Calendar Spread
1. Front and Back Contracts

Every financial derivative has a date on which the contract matures. On that day, the value of the derivative is the contingent payoff. Depending on the market conditions prevailing on the maturity date, the payoff is fixed. As soon as the payoff is confirmed and processed for settlement, the contract expires and exists no more. Futures contracts are no different.

In the futures markets, contracts on the same underlying asset but different maturity dates are offered by the exchanges for traders to trade. The front-month futures contract refers to a contract for which the expiration date is closest to the current date. Contracts that mature a month or so longer than the front month contracts are known as back month contracts.

Many futures contracts do not mature on the monthly basis. For example, the Brazilian Ibovespa index futures contract matures on the even-numbered months (February, April, June, August, October, and December). Major index futures contracts, such as the Emini S&P 500 index futures, are on the quarterly cycle; the maturity months are March, June, September, and December. It is more appropriate, therefore, to refer to the futures contract that are nearest to maturity as the front contract, and the next nearest as the back contract.

The calendar spread is simply the market price difference:

\[
\text{calendar spread} = \text{price of back contract} - \text{price of front contract}.
\]

You can see from this definition of calendar spread that it is market neutral. Whether the market is going up or going down, the value of the calendar spread does not change. By trading calendar spread, you are taking a neutral stance, as you don’t bet on the market direction. You don’t even have to have an outlook, going forward.

What will happen to the calendar spread position when price moves? Suppose the price of front contract moves up by 14 ticks, the back contract is most likely to move up 14 ticks as well. Since the calendar spread is essentially a subtraction of one price from another price, the move of 14 ticks cancel out. Hence, the price of the calendar spread remains unchanged. As an illustration, consider the MSCI Singapore index futures, which is known as the Simsci futures on the street. Suppose the front contract is traded at 350.10, and the back month’s market price is 349.00. The calendar spread price is therefore

\[
349.00 - 350.10 = -1.10.
\]

If the front and back markets move down by 14 ticks, the two futures prices will become, respectively, 349.40 and 348.30, because each tick is 0.05 index points. Despite the price moves, the calendar spread is still \(-1.10(= 348.30 - 349.40)\). Therefore, with calendar spread, the risk of making a wrong bet in the market direction is mitigated.

Everything else being equal, typically the front futures contract is the more liquid compared to the back contract, and other longer-term futures contracts. So logically, to execute a calendar spread, it makes sense to trade the back contract first, and then immediately execute a hedging trade of the front contract.

Following the market convention, buying the back futures contract in conjunction with selling the front futures contract constitutes a purchase of the calendar spread. Conversely, selling the back contract and buying the front contract is known as taking a short position in the calendar spread. It goes without saying that to make a round trip of a calendar spread, you need four trades: two to open a calendar spread position, and another two to close it.
What’s the point of trading a calendar spread? The point, really, is to earn the difference between the bid and ask prices in a much less risky way. Every market maker posts bid and ask quotes at the market to attract customers to trade with him. If the price moves were mild, the market maker could make money with little risk by adjusting his quotes and position size. The same market making strategy can be implemented using limit orders at the bid and at the ask in the electronic market. But when the market moves rapidly, if the market maker is not nimble in adjusting both the quotes and the position size, he may lose substantially when the market direction runs against his position.

One of the ways to circumvent this price risk is to trade the calendar spread. If you sell the calendar spread at $-1.0$ and manage to square off your short position at $-0.9$, you will make a profit of 0.1 index points. The calendar spread trading is the round-about way of earning the bid-ask spread in a way that is (almost) invariant to the market direction. In that sense, calendar spread traders provide liquidity to the market. We shall see in the subsequent sections that the liquidity provision is indeed the positive externality of calendar spread trading.

But like all strategies, calendar spread trading is also not immune to risks. Chief among the risks is the sudden jump in both the quoting leg and the hedging leg. The jumps will lead to mis-hedges, which mean losses, more often than not. When mis-hedge occurs, the spread is said to be legged and a directional trade is said to have occurred. In the age of high-frequency algorithmic trading, a sudden intra-day plunge or surge in the electronic market appears to occur more frequently. These sudden jumps are reinforced by the trigger of stop orders to cut loss. In other words, spread trading in general is subject to the risk of mis-hedge when both legs jump.

