Searching for Asymmetry: The Case of Crude Oil

Bluford Putnam, Ph.D.
Chief Economist, CME Group; and Member of the J.P. Morgan Center for Commodities' (JPMCC's) Research Council at the University of Colorado Denver Business School

Dr. Bluford Putnam, Ph.D., Chief Economist at the CME Group, presenting at a J.P. Morgan Center for Commodities' international commodities symposium held at the University of Colorado Denver Business School.

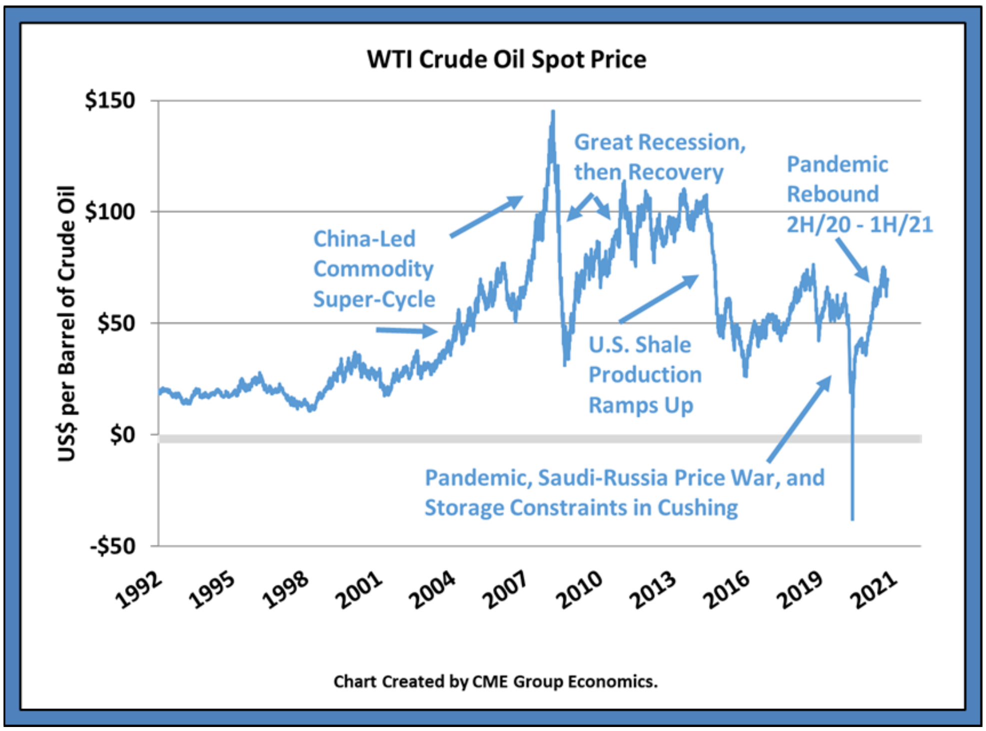
As an analytical approach, one can gain considerable insights into market behavior by searching for asymmetry and irregularities in patterns in the price discovery process. From an informational content perspective, the current price is just the tip of the iceberg in terms of inputs into the analytical process. Here we want to take the case of the crude oil market as an example, and work through what may be gleaned from going beyond the current price, to study the forward maturity curve from the futures market, the volume and open interest patterns in options trading, approaching implied volatility from different perspectives, and creating hypothetical risk-return distributions to enhance the analysis.

Markets are complex systems with a myriad of feedback loops. Production is adjusted, demand shifts, transportation challenges may come and go, inventories go up and down, and the political environment evolves, in addition to other factors. While analysts monitor all these developments as fundamental drivers of the market, in a complex system we also need to understand how market participants are reacting. So, here, as we work through the different metrics that may tell us something about market behavior, we are always searching for asymmetrical or irregular patterns that may provide clues about the debates swirling inside market activity and that may help us improve our risk management processes.

Appreciating the Events that Move Markets

Tracking patterns in the price of a commodity, such as crude oil, can highlight the magnitude of the impact of key fundamental drivers on market activity. During calm times with relatively small price moves, it can be very hard to tease out of the price data the impact of any given factor when the evolution of the different influential factors is slow moving and multiple factors are in play simultaneously. Larger price irregularities offer the opportunity to better appreciate which factors are the key drivers and to gauge whether these factors are increasing or decreasing in influence on the price. Figure 1 provides an illustration of what was driving large price moves coming from such factors as demand growth from China, the financial panic that led to the Great Recession of 2008-09, the explosion of shale oil production in the U.S., the onset of the pandemic of 2020 that led to a production battle between Saudi Arabia and Russia, and later the demand increases with the rebound from the pandemic.

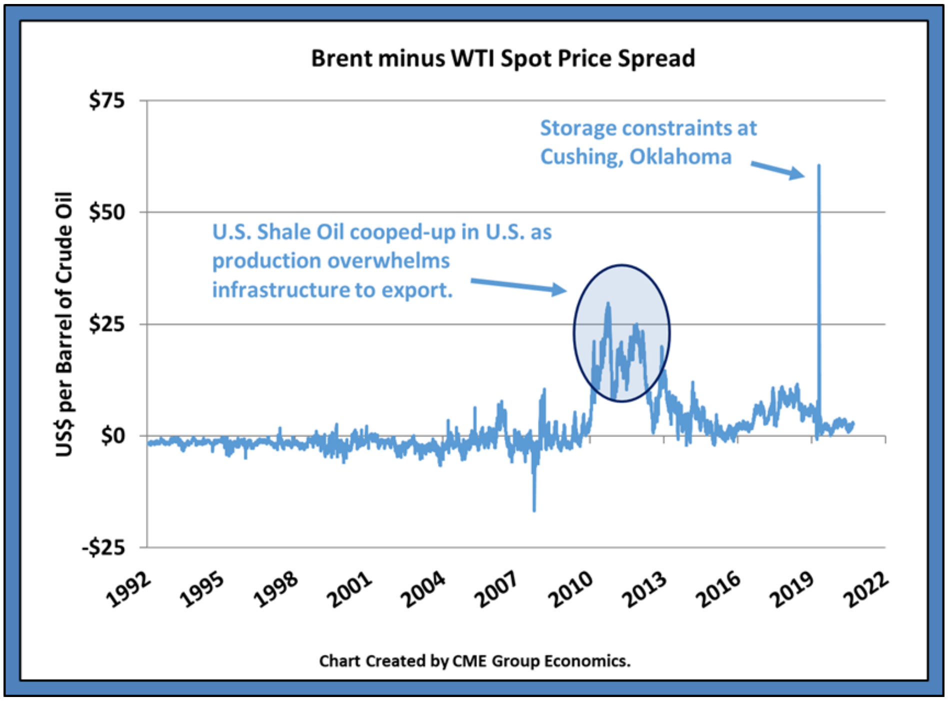
Figure 1



Source: Bloomberg Professional (WTI = USCRWTIC).

