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**"MANAGING ASYMMETRIC RISK:
SIX EPISODES IN CRUDE OIL"**



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Managing Asymmetric Risk: Six Episodes in Crude Oil

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Introduction

Market sentiment is often assumed to be symmetric, or balanced in terms of the risk of potential price moves to the upside or downside. While this sentiment may well be in line with a bell-shaped probability distribution most of the time, our perspective is that risk managers need to be especially aware of market conditions in which significant variability in risk perceptions may be present. For example, if the behavior of market participants suggests that an abrupt and large upside price move has some reasonable probability while prices are expected to grind lower gradually, then one may well see this asymmetry reflected in the prices of options and trading volumes and need to adjust risk-management approaches accordingly.

In this research we use the crude oil market as our case study, and we introduce a method of assessing whether there is meaningful price-risk asymmetry reflected in options pricing. Specifically, we use CVOL, an implied volatility calculation from the CME Group, to look into whether there are important differences between the upside price risk reflected in out-of-the-money call options compared to the downside price risk reflected in out-of-the-money put options.

Our research is divided into three sections. First, we briefly describe CVOL and touch on why this method of calculating implied volatility has some distinct advantages relative to implied volatility measures derived from Black-Scholes-Merton types of option valuation models. Second, we apply our analysis to the crude oil market over the last several years, identifying periods when risk asymmetry was important. And the last section provides a summary of our findings, with particular attention to how risk-management approaches might need to be adjusted when price-risk sentiment is significantly asymmetric.

CVOL and Identifying Periods of Asymmetric Risk Perceptions

CVOL is a technique to measure implied expected volatility and is especially useful for identifying market environments where a distinct asymmetry appears to exist in the form of a large expected price move in one direction versus more moderate moves in the other direction. That is, we want to know more than a single metric of expected volatility; we also want to know when risk sentiment is skewed in one direction or the other. While there are many ways to get at this question of identifying asymmetry in expectations or skewness, they are typically quite complex to implement and often require considerably more



Managing Asymmetric Risk: Six Episodes in Crude Oil

information than is needed for CVOL. This excess information may unnecessarily complicate the analysis. And the underlying or embedded assumptions in these alternative techniques can be inappropriate to understanding market price-risk asymmetry when it exists. Specifically, we note the following advantages of CVOL:

- It is a straightforward method to calculate expected or implied volatilities from options prices.
- CVOL's calculation does *not* assume either a normal or log-normal probability distribution (*i.e.*, the CVOL method is independent of the underlying probability distribution).
- Price gaps are incorporated (*i.e.*, discontinuity is allowed, and so the calculation does *not* assume or require smooth price continuity as prices abruptly move up or down).
- The technique provides separate basic measures for upside and downside risk expectations in an intuitive manner (*i.e.*, there is no need to calculate the whole volatility surface or create the options "smile," strike by strike, to assess convexity or skewness).

One can observe from typical options volatility curves that out-of-the-money options imply higher volatility than at-the-money options for the same underlying asset with the same maturity. Since every strike on the options volatility curve potentially has a different implied volatility level, the calculation of CVOL, which utilizes all the options strike prices for a given maturity, makes the result unambiguous. Specifically, out-of-the-money put options are used to calculate downside price risk, and out-of-the-money call options are used to calculate upside price risk. For a single measure of implied volatility, we combine the out-of-the-money options volatility metrics for both puts and calls. To assess asymmetry in risk sentiment or skewness, we look at the difference in the upside and downside implied volatility metrics. For a mathematical description of both CVOL and its "Derivative Indicators," one may consult CME Group (2023) as well as refer to the Appendix for this article.