2. Fair Value of the Calendar Spread

You may wonder why should the calendar spread be of a particular value, such as $-1.10$ in the earlier example. Futures is a simple linear-payoff derivative, its fair value can be easily derived. In the case of calendar spread, its fair value is simply the difference between the fair value of the back contract and that of the front contract:

\[
\text{theoretical calendar spread}_t = F_{\text{back},t} - F_{\text{front},t}.
\]

Here, $F_{\text{back},t}$ is the fair value of the theoretical price of the back contract while $F_{\text{front},t}$ is the fair value of the front contract at any given time $t$.

Recall that the fair value of a futures contract is primarily determined by the cash index. When expressed in index points, the fair value is

\[
\text{cash index} + \text{costs of holding the underlying asset} - \text{benefits of holding the underlying asset}.
\]

In a calendar spread, the cash index is common to both the front and the back contracts. Being a difference, the cash index cancels out. Therefore the value of the theoretical calendar spread is marginally dependent of the cash index value.

What about the costs of holding the underlying assets? Suppose the only cost is the interest amount. The front month contract matures at time $T_1$ and the interest at time $t$ is

\[
\text{cash index} \times r_{1,t} \times (T_1 - t).
\]

where $r_{1,t}$ is the benchmark risk-free rate corresponding to the tenor of $T_1 - t$ years.
Likewise, for the back month contract with the maturity date $T_2$, the interest amount is
\[ \text{cash index} \times r_{2,t} \times (T_2 - t). \]
Analogously, $r_{2,t}$ is the benchmark risk-free rate at time $t$ for tenor of $T_2 - t$ years. The fair value of the calendar spread attributable to the interest rate is
\[ \text{cash index} \times (r_{1,t} (T_1 - t) - r_{2,t} (T_2 - t)). \]

As an illustration, suppose the front contract has 15 days to maturity and the back contract matures in 45 days. From the swap rate curve, you find that the annualized interest rates are 1.0% and 1.05%, respectively, for these two tenors. Suppose further that there is no benefit accrual from holding the underlying asset. Moreover, the cash index level is 340.44, and that a year has 365 days. The theoretical value of the calendar spread is, in index points,
\[ 340.44 \times \left( 0.0105 \times \frac{45}{365} - \times 0.01 \times \frac{15}{365} \right) = 0.30. \]
This differential in the interest amount, which is the fair value of the calendar spread in this case, is 0.088356% of the cash index level. In terms of ticks, the calendar spread is 6 ticks (since every tick is 0.05 index points).

What about if a component stock is paying dividend? Suppose the dividend payment is $0.40 per share and the ex-date is 30 days from time $t$. Moreover, suppose the (free-float) shares outstanding is 100 million shares. The dividend payment works out to be 40 million dollars. To convert the dollar amount to index points, simply divide by the cash index’s divisor.

Using the same example of the Simsci futures, since the front contract expires in 15 days’ time, the front contract does not get to receive the dividend. The back contract expiring in 45 days will have this dividend benefit. For simplicity, suppose the divisor is 25 million. Accordingly, the dividend payment of 40 million dollars is equivalent to 1.6 index points, which correspond to 32 ticks.

When combined with the earlier analysis involving the interest amount, the fair or theoretical value of the calendar spread is, in index points,
\[ 0.30 - 1.60 = -1.30. \]
Notice that this fair value of the calendar spread is different from −1.10 traded in the market. It should not come as a surprise to you that the market price of spread is different from the fair value. The difference of 0.20 or 4 ticks does not necessary mean that the best bid and best ask is 4 ticks apart. Neither does it imply that there is an arbitrage opportunity. To traders, the disparity represents the market expectation of changes in costs and/or benefits. The expected changes are not equal for the front and back contract. In this particular example, the market expects the cost of interest rate to rise.