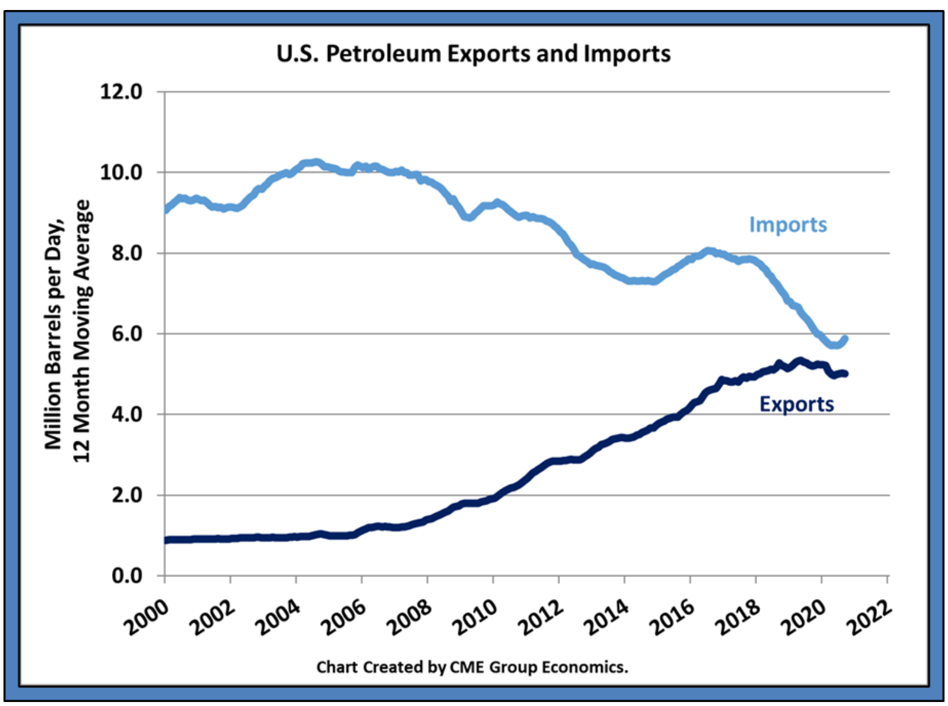
Monitoring the price movements of adjacent markets, such as comparing the price spread between Brent crude oil and West Texas Intermediate (WTI) crude oil, can also yield valuable insights when patterns become irregular or shift gears. Figure 2 on the next page highlights the widening of the spread between Brent and WTI crude oil during the period when U.S. shale production was soaring, but the domestic infrastructure was not ready to switch to exporting oil. During this period, roughly 2011 into 2013, U.S. oil production was cooped-up domestically so prices for WTI were lower than for Brent. When the U.S. was able to start exporting oil, as shown in Figure 3 also on the next page, the markets for Brent and WTI reconnected, and the price spread collapsed.[1]

Figure 2



Source: Bloomberg Professional (Brent = EUCRBRDT, WTI = USCRWTIC).

Figure 3



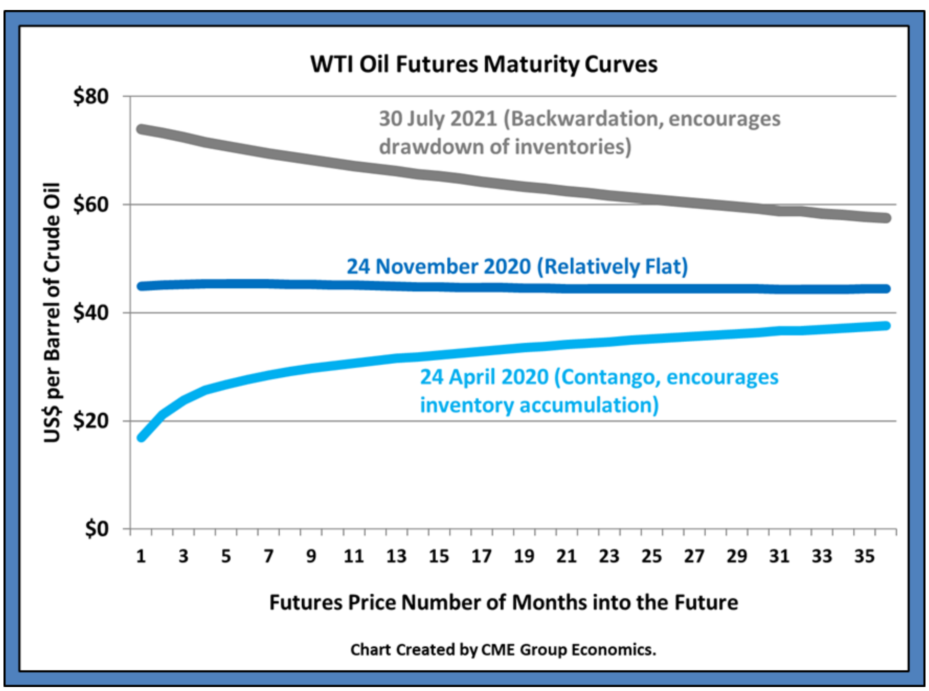
Source: Bloomberg Professional (DOEBCEXP, DOCRTOTL).

Implications from the Shape of the Futures Maturity Curve

Crude oil futures markets provide some incredibly important information about how the price discovery process works for the risk management of oil transactions many months and years forward in time. In particular, the shape of the forward maturity curve can be especially enlightening. Backwardation occurs when the nearby futures price is higher than prices farther out into the future. Contango occurs when the nearby futures price is lower than prices farther out into the future. When contango is relatively severe, this market state can provide incentives for market participants to hoard oil, putting oil into storage now and selling oil forward in the futures market, so long as the calendar price spread more than offsets the costs of storage. Vice-versa when backwardation is severe, there is an incentive to sell oil into the spot market immediately, reducing oil inventories.