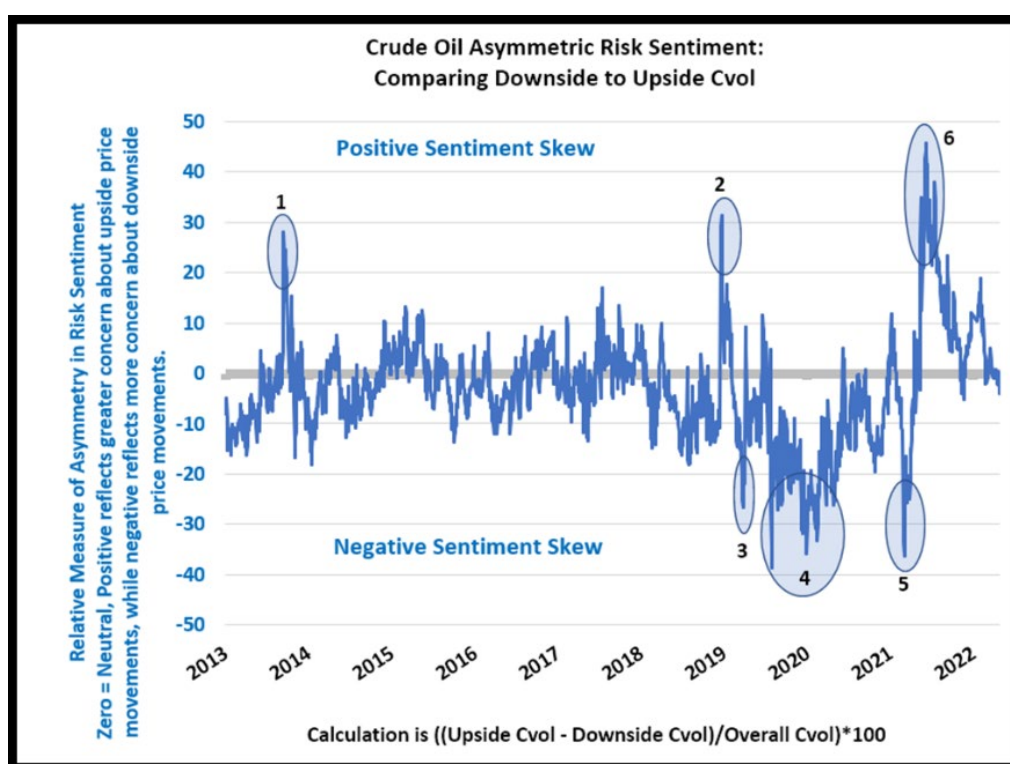
There are several things to note about CVOL compared to more traditional Black-Scholes-Merton style implied volatility calculations. First, the shape of the distribution is determined by the market and the forced assumption of either a normal or log-normal distribution is not required. Second, since CVOL uses all the strike prices and since out-of-the-money implied volatilities are generally higher than the at-the-money, CVOL will generally produce a slightly higher implied volatility measure than an implied volatility taken only from the at-the-money call and put options. This means CVOL is able to capture the effect of the "volatility smile" in providing a more realistic expectation of future volatility. All in all, CVOL's lack of unrealistic assumptions embedded in traditional Black-Scholes-Merton style implied volatility calculations very much appeals to us. And, as our goal in this research is to explore the potential for asymmetric risk sentiment, we can use differences in the downside put implied CVOL relative to the upside call implied CVOL. With these observations in mind, we can now move to our case study of the WTI crude oil market, which, in turn, explains the relevance for risk management of comparing downside and upside implied volatilities.



Crude Oil and Periods of Asymmetric Risk

Our examination of the WTI crude oil options market provides us with an interesting perspective on how to use the upside (call) and downside (put) price risk implied by our CVOL calculations to explore the cases where distinct asymmetry was present. Since 2013, there are six episodes where the asymmetry was noticeably extreme in the crude oil market: three to the upside and three to the downside. See Figure 1. We will take a brief look at each episode. Since there are only six episodes, please avoid jumping to any generalized conclusions. Nevertheless, there are definitely a few insights we can gain from examining each of the six episodes.

Figure 1
Identifying Asymmetric Risk Sentiment in the Crude Oil Market



Source: CME Group.

Also, the time frequency matters. In this case study, we are always using a one-month CVOL, estimated from the option contracts expiring in just less than one month combined with the options contracts expiring shortly beyond one month to give us a representative 30-day option CVOL. To identify periods of distinct asymmetry between the upside and downside implied volatilities from CVOL, we standardize by taking the difference in the upside and downside volatilities divided by overall CVOL for each day since the beginning of 2013. When this asymmetry sentiment risk metric is above zero, it indicates a bias toward upside potential price moves. A reading below zero implies a bias toward downside potential price moves. A reading of zero (or close to zero) implies a balance in the sentiment risk.