### 3. Outright Calendar Spread

Futures contracts entail obligations on both the buyer and the seller. Holding a futures position through expiration legally binds the holder of the contract to settle the position in accordance to the futures’ terms of delivery. Most traders usually square off their futures position by going into an equal and opposite
transaction before the last trading day of the contract. The intention is to avoid delivery and its accompanying uncertainties altogether.

Another way to avoid delivery is to roll forward by closing off the expiring position (front contract) and going into a similar futures transaction for a later expiration (back contract). Managed futures hedge funds run by commodity trading Advisors (CTA) need to roll over their long or short positions regularly. To continue in a long position, CTA will buy the calendar spread. By so doing, effectively the CTA closes the long position in the front contract expiring soon, and simultaneously opens a new long position in the back contract.

To facilitate the roll, exchanges offer a product called the outright calendar spread. By trading the outright spread, CTA can achieve their roll objective with absolute certainty. In other words, there is no possibility of missing the boat when prices in the near and back contracts start to shift rapidly. This certainty provides CTA the peace of mind in managing their myriad futures positions. Being important clients as their trade sizes are large, the outright calendar spread is a great innovation that serves them well.

But more importantly, the outright calendar spread, by design, ensures that the demand to roll a large position will not create havoc on both the front and back futures themselves. If there was no calendar spread and if a CTA tried to buy and sell directly on the front and back contracts, then their trades would shock the liquidity providers (limit-order traders), leaving them no alternative but to pull their offer prices higher when CTA was buying on one calendar leg, and to lower their bid prices on the other calendar leg as CTA was selling heavily. Due to the large price impact, the calendar spread would tear wider. This distortion is extremely detrimental to CTAs, and to the integrity of the futures market as a whole. The same tear will happen not just for CTAs but also any institutional investors who need to roll over a large position.

Nearer to the expiration, the limit orders on the outright calendar spread increase substantially. Many prop traders, CTAs, and other institutional traders strive to get in front of the queue to buy and to sell the outright calendar spread. Prop traders who usually do not carry an inventory of calendar spreads overnight become active. By getting in front of the queues and placing big chunk of limit orders at the market, they effectively become market makers, providing liquidity to CTAs and calendar rollers in general.

4. Synthetic Calendar Spread

These days, professional trading software allows prop traders to configure a strategy to trade the calendar spread. The resulting price ladder is known as the synthetic calendar spread. By “synthetic”, a distinction is made from the outright calendar spread, which is a derivative product offered by the futures exchange.

A synthetic calendar spread is made up of two legs: quoting leg and hedging leg. Traders prefer to call the futures contracts as legs when they open or close a calendar spread position. The difference in prices of the quoting and the hedging legs is the spread.

The quoting leg is the bait. As a matter of practice, the bait should be placed on the leg that is less liquid. The idea is that as soon as the bait is taken, you can hedge at the hedging leg without difficulty. By hedging, you establish a spread position. Given the higher liquidity at the hedging leg, it is more likely (but not always!) for you to hedge at the more liquid leg whenever the bait is taken at the less liquid leg. Specifically, an at-the-market limit order will be submitted to the hedging leg’s limit order book as soon
as the bait is taken. If the bait is a sell limit order, a limit price at the best offer price will be submitted to the hedging leg to buy as quickly as possible. Conversely, if the bait is a buy limit order, then the synthetic calendar spread requires the trader to sell, as soon as possible, at the best bid price of the hedging leg.

The bait has to be dynamic. Its limit price must change in tandem with the market price of the less liquid quoting leg. The reason is that the synthetic spread price is a target price, and to achieve the target price, the limit price of the bait has to adjust according to the market prices at both legs. For example, suppose you want to buy the spread at \(-1.10\). Your quoting leg is the back contract, which is at the best bid and ask of 360.10 and 360.15. Your bait is a sell limit order at 360.15, as the front contract serving as the hedging leg is traded at the best bid of 361.20 and the best ask of 361.25. If the bait is taken at the offer price of 361.15, then a buy limit order will be submitted immediately to the hedging leg to attempt to buy at the offer price of 361.25. The difference of these two prices is 360.15 – 361.25 = -1.10, and you have achieved the goal of selling the calendar spread at \(-1.10\).

