R.J. O'BRIEN ESTABLISHED IN 1914

VOLATILITY TRADING IN AGRICULTURAL OPTIONS

This article is a part of a series published by R.J. O'Brien on risk management topics for commercial agri-business clients.

This article examines the volatility aspects of trading agricultural options. First, we provide a brief refresher on the various ways of defining and quantifying volatility. We then look at how volatility has behaved in agricultural options in recent years under different market conditions. The implied volatility and seasonal charts provided in this section will hopefully serve as a useful reference for traders of agricultural options. Finally, we examine various trading strategies regarding volatility, including delta neutral positions. This article is not just for speculators. Hedgers that use options will also benefit from a greater appreciation of the volatility implications of their hedging strategies.

Note: This article refers exclusively to exchange-traded options on futures.

I. VOLATILITY REFRESHER

Volatility is simply a measure of the speed at which a market moves. A corn market with daily price fluctuations of 5-10 cents is clearly more volatile than a market moving up or down by only 1-2 cents each day. While a flat price trader is concerned only with price direction, an option trader must also be concerned with the speed at which the market moves, since this plays a key role in determining the value of the option.

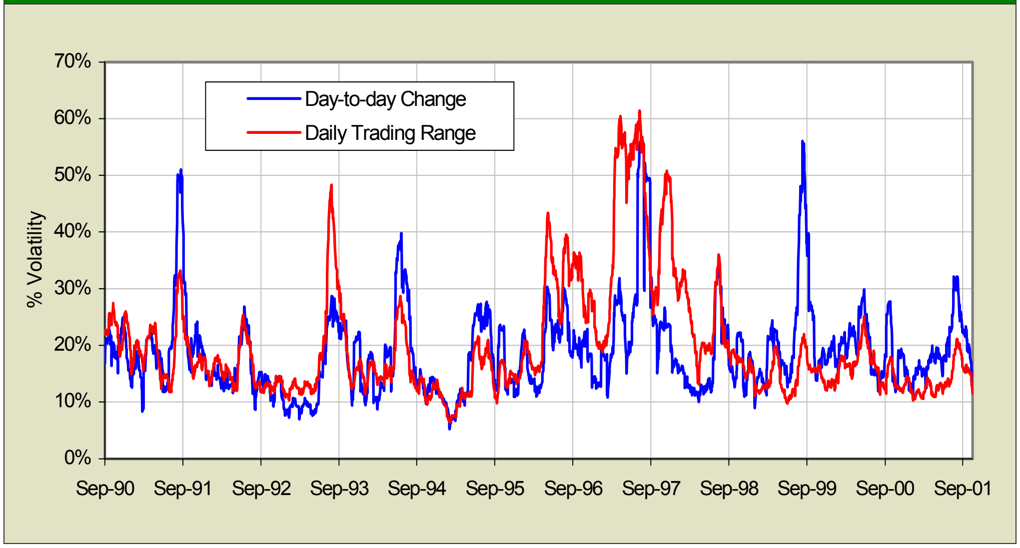
While the futures market is all about price discovery, the option market is the forum where we "discover" volatility. Or more precisely, the options pit is where we discover the market's opinion of the future volatility of the underlying futures. Saying that a Sept 250 corn call is "cheap", because its premium is only 5 cents per bushel is meaningless, since the true economic value of this option depends on where the strike price is in relation to the underlying futures, the number of days to expiration and other factors. Often options that are deep out-of-the-money, while being cheap in absolute terms, are quite expensive in volatility terms. Experienced option traders are more interested in the implied volatility of an option than they are in the absolute premium.

Volatility Defined…

Let's step back for a moment and define the different types of volatility. First, we can actually measure the volatility in the underlying futures over any historical period. This is referred to as **historical volatility**. To calculate historical volatility we use the statistical measure of standard deviation. This is simply a calculation of the average deviation from the mean for a series of futures prices over a given time period. (To avoid the possibility of negative prices, the standard deviation is usually calculated using natural logs of rates of change rather than the absolute difference in closing futures prices.)