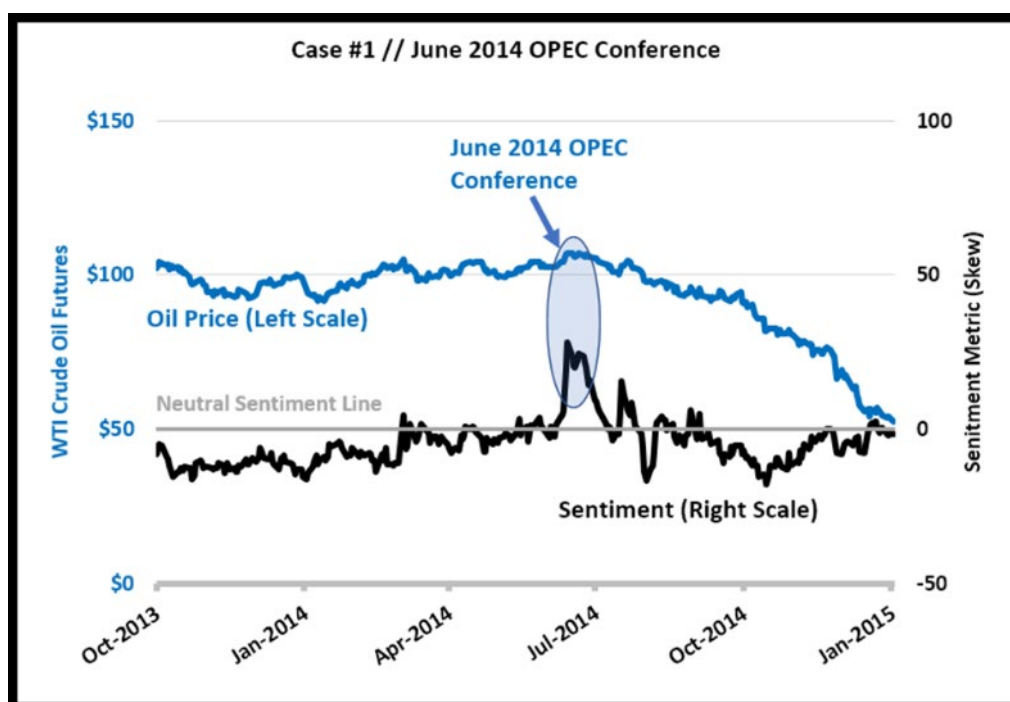
Managing Asymmetric Risk: Six Episodes in Crude Oil

Case #1: June 12 – June 25, 2014: Upside Price Risk (OPEC)

WTI crude oil prices had been hovering around \$100/barrel (nearby futures price) or just above \$100 for the first five months of 2014. The June OPEC conference that year (technically the 165th session of the OPEC conference) was very much on the minds of oil market participants.

Figure 2

WTI Crude Oil Prices & Risk Sentiment, October 2013 – December 2014



Source: Bloomberg Professional for oil prices (CL) and CME Group CVOL sentiment (skew) metric.

Economic growth was moderate to relatively robust from the U.S. to Europe to China. OPEC had held discussions in Moscow about coordination with Russia earlier in 2014. Our reading of the overall consensus of market participants at the time was that OPEC would not announce any production cuts or increases. That said, some oil market participants were afraid of any signs that OPEC might want to constrain production and try to push market prices well above \$100/barrel. Because of the relatively positive picture on global economic growth, concerns about a sharp fall in the price of oil were relatively minimal. Hence, there was a skew to the upside in price-risk sentiment.

Worth noting is that the WTI crude oil futures maturity curve was in severe backwardation. During the time of the OPEC meeting in June 2014, the nearby futures contract was trading about \$15/barrel higher than the 24-month out futures contract. Once the short-term concerns of some market participants were removed by OPEC doing nothing on production at its meeting, oil prices started to trend lower for the rest of 2014. In this case, and please avoid generalizing this scenario as already advised, once the upside price