The existence of either severe contango or severe backwardation complicates the analysis of changes in the patterns of inventory accumulation as shown in Figure 4. When demand falls sharply, say due to an economic disruption, then one would interpret a rise in inventories as reflecting the magnitude of the fall in demand. This interpretation of magnitude, however, needs to be tempered by studying the oil maturity curve. That is, if the oil maturity curve is in contango, even as demand starts to grow again, inventory may continue to rise so long as storage costs can be more than offset by selling oil forward in the futures markets for a significantly higher price. Equally, the interpretation of falling inventories when there is severe backwardation also needs to be treated with caution. Falling inventories are usually associated with rising demand, but at some point, higher spot prices relative to farther out futures prices create the incentive to sell inventories even if the fundamental demand picture has reversed direction.

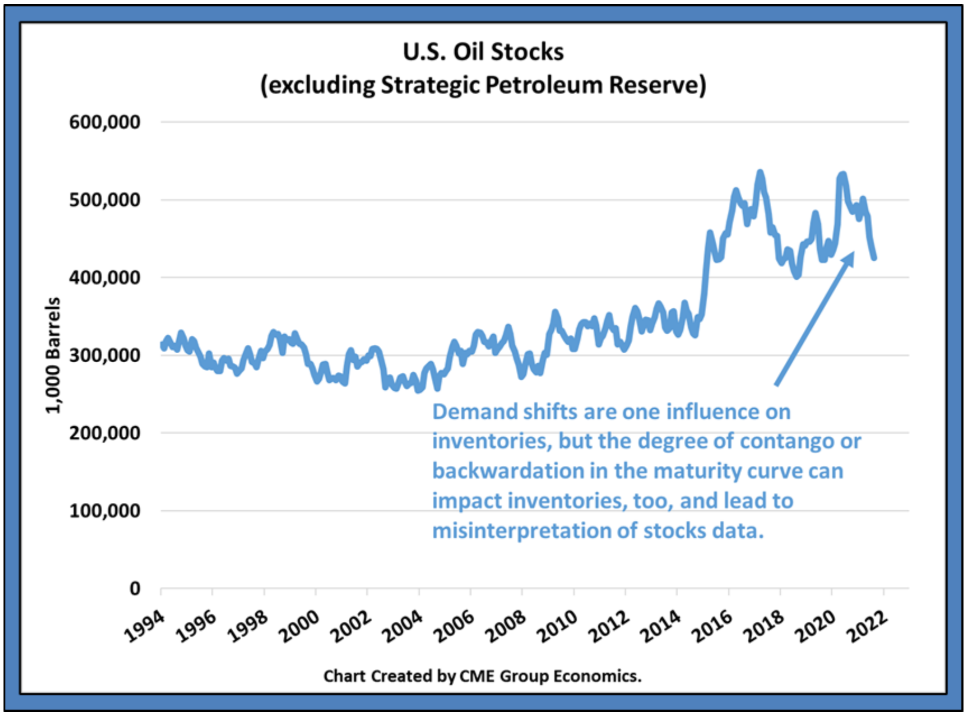
Figure 4



Source: Bloomberg Professional (CL1 through CL36).

Figure 5 shows how backwardation can encourage sales from inventories, even when demand might be slowing, as in July-August 2021.

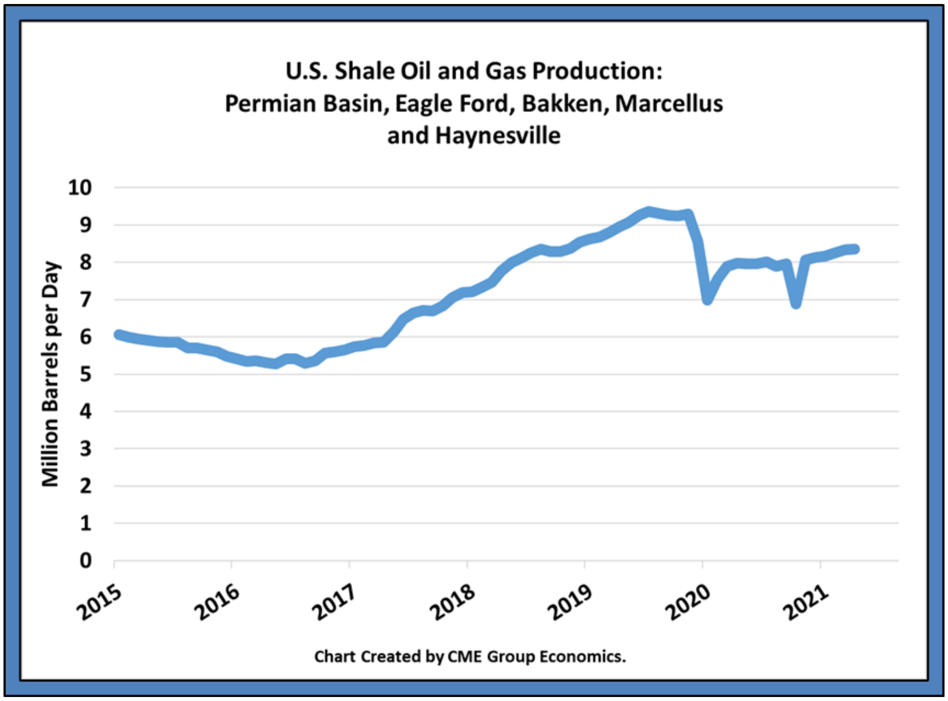
Figure 5



Source: Bloomberg Professional (DOESCRUD).