Typically, when we calculate historical volatility, we base the calculation on the daily change in the closing futures price over a given time period, such as the most recent 20 or 30 days. So when you see a time series of historical volatility, the daily volatility calculation is usually based on a rolling 20 or 30 day period. However, there is no definition of what constitutes the "correct" calculation of historical volatility. For example, rather than basing the calculation on the *daily change* in closing prices, we could base it on the *daily trading range*. By doing so, we are getting a better measure of intra-day volatility that is lost in the more conventional calculation of volatility based on day-to-day closing prices. Figure 1 shows historical volatility for nearby soybeans using both the day-to-day change in closing prices, as well as the daily trading range. Both calculations are based on a rolling 20-day period. We can also vary the time period over which we calculate historical volatility (20 days, 30 days, etc.), as well as the time period between each observation. For example, we could use the week-to-week closing price change rather than the daily change in the volatility calculation.

Figure 1. **Historical Volatility—Soybeans Sep/90 to Sep/01**



While a basic understanding of the formula used to calculate volatility is useful, from a practical trading standpoint we are more interested in getting a "feel" for what constitutes a high or low volatility level. For our purposes, it is sufficient to understand that 20% volatility suggests that the underlying futures price will trade within 20% of the current price (up or down) over a 12-month period with a reasonably high probability (68.3% to be exact). So if volatility is 20% and the current futures price is $4.00 per bushel, we can say there is a high probability that the underlying futures will trade between $3.20 and $4.80 per bushel over a 12-month period. Depending on the underlying futures contract, 20% volatility might be considered high or low. For example, for currencies, 20% volatility would be considered very high, whereas, for soybeans it would be considered reasonably low.

The other key measure of volatility is **implied volatility**. This is the market volatility that is suggested or "implied" by an option's premium. Each time an option is traded, the buyer and seller are expressing their opinion about the future volatility of the underlying futures. We can calculate what volatility is "implied" by a given premium by using an option-pricing model. We do this by plugging in the current futures price, the strike price, the number of days to expiration, the interest rate and the current options price (all of which we know with certainty) and solving the model for what volatility this "implies". This is just the opposite of using the model to calculate the theoretical value of an option by plugging in the current futures price, the strike price, the number of days to expiration, the interest rate and some assumption for volatility. Table 1 illustrates these two applications of an option pricing model.

As shown in Table 1, using a volatility assumption of 24% results in a theoretical value for our call option of 19 3/4 cents per bushel. Logically then, an option premium of 19 3/4 cents per bushel *implies* a volatility level of 24% (holding all other factors constant). Based on the above, we can see that implied volatility represents the market's opinion of **future volatility** in the underlying futures as embodied in the current option price.

We can calculate implied volatility for any option as long as we know the five inputs shown in Table 1. Therefore, we can go back in history and calculate a time series of implied volatility. This is often given the confusing term of **historical implied volatility**, which has nothing to do with historical volatility as defined above. It simply refers to a historical time series of implied volatility calculations. Part II provides a number of examples of historical implied volatility.

When data vendors quote implied volatility for a commodity they often use different conventions. For example, some vendors quote implied volatility for the at-the-money calls in the nearby contract. Others will quote an average implied volatility for a number of different strikes or months, such as the three closest-to-the-money strikes for both puts and calls. Given that there are often differences in implied volatility for different strikes (known as the skew) and delivery months, its important to know what methodology is being used to calculate implied volatility.

Table 1. **Using an Option Pricing Model to Calculate Theoretical Value and Implied Volatility**

Calculating Theoretical Value (Call Option)

Inputs	**Output**
Strike Price (400) Days to Expiration (50) Current Futures Price (410) Interest Rate (6%) Volatility (24%)	Theoretical Value (19 3/4)

Calculating Implied Volatility

Inputs	**Output**
Strike Price (400) Days to Expiration (50) Current Futures Price (410) Interest Rate (6%) Current Option Price (19 3/4)	Implied Volatility (24%)

Finally, the obvious question is which volatility should traders be concerned with? Generally speaking, traders focus most heavily on implied volatility since it provides the most accurate indication of how the options actually performed under different market conditions. As a result, implied volatility gives us the best clue as to how an option will perform if market conditions are replicated in the future. Historical volatility is always backward looking, and thus can only tell us how volatile the underlying futures price has been in the past. Just because current implied volatility is lower than recent historical volatility, it does not mean the option is under-valued. It may simply suggest that the market expects that the underlying futures will be less volatile in the near future than in the recent past. However, if there are large differences between historical and implied volatility then it may be an indication that an option is either over or under-valued. As discussed in Part III, different measures of historical volatility, such as using the high/low instead of the daily change, can also be useful indicators for specific trading strategies.