Managing Asymmetric Risk: Six Episodes in Crude Oil

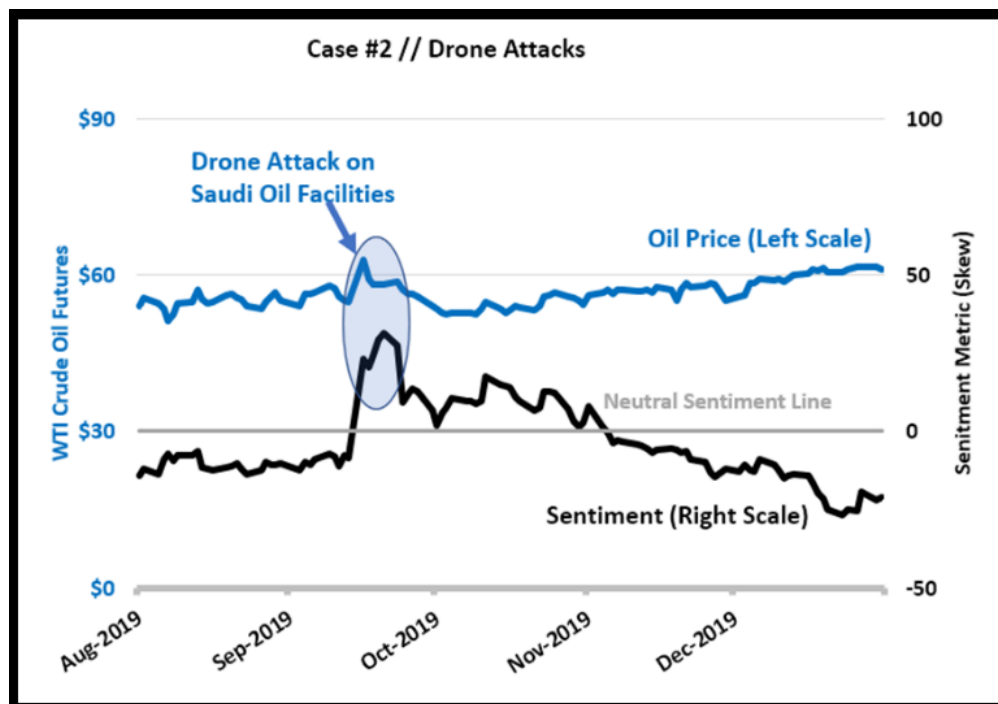
fears were removed, the market commenced a steady trend toward lower prices. See Figure 2 on the previous page.

Case #2: September 16 – September 23, 2019: Upside Price Risk (Drone Attack on Saudi Arabia)

The upside price concerns evident in the CVOL metrics for September 2019 were directly related to the attacks on crude oil production, which was down 1,318,000 barrels per day in September compared to the previous month. The oil production decline was due to the drone attack on the Saudi oil complexes at Abqaiq and Khurais, which occurred on September 14, 2019. There were fears among many market participants of further attacks causing additional production losses and sharply higher prices. Those fears quickly proved unfounded, as Saudi Arabia brought oil production back to normal in a very rapid process. See Figure 3.

Figure 3

WTI Crude Oil Prices & Risk Sentiment, August 2019 – December 2019



Source: Bloomberg Professional for oil prices (CL) and CME Group CVOL sentiment (skew) metric.

Case #3: April 23 – May 8, 2020: Downside Price Risk (Start of the Pandemic)

The concerns about a large downside price movement in late April 2020 were triggered by the spread of the COVID-19 virus and the partial shutdown of the service sector all over the world, dramatically reducing the demand for refined petroleum products for transportation, especially air travel but also for moving people and goods by trains, trucks, buses, and cars. The unanticipated sharp decline in oil demand resulted in a rapid build of oil stocks in storage facilities around the world, with attention focused on the