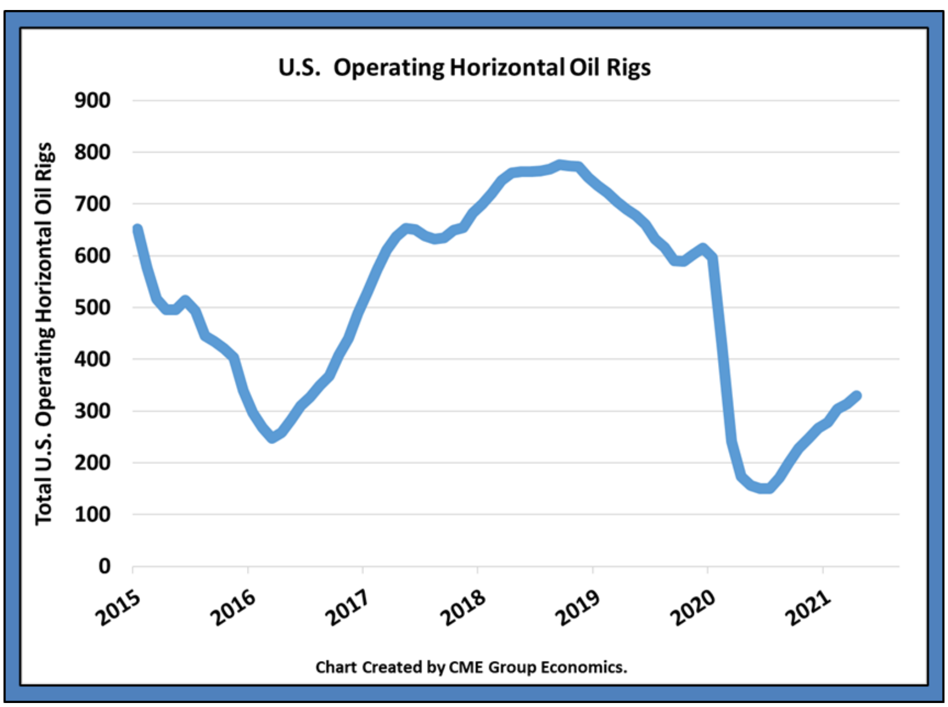
The shape of the oil futures maturity curve also has an influence on the decisions by U.S. shale oil producers to drill new wells or not. During the pandemic rebound period (H2/2020 – H1/2021) as oil prices rallied from their pandemic lows to the $70/barrel territory, there were expectations of sharp increases in U.S. shale oil production. While more wells were drilled and production rose, the production increases were quite modest. See Figures 6 and 7 on the next page. Part of the story can be interpreted through the lens of the oil maturity curve. U.S. shale oil wells have a fairly well-defined life span. The well is drilled and completed, oil starts to flow, peak oil production occurs in 4-6 months, then declines, and the well is shutdown after 18-24 months. From a risk management perspective, the price of oil along the maturity curve during the expected period of production is what matters, not the current spot price. So, severe backwardation works to temper the decision to drill new wells. Other factors also play a role, and the lack of an abundant availability of financing for new wells also appeared to slow the rebound in shale production even as the spot price of oil rose well above estimated break-even production costs. That is, lenders are also studying the oil futures maturity curve to assess appropriate risk management strategies.

Figure 6



Source: Bloomberg Professional (USPSTTPO).

Figure 7



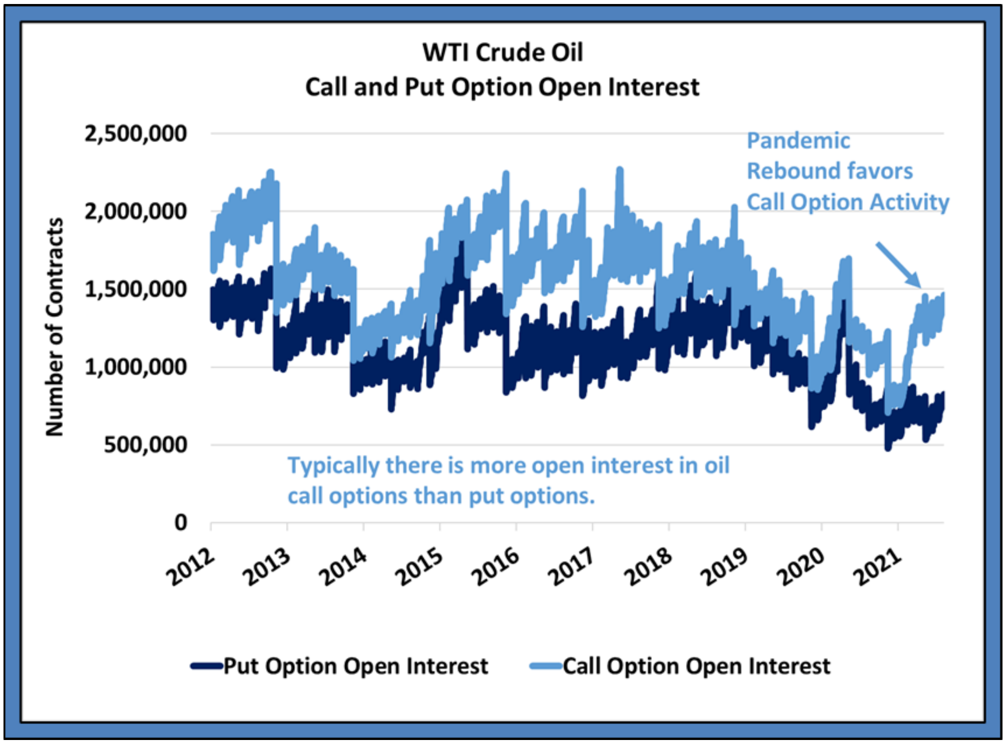
Source: Bloomberg Professional (USPSTTHO).

Changing Patterns of Trading Volume and Open Interest in Options Markets

Moving away from price metrics, one can gain additional insights into market behavior from studying trading volume and open interest in the options markets. Open interest is the quantity of contracts that are outstanding at the end of a given trading day. Trading volume is the number of transactions that occurred during the day. Both are worthy of examination.

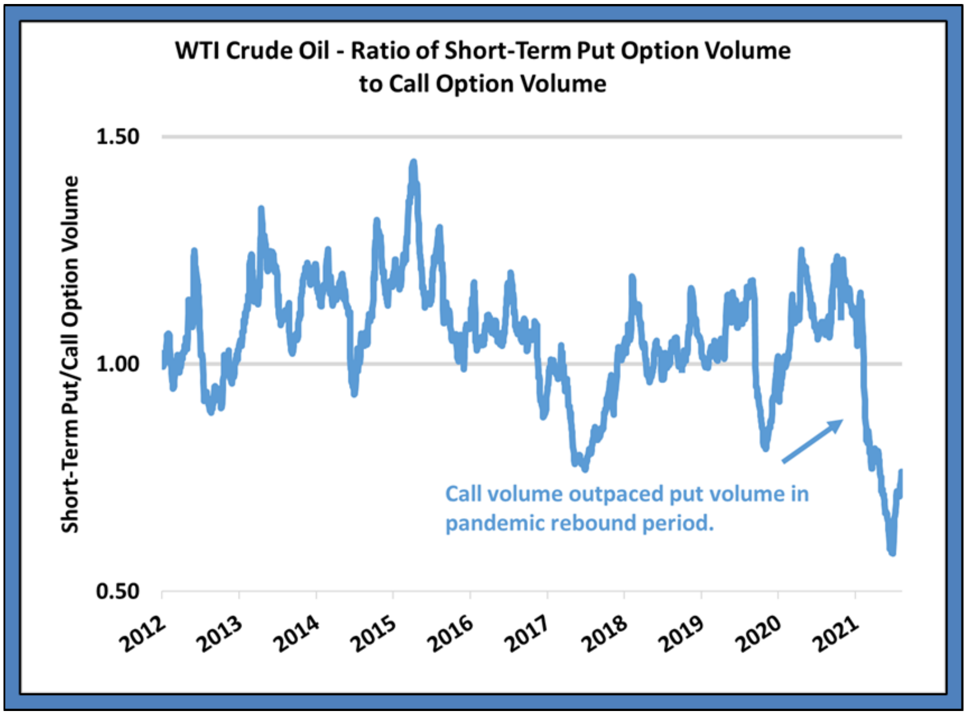
Our focus is on options markets because different trading activity in put options compared to call options can tell us which side of the market is getting the most attention; see Figure 8. This type of asymmetry can yield some interesting insights for risk management.