II. IMPLIED VOLATILITY LEVELS IN AGRICULTURAL OPTIONS

This section looks at call option implied volatility levels in CBOT corn, wheat, soybeans, meal and oil from January/92 to September/01. First, we look at the historical implied volatility levels to get a feel for the range within which each option tends to trade. We then look at the *seasonality* of implied volatility by calculating the average implied volatility for each trading day over a number of years. Given the distinct seasonal nature of crop production, it is not surprising that we find very strong seasonal tendencies in most grain and oilseed options.

Corn

As shown in Figure 4 (next page) covering the period from January/92 to September/01, implied volatility for corn tends to range between 15-30%. Over the study period, the average implied volatility was 22.18%, with a range of 10.85% to 51.84%. There is a very distinct seasonal pattern in corn implied volatility as shown in the seasonal chart, which coincides with the key growing period of the U.S. corn crop (Figure 3). Implied volatility typically starts increasing in April and peaks in late-June/early-July, as the corn crop goes through its critical development period.

It is noteworthy that even in years when there has been a problem with the crop, implied volatility tends to fall off in the late summer or early fall. This is explained by the fact that even though the crop experienced a problem, by early fall the market has been able to quantify the problem and adjust futures prices to reflect the situation. In mid-summer, however, the market must deal with a constant state of uncertainty over the size of the crop and therefore bids up volatility accordingly.

However, lest we start thinking that corn volatility will never exceed about 40%, let's take a look at how it performed during the 1988 drought. As illustrated in Figure 2, during the June-August/88 period, implied volatility in corn fluctuated between 50 and 90%!

Figure 2. **Corn Implied Volatility During the 1988 Drought**

Figure 3. **Corn Seasonal Implied Volatility Jan/92 to Sept/01**

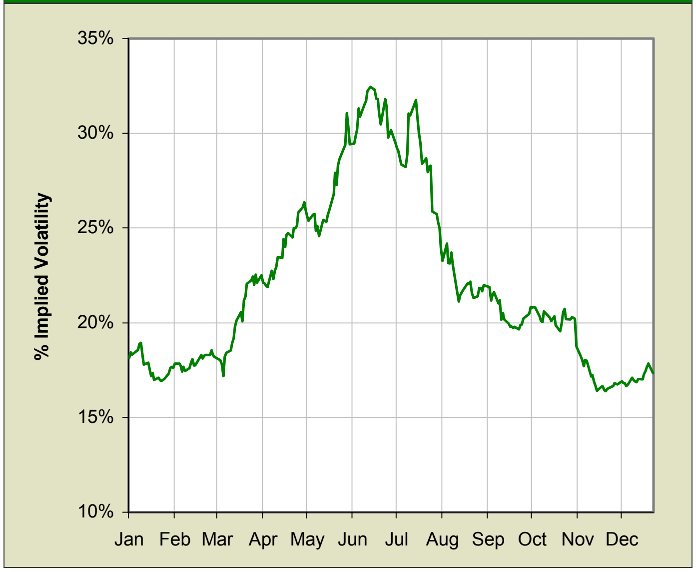


Figure 4. **Corn Implied Volatility Jan/92 to Sept/01**

Wheat

As shown in Figure 7, wheat implied volatility tends to trade in a similar range to corn, typically ranging between 18-30%. Over the study period (January/92 to September/01), the average implied volatility was 23.00%, with a high of 45.65% and a low of 15.09%. Wheat volatility also exhibits a seasonal pattern, although not as strong as that of corn (Figure 6). Note that while corn volatility on average gains about 15% into its seasonal peak, wheat only gains about 7% on average. Wheat volatility tends to start increasing in late-March/early-April and peaks in May. This coincides with the key growing season of the U.S. winter wheat crop. Given that we are looking at CBOT wheat options, it is the soft red winter crop season that we are most concerned with in this case.

How did implied volatility behave when CBOT wheat prices hit record highs during the spring of 1996? As shown in Figure 5, during this period implied volatility rose to a peak of around 45%, which is surprisingly low considering the delicate world supply/demand balance for wheat during that time period.