Essentially, a dynamic limit order is really a series of cancelation orders and limit orders. A simple algorithm is to submit a cancelation order to cancel the current limit order, and simultaneously submit a new limit order with a different limit price. The limit price difference is usually a tick. When the market moves up by a tick, the bait will need to move up by a tick as well. Likewise, the bait’s limit price must move down a tick whenever the market moves down by a tick.

5. How Is the Bait Taken?

As mentioned earlier, the limit order as a bait in the quoting leg is dynamic in nature. When the market is moving up by one tick, the bait will also move up by a tick. Likewise, the bait will move down by a tick when the market moves down. So how it is possible for the bait to be taken or hit?

It turns out that a major factor leading to the bait being traded against an incoming market or marketable limit order depends on how far the bait is from the market (best bid or best ask). If the bait is at or one tick behind the market, a BIG market or marketable limit order will consume the liquidity in the quoting leg, including the limit order of your quoting leg. In fact, by posing a limit order, albeit a dynamic one, calendar spread trader is providing liquidity to the market participants for the quoting leg, which lacks liquidity.

Now, as soon as a BIG liquidity consuming order arrives at the quoting leg, it will surely impact the limit order book by taking out a few levels up if it is a buy order or down if a sell order.

As discussed earlier, to prevent not achieving the target spread price, the default order is a limit order with the limit price set at the price by which the target spread price is achieved. In the case of bait taken at the market, the limit price is the best offer price immediately before the bait is taken. But things won’t happen exactly to your preference. If the best offer price at the hedging leg has already been bought by other traders, your limit order will not get executed, and a mis-hedge is said to have occurred. To absolutely prevent mis-hedges, of course you can also use the market order to buy. But the danger is that you might not be able to sell the calendar spread at the spread price you have set out to achieve.

As an example, consider 6E futures for EUR/USD. The outright spread is traded at 30.0 bid and 30.5 offer. Suppose the contract at the quoting leg (6E Jun16) is your bait at 10934. If it is taken and if the sell limit orders at the hedging leg (6E Mar16) are still there, you should be able to hedge by buying at the price of 10903. With these two trades, you have opened a short spread position of 31. Note that this is higher than the best offer price of 30.5 at the outright calendar spread.
Table 1: The back and front contracts, and the outright spread of EUR/USD futures on December 17, 2015 7 PM EST.

If the hedging leg moves up by one tick, your current bait should be canceled and a new bait is submitted at a tick higher, i.e., 10935 is the new limit price. Conversely, the new bait will be a tick lower at 10930 if the hedging leg moves down by a tick.

Now, what if you want to short the calendar spread at a higher price of 32? In this case, your bait should be at the price of 10935, which is behind the market. For your bait to be taken, a buying order must arrive, take out the one contract offered at 10934 and then take some liquidity at 10935. Your hedging order will be sent out as fast as possible to try to buy at the price of 10903. But it is by no mean an easy task, because given a strong buying pressure at the quoting leg, the hedging leg will also move up. Either the 10 contracts at 10903 are canceled, or they are taken by other traders. If your system can beat them and buy before these 10 contracts disappear, then you are in a very good position to profit from this statistical arbitrage. Otherwise, you will surely suffer many mis-hedges.

One of the solutions is to make your hedging a litter bit smarter. If mis-hedge occurs, cancel the mis-hedged limit order and simultaneously submit a marketable limit order to buy. If you are lucky, you could buy at the price of 10904, in which case you manage to short a calendar spread at the price of 31. This calendar spread price of 31 is the same price as the earlier scenario when your bait is at the market.

In any case, it is very important to ascertain the liquidity of the hedging leg before putting the bait. If you have historical tick-by-tick data you can back-test to examine the jump frequencies, the quantum of price changes (one tick, two ticks, and so on) and their occurrence frequencies. Also useful is to examine how the lead-lag relationship between these two calendar months.

6. Quoting on Both Legs

When the front contract is about to expire and the back contract is about to take over as the front contract, liquidity on both legs tends to become more or less the same. In other words, on the last trading day of the front contract and a few days prior to that day, you can put baits on both legs. The objective is to increase the number of calendar spread trades.