Figure 8



Source: CME Market Sentiment Meter (CLLO).

Figure 9



Source: CME Market Sentiment Meter (CLLO).

The pandemic rebound period (H2/2020 – H1/2021) can again serve as a case in point. Options themselves are asymmetric in their return profiles. Call options provide purchasers (i.e., long a call option) with a limit to the downside risk while providing increasing rewards when prices rise. Sellers of call options (i.e., short a call option) are essentially providing insurance (e.g., receiving a premium) against a price rise, and they can lose their premium and more if the price rise is substantial. In the U.S. WTI crude oil market for options on futures contracts, it is typical for call options to have more open interest than put options, so we are looking for changes from the usual pattern. During the pandemic rebound period, as oil prices were rallying from their low point in April 2020, call options saw substantially elevated trading activity and open interest compared to put options; see Figure 9. The elevated risk management activity on the call side of the options market can be interpreted as market participants focusing on the potential for further price increases, with considerably less attention on the possibility for price declines. A reversal of the volume and open interest trends can also be interpreted as confirmation that the market is reaching a more balanced supply-demand state in which price rises or declines are again viewed symmetrically. This information about a mismatch in put versus call options volume should not be interpreted as a directional price expectation, as one must remember that there is a buyer for every seller.

Also, studying the volumes and open interest for specific option strike prices can be informative. Starting in March 2021, and lasting for several months, there was a spike in the open interest associated with WTI crude oil call options with strike prices at $100/barrel or higher. At the time, a $100/barrel strike price was some $30 to $40 above the spot price (i.e., way out-of-the-money), so this was another indicator of the asymmetric price expectations in the oil market, which generally are temporary or short-lived, as the price either continues its upward momentum or it stalls out and market behavior shifts again in response.

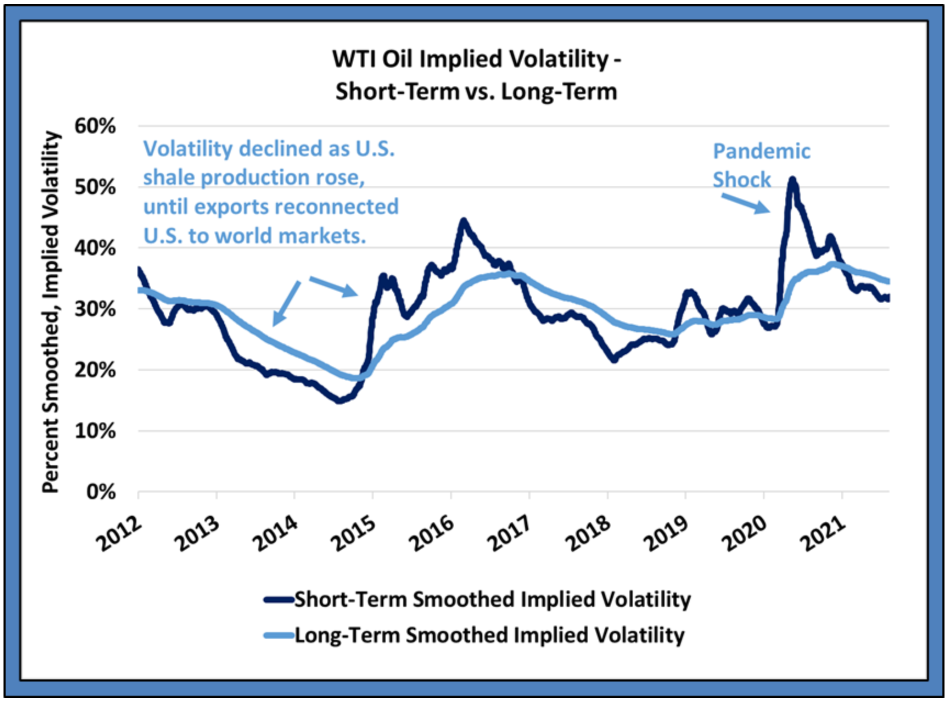
Analyzing Implied Volatility from Multiple Perspectives

Aside from looking at put and call options volume and open interest, options markets are commonly associated with providing a view on future volatility. We study both historical volatility and implied volatility where volatility is measured as the standard deviation of daily percentage price change movements, and typically is reported with an adjustment to annualize the daily standard deviation. Implied volatility is derived by using an options pricing model, such as Black-Scholes-Merton, to backout the volatility assumption that is embedded in the price of the option (Black and Scholes, 1973; Merton, 1973).

Implied volatility is often considered to reflect a pattern of mean reversion. That is, a period of elevated implied volatility will be followed by lower implied volatility. This can be observed in Figure 10 on the next page, which compares a measure of short-term implied volatility with a long-term measure. The pattern of mean reversion is clear, with the critically important caveat that when implied volatility moves higher and then later reverts, it does not always tend go back to the previously lower level of volatility but finds a new valley. For example, the U.S. shale oil revolution initially lowered implied volatility in the WTI crude oil options markets until rising U.S. exports reconnected WTI to the rest of the world. Implied volatility rose, and it never came back down to the lowest levels of volatility previously observed. Ditto for the pandemic shock that raised implied volatility in 2020, yet the subsequent decline in volatility did not go all the way back to previous volatility levels.