Figure 5. **CBOT Wheat Implied Volatility During Record 1996 Price Period**

Figure 6. **CBOT Seasonal Wheat Implied Volatility Jan/92 to Sept/01**

Figure 7. **CBOT Wheat Implied Volatility Jan/92 to Sept/01**

Soybeans

During the January/92 to September/01 study period, implied volatility for soybeans averaged 20.71%, and ranged from a low of 10.47% to a high of 50.78%. Soybeans exhibit a strong seasonal pattern that is almost identical to corn. This is not surprising given that corn and beans are grown in the same areas of the U.S. and have similar production seasons (soybeans are typically 2-3 weeks later than corn in terms of seeding).

As shown in Figure 8, implied volatility typically starts rising from the 15-20% range in early spring, and peaks at 30-35% in mid-June/early-July. During the 1988 drought, soybean implied volatility peaked at 72.8%.

Soybean Meal

Implied volatility in meal during the study period averaged 20.46%, and ranged from a low of 9.42% to a high of 57.81%. Volatility in meal options appears to have been gradually trending higher over the past few years. Not surprisingly, meal volatility follows a very similar pattern to soybeans.

Figure 8. **Soybean Seasonal Implied Volatility Jan/92 to Sept/01**

Figure 9. **Soybean Meal Seasonal Implied Volatility Jan/92 to Sept/01**

Figure 10. **Soybean Implied Volatility Jan/92 to Sept/01**

Figure 11. **Soybean Meal Implied Volatility Jan/92 to Sept/01**

Soybean Oil

Finally, implied volatility in soybean oil tends to follow the same patterns as soybeans and meal, however, oil volatility tends to trade in a tighter range. Over the study period, oil volatility averaged 20.79%, and ranged from a low of 11.84% to a high of 52.10%.

III. VOLATILITY SKEW

To this point, we have concerned ourselves only with the volatility of the options that are near-the-money and in the nearby month. However, there are normally differences in implied volatility for different strike prices as well as for different delivery months. Table 2 shows the implied volatility levels for CBOT corn options as of October 30, 2001 (based on closing prices), which illustrates the different implied volatility levels for different strikes and delivery months. Implied volatility in agricultural options tends to be the lowest for the in-the-money options and highest for out-of-the-money options.

Table 2.
Snapshot of Closing Corn Implied Volatility Levels on October 30, 2001

Chicago Board of Trade Corn Puts

	3OTM	2OTM	1OTM	ATM	1ITM	2ITM	3ITM
Dec-01	22.27	21.81	20.42	20.20	21.14	21.70	20.88
Mar-02	21.21	20.54	19.31	19.15	17.37	17.33	
May-02	21.27	20.37	19.61	18.89	18.59	17.22	

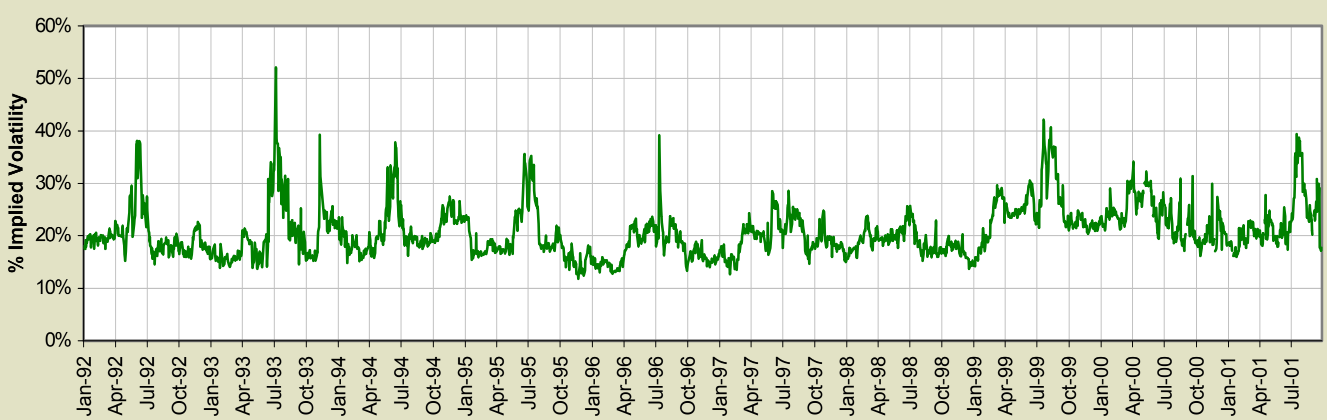
Chicago Board of Trade Corn Calls

	3OTM	2OTM	1OTM	ATM	1ITM	2ITM	3ITM
Dec-01	21.95	21.09	20.32	20.79	20.48	21.99	22.67
Mar-02	17.77	18.10	18.55	19.19	19.69	20.36	20.55
May-02	16.87	17.72	18.34	19.04	19.95	20.98	

Notes:
ATM = At the money
1OTM = 1st Out of the Money etc.
1ITM = 1st In the Money etc.

