil term structure is in contango and the Sep/Oct calendar spread is trading at -$1.50. This means it would cost the trader $1.50 to roll his futures position forward and maintain his long position should the term structure remain near this level for 30 days. Given the trader's desire to roll his long position, he will need to sell the Sep/Oct calendar spread in order to close out the September position and initiate a long position in October.

The trader wants to hedge against the cost of rolling his position into a higher priced futures contract. High volatility in the near month CSOs has increased option premiums, thus he decides to sell a call against his position. He sells the Sep/Oct $-1.30 call for a premium of $0.20.

- Scenario A:

  At September futures expiration, the Sep/Oct spread has steepened and settles at $-1.70. This increases the trader's cost to roll. However, since he collected $0.20 premium selling the call, which is now out of the money and expires worthless, his roll costs are reduced by $0.20 to -$1.50, the original spread cost.

- Scenario B:

  At September futures expiration, the Sep/Oct spread contracted to -$1.00. This move was in the trader's favor which lessens his rolling cost. However, since he sold a physically-settled CSO

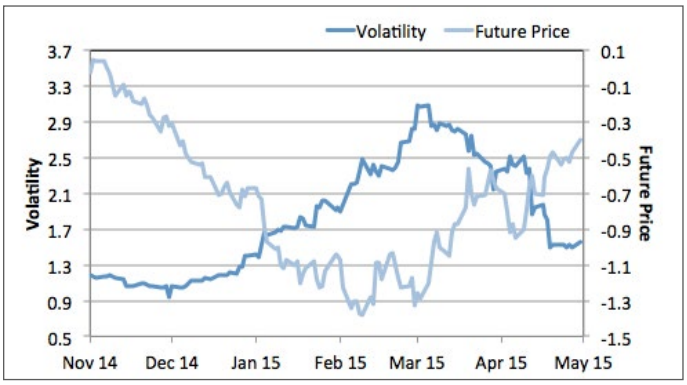
call at a strike of $-1.30, the option expired in-the-money and he will receive a short September futures position and a long October futures position—the transaction he would have needed to perform to roll. When he initiated the trade, the calendar spread was $-1.50. It finished at $-1.00, a move in his favor which reduced his roll costs by $0.50. While the trader benefitted from the spread price contraction of $0.50 and collection of the option premium of $0.20, the move was adverse for the short call position. His net result was a $0.10 cost for insurance to lower his rolling cost ($0.30 loss on the call offset by the $0.20 premium collected).

In Example 2, the trader was able to employ a CSO position to flexibly lower his roll costs. He could also repeat this same transaction each term, or depending on how long he wants to maintain his long futures position, he could sell CSO calls each month to reduce his overall roll costs.

Pricing

Option pricing models and hedging tools that are traditionally utilized for standard vanilla options should not be applied to spread options for a variety of reasons, most notably the possibility of negative strike prices. Spread option pricing varies, but can be classified into two main approaches: numerical models and analytical models. Numerical models include Monte Carlo simulation, fast Fourier transform, and numerical integration. The primary analytical model is a closed-form solution (CFS), known as the Bachelier[1] model. The Bachelier model relies on the assumption that the underlying spread follows a symmetrically normal price distribution. Since the price follows a normal distribution, volatility also needs to be treated differently [See Chart 5 for a Price vs. Volatility example]. These models are commonly used across the CSO trader community.

Chart 5: WTI CSO Price vs. Volatilty



Source: QuikStrike

Summary

Oil and gas prices are highly elastic with respect to various fundamental factors including weather, geopolitical risk, and unanticipated supply/demand. Unpredictable changes from any of these factors can have an impact on forward curve prices and the correlation between the calendar months.

CSOs are flexible products that are sensitive to the slope of the forward term curve and will rise or fall in value as the shape of that term curve changes with time. A move from contango to flat to backwardation will change the values of term differences all along the curve and CSOs can be leveraged to realize those steepening or flattening changes.

CME Group has a diverse product offering of Calendar Spread Options across Crude Oil, Natural Gas, and Refined Products. Additionally, CME offers inter-commodity spread options such as WTI-Brent and Crack Spreads. The following table lists the complete offering of CME Group Energy spread options.

[1] Bachelier, "Theory of Speculation (English translation) by Paul Cootner," Risk, January (2000), pp. 50-55.
Poitras, "Spread options, exchange options, and arithmetic Brownian motion," Journal of Futures Markets, 18 (1998), pp. 487-517.
Shimko, "Options on future spreads: Hedging, Speculating, and Valuation," Journal of Futures Markets, 14, No. 2 (1994), pp. 183-213.
Wilcox, "Energy futures and options: Spread options in energy markets," Goldman Sachs & Co., New York, 1990.