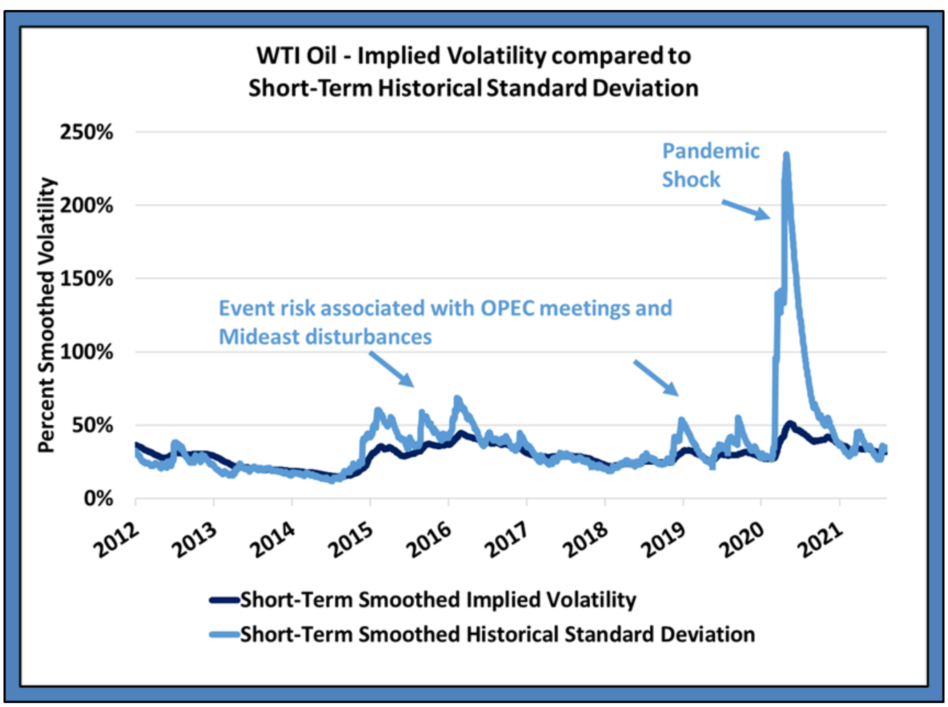
Another useful analytical technique is to look for differences in implied volatility and historically observed volatility. It is typical after a market surprise or shock that raises observed volatility for implied volatility to not reflect the full extent of the spike in actual volatility. That is, the options market is pricing-in the likelihood that after the surprise or shock, market volatility will decline, which is illustrated in Figure 11, also on the next page, comparing implied volatility with historical volatility.

Figure 10



Source: CME Market Sentiment Meter (CLLO).

Figure 11



Source: CME Market Sentiment Meter (CLLO).

There are additional analytical techniques that utilize implied volatility from options markets. We will make some quick comments on a few of the other analytical techniques, mainly to alert the reader that searching for asymmetrical behavior is critical to getting the most insights out of the available market behavior data.

Examining options smiles for skew or asymmetry is a popular technique. At-the-money (ATM) strike prices will usually show a lowered implied volatility than out-of-the-money strike prices for put or call options. It gets interesting when one side of the market – that is, out-of-the-money puts or out-of-the-money calls – display a different pattern or are skewed one way or the other.

One of the analytical techniques of additional interest is to study the option smile or skew at different maturity dates. Here we offer two possible interpretations when the implied volatilities from different strike prices are decidedly different for two different maturity dates. If the closest-in maturity date has the more elevated implied volatility or is skewed materially in one direction or the other compared to the further-out option maturity dates, our perspective is that this case often represents a reaction to a surprise or shock event that just happened. In this scenario, the concept of mean reversion of volatility is dominant.

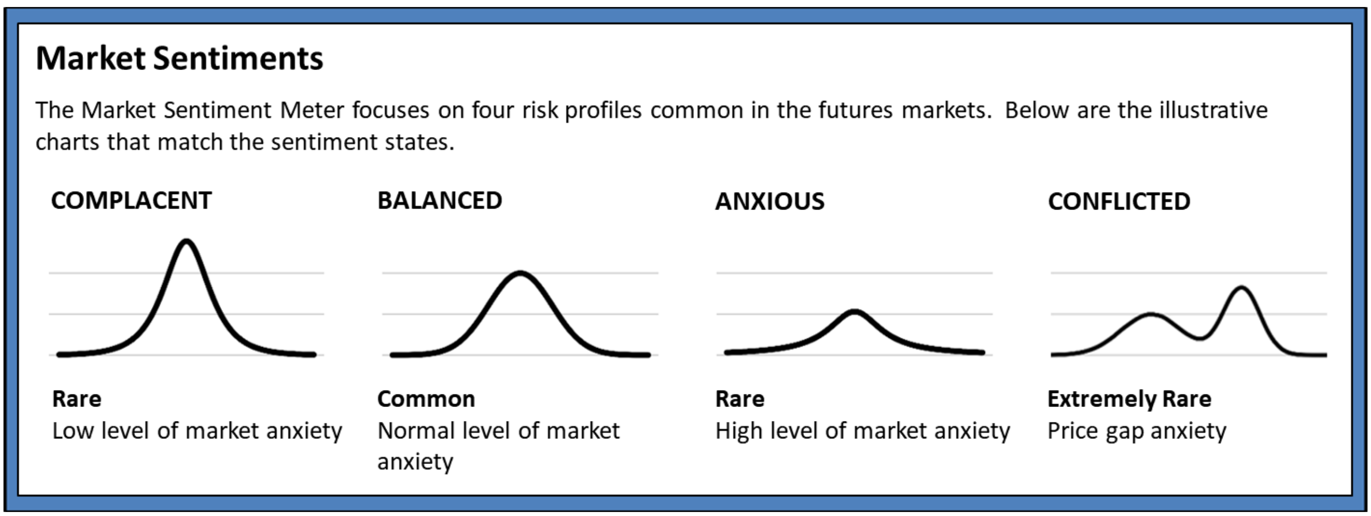
In rare cases, however, the implied volatilities across strike prices for the further-out maturities may be materially elevated relative to the nearby observations. In this scenario, our perspective is that market participants are concerned that there may be an event that might occur in between the maturity dates that could cause an abrupt price change one way or the other. Such a case might occur before an especially pivotal Organization of the Petroleum Exporting Countries (OPEC) meeting, for example. This raises some important issues for interpreting implied volatility. The standard interpretation based on Black-Scholes-Merton option pricing models is that implied volatility represents an expectation about future volatility. But, and it is a big one, Black-Scholes-Merton models have embedded in them the theoretical assumption that there can be no abrupt changes in price. That is, price changes occur in a continuously evolving manner with no price gaps. If market participants expect that there is a meaningful probability of a price gap occurring, then the implied volatility calculated with a Black-Scholes-Merton model will be elevated because it will be pricing both expected volatility *and* the probability of an abrupt price gap. Put another way, when implied volatility is higher in the farther-out option expirations or maturities, then our interpretation is that market participants may be pricing in the risk of an abrupt price gap, but the price move could be up or down.