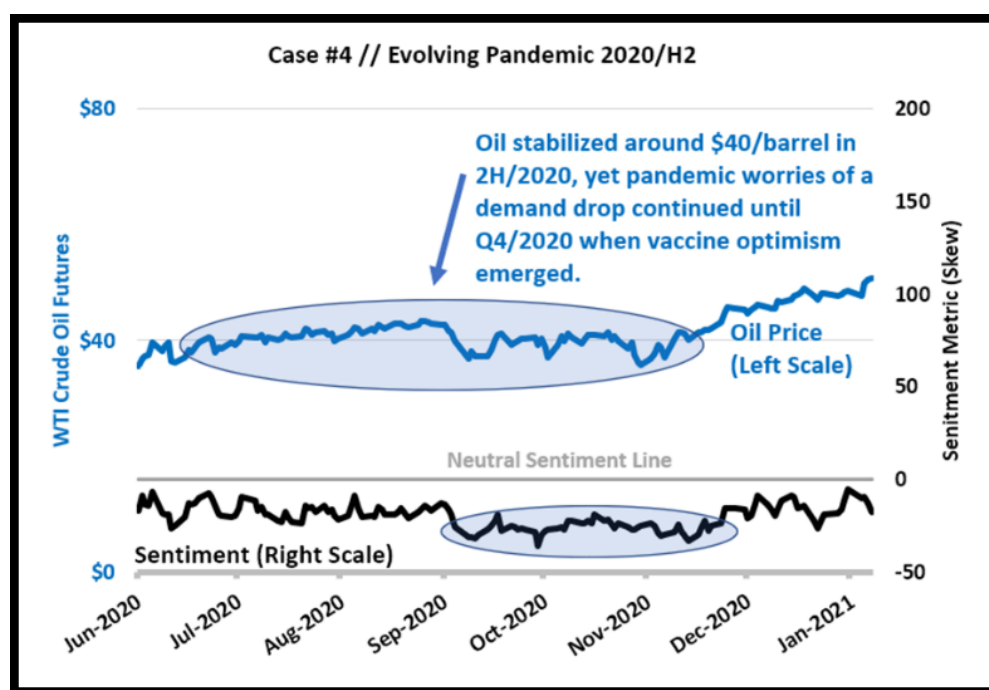


Managing Asymmetric Risk: Six Episodes in Crude Oil

build-up at Cushing, Oklahoma, due to its role as a delivery point for WTI crude oil futures contracts if held to expiration. An extremely small percentage of futures contracts are held to expiration and require the short-side of the market to deliver oil to the long-side, as over 90% of all futures contracts are closed or rolled into the next maturity before expiration and entering the delivery period. Even so, in this event, the nearby WTI crude oil futures price actually turned negative at expiration for one day. Futures participants quickly rolled positions out an extra month to avoid any delivery risk, and at the same time the inventory backlog was spread across other storage facilities, including oil shipping tankers. The downside price fears quickly abated, and prices commenced an upward price pattern. See Figure 4.

Figure 4

WTI Crude Oil Prices, 2020/H2 and the Evolving Pandemic



Source: Bloomberg Professional for oil prices (CL) and CME Group CVOL sentiment (skew) metric.

Case #4: June 25 – November 23, 2020: Downside Price Risk (Pandemic fatigue)

For many months after the negative oil price shock of late April 2020, the uncertainties related to the unfolding of the pandemic, the lack of vaccinations, and general worries over the extent of economic deterioration that might impact oil prices to the downside were factors in causing persistent asymmetry in oil market price-risk sentiment. The downside price worries remained elevated even though the nearby futures oil price stabilized in the \$40/barrel territory from June through October 2020. The imminent arrival of effective vaccines toward the end of 2020 removed the fears of demand falling and created an atmosphere of general optimism that economic growth would resume. Greater symmetry returned to oil price-risk sentiment and a pattern of price rises followed as well. See, again, Figure 4.