Energy Calendar Spread Options

Option Contract Name	Underlying Future	Term (months)	Symbol	Settlement
WTI Crude Oil 1 Month Financial Calendar Spread Option	WTI Crude Oil	1	7A	Financial
WTI Crude Oil 2 Month Financial Calendar Spread Option	WTI Crude Oil	2	7B	Financial
WTI Crude Oil 3 Month Financial Calendar Spread Option	WTI Crude Oil	3	7C	Financial
WTI Crude Oil 6 Month Financial Calendar Spread Option	WTI Crude Oil	6	7M	Financial
WTI Crude Oil 12 Month Financial Calendar Spread Option	WTI Crude Oil	12	7Z	Financial
WTI Crude Oil 1 Month Physical Calendar Spread Option	WTI Crude Oil	1	WA	Physical
WTI Crude Oil 2 Month Physical Calendar Spread Option	WTI Crude Oil	2	WB	Physical
WTI Crude Oil 3 Month Physical Calendar Spread Option	WTI Crude Oil	3	WC	Physical
WTI Crude Oil 6 Month Physical Calendar Spread Option	WTI Crude Oil	6	WM	Physical
WTI Crude Oil 12 Month Physical Calendar Spread Option	WTI Crude Oil	12	WZ	Physical
Daily WTI Crude Oil 1 Month Calendar Spread Option	WTI Crude Oil	1	DNM	Financial
Daily WTI Crude Oil 2 Month Calendar Spread Option	WTI Crude Oil	2	DTM	Financial
Brent Crude Oil 1 Month Physical Calendar Spread Option	Brent Crude Oil	1	AA	Physical
Brent Crude Oil 2 Month Physical Calendar Spread Option	Brent Crude Oil	2	AB	Physical
Brent Crude Oil 3 Month Physical Calendar Spread Option	Brent Crude Oil	3	AC	Physical
Brent Crude Oil 6 Month Physical Calendar Spread Option	Brent Crude Oil	6	AM	Physical
Brent Crude Oil 12 Month Physical Calendar Spread Option	Brent Crude Oil	12	AZ	Physical
Brent Crude Oil 1 Month Financial Calendar Spread Option	Brent Crude Oil	1	9C	Financial
Brent Crude Oil 2 Month Financial Calendar Spread Option	Brent Crude Oil	2	9B	Financial
Brent Crude Oil 3 Month Financial Calendar Spread Option	Brent Crude Oil	3	9D	Financial
Brent Crude Oil 6 Month Financial Calendar Spread Option	Brent Crude Oil	6	9L	Financial
Brent Crude Oil 12 Month Financial Calendar Spread Option	Brent Crude Oil	12	9Y	Financial
Natural Gas 1 Financial Month Calendar Spread Option	Natural Gas	1	G4	Financial
Natural Gas 2 Financial Month Calendar Spread Option	Natural Gas	2	G2	Financial
Natural Gas 3 Financial Month Calendar Spread Option	Natural Gas	3	G3	Financial
Natural Gas 5 Financial Month Calendar Spread Option	Natural Gas	5	G5	Financial
Natural Gas 6 Financial Month Calendar Spread Option	Natural Gas	6	G6	Financial
Natural Gas 12 Financial Month Calendar Spread Option	Natural Gas	12	G7	Financial
Natural Gas 1 Month Calendar Spread Option	Natural Gas	1	IA	Physical
Natural Gas 2 Month Calendar Spread Option	Natural Gas	2	IB	Physical
Natural Gas 3 Month Calendar Spread Option	Natural Gas	3	IC	Physical
Natural Gas 5 Month Calendar Spread Option	Natural Gas	5	IE	Physical
Natural Gas 6 Month Calendar Spread Option	Natural Gas	6	IM	Physical
Natural Gas 12 Month Calendar Spread Option	Natural Gas	12	IZ	Physical
Low Sulphur Gasoil 1 Month Calendar Spread Option	Gasoil	1	GXA	Physical
Low Sulphur Gasoil 2 Month Calendar Spread Option	Gasoil	2	GXB	Physical
Low Sulphur Gasoil 3 Month Calendar Spread Option	Gasoil	3	GXC	Physical
Low Sulphur Gasoil 6 Month Calendar Spread Option	Gasoil	6	GXM	Physical
Low Sulphur Gasoil 12 Month Calendar Spread Option	Gasoil	12	GXZ	Physical

Energy Calendar Spread Options

Option Contract Name	Underlying Future	Term (months)	Symbol	Settlement
NY Harbor ULSD 1 Month Calendar Spread Option	ULSD	1	FA	Physical
NY Harbor ULSD 2 Month Calendar Spread Option	ULSD	2	FB	Physical
NY Harbor ULSD 3 Month Calendar Spread Option	ULSD	3	FC	Physical
NY Harbor ULSD 6 Month Calendar Spread Option	ULSD	6	FM	Physical
NY Harbor ULSD 12 Month Calendar Spread Option	ULSD	12	FZ	Physical
RBOB Gasoline 1 Month Calendar Spread Option	RBOB Gasoline	1	ZA	Physical
RBOB Gasoline 2 Month Calendar Spread Option	RBOB Gasoline	2	ZB	Physical
RBOB Gasoline 3 Month Calendar Spread Option	RBOB Gasoline	3	ZC	Physical
RBOB Gasoline 6 Month Calendar Spread Option	RBOB Gasoline	6	ZM	Physical

Energy Inter-Commodity Spread Options

Option Contract Name	Underlying Future	Symbol	Settlement
WTI-Brent Crude Oil Spread Options	WTI/Brent	BV	Financial
Low Sulphur Gasoil Brent Crack Average Price Options	Gasoil/Brent	3U	Financial
NY Harbor ULSD Crack Spread Average Price Option	ULSD/WTI	3W	Financial
NY Harbor ULSD Crack Spread Option	ULSD/WTI	CH	Physical
RBOB Gasoline Brent Crack Spread Average Price Options	RBOB/Brent	RBC	Financial
RBOB Gasoline Crack Spread Average Price Options	RBOB/WTI	3Y	Financial
RBOB Gasoline Crack Spread Options	RBOB/WTI	RX	Physical

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