We can extend this discussion of the embedded assumptions in Black-Sholes-Merton to discuss the assumption of constant volatility as well as imposing a normal distribution on price returns. We want to raise the issue of whether one might calculate implied volatility using a different method that avoids making any assumptions of the underlying probability distribution of market returns or the probability of price gaps or price discontinuities. One such alternative method of calculating implied volatility has been supplied by the CME Group in the form of "Cvol" (CME Group, 2021). Cvol uses the prices for out-of-the-money call options for one side and out-of-the-money put prices for the other side. A distribution is created in which the area under the curve can be interpreted as a measure of the variance, and then be converted into an annualized implied volatility without making any assumptions about the nature of the underlying risk-return probability distribution.

Constructing Hypothetical Risk-Return Distributions

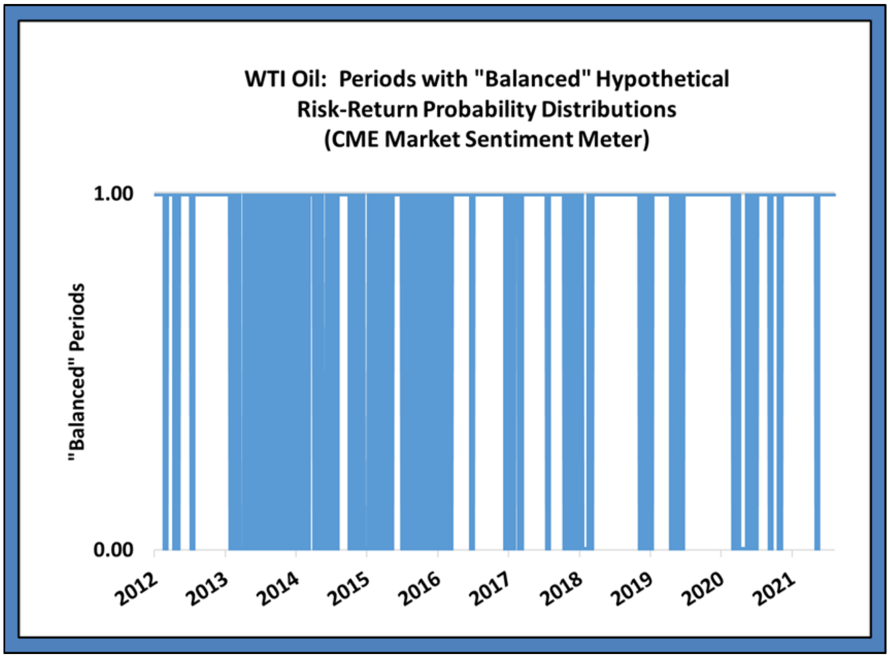
We also can go a step further with our analysis by combining a variety of observed metrics which inform the market behavior of participants and then make some heroic assumptions to create a hypothetical risk-return probability distribution that is completely independent of any assumptions about the shape of the probability distribution. That is, unlike Black-Scholes-Merton which requires a well-behaved single-mode, bell-shaped probability distribution, we can break free of that highly constraining assumption that is clearly at odds with the price patterns observed in the market. Our version is known as the Market Sentiment Meter (or MSM) and is constructed using metrics for implied volatility, historical volatility, intra-day high-low price spreads, and put and call options trading activity, in which two different distributions are created and then combined in a mixed-distribution process. Even if both probability distributions are "normal," the mixture distribution can take on a wide variety of interesting shapes, is not required to be bell-shaped, and can even be bimodal in rare circumstance. In the case of the hypothetical MSM risk-return probability distributions the possible shapes are classified into four sentiment states as show in Figure 12.[2]

Figure 12
Market Sentiment Meter Classification of Sentiment States



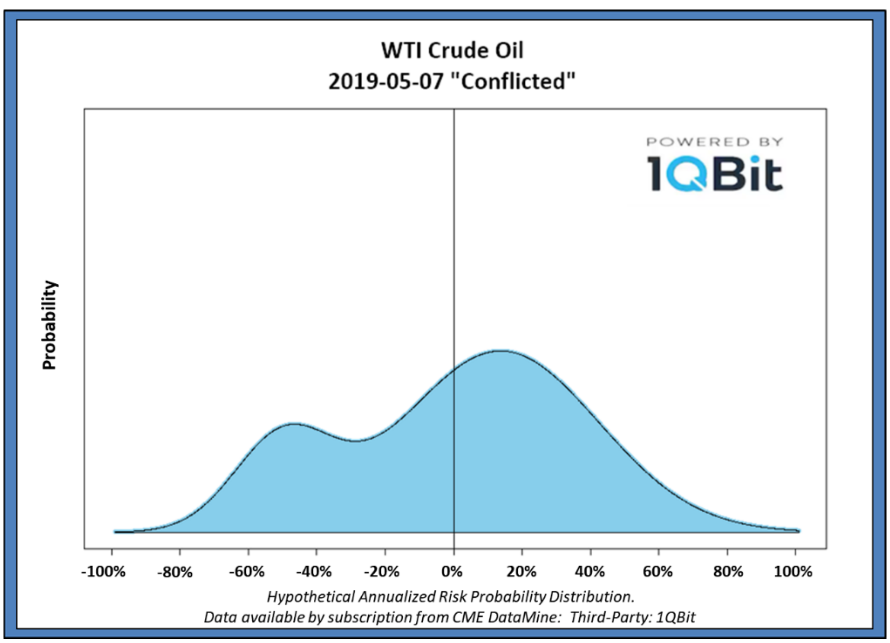
Most of the time, the sentiment state is classified as "balanced," as shown on Figure 13 on the next page. The balanced state is associated with relatively symmetrical market metrics, and thus provides no special insights into risk management challenges.