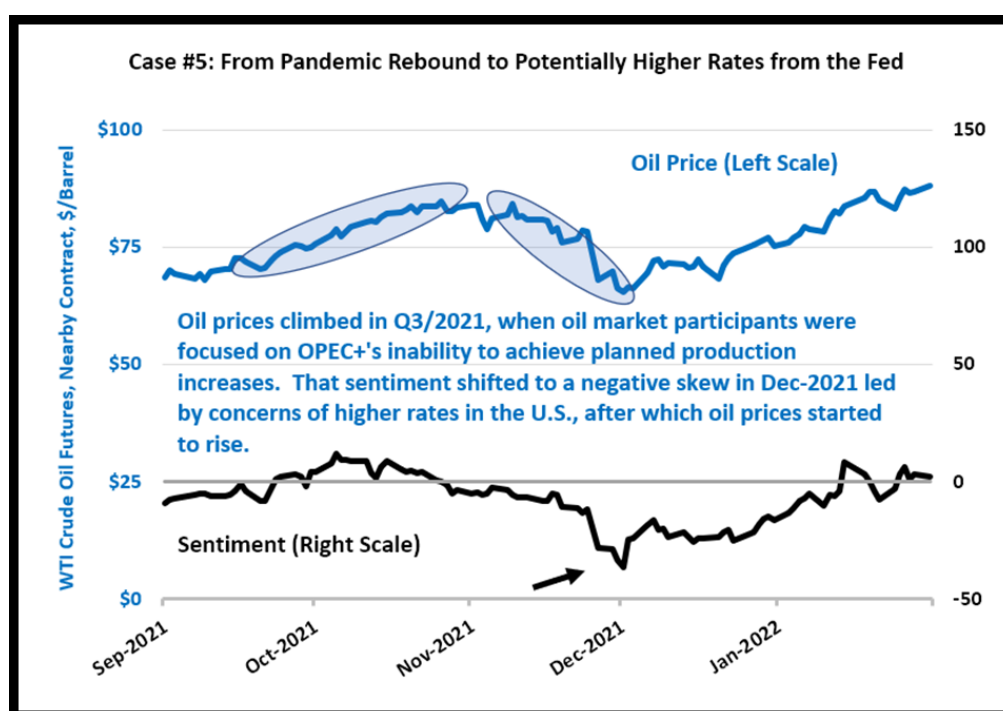


Managing Asymmetric Risk: Six Episodes in Crude Oil

Case #5: November 26 – December 28, 2021: Downside Price Risk (From OPEC+ to Higher U.S. Interest Rates)

Oil prices climbed from August 2021 through October 2021. During that period, oil market participants were focused on OPEC+, and its inability to achieve planned production increases. The positive sentiment abruptly shifted to negative sentiment and downside price concerns led by expectations of higher rates in the U.S. and weaker economic activity globally. The negative sentiment was short-lived. Sentiment returned to a neutral state as oil prices started to rise in early 2022, even before the Russian invasion of Ukraine. See Figure 5.

Figure 5
WTI Crude Oil Prices, 2021



Source: Bloomberg Professional for oil prices (CL) and CME Group CVOL sentiment (skew) metric.

Case #6: February 11 – May 9, 2022: Upside Price Risk (Russia Invades Ukraine)

Russia's invasion of Ukraine in February 2022 set in motion an emphasis on the risk of a sharp upside price move if Russia were to abruptly cut off the flow of oil and natural gas to western Europe. Natural gas prices in Europe, already rising before the Russian invasion, shot skyward. Oil and wheat prices also surged due to the invasion. With the U.S. and European Union imposing sanctions on Russia, concerns about an oil price surge were elevated. By the summer, though, oil market participants realized that the worst-case scenario of an oil price surge was increasingly unlikely, and as the price pattern shifted to a downward trend, market sentiment came back into balance. See Figure 6 on the next page.



Managing Asymmetric Risk: Six Episodes in Crude Oil

Figure 6
WTI Crude Oil Prices 2022



Source: Bloomberg Professional for oil prices (CL) and CME Group CVOL sentiment (skew) metric.

Risk Management During Periods of Asymmetric Risk

We have studied only the six episodes of distinct oil price-risk sentiment asymmetry that have occurred since 2013. With this limited data set, we caution against making any confident assessments of what might happen when these periods develop. Nevertheless, as shown in a straightforward manner through our use of CVOL to analyze market sentiment, periods of heightened asymmetry in oil price-risk sentiment do seem to suggest an elevated probability of a change in the previous price trend. Either the risk about which many market participants are concerned materializes, or it does not. That is, the appearance of distinct asymmetry in CVOL-calculated upside and downside implied volatility from the options market, looking across the full spectrum of strike prices for the same maturity, can be an important signal of event risk. In our interpretation, the event risk is characterized by two scenarios, both with meaningful probabilities and yet, over time, only one scenario can prevail. Once one scenario or the other prevails, then the market generally reverts to a more balanced price-risk sentiment, and often a new price trend.