Figure 12. **Soybean Oil Seasonal Implied Volatility Jan/92 to Sept/01**

Figure 13. **Soybean Oil Implied Volatility Jan/92 to Sept/01**



Why do we have different implied volatility levels for different strikes when there is only one underlying futures contract? If we believe fair market volatility in December corn futures is 24%, as reflected in the at-the-money option, then why do we not use the same volatility assumption when pricing the out-of-the-money strikes? The best explanation of positive skew is that most pricing models (such as the Black model) appear to underestimate the extremes within which commodities prices will normally trade. In other words, commodity prices tend to have greater extremes than that suggested by the log-normal probability distribution that underlies most pricing models. Another common explanation is that option buyers are willing to pay more for out-of-the-money options (in volatility terms) due to their low absolute cost and potential for large, albeit infrequent, payoffs.

As noted above, different delivery months sometimes also trade at different implied volatility levels. For example, July and September corn options often trade at higher volatility levels than the other months (December, March and May). This is due to the production risk (for the U.S. corn crop) during the May to September period. Thus, different implied volatility levels in different option months usually reflect the fact that some underlying futures contracts are inherently more volatile than others.

Finally, the put and call implied volatility for the same strike and delivery month should be virtually the same, otherwise an arbitrage opportunity will exist. This is basically the equivalent of the well-known **put-call parity theorem**. For example, if the Dec 350 corn calls are trading at 23% volatility and the Dec 350 corn puts are trading at 25% volatility, we can lock in a riskless profit by buying the 350 calls, selling December futures and selling the 350 puts (in equal number). However, transaction costs usually make this type of arbitrage play feasible only for the local floor traders.

IV. VOLATILITY TRADING APPROACHES

While we can explicitly trade volatility in a number of ways (discussed below), it should be recognized that almost every option position has a volatility aspect to it. Each time we buy or sell an option, as a hedge or a pure speculative play, we are taking a volatility position. As we have discussed in previous articles, depending on the degree of conviction we have regarding volatility, we can either bolster or dilute our exposure to volatility by choosing different option strategies. A good option-pricing model can be an invaluable tool for quantifying the amount of exposure to implied volatility in any given position.

Let's take a simple example where a soybean meal buyer wants to obtain some call option protection against an increase in meal prices, but has no strong view on volatility and wants to limit her exposure to changes in implied volatility. By simply choosing a different delivery month, the buyer can significantly alter their exposure to implied volatility. Table 3 shows the two strategies (each for 300,000 short tons worth of coverage). Strategy 1 (August 135 calls) has a vega of $5,870, meaning that for every one percentage point (100 basis point) increase in implied volatility, the value of this position will increase by approximately $5,870 (and vice versa). Strategy 2 (December 140 calls) has almost double the exposure to changes in implied volatility (vega of $11,054). More complex option strategies can be used to further reduce the exposure to changes in implied volatility.

Even if you are not explicitly trading volatility, you should be aware of the volatility implications of all positions you undertake. There are numerous ways of either increasing or muting your exposure to changes in implied volatility.

Table 3.
Meal Hedging Strategies—Volatility Exposure

Strategy 1 Long SMQ 135 Calls (100 Contracts)	Vega = $5,870[1/]
Strategy 2 Long SMZ 140 Calls (100 Contracts)	Vega = $11,054[1/]

[1/] Vega is the change in the value of the option position given a 100 basis point change in implied volatility.

Straddle/Strangle

The most common example of a volatility play is a straddle or strangle. A long straddle consists of buying both a put and call with the same strike price and expiration date. For example, we could simultaneously buy a 300 December wheat call and a 300 December wheat put. The dual rationale for doing this is that we are bullish volatility and expect a sharp price breakout up or down (but we're not sure which way). A strangle also consists of buying a put and call on the same underlying futures contract, but at different strike prices. An example of a long strangle would be simultaneously buying a 230 December corn call and a 200 December corn put. Buying a straddle/strangle puts us long volatility and selling a straddle/strangle puts us short volatility.