Figure 13
"Balanced" Sentiment State



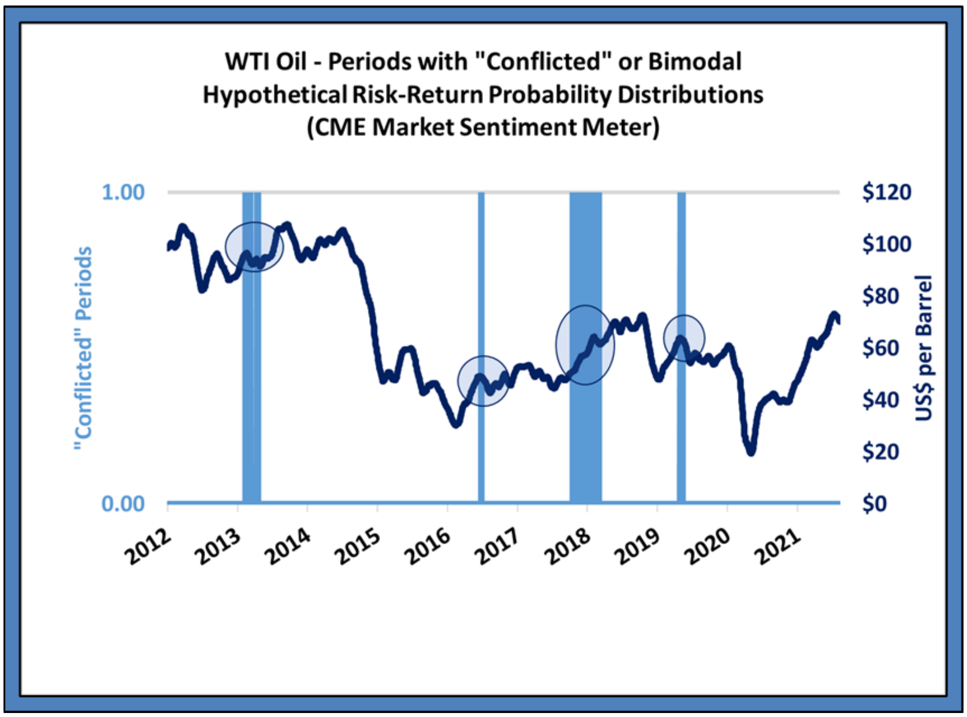
Source: CME Market Sentiment Meter (CLLO).

Figure 14
"Conflicted" Sentiment State



In rare cases, though, a bimodal hypothetical risk-return probability distribution is observed, which is termed "Conflicted." We interpret "Conflicted" distributions as indicating an elevated probability of event risk in which market participants are evaluating two very different scenarios with different outcomes and only one can prevail, an example of which is on the previous page in Figure 14. Our perspective is that when "Conflicted" sentiment states occur, risk managers should be on high alert for abrupt price changes where there is no view of the direction of the change. The "Conflicted" or bimodal case is rare and episodic, as shown in Figure 15. While much more research is needed, non-directional options strategies, such as straddles (i.e., buying ATM puts and calls) may be indicated as possible risk management approaches.[3]

Figure 15



Source: CME Market Sentiment Meter (CLLO).

Bottom Line: Using all the Information to Search for Asymmetries

Our message is that to appreciate all the feedback loops in a complex market system, one needs to pair an array of fundamental data with a wide variety of market behavior metrics to acquire a robust view of what is happening. In this research, we have used the crude oil market to provide a set of metrics and our interpretation of them to illustrate the value of searching for asymmetrical behavior or irregular patterns in the metrics. The current price is merely a starting point for understanding what is driving markets.

Our analytical methods go beyond the current price to also focus on:

- the forward maturity curve from the futures market,
- the volume and open interest patterns in options trading,
- implied volatility for different perspectives, and
- creating hypothetical risk-return distributions to enhance the analysis.

The objective is to enhance our risk management approaches by gaining a more complete appreciation of the activity inside markets that is interacting with the fundamental forces driving markets. We want to leave no information source untouched as we go behind the scenes to analyze complex market behavior.

Endnotes

Dr. Putnam presented on this topic at the JPMCC's 4th Annual International Commodities Symposium during his Industry Keynote speech on August 16, 2021. The Symposium's Program Committee Co-Chairs were Dr. Jian Yang, J.P. Morgan Endowed Chair & JPMCC Research Director and Dr. Thomas Brady, Executive Director of the JPMCC.

Dr. Putnam is a regular contributor to the *GCARD*'s Economist's Edge section. In addition, for further coverage of the crude oil markets, one can also read past *GCARD* articles on this topic.

All examples in this report are hypothetical interpretations of situations and are used for explanation purposes only. The views in this report reflect solely those of the author and not necessarily those of CME Group or its affiliated institutions. This report and the information herein should not be considered investment advice or the results of actual market experience.

1 Similarly, as discussed in Till and Eagleeye (2017), by the end of 2013, near-month refinery margins also no longer needed to rally to extraordinary levels to incentivize the transporting and refining of burgeoning domestic crude oil supplies.

2 The classification of market risk profiles into four sentiment states was originally discussed in Putnam (2019).

3 For a statistical analysis of non-directional strategies as applied to equities, see in Kownatzki *et al.* (2021).

References

Black, F. and M. Scholes, 1973, "The Pricing of Options and Corporate Liabilities," *Journal of Political Economy*, Vol. 81, No. 3, May-June, pp. 637-654.

CME Group, 2021, "CME Group Volatility Index (CVOL™)." Accessed via website: https://www.cmegroup.com/market-data/cme-group-benchmark-administration/cme-group-volatility-indexes.html on October 19, 2021.

Kownatzki, C., Putnam, B. and A. Yu, 2021, "Case Study of Event Risk Management with Options Strangles and Straddles," *Review of Financial Economics*, Version of Record online: July 27.

Merton, R., 1973, "Theory of Rational Option Pricing," *The Bell Journal of Economics and Management Science*, Vol. 4, No. 1, Spring, pp. 141-183.

Putnam, B., 2019, "Commodity Risks: Describing the Unobservable," Research Council Corner: The Economist's Edge, *Global Commodities Applied Research Digest*, Vol. 4, No. 1, Summer, pp. 23-31.

Till, H. and J. Eagleeye, 2017, "Inferring Energy Fundamentals through Price-Relationship Data," Editorial Advisory Board Commentaries, *Global Commodities Applied Research Digest*, Vol. 2, No. 2, Winter, pp. 111–133.

Author Biography

BLUFORD PUTNAM, Ph.D.
Chief Economist, CME Group

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.

Prior to joining CME Group, Dr. Putnam gained experience in the financial services industry with concentrations in central banking, investment research and portfolio management. He also has served as President of CDC Investment Management Corporation and was Managing Director and Chief Investment Officer for Equities and Asset Allocation at the Bankers Trust Company in New York. His background also includes economist positions with Kleinwort Benson, Ltd., Morgan Stanley & Company, Chase Manhattan Bank and the Federal Reserve Bank of New York. Dr. Putnam holds a Bachelor's degree from Florida Presbyterian College (later renamed Eckerd College) and a Ph.D. in Economics from Tulane University.

Dr. Putnam has authored five books on international finance, as well as many articles that have been published in academic journals, including the *American Economic Review*, *Journal of Finance*, and *Review of Financial Economics* among others. His newest book, Economics Gone Astray, is now available from World Scientific (WS) Professional.

Dr. Putnam is also a member of the J.P. Morgan Center for Commodities' Research Council.