What this means for risk management is that there are heightened probabilities for an abrupt change in prices, up or down, and/or a new price trend developing. The potential for an elevated probability of price gaps makes some risk-management approaches less viable, such as delta hedging. Our conclusion is that risk managers need to be on high alert during these periods of asymmetric price-risk sentiment, carefully studying the underlying causes. In each of our six cases, the underlying causes were strikingly different, from an OPEC meeting to the pandemic and the Russian invasion of Ukraine. So, the emphasis for risk



management is to develop a scenario-based approach that takes into consideration the distinctly different possible outcomes when event risk is present.

Appendix: Calculating CVOL

The CVOL calculation method is known as a variance estimate. Start with a hypothetical table of out-of-the-money put and call options prices for one specific maturity or expiration date. See Figure 7 below. Then, consider a chart with the options prices on the vertical axis with the different strike prices arranged along the horizontal axis. See Figure 8 on the next page. The area inside all the boxes, representing the distance between strike prices multiplied by the option price, is used to calculate the estimated variance, which can then be adjusted to provide a standard deviation estimate and annualized. As can be observed in this example, the shape of the probability distribution is determined by the market prices for the different available strike prices and does not embed heroic or unrealistic assumptions about the shape of the probability distribution as is done with Black-Scholes-Merton type estimates for implied volatility. We also point out that with the CVOL method, one easily can do a calculation of the estimated variance just using the downside (puts) and the upside (calls). As a quick note, the at-the-money price used is an interpolation of the closest put and call prices to the underlying asset price.

Figure 7
Table of Prices and Strikes

Hypothetical Options Strikes and Prices				
At-the-Money equals 76.5				
Put Options Prices	Strike		Call Options Prices	Strike
2.73	76.50		0.35	80.00
2.49	76.00		0.75	79.50
1.99	75.50		1.31	79.00
1.49	75.00		1.56	78.50
0.99	74.50		1.81	78.00
0.49	74.00		2.06	77.50
0.05	73.50		2.30	77.00
0.03	73.00		2.55	76.50

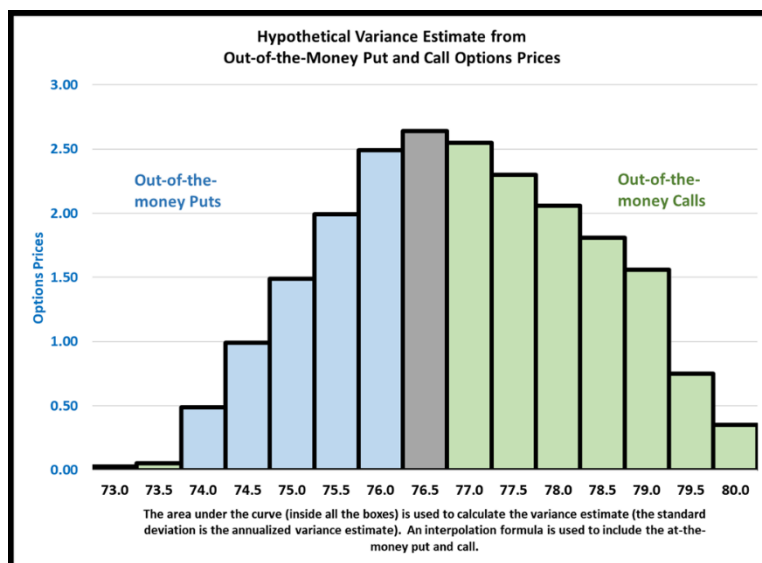
Source: CME Group. For a more comprehensive explanation, see:

<https://www.cmegroup.com/education/courses/introduction-to-cvol/understanding-the-cvol-index.html>.



Managing Asymmetric Risk: Six Episodes in Crude Oil

Figure 8
Probability Distribution for Variance Estimate Calculation



Source: CME Group.

Reference

CME Group, 2023, "[CME Group Volatility Index \(CVOL\) Benchmark Methodology](#)," Version 1.3.1, February 13.

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Dr. Bluford Putnam is Managing Director and Chief Economist of CME Group. As Chief Economist, Dr. Putnam is responsible for leading the economic analysis on global financial markets by identifying emerging trends, evaluating economic factors and forecasting their impact on CME Group and the company's business strategy. He also serves as CME Group's spokesperson on global economic conditions and manages external research initiatives.

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Managing Asymmetric Risk: Six Episodes in Crude Oil

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