We'll spare you the usual hockey stick diagrams of this strategy, as most readers of this paper will be more than familiar with the pay-off structure of a straddle or strangle. In our view, a straddle or strangle is a poor way to go long or short volatility. If your goal is to buy or sell volatility you are much better off with a delta-neutral position (discussed below). Buying a straddle or strangle has a large upfront cost and incurs significant time decay. You generally need a very large price move to make this type of position pay. If you are so unsure about price direction, then it makes more sense to trade delta-neutral anyway. Selling a straddle or strangle is certainly one way of getting short volatility, but it carries with it flat price risk on both the downside and the upside.

Delta-Neutral Positions

A more efficient way of trading volatility (long or short) is with a delta-neutral position. This refers to buying or selling options and then neutralizing the flat price characteristics of the option by taking an offsetting futures position. For example, if we bought 100 contracts of the SU500 calls, with a delta of 0.5, this is equivalent to being long 250,000 bushels of Sept futures (100 contracts * 5,000 bushels * 0.5 delta). Thus, to make this delta-neutral, we can sell 50 Sept soybean futures (250,000 bushels). Recall that the delta represents the change in the option premium given a change in the underlying futures. Thus being long 500,000 bushels worth of calls with a delta of 0.5, is the flat price equivalent of being long 250,000 bushels of futures.

You will also recall, however, that delta is not static. Delta will increase or decrease as the option moves in and out-of-the-money. Thus, to maintain a delta-neutral position, we need to rebalance the futures periodically. We can go "long volatility" either by buying calls and selling futures, or by buying puts and buying futures (on a delta-equivalent basis). The characteristics of these positions are virtually identical. Logically, we can go "short volatility" either by selling calls and buying futures, or by selling puts and selling futures (on a delta-equivalent basis).

One important feature of delta-neutral positions is gamma risk. This refers to the fact that a delta-neutral position does have flat price characteristics during the periods that it is out of balance. For example, if we are long calls with the offsetting short futures, as the market rallies, the calls will move into-the-money and the delta will increase. Thus, as the futures price increases, we are becoming increasingly long. Conversely, as the futures price drops, the calls are moving out-of-the-money and the delta is decreasing. Thus as the futures price decreases, we are becoming increasingly short. This is referred to as being long gamma. Gamma is the change in delta given a change in the underlying futures. In other words, gamma quantifies the speed at which our delta-neutral position will become out-of-balance given a change in the underlying futures.

If we are long volatility on a delta-neutral basis (and thus long gamma), we benefit from movement in the underlying futures, since our position gets increasingly long as the market rallies and increasingly short as the market drops. Thus, this type of position will benefit both from increases in implied volatility, and also from gains made through the rebalancing of the position. Often traders overlook this aspect of delta-neutral trading. When we are long options on a delta-neutral basis, we want the market to move as fast as possible since we benefit from large price swings either way. In this type of position we welcome limit moves, since they provide the potential for large windfall gains. (Note that the speed at which the market moves is important since if it goes up or down slowly, you will likely rebalance too soon and miss out on the windfall rebalancing gains). Since we make gains in this type of position on rebalancing, we are concerned with both day-to-day volatility, as well as intra-day volatility. This is therefore one example where using the daily range to calculate historical volatility can be a better indicator than the more conventional approach of using the daily close.

On the flipside, if we want to be short volatility, then we will have to sell either puts or calls and take the offsetting futures position to get delta-neutral. For example, we could sell 200 soybean meal puts with a delta of 0.4 and then sell 80 meal futures contracts to get delta-neutral. Note that in this case, we are short gamma, meaning that as the underlying futures price rallies, we are getting increasingly short, since the short puts are moving further out of the money and their delta is decreasing. Conversely, if the futures price falls, this position is getting increasingly long, since the short puts are moving deeper into the money and their delta is increasing. Thus, being short options on a delta-neutral basis exposes the trader to this type of rebalancing losses or "gamma risk". Limit moves are not fun when you are short options on a delta-neutral basis. However, offsetting the gamma risk inherent in this type of position is the fact that you are earning time premium on the short options.

Let's look at a simple example of a delta-neutral position that should help to reinforce some of the above ideas. We assume that a trader buys 500 WZ350 calls on day 1 and then immediately sells futures against this position on a delta-equivalent basis. Each day the position is rebalanced based on the closing price. By carefully going through the transactions and P&L in Table 4, you will get an appreciation for what is involved in delta-neutral trading.

The above example shows a net gain (after 5 days) of $38,250, ignoring transaction costs. The market rallied on days 2, 3 & 4, which required adding to the short futures position each day. On the 5th day, the market reversed, requiring the trader to buy back 25 contracts of futures. The majority of the gain in this position was due to the increase in implied volatility from 17.7% on day 1 to 19.5% on day 5 (an unlikely increase in this short a time frame). Using an option-pricing model we can calculate that $26,750 or 70% of the gain was due to this increase in volatility. The remainder of the gain was due to gains made in rebalancing the position.

How often you should you rebalance a delta-neutral position? The answer is that there is no answer. Actually, while there is no definitive answer, traders will use different rules for rebalancing, such as once per trading session (e.g., on the open), or after a certain size move in the underlying futures. Other traders will simply rebalance their position on "gut feel", which starts to move us away from a delta neutral position back into a flat price trade (albeit to a much lesser degree than an outright long or short position). Knowing when to rebalance is the art of delta neutral trading.

Table 4.

Example of Delta Neutral Position

	Action	Futures Price	Options Price	Implied volatility	Options Delta	Option P/L	Futures P/L	Combined P/L
Day 1	Buy 500 WZ300 Calls Sell 180 WZ9 Futures	286.00	8.00	17.7%	0.36	$ - $ -	$ - $ -	$ - $ -
Day 2	Sell 30 WZ9 Futures	291.00	10.10	18.0%	0.42	$52,500	$(45,000)	$ 7,500
Day 3	Sell 20 WZ9 Futures	295.00	12.66	19.1%	0.46	$116,500	$(87,000)	$ 29,500
Day 4	Sell 10 WZ9 Futures	297.00	13.48	19.0%	0.48	$137,000	$(110,000)	$ 27,000
Day 5	Buy 25 WZ9 Futures	292.00	11.53	19.5%	0.43	$88,250	$(50,000)	$ 38,250

Delta Hedging

The final example of volatility trading we will examine is the concept of delta hedging. This is basically replicating an option position by using the futures market. Let's assume that a trader wants to obtain call option protection against his intended meal purchases, but feels that meal options (in volatility terms) are over-valued. What this trader is really saying is that he believes the underlying meal futures will be less volatile that what is reflected in the option premium. Rather than buying the call option, this trader can replicate a call by buying meal futures on a delta-equivalent basis, and then rebalancing the position to replicate the delta that the call option would have otherwise provided.

For example, the trader could have bought 100 SMQ140 calls with a delta of 0.5. However, since this is the equivalent to buying 5,000 short tons of futures (50 contracts) the trader can buy 50 contracts of SMQ futures to replicate the call options. As meal prices rally, the option position would be moving into the money and its delta would be increasing. To replicate this position, the trader simply adds to his long futures position to match this position. As meal prices fall, the option position would be moving out of the money and its delta would be dropping. To replicate the call, the trader simply sells futures to keep the delta in line with the call option.

By delta hedging rather than buying the call option, this trader is betting that the market will not be as volatile as that suggested by the current option premium. Note that this trader pays no premium (or time decay) by replicating this option, but there is a cost. The cost is that he has basically gone "short gamma" and is exposed to the risk of losses in rebalancing his delta hedge. This is the same risk incurred when a trader sells options on a delta-neutral basis. If the market remains calm, the trader will be far better off having delta hedged, since he was able to avoid the time decay associated with the call. However, if the market is very choppy, this trader will likely lose more in the rebalancing process than he would have paid in time decay by buying the option outright. Delta hedging is also a useful strategy in markets that either do not trade options, or where the options are too illiquid to trade effectively.

V. SUMMARY

Volatility is the heart and soul of option trading. Every option position should be undertaken with an explicit view toward, and strategy regarding, volatility. As we have shown in this article, we can use historical and historical implied volatility as a guidepost for trading decisions regarding volatility. We should also be aware of the very strong seasonal tendencies in implied volatility in agricultural options. Finally, we have briefly touched on a number of ways to trade volatility. In future articles we will delve into the topic of delta neutral trading strategies in more detail.

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